Impulsivity, Parenting and Soft Drink Consumption in Emerging Adults and Children

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Abstract

Obesity is a growing major health concern affecting Australian adults and children. Sugar Sweetened Beverage (SSB) consumption is a considerable source of dietary sugar linked to obesity and several other health consequences. Poor decision-making and impulsivity have been implicated as potential routes towards excess SSB consumption and obesity. Decision-making and the ability to inhibit inappropriate behaviours is one of the last regions in the brain to mature. This makes children and emerging adults most vulnerable to poor decision-making skills. In addition, evidence points to impaired decision-making capacity resulting from a western style diet or one high in sugar. More impulsive individuals may be at risk of obesity via reduced self-control and inability to cease SSB consumption. It is possible that once started, more impulsive individuals may be less able to stop consuming desired foods such as SSB. As emerging adults and children are the highest consumers of SSB, it is important to understand and mitigate the factors driving SSB consumption. Most evidence to date linking SSB to impulsivity relies on self-report of SSB consumption and indirect measures of impulsivity. This thesis aimed to link impulsivity measures directly with SSB consumption. The primary aim of this thesis was to address limitations in the literature surrounding the role of impulsivity in SSB consumption and obesity; and to relate two naturalistic behavioural measures of impulsivity with SSB consumption, one involving SSB consumption directly, the other involving a delay of gratification in emerging adults and children. Study 1 (N =178) used a self-report measure of impulsivity to predict actual SSB consumption and delay of gratification in a group of emerging adults and to relate these with measures of obesity. Results indicated that self-report impulsivity predicted the delay of gratification measure. Self-reported impulsivity was not predictive of SSB consumption under experimental conditions, usual SSB consumption or obesity in this cohort. No mediating or moderating effect of usual SSB consumption on the relationship between impulsivity and obesity was found. Study 2 (*N* = 107) addressed potential methodological limitations and replicated Study 1 findings in a second sample of first year university students. Results from Study 2 were similar to those of Study 1 and substituting soda water as the control and providing regular reminders to participants for the final reward created additional confounds. The second aim of this thesis was to investigate the role of parents in regulating their child's SSB consumption. Parenting style can contribute to determining their child's attitude and consumption of SSB. However, there is limited evidence examining the role of parenting, parental impulsivity and child impulsivity as factors influencing SSB consumption and the resultant pathway to obesity. Study 3 (*N* =56) used the methodology from Study 1 in a sample of children as the cohort of interest. Study 3 tested the self-report impulsivity measure against the two behavioural measures with children aged 10-12 years. Study 3 also accounted for parenting style and compared parent - child impulsivity to further understand the factors leading to excess SSB consumption and pathway to obesity. Although the studies did not demonstrate the predictive capacity of self-report impulsivity over the two behavioural measures of impulsivity, several potential reasons were discussed including self-selection bias. Investigation of the role of parenting style revealed that negative aspects such as poor supervision are risk factors for their children's impulsivity and SSB consumption. These results have implications for encouraging parental involvement in their child's food choices worthy of a targeted intervention. The results of this thesis provide a promising basis for future research to target at-risk children and emerging adults, and to encourage policy makers, educators and parents to limit SSB access to young, developing brains.

Statement of Originality

This body of work has not previously been submitted for a degree or diploma in any University. To the best of my knowledge and belief, this thesis contains no material previously published or written by another. The data for this research was collected and analysed by the author.

Signed

Robyn E Stumm Date: 13/05/2022

Acknowledgement of Papers included in this Thesis

Included in this thesis are a paper in Chapter 4 which is co-authored with other researchers. My contribution to the co-authored paper is outlined at the front of the relevant chapter.

Chapter 4: Study 1: Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults

Appropriate acknowledgements of those who contributed to the research but did not qualify as authors are included in each paper.

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Stumm, R., Oaten, M., Occhipinti, S., & Loxton N.J. (2022). Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults.

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CHAPTER 1

Overview and Aims of the Thesis

Obesity is a growing major health concern affecting Australian adults and children. Sugar Sweetened Beverage (SSB) consumption is a considerable source of dietary sugar that is linked to obesity and resultant health consequences (Australian Bureau Statistics, 2018). Similarly, there may be long term cognitive consequences such as impaired decision-making capacity resulting from a western style diet or one high in sugar (Reichelt et al., 2015). Poor decision-making and impulsivity have been implicated as potential routes towards excess SSB consumption and obesity. Decision-making ability is one of the last regions in the brain to mature, making the adolescent most vulnerable to poor decision-making skills (Romine & Reynolds, 2005). Similarly, more impulsive individuals may be at risk of obesity via reduced self-control and inability to cease SSB consumption (Lumley et al., 2016). It is possible that once started, more impulsive individuals may be less able to stop consuming desired foods such as SSB. Coupled with an immature executive function, this leaves children and emerging adults most vulnerable to poor choices. Youth are also the highest consumers of SSB (Australian Bureau of Statistics, 2018), highlighting the importance of understanding and mitigating the factors responsible. It is yet unclear if trait impulsivity promotes excess SSB consumption or if high SSB consumption promotes state related impulsivity and whether the effect of obesity perpetuates the cycle. There is evidence that obesity itself, may promote poor decision-making capacity in vulnerable individuals (Brooks et al., 2013). The relationship between impulsivity, SSB consumption and obesity is complex, with existing evidence demonstrating associations between impulsivity or SSB consumption with obesity and between impulsivity with SSB consumption. Therefore, investigation of the effect of SSB and impulsivity on obesity in emerging adults warrants further investigation. There is a gap in the literature exploring the relationship directly between impulsivity, SSB consumption and obesity. Chapters 2 and 3 provide more theoretical understanding behind the relationships and potential interactions between SSB consumption, obesity and impulsivity. Chapters 4 and 5 are experimental studies directly exploring SSB consumption and impulsivity in emerging adults to establish the nature of the interactions in adults whose SSB consumption patterns have already been established.

Finally, Chapters 6 and 7 focus on SSB consumption, impulsivity and obesity in children aged 10-12 years. Children have yet to assert their independence and remain under their parent's direction and guidance and as such are influenced by parental attitudes and behaviours. One of the questions that arises in the final study is the role of parents in regulating their child's SSB consumption. Parenting style can determine their child's attitude towards SSB consumption, with a more permissive and accepting parental attitude leading to greater SSB consumption in their child (Gebremariam et al, 2016; Reid et al., 2015). Adolescents who perceived their parents as being either moderately strict, or more highly involved, reported less SSB consumption (van der Horst et al., 2007). Overall, parents influence their child's SSB consumption through parental style and SSB availability. Chapter 6 explores in more detail the relationship between parental impulsivity, parenting style and child impulsivity with a view that more impulsive parents, via a negative parenting style, may enable more impulsive behaviours in their offspring.

More impulsive parents may have more impulsive children, and this genetic predisposition, coupled with more accepting attitudes towards SSB, creates an additive effect where impulsivity leads to excess SSB consumption which then leads to greater risk of obesity. Thus, parents play an important role in both modelling behaviour and in shaping their child's decision-making capacity. More impulsive children who engage in more impulse driven behaviour result in poorer parenting style which then translated to greater impulsive risk taking behaviour in middle adolescence (Elam et al., 2017). In addition, more impulsive parents engaged less with their impulsive children (Elam et al., 2017). There is limited evidence examining the link between parental, and child impulsivity on dietary behaviour and SSB consumption. Similarly, there is a gap in the literature linking parental and child impulsivity as a pathway to obesity. Therefore, one of the aims of this thesis is to explore parenting style and parental impulsivity on their child's SSB consumption, impulsivity and obesity. Chapter 7 involves an experimental study similar to chapters 4 and 5. Whereas the first two studies investigated emerging adults, the final study in Chapter 7 investigates children aged 10-12 years SSB consumption under experimental conditions plus their parents impulsivity and parenting style. The overall aim of this thesis is to address limitations in the existing literature surrounding the role of impulsivity in SSB consumption and the resultant link with obesity in emerging adults and then children aged 10-12 years via their parents' influence.

SSB Consumption

One of the potential confounds of the current literature around SSB consumption and impulsivity is that SSB consumption is assessed via self-report measures, and impulsivity via unrelated laboratory measures (e.g., Ames et al., 2014; Lumley et al., 2016; Nederkoorn et al., 2007). To date, there is no specific measure of state-induced impulsivity (that is, the ability to exercise restraint and self-control over desired wants) measured using SSB consumption directly (Moran & Mullen, 2020). This project will seek to relate SSB consumption directly with measures of state and trait impulsivity. In addition, to better understand how state and trait impulsivity are influenced, the project will demonstrate a naturalistic and relevant behavioural delay of gratification measure of state impulsivity and correlate this to SSB consumption and a trait self-report measure of impulsivity.

Although there are multiple behavioural and self-report measures for determining an individual's degree of impulsivity, the challenge is a lack of inter-correlation and relatedness to real-world scenarios. In addition, there is no measure determining a loss of control over SSB consumption. The following section will demonstrate the issues with current measures with a view to incorporating a naturalistic real-world behavioural measure with a simple self-report measure and then introducing the concept of an SSB related measure of impulsivity.

Issues in Determining Impulsivity

Impulsivity has differing constructs and operationalisations, with some theorists using a singular construct (Guerrieri et al., 2007), others incorporating the constructs of sensation seeking with reward sensitivity, (Davis & Carter, 2009), while others use a multifactorial description (Cyders & Coskunpinar, 2011, 2012; Dawe & Loxton, 2004; Dougherty, Mathias, Marsh, & Jagar, 2005), or utilise terms such as poor executive function and inability to override specific behavioural responses (Enticott, Ogloff, & Bradshaw, 2006). Therefore, obtaining a consistent and accurate representation of the impulsivity construct can be difficult. Three broad, unrelated, aspects of impulsive behaviour that are commonly measured in laboratory testing with adolescents involve impulsive decision-making, ability to sustain attention, and inhibiting motor behaviour (Reynolds, Penfold, & Patak, 2008). In an attempt to find common ground between self-report and behavioural measures of impulsivity, Aichert et al., (2012) compared impulsivity using the Barratt Impulsivity Scale (BIS-11) with four response inhibition paradigms in 504 healthy adults aged 18 to 54 (M = 26.7) years. The results were mixed and conflicting, with the BIS-11 correlating with two of the behavioural measures, but few of the behavioural tasks correlated with each other, indicating large heterogeneity across constructs. The discrepancies were attributed to differing constructs, as the self-report measure tends to identify overall cognitive and behavioural patterns, whereas each behavioural measure identified specific momentary impulse behaviours in a laboratory setting (Aichert et al., 2012).

In addition, these simple, impulse driven behaviours may not fully encompass reward driven behaviour, or the ability to exercise restraint over desired rewards. Dawe and Loxton (2004) proposed that trait impulsivity may comprise of two factors, reward sensitivity and rash impulsivity. Reward sensitivity comprises the heightened sensitivity and motivation to approach rewarding opportunities, whereas rash impulsivity may refer to a loss of self-control in the pursuit of rewards or desired goals (Dawe & Loxton, 2004). This notion was further supported by Dawe, Gullo, and Loxton (2004) and then Gullo, et al., (2011) who investigated these two components with alcohol and drug behaviour in a sample of 454 British and Australian young adults aged between 18 and 23 years. The authors utilised structural equation modelling to determine which of a variety of aspects of reward driven and impulsiveness behaviour best predicted hazardous substance use. The results implied that impulsivity was part of a multifactorial construct when looking at problematic behaviour (Gullo et al., 2011).

Lange and Eggert (2015) acknowledged the complex nature of establishing relationships between behavioural and self-report measures of impulsivity. These authors introduced a monetary delay discounting procedure to tap into potentially reward driven impulsive decision-making behaviour with one other response inhibition task and the BIS self-report measure in a sample of 70 adults (*M* age = 21.8 years). Surprisingly, no association was found between the measures suggesting that perhaps the behavioural measures used did not tap into the impulsivity construct of interest. Similarly, self-report questionnaires require a level of insight which more impulsive individuals may not possess (Reynolds et al., 2006), are subject to demand characteristics such as social desirability, and in some instances may not fully represent the actual behaviour being assessed.

For example, Bennett and Blissett (2019) attempted to redress the issue of inconsistencies between behavioural self-report measures of impulsivity, obesity and food consumption under experimental conditions using four different measures of behavioural impulsivity. Fifty children aged 7 – 11 years completed four behavioural measures of impulsivity, the go/no-go, door opening, delay discounting, and circle drawing tasks, while their parents completed two measures rating their child's impulsivity. After completing the impulsivity tasks, the child had unlimited access to sweet and savoury snack foods over a 10-minute period. The results demonstrated conflicting relationships between measures. Although parent-reported impulsivity was associated with greater BMI and waist circumference, none of the behavioural measures showed a relationship with BMI. Conversely, two of the behavioural measures, go, no-go and delay discounting, showed a positive relationship with snack food intake under experimental conditions. That is, those higher in impulsivity consumed more snack food, suggesting a relationship between impulsivity and inability to restrain intake (Bennett et al. 2019). However, one important message from this study is that child-report behavioural measures of impulsivity did not correlate with parent-report measures, therefore, it is important to identify behavioural measures that are better able to identify eating behaviour impulsivity.

To explore the relationship between eating behaviour, impulsivity, and obesity, Goldschmidt, et al., (2019) used real-time reporting by 40 overweight or obese children and adolescents aged 8 to 14 years. Participants were asked every 2 to 3 hours to record emotional and cognitive states, questions around ability to control intake and recent food intake for 14 days. Impulsivity was determined via self-report questionnaire plus a visuomotor processing test of inhibitory control. Interestingly, loss of control over intake was associated with impulsivity only when negative mood was also present (Goldschmidt et al., 2019), which indicates that perhaps negative mood creates a cognitive load or diminishes an individual's capacity to resist the urge to eat. However, it should be noted that only one aspect of the self-report impulsivity scale (lack of perseverance) was associated with loss of control of intake. Therefore, the measures used may not have fully tapped into the construct of eating behaviour impulsivity.

It is not surprising then that the various methodologies poorly correlate with each other. For example, a meta-analysis of 28 studies using self-report plus a variety of impulsivity behavioural measures demonstrated only a small relationship between self-report and behavioural measures of impulsivity (Cyders & Coskunpinar, 2011). The authors used a correlational analysis to identify commonalities across 10 dimensions of self-report and behavioural measures. The resultant poor correlation between the measures was consistent with Reynolds et al., (2006) where self-report tests measured trait impulsivity, and behavioural tests measured state or momentary impulsivity (Cyders & Coskunpinar, 2011). Rather than utilising a global term of impulsivity, it may be more useful to operationalise each construct under investigation in terms of the particular aspect of impulsivity that is most relevant (Cyders & Coskunpinar, 2011, 2012). Different behavioural measures of impulsivity may in fact represent aspects of impulsivity that are not covered by self- report measures (Meule & Blechert, 2017). Impulsivity may impact obesity via an individual's belief in their ability to regulate intake (Meule & Blechert, 2017). In addition, a combination of self-report and behavioural measures of impulsivity may complement each other and offer unique contributions thus providing more of a complete picture of the impulsivity construct (Dougherty et al., 2005; Meule & Blechert, 2017).

One laboratory measure of impulsivity that does tap into the element of reward restraint, involves delay discounting, where a series of hypothetical computer-based choices are made between small immediate rewards, and larger rewards over increasing periods of delay (Reynolds & Schiffbauer, 2005). Delay discounting tasks, however, require complex cognitive choices and levels of abstract thinking that may not be appropriate for younger adolescents or children (Isen, et al., 2014; Reynolds & Schiffbauer, 2005), and may not accurately reflect immediate reward driven behaviour.

Measures of Impulsivity in the Current Thesis

Delay of Gratification

Delay of gratification, however, taps into an individual's ability to both inhibit reward motivation, and exert restraint over an immediate available reward in favour of a delayed larger reward, and may be more age appropriate for younger individuals (Reynolds & Schiffbauer, 2005). The additional benefit of using delay of gratification is the ability to test in a real-life domain. Hypothetical or laboratory behavioural measures often lack the immediacy and ecological validity of real-life outcomes and measures (Isen et al., 2014). For example, examination of a meta-analysis of research involving either delay of gratification or delay discounting protocols, revealed that only three used real money, with all delay of gratification protocols utilising small amounts of money (cents) and short timeframes (minutes), thereby reducing the validity of this in real terms (Doidge, Flora & Toplak, 2021). These protocols may lack significance and sufficient rewarding properties to some impulsive older children or young adolescents. Furthermore, Xu, Xiao, and Rao (2019) compared real versus hypothetical money rewards in a commonly used delay discounting measure with a total of 82 undergraduate students and using differing magnitudes of reward. Students were more risk averse with real money, and also with increasing the magnitude of real loss compared to hypothetical money, indicating the legitimacy of using real monetary rewards.

Wulfert et al., (2002) adapted Mischel's (1970) delay of gratification test for use in young (aged 11 to 14 years) and older adolescents (aged 15 to 18 years), involving an immediate more significant cash reward of $5 to $7, or a larger delayed cash reward of $7 to $10. The measure has been previously validated against externalising behaviours of impulsivity and has the benefits of being salient to the age group, naturalistic, and models real-life decision-making processes (Anokhin et al., 2011; Isen et al., 2014; Wulfert et al., 2002). Moreover, monetary incentives relative to other incentives may be more motivating for young people (Wulfert et al., 2002). In addition, offering non-food-based rewards eliminates the potentially confounding cueing effect of food for obese individuals (Caleza et al., 2016). Food rewards can trigger an increased feeding behaviour in obese individuals that is more related to the sight of that food rather than ability to exercise restraint (Caleza et al, 2016). Therefore, using desirable non-food rewards such as money may act as a suitable stimulus to induce impulsivity. Plus, the reward is real rather than computer-based and physically tangible, being right in front to the individual. This means the individual needs to exert considerable willpower to overcome the immediate choice in favour of a delayed reward (Doidge, et al., 2021).

Impulse Driven SSB Consumption

As discussed earlier, there is no measure determining a loss of control over SSB consumption. All studies involved in this thesis used a thirst induction paradigm similar to Brannigan, Stevenson and Francis (2015). The authors investigated the role of thirst satiety recognition with participants who regularly consumed either a high fat, high sugar diet or low fat and sugar diet. The authors induced thirst and then determined participants' sensitivity to satiety signals when given access to *ad libitum* water. The authors observed that those who consumed a high fat high sugar diet were less able to recognise satiety cues and consumed more fluid after thirst was induced (Brannigan et al., 2015). It then follows that these individuals would be less able to cease overconsumption of SSB compared to water. One possibility raised from their study was that those who regularly consume a high fat and sugar diet may also be more impulsive, that is, less able to stop overconsumption, once started. This then raises the possibility that an inability to cease drinking once satiated may be related to increased impulsivity. Once started, more impulsive individuals may be less able to stop consuming highly desired foods such as SSB. Emerging adults are most vulnerable to poor choices. They are also the highest consumers of SSB (ABS,2018), emphasising the importance of understanding and mitigating the factors responsible. Although Brannigan et al., (2015) did not investigate SSB overconsumption due directly to impulsivity, the premise used in this thesis is that those more impulsive individuals who consume a high sugar diet would be less sensitive to thirst satiety cues and will then overconsume.

Measurement of Trait Impulsivity

One of the aims of the thesis is to investigate the relationship between the two behavioural measures of impulsivity discussed above with a self-report trait measure of impulsivity. The Barratt Impulsiveness Scale (BIS-11) is a 30-item self-report scale designed to assess the personality trait of impulsivity in adults (Patton et al., 1995). In an update of the psychometric data for the Barratt Impulsiveness Scale (BIS-11), Stanford et al., (2009) reported good psychometric properties consistent with other commonly used self-report measures of impulsivity, but poor correlations with behavioural measures of impulsivity. Stanford et al, (2009) also cited correlational evidence of the BIS-11 with substance use disorders and ADHD. This is consistent with previous research (Cyders & Coskunpinar, 2011, 2012; Dougherty et al, 2005) that reflects the differences between individual patterns of behaviour across time, and state-dependant impulsivity (Stanford et al., 2009). An adolescent version of the adult BIS-11 has been translated and validated across Italian (Fossati, et al., 2002), German (Hartmann, et al., 2011), Spanish (Cosi et al., 2008), Indian (Bhat et al., 2018) and Portuguese adolescents (Pechorro, et al., 2016), demonstrating usefulness across cultures, plus, an ability to differentiate impulsive children and emerging adults. Together, these findings suggest that the adolescent BIS-11 may be a useful measure to discriminate and quantify trait impulsivity in older children and adolescents.

The Current Thesis

It is anticipated that under experimental conditions of restraint, more impulsive individuals will be more obese, and consume more SSB. Similarly, more impulsive individuals will also choose the more immediate reward. No evidence to date has investigated the role of parental impulsivity on child impulsivity and subsequent SSB consumption. Therefore, the current project will add to the existing knowledge by investigating the relationship between emerging adult impulsivity and subsequent SSB consumption, parental style, impulsivity, and their child SSB consumption, impulsivity and obesity.

The purpose of this thesis is first; to examine the predictive properties of a self-report measure against two behavioural measures of impulsivity, one involving soft drink consumption, and the other involving a delay of gratification test, under experimental conditions, in a sample of emerging adults and then children aged 10 to 12 years. The second aim is to investigate the associations between impulsivity, obesity, and SSB consumption. The third aim of the project is to investigate the association between parental impulsivity and parenting style on the relationship between their child's impulsivity and SSB consumption. It should be noted that as Study 1 and 2 were investigative studies for the third study for this thesis, which involved children aged 10-12 years, the reward sensitivity aspect of impulsivity was not specifically determined due to time and concentration constraints for children.

Study 1 assesses SSB consumption restraint and compares this against a delay of gratification task and a self-report measure of impulsivity in a group of emerging adults. Study 2 addresses potential methodological confounds from Study 1 and replicates Study 1 findings in a second sample of emerging adults. The final study tests the properties of self-report measure with the two behavioural measures in a sample of children aged 10-12 years recruited from the community. The final study utilises parents and their child (or children) aged 10 to 12 years to account for parenting factors that influence their child's SSB consumption. Parental impulsivity and parenting style are assessed using self-report measures, plus the previous studies findings are replicated in a group of children aged 10 to 12 years recruited from the community. All studies recruited participants interested in SSB consumption, although not all participants subsequently identified as consumers of SSB. The subsequent analyses removed participants who identified as non-drinkers of SSB and those who consumed artificially sweetened SSB. The table below summarises the complete study methodology:

Table 1.1

Summary of Studies, Participants and Methodological Differences

Study	Sample Size total (N)	Sample Size (n)		Non-Collection of reward (n)	Final Sample size (those who consume SSB only)	Difference in methodology and participants
		Control	Experimental			
Study 1	266	84	94	29	178	Water Control Emerging Adults
Study 2	137	52	55	8	107	Soda Water Control + regular reminders Emerging Adults
Study 3	68	29	27	0	56	Water Control children and parents' impulsivity and parenting style

The hypotheses that are investigated in Studies 1 and 2 in emerging adults: Hypothesis one was that the BIS-11 self-report measure of impulsivity would predict behavioural impulsivity by (i) an increase in SSB compared to water consumed under experimental conditions and (ii) choice of immediate over delayed gratification. Hypothesis two was that self-report impulsivity would predict usual SSB consumption and obesity in this group of emerging adults. One research aim was to explore the relationship between impulsivity, usual SSB consumption and obesity. Hypothesis three refers to an exploration of the relationship between impulsivity, SSB consumption and obesity with usual SSB consumption either mediating or moderating the relationship between impulsivity and obesity.

Study 3 addresses a further research aim of the current research which was to investigate the relationship between parental, child impulsivity, and parenting style on SSB consumption and obesity in children aged 10-12 years. In addition to the above hypotheses, the following hypotheses were investigated in Study 3: Hypothesis four proposed that parental impulsivity would be associated with their child's impulsivity, in that more impulsive parents would have more impulsive children. Hypothesis five proposed that a negative parenting style would moderate the relationship between child trait impulsivity and child SSB consumption, with more impulsive children consuming more usual SSB when parents have a more negative parenting style. Hypothesis six proposed that parenting style would mediate the relationship between parent impulsivity and child impulsive behaviour. That is, a poorer parenting style would result in more impulsive parents providing a less supportive environment to their children, thereby facilitating more impulsive behaviours from their children such as increased usual SSB consumption. Finally, hypothesis seven explored the relationship between child trait impulsivity, SSB consumption and obesity. It proposed that increased obesity (waist circumference or BMI) would result from child trait impulsivity through increased SSB consumption.

CHAPTER 2

Soft Drink Consumption and Health

This chapter explores the existing research and literature around SSB consumption in adults and children, and then discusses the implication and subsequent health consequences from excess consumption. This is an important issue as the proportion of Australians who are overweight or obese is increasing, with over two-thirds of Australian adults, almost half of people aged 18 to 24 years, and a quarter of children being either overweight or obese (Australian Bureau of Statistics, 2018). Therefore, overeating and excess weight gain is a major public health problem and is linked with SSB consumption.

SSB include non-alcoholic beverages that are sweetened with sugar, (such as soft drinks, sports and energy drinks, cordial, flavoured mineral water, iced tea, and fruit drinks), and are a major source of dietary sugar with around half of adults consuming SSB weekly (Australian Bureau Statistics, 2018). Australian data from the 2017 National Health Survey showed that consumption of SSB increased with age across childhood, with over 44% of children aged 2-17 years consuming, on average, 2.4 cups SSB daily (Australian Bureau of Statistics, 2018). Data collected from US National Health and Nutrition Surveys from 2003 to 2014 of 18,600 children and adolescents aged 2 to 19years and 27000 adults, showed an overall trend of reduced SSB consumption in keeping with improved general knowledge associated with SSB intake (Bleich et al., 2018). However, adolescents aged 12 to 19 years remained the highest consumers of both SSB and artificially sweetened SSB (Bleich et al., 2018) highlighting this age group as at risk of health consequences.

Sugar sweetened beverage consumption has been linked with obesity, metabolic syndrome, and Type 2 Diabetes Mellitus (Gross et al., 2004; Johnson et al., 2009). A nine-year longitudinal study utilising 51,600 middle-aged women showed that when SSB consumption increased from weekly to daily, it resulted in an average of 8.8 kg weight gain and an increased incidence of Type 2 Diabetes Mellitus (Schulze et al., 2004). Using soft drink sales data and national statistics on obesity prevalence across 75 countries, Basu, et al., (2013) also linked increased SSB consumption with obesity.

Similarly, Malik et al. (2010) conducted a meta-analysis of nine studies that estimated SSB consumption using food frequency questionnaires, with a total of 330 000 adults across the United States, Europe, and Asia. They reported an increased risk of developing either Type 2 Diabetes Mellitus or metabolic syndrome with increased SSB consumption. Metabolic syndrome is a precursor to Type 2 Diabetes and is characterised by being overweight or obese, having elevated plasma lipids, hypertension, and elevated fasting blood glucose (Malik et al., 2010). The authors proposed that SSB contributed to both excess weight gain and a high sugar load which then precipitated impaired blood glucose control and subsequent metabolic consequences (Malik et al., 2010). In a meta-analysis of 22 longitudinal studies assessing the long-term impact of SSB on weight gain in a total sample of 25,700 children aged 2 to 16 years and 170,000 adults, SSB consumption was positively associated with weight gain (Malik et al., 2013), highlighting SSB consumption as a preventable risk factor for obesity and metabolic syndrome. A longitudinal study of SSB consumption over six years of 4,164 Australian children aged 4 to 10 years, identified a significant positive relationship with SSB consumption and BMI, with higher SSB consumption associated with higher BMI (Millar, et al., 2014). Ludwig, Peterson, and Gortmaker’s (2001) landmark study examined self-reported SSB consumption, activity levels and BMI in a group of 548 children aged 11 to 12 years over a two-year period. After adjusting for baseline BMI and physical activity levels, increased SSB consumption was strongly related to the incidence of obesity (Ludwig et al., 2001).

Cantoral, et al., (2016) investigated the relationship between age of introduction to SSB and risk of later obesity in a sample of 227 children/adolescents aged 8 to 14 years.

Current SSB consumption was associated with obesity in this age group with those consuming more SSB also more obese (Cantoral et al. 2016). The evidence therefore presents a positive relationship between SSB intake and obesity in adults and children, adolescents and emerging adults.

It is possible that SSB may be significantly more obesogenic than food. For example, in a systematic review covering including a total of 32 studies that assessed quantity of SSB, Della Torre, Keller, Depeyre et al., (2016) reported a significant association between SSB consumption and obesity in children and adults. Zheng et al., (2015) investigated dietary intake of liquids versus solids in a sample of 158 children aged 9 years. The authors reported a significant increase in adiposity and obesity with every quartile increase in SSB consumption. This association was not found with other beverages or solid foods, implying that SSB is more obesigenic than solid foods (Zheng et al., 2015). Ludwig et al. (2001) proposed that consumption of a liquid form of energy such as SSB, might be less able than solid food to elicit a satiety based compensatory response to reduce food intake at subsequent meals. Rather than replacing energy from food, SSB may add to the total energy consumed, thereby contributing to weight gain (Della Torre, et al., 2016; Ludwig et al., 2001; Zheng et al., 2015). Given that children and adolescents appear to be the highest consumers of SSB, this may be particularly relevant in preventing obesity in these age groups. It also highlights the importance in determining the pathways involved when looking at SSB consumption and obesity prevention. The following section provides a review of the evidence assessing the impact of sugar on memory, learning and cognitive function.

Sugar Intake and Cognitive Function

Although SSBs are a major contributor to dietary sugar intake and resultant obesity (Australian Bureau of Statistics, 2018), less is known about the cognitive and behavioural consequences of long-term sugar intake. Brain reward systems are involved in the motivation to seek out and experience pleasurable responses to food (Colantuoni et al., 2001; Smith & Robbins, 2013; Volkow, Wang, & Baler, 2010). Increased activation of dopamine sensitive neurons within the reward systems leads to reinforcement of the behaviour. Sugar is a natural reward with prolonged sugar intake producing altered dopamine responses in the brain similar to the effect of drugs such as cocaine and amphetamine (Colantuoni et al., 2001; Rada et al., 2005; Smith & Robbins, 2013; Unterwald et al., 2001; Vanderschuren & Kalivas, 2000; Volkow et al., 2010). The following section discusses the evidence linking a high sugar intake and cognitive effects.

Neurobiological Underpinnings between Sugar and Cognition: Animal Studies

Animal studies have investigated structural and functional cognitive deficits resulting from high dietary sugar. Preliminary studies (Molteni, et al., 2002) examined the effect of a high fat, high sugar diet on memory and learning capacity in adult rats. Compared to rats fed a control diet, two months on the high fat, high sugar diet was sufficient to reduce brain derived neurotropic factor, a protein that supports neurogenesis and plasticity in the hippocampus and cortex. Rats fed the high fat, high sugar diet also showed comparable deficits in behavioural learning ability, demonstrating the negative consequences of fat and sugar (Molteni et al., 2002). Ross, Darling, and Parent (2013) demonstrated that compared to rats fed a normal diet, rats fed a high fat, high sugar diet for four weeks demonstrated impaired spatial memory learning.

Further evidence linking sugar consumption with structural and functional brain deficits was provided by Reichelt, et al. (2015) who investigated long-term SSB consumption on memory, attentional shifting and object recognition in juvenile rats. Rats had access to either a sucrose solution or water in addition to their regular food for 28 days and were then tested for learning and memory. Those fed sucrose solutions were heavier, had greater fat depositions than control fed rats, and performed worse on memory and learning tests than the control condition. Furthermore, eight weeks after access to the sucrose was ceased, brain structural changes were investigated. Longer term deficits included significantly fewer Gamma Amino Butyric Acid (GABA) inhibitory neurotransmitter cells in the hippocampus and prefrontal cortex (PFC) indicative of reduced executive control in these regions (Reichelt et al., 2015). The results demonstrated that in adolescent rats, longer term access to sucrose not only resulted in functional changes on memory and learning, but also demonstrated concurrent structural changes in the hippocampus and PFC (Reichelt et al., 2015).

A recent study compared a high sugar or cafeteria style high fat and sugar with a control diet on hippocampal structure, memory and learning in juvenile rats (Ferreira et al., 2018). Juvenile rats fed a high sugar diet for eight weeks showed no significant differences on memory and learning tests and showed no major neurological deficits compared to rats fed a control diet. Those fed a combined high fat and sugar diet, however, showed structural hippocampal deficits and impaired learning and memory (Ferreira et al., 2018). In contrast however, juvenile rats fed a 10% sucrose diet for four weeks demonstrated impaired spatial memory, increased anxiety behaviour and fewer hippocampus neurones indicative of impaired structural and functional activity (Xu & Reichelt, 2018). Furthermore, in an experiment comparing the effect of sugar on adolescent versus adult brains, Hsu et al. (2015) fed 38 adolescent and 38 adult rats either a high sugar or control diet for 30 days. The rats were then tested for learning, and memory. Compared to both adolescent and adult rats fed the control diet, and adult rats fed the high sugar diet, adolescent rats fed the high sugar diet showed substantial deficits in spatial learning ability and memory (Hsu et al., 2015). Beilharz and Morris (2016) demonstrated that provision of either a high sugar diet or cafeteria style high sugar and fat diet for just one week was sufficient to substantially impact the rat brain. Rats fed a high sugar diet showed increased hippocampal inflammatory markers in conjunction with poor memory performance. Similarly, rats fed a high sucrose diet for four weeks demonstrated concurrent weight gain in addition to impaired spatial memory performance (Abbott et al., 2016). The evidence presented above suggests that diet composition detrimentally influences adolescent rats' brain development. Adolescent brains may be particularly susceptible to the structural and functional effects of long-term sugar intake.

In addition to the impact that a high sugar diet has on cognitive development, significant metabolic consequences have also been demonstrated in rats. In a study examining the metabolic and cognitive consequences of a high fat, high sugar diet, three-week old rats were fed one of three diet regimens; a high fat high sugar diet, a normal diet for four months, or a high fat sugar diet which switched to a normal diet after three months (Gomez-Smith et al., 2016). Rats fed the high fat, high sugar diets were more obese and demonstrated changes associated with metabolic syndrome which were then reversed after one month on a normal diet. Although the high sugar, high fat diet was not associated with cognitive memory deficits, histochemical analysis revealed significant neuroinflammation within the hippocampus (Gomez-Smith et al., 2016). The results suggest that perhaps obesity and diet-related structural deficits may occur prior to any significant functional impairements. The implications for humans may be similar, in that a high sugar diet may produce similar metabolic and structural changes during periods of cognitive development such as childhood and adolescence (Steinberg, 2005).

Clinical Studies

Human studies demonstrating similar effects on adults are beginning to emerge. Francis and Stevenson (2011) investigated the effect of a habitual high fat, high sugar diet on hippocampal function and sensitivity to hunger and fullness. Initially, 498 university undergraduate students (mean age 20.53 years, mean BMI 22.44) completed a dietary sugar and fat assessment questionnaire plus subsets of the Weschler memory scale. The results indicated that those with higher fat and sugar diets performed worse on the memory tasks, demonstrating impairment associated with a high fat and sugar diet. A subset of 32 students was allocated into either a low or high sugar and fat diet group based on their responses to the dietary fat and sugar questionnaire. Participants completed further cognitive testing and a subsequent snack and test meal consumption. Those who regularly consumed a high fat, sugar diet performed worse on memory testing. Poor memory recall and performance were suggestive of deficits in hippocampal memory associated with the higher fat and sugar diets (Francis & Stevenson, 2011). Additionally, participants who regularly consumed the higher fat and sugar diets consumed more at a test meal and had less accurate recall of food consumed, implying a deficit in the ability to remember and regulate food intake. Overall, the results support animal findings in that a high fat and sugar diet may impair hippocampal memory. Additionally, given that the participants were of normal BMI, these findings support a possible cyclical model of obesity (Kanoski & Davidson, 2011), whereby long-term intake of a high fat and sugar diet disrupts hippocampal dependant memory involved in satiety and food regulation. Over time, this disruption may lead to overconsumption and further hippocampal dysfunction affecting other memory and learning domains.

Berridge (2009) proposed differences in brain reward mechanisms responsible for ‘wanting’ versus ‘liking’ sweet substances. ‘Wanting’ may be associated with the specific reward and motivational value of food based on hippocampal food memory and may not necessarily be under conscious control, whereas, ‘liking’ is more associated with the feelings of pleasure associated with that food and is under conscious control. Berridge (2009) proposed that although the combination of both is necessary for active pursuit of the reward, it is also possible to have ‘wanting’ without ‘liking’ drive food cravings.

To shed light on the relationship between a high fat, high sugar diet and memory associated with satiety and food regulation, Attuquayefio et al. (2016) proposed that memories associated with ‘wanting’ food normally under hippocampal control would be inhibited when feeling satiated. However, this hippocampal dependant inhibition process may be less effective with those who consume a high fat and sugar diet, resulting in poor memory of foods consumed, with poor satiety recognition even when their stomachs feel full. Ninety-seven adults with normal BMI with no health issues, undertook a series of hippocampal memory tests, and a self-report dietary fat and sugar intake. In addition, self-report and salivary responses were measured for ‘wanting’ (after seeing) versus liking (after tasting) palatable snack foods, both when hungry and after consuming a test meal. The results demonstrated that diets high in saturated fat and sugar were associated with poorer performance on the hippocampal memory tests. Also, there was less difference between measures related to ‘wanting’ (versus liking) the palatable snack foods between hungry and full for participants who consumed a higher fat and sugar diet (Attuquayefio et al., 2016). This result indicates that those who consume a high fat and sugar diet were less able to inhibit memories of ‘wanting’. Overall, the study suggested that high fat, high sugar diets were associated with hippocampal impairments, not only associated with learning and memory, but also with impaired inhibition of hippocampal dependant food memory processing. These results provide human evidence in support of hippocampal impairments associated with a high fat and sugar diet.

Much of the human evidence presented thus far has focused mainly on a western style diet, high in sugar and saturated fat (Baym et al., 2014). However, regardless of fat intake, sugar may have specific and unique effects on memory and cognition. Type 2 Diabetes Mellitus is associated with impaired glucose metabolism with elevated blood sugar levels (The Royal Australian College of General Practitioners, 2016). Therefore studying hippocampal structure and function in those with Type 2 Diabetes may provide an insight into the specific effects of elevated blood sugar levels. Gold et al. (2007) compared brain volumes using Magnetic Resonance Imaging (MRI), and performance on a number of memory test measures with 23 control and 23 participants with well controlled Type 2 Diabetes, (mean age 59 years) who were matched for age, gender, education and general intelligence. Participants with diabetes showed poor performances on memory testing together with hippocampal atrophy via MRI (Gold et al. 2007). The results suggest an association between poor blood glucose control with structural and functional changes in memory performance.

It is possible that the damage to the hippocampus may be attributable to long-term elevated blood glucose levels. Furthermore, Weinstein et al. (2015) investigated the long-term effects (over 7 years) of glucose metabolism on memory, executive function, perception, reasoning and brain integrity in 1597 adults (mean age 40 years) with and without Type 2 Diabetes. After controlling for confounding factors such as age, BMI and hypertension, participants with Diabetes performed worse on memory, perception and attention tasks and demonstrated more hippocampal, frontal lobe atrophy and white matter structure damage via MRI (Weinstein et al, 2015). The results provide further support that long-term impaired blood glucose levels lead to structural hippocampal damage with resultant memory consequences.

Although the above studies provided evidence of the long-term damage of sugar for individuals with Type 2 Diabetes, it can also be argued that sugar can cause memory impairments in the general population. In a longitudinal functional Magnetic Resonance

Imaging (fMRI) study over four years, Cherbuin et al. (2012) examined brain volumes in 266 healthy adults aged 60 to 64 years. After excluding participants who developed Diabetes Mellitus or neurological disorders, higher fasting blood glucose levels, although still within the normal range of < 6.1mmol/l, were positively associated with hippocampal and amygdala atrophy 4 years later (Cherbuin et al., 2012). While the study did not investigate cognitive function or dietary intake, this evidence suggests that long-term minor increases in blood sugar levels in individuals without disease, may cause changes in brain structure.

The evidence above highlights a pathway from elevated blood glucose levels in adolescent rodents and adult humans to impaired brain structure and function. It also follows that sugar may have a detrimental effect on children whose brains are still developing. For example, in a within-subjects study, 19 children aged between 6 to 7 years were randomly allocated one of three test breakfast meals, a high sugar meal or one of two lower sugar meals, each day for nine days. The occasions when the children consumed the high sugar meal resulted in subsequent poorer memory measure scores and reduced ability to maintain attention compared to days when they consumed the lower sugar breakfast meals, thus demonstrating the short-term effects of sugar on cognition (Benton, et al., 2007). Falbe et al. (2019) examined the potential addictive properties of SSB in a sample of 25 over-weight regular SSB consuming adolescents. Cessation of SSBs for three days induced symptoms of headache, craving, poor concentration and motivation, consistent with substance withdrawal. When the authors eliminated caffeinated SSBs, results were similar, indicating that in addition to caffeine, the sugar itself contributed to the withdrawal effect. The study demonstrates the negative consequences of regular SSB consumption (Falbe et al., 2019). Similarly, Feldstein Ewing et al. (2017) examined fMRI responses to SSB consumption in a sample of 24 overweight or obese adolescents aged 14 to 19 years. SSB consumption was associated with increased activation across areas associated with reward and addiction, that is, the orbitofrontal cortex, nucleus accumbens and amygdala (Feldstein Ewing et al., 2017). These findings are in line with the potential addictive qualities and negative neurological consequences of SSB consumption.

Other studies have examined the longer-term effects of sugar on cognitive development. Northstone et al. (2012) examined longer term effects of different dietary styles with 7044 children using a parent-reported food questionnaire and suggested that a 'processed' style (high fat, high sugar, western style) diet at 3 years of age may be related to lower verbal and performance intelligence scores at 8 years of age. Similarly, in a sample of 602 Australian adolescents, a western style, high fat, high sugar diet at 14 years of age was associated with reduced visuospatial learning and long-term memory at 17 years (Nyaradi et al., 2014). Also using self-report survey data, Abargouei et al. (2012) examined the relationship between diet and fluid intelligence in 236 children aged 6 to 7 years. After controlling for BMI, high sugar diets were significantly associated with reduced fluid intelligence, suggesting that high sugar diets may be associated with cognitive deficits in children. The evidence presented adds weight to the possibility that a high fat or high sugar diet is associated with changes to hippocampal memory function and that these changes can be seen to emerge in childhood. Furthermore, some of the changes may be related to one's ability to monitor or control intake which will be discussed in the following section.

CHAPTER 3

The following chapter explores the role of higher order cognitive processes and the personality trait of impulsivity on SSB intake, obesity and the potential for an additive effect. Executive function overlays impulsivity, where the prefrontal cortex (PFC) acts as the overarching control centre over the lower cognitive domains of impulsivity and reward motivation and prevents impulsive behaviours from being enacted (Ames et al., 2014, Enticott et al., 2006). Executive function is an important developmental shift into adult hood and decision making. This chapter will argue that for those more impulsive individuals in combination with the negative cognitive effects of high SSB consumption, creats poor decision making and places those individuals at risk of later obesity. Firstly, the evidence linking neurobiology, impulsivity, obesity and executive function will be presented followed by the relationship between SSB consumption, impulsivity and the above constructs.

Neurobiological Underpinnings of Executive Function, Impulsivity and Obesity

Diets high in sugar may contribute to obesity by means of the potential rewarding and reinforcing aspects of these palatable foods (Morris et al., 2015). It is possible that differences in executive function within the PFC may underlie the ability to monitor and control food intake, with obesity resulting from poor decision-making and impulse control. Executive function is a construct made up of high-order cognitive processes around self-regulation, planning, and decision-making and includes the ability to inhibit inappropriate behaviours (Allom & Mullen, 2014). Development of executive function and the PFC is the final region within the brain to mature with development continuing throughout childhood and adolescence into early adulthood (Romine & Reynolds, 2005). However, adolescence also signals early maturation of, and improved connectivity within, the reward and motivation areas of the brain enabling adolescents to become more reward focused (Anokhin et al., 2011; Steinberg, 2005). This discrepancy between an immature PFC and executive function combined with a relatively mature motivation and reward system places adolescents at a greater risk of making impulsive decisions (Steinberg, 2005). Therefore, investigation into factors that impact executive function may be particularly relevant for understanding children and emerging adult SSB consumption and obesity.

In addition to the specific impact of a high fat or high sugar diet, obesity itself may produce structural PFC changes (Brooks, Cedernaes, & Schioth, 2013). Shott et al. (2015) suggested that executive control over food approach motivation pathways may not be as strong in obese individuals, leading them to be less sensitive to satiety feedback mechanisms. Yau et al. (2014) found that compared to lean adolescents, those who were obese demonstrated impaired executive function and structural brain deficits. Thirty obese and matched lean adolescents aged 14 to 20 years underwent a series of cognitive and MRI testing. Although obese participants were still within the normal range for memory and executive function tests, the MRI demonstrated a significant reduction in cortical thickness of the frontal cortex, indicating subtle changes in brain structure associated with greater obesity (Yau et al., 2014).

Similarly, Medic et al. (2016) investigated cortical thickness using MRI in 202 healthy human adults aged from 18 to 50 years with a BMI from 18.5- 46. Although the adults reported no known clinical conditions, the results demonstrated reduced thickness in the brain areas associated with goal-directed behaviour and decision-making with obesity. Furthermore, Lim et al. (2021) looked at PFC cortical thickness and trait impulsivity in 100 healthy adults aged between 19 and 65 years. The authors specifically allocated the participants into high or low trait impulsivity based on their scores on the Barratt self-report impulsiveness scale. Those with higher trait impulsivity had significant cortical thinning compared to those who identified as low impulsiveness on the Barratt scale (Lim et al., 2021). Direct causality cannot be determined from this study, however, it is possible that poor structural connectivity may determine reduced functional ability to control behaviour, leading to greater impulsivity. Although a measure of obesity was not conducted in Lim et al. (2021), the results demonstrate a link between functionality and structural deficits. Overall, the results support Gomez-Smith et al. (2016) study with rodents, suggesting that obesity resulting from a high fat, high sugar diet may produce structural changes within the executive area of the brain, and that these structural changes occur before functional deficits become apparent. This may be particularly problematic at an early stage of brain development such as adolescence and has significant implications when considering the long-term consequences of obesity on executive function.

Further evidence of obesity-related structural brain alterations in the frontal cortex was provided in a study of 79 obese and 51 lean adolescents aged 15 to 21 years (Ross, Yau, & Convit, 2015). Participants completed a series of cognitive tests of executive function in addition to MRI measures of brain integrity. Although there was no difference between obese and lean participants in tests of executive function, orbitofrontal cortex (OFC) brain thickness was reduced in the obese participants (Ross et al., 2015). The results provide further support that obesity may be associated with early frontal lobe structural changes in adolescents. However, the evidence was inconclusive around whether theses changes were linked to significant executive function deficits. Similarly, Maayan et al. (2011) examined the relationship between obesity, executive function, disinhibited eating style and brain volume in a group of 54 obese and 37 lean adolescents with a mean age of 17 years using a series of cognitive tests and MRI data. Compared to lean participants, the obese adolescents demonstrated lower OFC volumes with concurrent poor executive functionality across all executive function measures and higher levels of disinhibition. These findings in combination with those of Ross et al. (2015) offer support for the possibility that obesity may be related to reduced executive functionality (Maayan et al., 2011). The evidence presented a link between structural brain data and laboratory based measures of executive function. However, the studies utilised laboratory based measures of executive function, such as word association and the Stroop task, that although they may demonstrate differences in diagnostic exectutive function, may not reflect real life behaviour in naturalistic settings.

To further elucidate the possible linkage between obesity, poor executive function and how that translates into actual behavioural implications, Blanco-Gómez et al. (2015), examined executive function and obesity in a sample of 221 children aged 6 to 10 years. Parents completed a child behaviour checklist to identify problem behaviours such as social issues, inattention, aggression or rule breaking. Children completed a series of neuropsychological assessments of executive function covering attention, inhibitory control, flexibility, and processing speed. After controlling for age, gender and parental income, obesity was predictive of reduced inhibitory control and mental flexibility scores and also behavioural issues as indicated by the parents. This study demonstrated a link between obesity, behaviour and executive control in children as young as 6 years (Blanco-Gómez et al., 2015). Although dietary factors were not reported, the study implied that differences in executive function and inhibitory control may lead children to poor eating behaviours with resultant obesity.

Ames et al. (2014) also investigated the relationship of SSB consumption with binge eating behaviour and performance on laboratory based executive function and impulse control measures in 198 adolescents, 14 to 17 years of age. Poor performance on the executive function and inhibitory control measures was associated with higher body mass index (BMI) and SSB consumption in boys, whereas binge-eating was associated with poorer inhibitory control performance and BMI in girls. The authors speculated possible gender differences to account for the different behavioural outcomes for boys and girls. A gender difference in SSB preference and usual consumption has been previously reported with boys

(8 to 13 years) reportedly preferring and consuming more SSB than girls (Grimm, Harnack, & Story, 2004). The study demonstrated that SSB is associated with adolescent executive function and impulse control (Ames et al., 2014). The authors proposed a model whereby dopamine reinforces pleasurable behaviour cues, which then become associated with positive memories. Over time, the behaviour becomes increasingly cue elicited rather than under conscious voluntary control (Ames et al., 2014). Here, SSB is thought to elicit dopamine release which then reinforces the behaviour (i.e., SSB consumption) and pleasurable memory of SSB, to a point where it becomes a habit and difficult to resist. This suggests a role of SSB in impaired behavioural regulation and decision-making.

In summary, there may be three potential routes from SSB intake to obesity and impaired decision-making ability. First, obesity may precede cognitive impairment (Yau et al., 2014), implying a causal component of obesity via SSB induced cognitive changes. Second, initial poor frontal lobe or executive function may result in poor dietary decisions (Blanco-Gómez et al., 2015) which then leads to increased SSB intake with obesity as an outcome. Third, obesity and poor executive control in combination produce poor dietary choices leading to persistent obesity and reduced control over SSB intake (Miller, Lee, & Lumeng, 2015). It is possible that obesity-induced neuro-inflammation may then interfere with synaptic pathways and brain integrity causing further disruptions and poor eating behaviours (Miller et al., 2015). The following section discusses specific avenues that explore how executive function and SSB intake may interact.

Impulsivity and SSB Consumption

It was suggested earlier that executive function overlays impulsivity, where the PFC acts as the overarching control centre over the lower cognitive domains of impulsivity and reward motivation and prevents impulsive behaviours from being enacted (Ames et al., 2014, Enticott et al., 2006). Impulsivity has been defined as a multidimensional construct, generally characterised as a personality trait, with an overall inability to delay gratification, heightened sensitivity to reward, poor decision-making ability, and difficulty stopping behaviours once they are engaged (Davis, 2009; Dawe, Gullo & Loxton, 2004; Dawe & Loxton, 2004; Pietrzak, et al., 2008; Reynolds & Mayers, 2012). In the current context, impulsivity includes differences in reward motivation and an overall inability to exert restraint over desired outcomes. De Decker et al. (2016) used parent-reported questionnaire measures of child SSB intake, BMI and reward sensitivity to investigate the relationship between SSB and reward sensitivity in a sample of 455 children aged 5 to 12 years. The results showed a positive relationship between reward sensitivity and both BMI and SSB consumption. The authors suggested that reward sensitive children may be more motivated to seek out and consume tempting foods such as SSB, and therefore more subject to weight gain.

It is possible that more impulsive children and adolescents have greater sensitivity to potentially rewarding temptation cues, thereby finding it difficult to stay within a healthy weight range. In a study examining the success of a weight loss program over a 12-month period, 19 obese children aged 8 to 12 years completed a laboratory measure of impulsivity plus an eight-week behavioural weight loss program, and were weighed at regular intervals up to 12 months post-treatment (Nederkoorn et al., 2007). The more impulsive children were the most overweight across all time points and lost the least amount of weight overall (Nederkoorn et al., 2007). Although activity levels and food intake data were not reported for this study, it is feasible to suggest that higher levels of impulsivity may have led to reduced control over food intake. One possible pathway is that the impulsive children and adolescents were more attuned to the rewarding properties of food and were thus less able to prevent giving in to tempting foods, thereby making it difficult to control intake and lose weight (Nederkoorn et al., 2007).

To shed light on the impact of impulsivity on food temptation, Nederkoorn et al. (2015) investigated the influence of hunger, satiety and impulsivity on high energy snack food intake (for example chips or chocolate). The authors hypothesised that more impulsive children would be both less able to acknowledge and respond to satiety cues, and more responsive to the tasty high energy snacks. In addition to a laboratory measure of impulsivity, a bogus snack food taste test consisting of low, medium or high energy snacks was administered to 88 children aged seven to nine years, before and after a test meal (Nederkoorn et al., 2015). Although there were no differences in BMI or satiety levels, impulsive children consumed more high energy snacks overall and were less able to inhibit eating when full. This result suggests that impulsive children and adolescents are more inclined to overeat when presented with tempting high-energy snack foods, regardless of satiety, relative to their less impulsive peers. It is possible therefore, that individual differences in impulsivity may lead to an inability to control ‘wanting’, with overeating of tempting foods and a potential for later obesity as a result.

To further identify the mechanism of how impulsivity affects food intake, Folkvord, et al. (2014) studied the role of ability to restrain intake with food versus non-food advertisements promoting high energy foods with 261 children aged 7 to 10 years. The intake restraint task involved offering participants a later reward if they refrained from consuming the snacks during the experiment. The authors predicted that exposure to food advertising would result in all children eating more but rewarding intake restraint would result in less consumption when exposed to food advertising. In addition, the authors predicted that impulsive children would be more attuned to the immediately rewarding aspects of tempting foods and would be less able to refrain from intake, regardless of the prospect of a later reward. Compared to less impulsive children, and impulsive children exposed to non-food advertising, the more impulsive children, when exposed to food advertising, were less able to limit eating even when offered a reward for restraint (Folkvord et al., 2014). Food advertising cues overrode their ability to limit intake. Impulsive children were more likely to give in to the temptation of tasty foods even when offered a reward for restraint. This suggests that exposure to food advertisements makes it more difficult for impulsive children to exercise restraint over their intake.

In addition to increased availability of and access to SSB, Scully et al. (2017) identified television viewing as an important factor in increased SSB consumption among a survey of 11,000 Australian adolescents aged 12 to 17 years. Bradbury, Turel and Morrison (2019) surveyed 32,000 US adolescents and identified electronic devise use as well as television viewing as associated with increased SSB consumption. Although SSB advertising may be linked to increased consumption, distraction and reduced satiety recognition have also been identified as potential routes to overconsumption (Marsh, Mhurchu & Maddison, 2013).

Similarly, it follows that if impulsive children and adolescents are more attuned to the immediately rewarding aspects of tasty food, then offering food variety may be equally challenging for impulsive individuals. In a study investigating food variety and impulsivity on intake, 78 children aged 8 to 10 years completed two laboratory measures of impulsivity, a response inhibition and a reward sensitivity test (Guerrieri, et al., 2008). Children were randomly allocated to a ‘variety’ group where they received five different flavoured, coloured and textured marshmallows, or a control group where they received standard pink or white marshmallows. Children with a heightened responsivity to reward were hypothesised to be more aware and to consume more of the different marshmallow types, while those with poor impulse control would tend to overeat, regardless of the novelty value of the food. As predicted, those who were reward focused ate more when presented with variety compared to reward focused children in the control group. Contrary to expectations, no association between the response inhibition measure of impulsivity and intake was observed. This result is similar to a previous study by the authors who used an adult sample (Guerrieri, et al., 2007), where self-reported trait impulsivity but not response inhibition was associated with increased food intake. Current methodological limitations were discussed in detail in Chapter 1. However, suffice to say, the behavioural measure of response inhibition used in the above study was based upon ability to inhibit motor responses to computer-generated stimuli, and as such, may not activate the same desire for food as food specific measures.

Houben, et al. (2014) suggested that the mixed evidence for the role of impulsivity in obesity could be explained by the nature of the task such that the ability to inhibit responses on a computer task was not related to overeating or obesity. Instead, the authors suggested a more food related impulsivity that came into play only when the urge to eat tasty food was strong or when tempting cues (e.g., the sight and smell of food) were present. In order to test this hypothesis, eighty-seven adult women (mean age 26 years) of whom 17 were overweight or obese, completed two computer-based response inhibition measures of impulsivity, one using food images and one using non-food images. Although BMI was not associated with differences in response times for the non-food images, overweight and obese participants performed worse when food images were presented, indicating greater levels of impulsivity (Houben et al., 2014). The results generate support for the possibility that rather than a global generalised impulsivity, obesity may be related to a more food specific impulsivity.

Meule et al. (2016) attempted to further tease apart specific aspects of impulsivity that directly influenced BMI in a sample of 122 children and adolescents between 10 and 18 years, (mean age of 13 years). The authors proposed that impulsivity may mediate obesity as it is linked to an inability to restrain eating behaviour. Participants completed a self-report impulsivity scale, perceived success at dieting measure as well as height and weight. Although perceived success at dieting was associated with both impulsivity and BMI, impulsivity was not directly associated with BMI. Instead, impulsivity indirectly influenced BMI through perceived dieting success. That is, impulsivity influenced BMI through the individual's belief in their inability to control food intake. More impulsive individuals who also believed they were less able to control intake were more likely to be overweight (Meule et al., 2016). These results imply a complex relationship between impulsivity and factors leading to food consumption, perhaps even a more food specific form of impulsivity.

Furthermore, Bennett and Blissett (2020) proposed that part of that complexity may be related to an interaction between impulsivity and dietary restraint. Fifty children aged 7 to 11 years completed several behavioural measures of impulsivity, a self-report measure of dietary restraint prior to having unrestricted access to various types of snack foods. Those who were high in both dietary restraint and impulsivity consumed significantly more snacks. This indicates that the combination of both impulsivity and increased dietary restraint perhaps heightened the salience of the foods and overloaded their ability to exert self-control, resulting in increased intake.

It is then possible that this food-related impulsivity may be more reliant upon hedonistic cues, such as the sight and smell of tempting foods and as such, may not be as responsive to traditional laboratory measures of impulsivity. In their definition of self-control, Gillebaart (2018) suggested a dual systems perspective whereby one system, the 'hot' system is continuously on, rapidly processing information to enable fast impulsive responses to stimuli. The other 'cold' system provides a more moderated approach to either pursuing or inhibiting the behaviour depending on longer term goals. Self-control is reliant upon having sufficient cognitive resources within the 'cold' to override the more impulsive 'hot' systems. Therefore, an ongoing dilemma exists between immediate gratification and the pursuit of longer-term goals (Gillebaart, 2018). When cognitive resources become depleted or when the incentive salience of 'wanting' or the 'hot' system becomes too much, self-control is lost resulting in more impulsive behaviour. Berridge's (2009) model of 'incentive salience' of 'liking' versus 'wanting', proposes that 'wanting' a food activates the brain's dopamine reward pathways, thereby increasing the motivational importance of that food. In this model, 'liking' refers to the pleasure derived from consuming the food and is under explicit conscious control. According to the incentive salience model, 'wanting' is triggered by cues such as the presence or thought of tempting foods, it occurs without conscious thought, and can trigger cravings and subsequent impulsive consumption of that food (Berridge, 2009).

Pender et al. (2019) suggested it may be more challenging to turn off the implicit 'wanting' of SSBs compared to solid foods, thereby contributing to excess consumption and subsequent weight gain. For example, in Study 1, 25 healthy university student participants rated their wanting versus liking of a range of snacks and SSBs before and after consuming a test meal. Although all ratings of wanting and liking reduced post meal, rating of wanting SSBs reduced significantly less, indicating that participants remained somewhat motivated to consume SSB after the test meal. In order to ensure that thirst was not a potential confound producing the effect, Study 2 was conducted using 31 healthy university students, but consisted solely of a liquid meal. Although the effect of wanting was eliminated in Study 2, when the studies were combined, participants overall still showed more wanting of SSBs compared to solid snack foods (Pender et al., 2019). These results indicate that there is something about SSBs particularly which, circumvents one's ability to control intake of desired foods (in that SSB produce a reduced physiological response to food intake).

Therefore, obesity may be consequential to overconsumption from heightened motivation from 'wanting' foods, with a more food-related impulsivity. It is possible that the presence of appetising food images creates a state of 'wanting' which then overrides the ability to exert self-control over the 'want'. Nederkoorn et al. (2012) tested whether a sample of 14 overweight children aged seven to nine years would respond differently to a sample of

75 lean children with food versus non-food images in a computerised cognitive response inhibition task. Children were shown images of either tempting food or non-food images. After viewing each image, they were asked to either make a keyboard response or to inhibit their response as accurately and quickly as possible, depending on a predefined signal. Compared to lean children, overweight children performed worse on the task when presented with the food-related images than non-food images (Nederkoorn et al., 2012). It is possible that the overweight children paid more attention to the food images with the resultant poorer performance on the task. It is also possible that the food images triggered an unconscious 'wanting' reaction in the overweight children. Perhaps the poorer performances by the overweight children were due to attempting to both control the 'wanting' and carry out the task, which resulted in overloading their available cognitive resources, leaving insufficient resources to do both tasks effectively (Nederkoorn et al., 2012). The 'wanting' process may be stronger or more active in overweight children, implying differential levels of control that makes it harder for these children to achieve a healthy weight. Regardless, it would appear from this that the overweight children paid more attention to the food images, which raises the question of what brain processes are involved.

It is possible that the pathways associated with wanting and subsequent craving of desirable foods, such as SSB, may override the PFC ability to inhibit the behaviour (Berridge, 2009; Goldstein & Volkow, 2002). Evidence using fMRI studies can be used to investigate whether SSB overstimulates the reward centres which may then prevent the PFC to inhibit the 'wanting'. Burger and Stice (2014) tested the neural responses in reward centres and PFC in response to the following stimuli: SSB consumption, tasteless control consumption, anticipated fluid consumption, and SSB advertisements. Participants included 13 habitual and 12 non-habitual SSB consuming adolescents (mean age 15.2 years) with BMIs within the normal range. Relative to the control, the MRI showed heightened responsiveness in habitual and non-habitual consumers by the SSB advertisements, SSB consumption and anticipated consumption. However, compared to non-consumers and non-habitual consumers, habitual consumers showed less pre-frontal cortex activation in response to anticipated intake, which indicated reduced inhibitory control over intake. The authors concluded that for habitual consumers, SSB promoted increased attention to the visual cues, with simultaneous reduced inhibitory control (Burger & Stice, 2014). This means that for habitual SSB consumers, increased attention to cues, and reduced inhibitory control may perpetuate ongoing consumption similar to Feldstein Ewing et al. (2017) addiction pathway discussed earlier.

This poor inhibitory control may then drive the risk of obesity from overconsumption of SSB. Using cerebral fMRI responses, Jastreboff et al. (2016) demonstrated differences in cerebral blood flow in the PFC and reward centres with glucose and fructose consumption compared to control liquid in 14 lean and 24 obese adolescents aged 13 to 19 years. Obese adolescents showed reduced PFC activation and increased reward motivational pathway activity when presented with SSB compared to the lean adolescents. Lean adolescents appeared to show increased PFC connectivity with brain satiety centres when presented with SSB, consistent with potentially better executive control over satiety and intake (Jastreboff et al., 2016). The results provide further neurological support that links obesity with disruption of satiety mechanisms, coupled with reduced inhibitory control. However, the study supplied a controlled amount of SSB to participants and stopped short of allowing participants *ad libitum* access to SSB. It is possible that, when allowed access to *ad libitum* SSB, more obese participants would demonstrate increased SSB intake coupled with altered brain responses, thereby showing a neural link between SSB overconsumption and behaviourally reduced restraint similar to Feldstein Ewing et al. (2017). The study is one of few experimental studies using actual SSB intake with response measurement in humans and demonstrates the need for an experimental behavioural measure of restraint or impulsivity as it applies to SSB consumption and obesity.

Batterink et al. (2010) also used fMRI to investigate a behavioural measure with neural links between BMI, food cues and impulsivity. The authors proposed that increases in BMI would be negatively associated with neural activity in the prefrontal cortex, and positively associated with a laboratory measure of impulsivity. Similarly, they predicted that BMI would positively correlate with reward centre activation during presentation of high fat, high sugar food cue images, indicative of greater responsivity to food-related cues in overweight individuals. Participants included 29 female adolescents (mean age 15.7 years), with a BMI range from 17 to 39. Relative to leaner subjects, overweight participants performed more poorly on the laboratory measure of impulsivity, together with reduced PFC activity and increased reward responsiveness to the high fat, high sugar food images. The results demonstrated a behavioural and neural relationship between impulsivity, reward sensitivity, PFC and obesity (Batterink et al., 2010). The evidence implies a potential dual role of heightened reward sensitivity and poor restraint in either initiating or perpetuating obesity. Individuals who are sensitive to the rewarding properties of food might be more likely to become obese, which in turn may further exacerbate impulsivity and impair their ability to control intake. This presents obesity as both impacting and being impacted by impulsivity. Although the behavioural measure of impulsivity utilised a computer-based task, it would have been interesting to investigate whether access to SSB would have followed a similar path resulting in more impulsive individuals consuming more SSB with concurrent neural pathway activation.

It is currently unclear whether poor diet quality promotes state impulsivity, or if trait impulsivity predisposes an individual to make poor dietary choices, and whether the effect of increasing obesity perpetuates the cycle. To highlight a potential sequence of events leading to poor dietary decisions, Lumley et al. (2016) first measured the extent of association between diet, BMI and self-report trait impulsivity and then investigated whether obesity and impulsivity were related, independent of dietary influences. In a preliminary study, 571 university undergraduate students (mean age 19.8 years) completed a self-report questionnaire of trait impulsivity in addition to a dietary fat and sugar questionnaire. After controlling for dietary influences, BMI was associated with impulsivity, indicating that the more impulsive individuals also had a higher BMI. Similarly, after controlling for BMI, impulsivity predicted dietary fat and sugar content. Higher fat and sugar diets (including SSB) were associated with greater impulsivity.

In a follow-up study, 56 normal weight students (mean age 19.5 years) were categorised into either low or high sugar-fat diets based on the dietary fat and sugar questionnaire (Lumley et al., 2016). Participants completed an eating behaviour questionnaire, and three types of behavioural measures of impulsivity, one related to food, and two more general measures. The food specific measure of state impulsivity comprised of a computer-based delay discounting task whereby participants were required to theoretically choose between small amounts of less desired food sooner, over varied later time delays of more desirable foods. The general measures of impulsivity involved a monetary version of the delayed discounting task and a matching figures task where participants were required to match one of six similar images to an image presented on the computer screen. Compared to the more general measures, the food specific measure of impulsivity was positively associated with higher fat and sugar type diets. Consistent with previous research (Folkvord et al., 2014; Guerrieri et al., 2008; Houben et al., 2014), the results suggest that there may be a food-related impulsivity which is then associated with a more western style diet. Lumley et al. (2016) further suggested that this food-related impulsivity may precede obesity, via consumption of high fat and sugar diets, providing a possible pathway of causality.

Peers or social influence may also impact on children and adolescents' propensity towards SSB consumption. In a survey of 694 Norwegian adolescents with an average age of 17 years, Melbye and Helland (2018) assessed the interrelationships between SSB consumption in a school setting, peer norms, and a food related measure of self-control. The authors proposed that self-control over SSB consumption would be impacted by peer norms and parental influence. SSB consumption was positively influenced by peer influences such that the more highly peers valued and consumed SSB, then equally, participants consumed SSB. Not surprisingly, a negative association was found between self-control and SSB consumption with greater SSB consumption related to poor self-control.

The evidence above argues that poor inhibitory control may then drive the risk of obesity from overconsumption of SSB. The combined effect of food-related impulsivity, plus the negative cognitive effects of SSB consumption and reward reinforcement of unhealthful food choices, places those more impulsive children and adolescents who consume SSB, at high risk for later obesity. This is especially relevant considering that late childhood and early adolescence is when executive function and inhibitory control are developed. Therefore, the role of parents to guide and model healthy behaviour is important in the development of inhibitory control. Parenting style will be examined more fully as it relates to child impulsivity, SSB consumption and obesity in Chapter 6. It will be argued in Chapter 6 that a negative parenting style enables more impulsive behaviour from their children. The following two chapters explore the relationship between SSB consumption, impulsivity and obesity in emerging adults with a mature PFC before moving to explore the role of parenting, SSB consumption and in a group of children with an immature PFC aged 10 to 12 years.

CHAPTER 4

Study 1: Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults

Introductory comments

This chapter builds upon the previous chapters by, first, determining the potential for using a specific measure of impulsivity that relate to SSB consumption and second, examining the interrelationship between impulsivity, usual SSB consumption and obesity prior to neurological consequences related to long-term SSB consumption. The purpose of this chapter's study (written as a manuscript submitted for publication) was to test the relationship between two behavioural measures of impulsivity against the Barratt Impulsivity Scale for adolescents (BIS-11) and to investigate the role of impulsivity on usual SSB consumption and obesity in emerging adults. This group of emerging adults was chosen as it would be expected that neurological effects of long-term SSB consumption and obesity would be minimal. Therefore, studying the effects of SSB on this group is important to understand the implications of SSB consumption without the potentially confounding effects of related neurological consequences.

Statement of Contribution

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My contribution to the published paper includes:

- Design of the research protocol
- Carrying out the research
- Data Analysis
- Manuscript preparation

(Signed) (Date) 13/05/2022

Robyn Stumm

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Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults

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Abstract

Sugar Sweetened Beverage (SSB) consumption is linked to obesity, health consequences and impaired decision-making capacity. The aim of this study was to investigate two behavioural measures of impulsivity, one being a SSB measure, the other being monetary delay of gratification. Both behavioural measures were assessed against the self-report Barratt Impulsiveness Scale (BIS-11). In addition, usual SSB consumption was used to provide further evidence of the link between self-report impulsivity, habitual SSB consumption and obesity. One hundred and seventy-eight participants of whom 131 were women (74%) mean age 18.56 years (*SD* = 1.24 years) with a mean BMI of 22.78 (*SD* = 4.03) and mean waist circumference of 79.53cm (*SD* = 10.82) were included in the final analysis. Participants were randomly assigned to receive either SSB or water. Consumption of salted potato chips was used to induce thirst. It was anticipated that more impulsive participants would consume more SSB than water than those less impulsive participants. Trait impulsivity was significantly associated with the choice of an immediate monetary reward over delayed reward but was not predictive of volume of SSB consumed during the experiment. Trait impulsivity was not predictive of usual SSB consumption nor obesity. No moderating or mediating effect of usual SSB consumption on impulsivity and obesity was found. Gender was the strongest predictor of waist circumference and experimental volume consumed. These results extend existing research by demonstrating a simple naturalistic delay of gratification tool as a measure of impulsivity. The results add a template for further investigation of the use of the experimental SSB measure of behavioural impulsivity with a more diverse cohort of participants. Further research to replicate and extend upon these findings is warranted.

Key words: Sugar Sweetened Beverage, Impulsivity, Obesity, Emerging Adults

Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults

1.1 Introduction

Obesity is a growing major health concern affecting Australian adults and children. Sugar Sweetened Beverage (SSB) consumption is a considerable source of dietary sugar that is linked to obesity and several resultant health consequences (Australian Bureau Statistics, 2018). Poor decision-making and impulsivity have been implicated as potential routes towards excess SSB consumption and obesity. Decision-making is one of the last regions in the brain to mature, making emerging adults vulnerable to more impulsive choices (Romine & Reynolds, 2005). More impulsive individuals may be at risk of obesity via reduced self-control and inability to cease SSB consumption.

1.1.1 Relationship between Impulsivity, SSB consumption and Obesity

Brannigan, Stevenson and Francis (2015) investigated the role of thirst satiety recognition with participants who regularly consumed either a high fat, high sugar diet or low fat and sugar diet. The authors induced thirst and then determined participants' sensitivity to satiety signals when given access to *ad libitum* water. In keeping with their hypotheses, those who regularly consumed a high fat high sugar diet were less sensitive to satiety signals. A further observation made was that those who consumed a high fat high sugar diet also consumed more fluid after thirst was induced (Brannigan et al., 2015). Although Brannigan et al., (2015) did not investigate overconsumption due directly to impulsivity, the premise was that those who consume a high sugar diet would be less sensitive to thirst satiety cues and would then overconsume. It also follows that these individuals would be less able to cease overconsumption of SSB compared to water. One possibility raised from their study was that those who regularly consume a high fat and sugar diet may also be more impulsive, that is, less able to stop overconsumption, once started. This then raises the possibility that an inability to cease drinking once satiated may be related to increased impulsivity. Once started, more impulsive individuals may be less able to stop consuming highly desired foods such as SSB. Emerging adults are most vulnerable to poor choices. They are also the highest consumers of SSB (ABS,2018), emphasising the importance of understanding and mitigating the factors responsible.

In addition, there may be a cyclical effect of SSB and obesity impairing cognitive and hippocampal function with a potential effect of impulsivity further exacerbating the deficits (Attuquayefio et al., 2016; Falbe et al., 2019; Francis & Stevenson, 2011; Kanoski & Davidson, 2011). Obesity may precede cognitive impairment (Yau et al., 2014), implying a causal component of obesity via SSB-induced cognitive changes. Alternatively, initial poor frontal lobe or executive function may result in poor dietary decisions (Blanco-Gómez et al., 2015) which then lead to increased SSB intake with obesity as an outcome. A further possibility is that obesity and poor executive control in combination produce poor dietary choices leading to persistent obesity and reduced control over SSB intake (Miller, Lee, & Lumeng, 2015). It is possible that obesity induced neuro-inflammation may then interfere with synaptic pathways and brain integrity causing further disruptions and poor eating behaviours (Miller et al., 2015).

The relationship between impulsivity, SSB consumption and obesity is complex, with existing evidence demonstrating associations between impulsivity or SSB consumption with obesity and between impulsivity with SSB consumption. Therefore, investigation of the effect of SSB and impulsivity on obesity in emerging adults warrants further investigation. There is a gap in the literature exploring the relationship directly between impulsivity, SSB consumption and obesity. There is evidence linking SSB consumption with obesity (Laverty et al., 2015; Langer et al., 2017) and impulsivity (Lumley et al., 2016; Melbye et al., 2016);

linking impulsivity with obesity (Giel et al., 2017; Liu et al, 2019); plus a potential moderating effect of impulsivity on SSB consumption (Kulbida et al., 2022; Johansen et al, 2019). No research to date has explored the interrelationship between these variables, thus this current study is novel. There is also evidence of a mediating influence of parental regulation on the relationship between impulsivity and SSB consumption in children (Melbye et al, 2016). The current study aims to further explore the interrelationship between these variables with SSB consumption having either a direct, moderating or mediating influence on impulsivity resulting in obesity.

1.1.2 Measurement of Impulsivity

Impulsivity has differing constructs and operationalisations, with some researchers using a singular construct (Guerrieri et al., 2007), whilst others use a multifactorial description (Cyders & Coskunpinar, 2011, 2012; Dawe & Loxton, 2004; Dougherty, Mathias, Marsh, & Jagar, 2005), or utilise terms such as poor executive function, and inability to override specific behavioural responses (Enticott, Ogloff, & Bradshaw, 2006). Obtaining a consistent and accurate representation of the impulsivity construct, therefore, is difficult.

It is not surprising then that self-report and behavioural methodologies poorly correlate with each other (Cyders & Coskunpinar, 2011; Reynolds et al., 2006). Rather than referring to a global term of impulsivity, it may be more useful to operationalise each construct under investigation in terms of the specific aspect of impulsivity that is most relevant (Cyders & Coskunpinar, 2011, 2012). Trait impulsivity represents a tendency to approach a desired behavioural outcome. However, many other environmental factors and potentially conflicting desires impact whether that tendency becomes actual behaviour (Meule & Blechert, 2017). Thus, self-report and behavioural measures of impulsivity together may complement each other and offer unique contributions, thus providing a more complete picture of the impulsivity construct (Dougherty et al., 2005; Meule & Blechert, 2017).

One laboratory measure of impulsivity involves delay discounting, where a series of hypothetical computer-based choices are made between small immediate rewards, and larger rewards over increasing periods of delay (Reynolds & Schiffbauer, 2005). Delay discounting tasks, however, require complex cognitive choices and levels of abstract thinking that may not be appropriate for young adults (Isen, et al., 2014; Reynolds & Schiffbauer, 2005), and may not accurately reflect actual behaviour. Hypothetical or laboratory behavioural measures often lack the immediacy and ecological validity of real-life outcomes and measures (Doidge, Flora & Toplak, 2021; Isen et al., 2014). Furthermore, real versus hypothetical money rewards provide real and legitimate consequences (Xu, Xiao & Rao 2019).

Moran and Mullen, (2020) as part of a study investigating self-regulation and SSB consumption, measured self-report usual SSB consumption along with a brief self-report measure of self-control. These authors found a significant relationship between increased SSB consumption and reduced self-control. However, after accounting for habit, intention and environmental cues, self-control no longer was a significant predictor of SSB consumption (Moran & Mullen, 2020). In line with the rationale for the current study, the authors proposed that current measures of trait self-control may not represent situational specific aspects of behaviour relevant to SSB consumption. The authors further suggested the development of a specific behavioural measure of SSB consumption related to self-control (Moran & Mullan, 2020) which is in keeping with the current study. A SSB specific behavioural measure of impulsivity will help identify predictive influences over SSB consumption.

1.1.4 Delay of Gratification

Comparable to delay discounting tests, delay of gratification taps into an individual's ability to both inhibit reward motivation and exert restraint over an immediate available reward in favour of a delayed larger reward (Reynolds & Schiffbauer, 2005). The additional benefit of using delay of gratification over delay discounting is the ability to test in a real-life domain. Wulfert et al., (2002) adapted Mischel's (1970) delay of gratification test for use in youth involving an immediate cash reward, or a larger delayed cash reward. The measure has been previously validated against externalising behaviours of impulsivity and has the benefits of being salient to the age group, naturalistic, and models real-life decision-making processes (Anokhin et al., 2011; Isen et al., 2014; Sparks et al., 2014; Wulfert et al., 2002). Moreover, monetary incentives relative to other incentives may be more motivating for emerging adults (Sparks et al., 2014; Wulfert et al., 2002). Additionally, the reward is real rather than computer-based and physically tangible, as it is in front of the individual. This means the individual needs to exert considerable willpower to overcome the immediate choice in favour of a delayed reward (Doidge, et al., 2021).

1.1.5 The Current Study

The first aim of this study was to investigate two behavioural measures of impulsivity, one being a SSB measure. It is expected that after inducing thirst, more impulsive participants will exert less self-control and consume a greater volume of SSB compared to less impulsive individuals and those assigned to receive the water control substance as per Brannigan et al., (2015). More impulsive participants assigned to the SSB experimental group will be less able to stop SSB consumption, thus demonstrating this task as a suitable behavioural measure of impulsivity. The second behavioural measure of impulsivity will be Wulfert's (2002) monetary delay of gratification. Both behavioural measures will be measured against the self-report Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995). The second aim of the study was to investigate the relationship between usual SSB consumption as determined by self-report questions, self-report impulsivity, and measures of obesity.

The study utilised an older group of emerging adults recruited from a pool of first year university students using advertising targeting those interested in soft drink. Participants were made to feel thirsty by first consuming a predetermined quantity of salted potato crisps as per Brannigan et al., (2015), and then later having access *ad libitum* to either water or SSB. Volume of either water or SSB consumed was measured. Hypothesis one proposed that the BIS-11 self-report measure of impulsivity would predict behavioural impulsivity by (i) an increase in SSB compared to water consumed under experimental conditions and (ii) choice of immediate over delayed gratification. Hypothesis two proposed that self-report impulsivity would predict usual SSB consumption and obesity in this group of emerging adults. Hypothesis three explored the relationship between impulsivity, usual SSB consumption and obesity with usual SSB consumption either mediating or moderating the relationship between impulsivity and obesity.

2.0 Method

2.1 Design

The study employed an experimental manipulation of condition (SSB v Water, between subjects) with fluid consumption measured (see Figure 1). Thirst was used to induce impulsivity (as per Brannigan, Stevenson, & Francis, 2015). The outcome variables were volume of fluid consumed after inducing thirst, choice of monetary reward, BMI, waist circumference and usual SSB consumption. The predictor variables were self-reported impulsivity, and group (SSB vs Water). Participants were randomly assigned to one of two experimental conditions using the randomisation function of the *Qualtrics* online survey tool. Ethical approval for was granted by the University Human Ethics Committee.

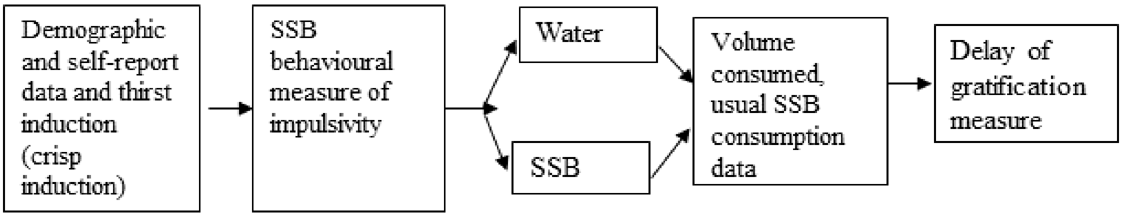


Figure 1. Experimental design demonstrating impulsivity with fluid consumption, preceded by self-report questionnaire, and finalised by the delay of gratification test.

Note. SSB = Sugar Sweetened Beverage

2.2 Participants

The total sample comprised of 266 participants (71% women) mean age 18.68 years (*SD* = 1.26 years) with a mean BMI of 23.18 (*SD* = 4.25) and mean waist circumference of 80.32cm (*SD* = 11.22). Participants were recruited across a number of trimesters from the first year University Participant Pool with the opportunity to gain course credit points. Participants were invited to the study via advertising on the University SONA website. Participants 21years of age or younger were targeted as this age group fits the general demographic of emerging adults (Nelson & Barry, 2005). Additional participants aged between 17 and 21 years were also recruited from the general student population via the University monthly volunteer broadcast emails. Additional participants recruited via the University monthly volunteer broadcast emails were eligible to enter a draw for a $50 gift card, via email submission of the study code. Advertising information advised those who may experience a negative reaction to exposure to soft drink and salted potato chips not to proceed to the booking phase. All participants attended the behavioural psychology laboratory at the University campus for the experimental phase.

2.3 Procedure

Participants were asked not to consume any food or liquid for 60 minutes prior to commencement of the study, to limit potential confounding variables. Prior to commencement of the protocol, participants were sent a reminder email not to eat or drink anything (including water) for at least one hour before their appointment. Upon arrival they were again screened to exclude those who may experience a negative reaction to exposure to soft drink or salted potato crisps. Participants were then asked when they last had something to eat or drink (including water) where response options included "*In the last hour*", "*In the last 2 hours*", "*In the last 3 hours*", and "*More than 3 hours ago*". Participants were excluded from further participation if they consumed food or drink in the past hour. Successful participants provided informed consent, and measurements of height, weight and waist circumference taken.

Thirst was induced via a small measure (19g) of salted potato chips (as per Brannigan et al., 2015). Participants were asked to consume all the chips prior to completing the self-report questionnaires. Participants rated their current hunger and thirst levels, then completed a series of online questions including the Barratt self-report measure of impulsivity using the online *Qualtrics* survey tool, prior to commencing the first behavioural experimental task of drink consumption.

Participants were randomly allocated to either the experimental group (soft drink) or the water (water) group and asked to drink as much as they wished in order to rate the drink under the guise of taste and rate "pleasantness". Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room.

Upon completion of first behavioural impulsivity measure, participants were again asked to rate their hunger and thirst, then completed questions to ascertain usual soft drink consumption. The experiment was finalised with participants completing the monetary delay of gratification measure as per Wulfert et al, (2002). Participants were given the opportunity to choose $7 immediately or $10 in one week's time (as per Wulfert et al., 2002). Participants were then thanked for participation and allowed to leave.

2.4 Measures

2.4.1 Demographic Data. Participants completed the following demographic questions: age, gender, ratings of hunger and thirst prior and post experiment, and when they last drank fluid. BMI was determined from actual height and weight measurements. Waist measurement was determined using a measuring tape checked monthly for stretching and replaced if stretched. The participant was requested to remove heavy outer garments, to stand with their feet fairly close together (about 12–15 cm) with their weight equally distributed and to breathe normally as per NHMRC guidelines (2013). The participant was then asked to wrap the measuring tape around their waist at the natural waist level in line with their umbilicus with the tape not tight but not loose (NHMRC, 2013). Overweight and obesity are generally defined as a BMI greater than 25 and 30 respectively, with waist circumference of 80cm and 88 cm respectively for women and 94cm and 102cm for men (NHMRC, 2013). Thirst and hunger were measured using a 10cm Visual Analogue Scale pre and post the experimental condition. Participants were asked to rate the statements “How hungry are you right now?” and “How thirsty are you right now?” (0 = *not at all*, 10 = *very much).*

2.4.2 Usual SSB Consumption. Frequency of SSB consumption was measured after the experimental phase via a self-report question of “How often do you usually drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks” with a 9 point Likert scale (1 = every day, 2= 6 days/week, 3= 5 days/week, 4=4 days/week, 5 = 3 days/week, 6 = 2 days/week, 7 = 1 day/week, 8= occasionally, 9 = never). Quantity consumed per occasion was measured by “When you do drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks, how many glasses do you have?” using an 8 point Likert scale (1 = 1 glass to 7 = 7 glasses, 0 = 0 glasses) and with a guide as to what comprises a 250ml glass. Average daily SSB consumption (ml/day) was calculated by multiplying the number of glasses per occasion by the number of days per week that SSB was consumed, divided by 7 and multiplied by 250ml. SSB included soft drink, cordial, energy drinks, iced teas, fruit type drinks, and flavoured mineral water drinks.

2.4.3 Barratt Impulsivity Scale -11 Adolescent. The Barratt Impulsiveness Scale – Adolescent (BIS-11-A) is a 30 item, 4-point Likert scale (1 = rarely/never to 4 = almost always/always) self-report questionnaire of impulsivity adapted from the adult BIS-11 and validated with emerging adults up to 20 years (Bhat, Roopesh, Bhaskarapillai, & Benegal, 2018; Fossati, Barratt, Acquarini, & Di Ceglie, 2002; Patton, Stanford, & Barratt, 1995). Items include “I act on the spur of the moment” with higher total scores representing greater levels of impulsivity. Scores were summed and ranged from 30 to 120 with higher scores indicating higher levels of impulsivity. The BIS-11-A demonstrated adequate internal consistency in this study ($\alpha = .75$).

2.4.4 Soft Drink Measure of Impulsivity. Thirst was induced by providing 19g of salted potato chips (equivalent to 0.28g of salt) prior to provision of the drink, and while participants completed the demographic questions. Participants were randomly allocated to either the experimental group (soft drink) or the control (water) group. The soft drink provided was a chilled 1.25 l bottle of Lemonade with labels removed, whilst the water was 1.5l bottle of chilled store-bought plain water with labels removed. Participants were provided with sufficient drink as to satisfy thirst and to compensate for any potential ceiling effect from insufficient drink and asked to taste-test and rate the pleasantness of the drink. Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room. It was anticipated that the sensation of thirst tested normal inhibition responses, such that more impulsive individuals would consume more than would normally be sufficient to quench their thirst (Brannigan et al., 2015). Beverage type and quantity consumed was measured upon completion of the experiment.

2.4.5 Monetary Delay of Gratification. Participants participated in the monetary delay of gratification at the completion of testing. The monetary delay of gratification offered a choice whereby emerging adults choose either $7 (smaller and immediate reward) immediately or $10 (larger and delayed reward) to be collected from the School of Applied Psychology reception in a week's time (as per Wulfert et al., 2002). Each participant was thanked for their participation, and the following instructions verbally delivered by the experimenter:

"We are interested in how people make decisions, so we are going to ask you to make a choice. As a token of our appreciation for your participation, we would like to offer you a cash bonus. You can either choose to have $7 right now [show cash to participant] or wait. If you wait, you will receive $10 in one week when you can come and collect it from Psychology reception [show cash and envelope to participant] to you. What would you like to do?"

If the participant chose the immediate reward, they were provided with $7 cash immediately. If the participant chose the delayed reward, they were asked to write their name and student number on an envelope. The experimenter placed the $10 inside the envelope, sealed the envelope, put the future date for collection and put the envelope aside. Participants were provided with directions to psychology reception and advised to collect their money in one week's time. Envelopes were taken to reception at the end of each day of testing, where staff were briefed on the collection criteria. Students were provided with one reminder to collect their money, if they had not already done so, at semester's end.

3.0 Results

3.1 Data Screening and Assumptions

Prior to analyses, data were screened using SPSS 27.0. The original dataset contained responses from 266 participants, of whom 29 (10.9%) did not collect the final reward of the study and were removed from further analysis. An additional 59 participants identified as consuming either artificially sweetened SSB or neither artificially sweetened SSB nor regular

SSB. These participants were removed from all analyses. Otherwise, the experiment was performed such that there was no missing data. Gender was dummy coded where 1 was equal to women. Data was assessed for normality using skewness and kurtosis statistics (Field, 2009). As expected, when sampling a non-clinical sample of young university students, volume consumed, usual SSB consumption waist circumference and BMI distributions were positively skewed indicative of a cohort where health considerations may have played a role in participation (Hong et al., 2016). All other variables were normally distributed. Data was screened for outliers. Eight statistically significant univariate outliers were identified in Usual SSB consumption using a p = .001 cut off. Removal did not change the nature of the results, therefore, they were included in the final analysis. Two multivariate outliers were identified using Mahalanobi's distance cut off p =.001 χ^2 = 18.47 and were subsequently removed from further analysis (Tabachnick and Fiddell, 2013). Waist, BMI, usual SSB consumption and experimental volume consumed were significantly positively skewed with skew to SE rates greater than 3.29 using a cut-off of p =.001. Log transformations did not significantly alter the results, so were not used in the final analysis. One hundred and seventy-eight participants of whom 131 were women (74%) mean age 18.56 years (*SD* = 1.24 years) with a mean BMI of 22.78 (*SD* = 4.03) and mean waist circumference of 79.53cm (*SD* = 10.82) were included in the final analysis.

3.2 Group Comparison and Descriptive Statistics

To check for successful randomisation, investigation of the two groups was conducted. Continuous variables were tested using independent t-test and categorical variables tested using chi-square tests. To test whether participants experienced reductions in both self-reported thirst and hunger after the testing period, a paired samples t-test was conducted. As expected, hunger and thirst reduced significantly post testing compared to before testing (see Table 1). A significant difference in volume consumed was found such that the water group participants consumed more than those in the SSB group (See Table 2). Similarly, participants in the water group reported significantly less thirst post testing than those in the SSB group (See Table2). A significant difference was found between in likability of Water group drink type (*M* =6.78, *SD* = 2.21) and SSB group drink type (*M* =5.29, *SD* = 2.35) group with those in the water group liking the drink more than the SSB group *t* (176) = 4.34, *p* <.001. A factorial ANOVA was performed on change in thirst under experimental conditions with group as the between factor and thirst as the within factor. As expected, there was a significant interaction of change in thirst by group *F* (1,176) = 8.32, *p* =.004 with those in the SSB group reporting significantly less reduction in thirst (refer Table 2). Also, there was a significant main effect of thirst *F* (1,176) = 399.67, *p* <.001 with thirst post testing significantly less than pre-test (refer Table 1) and a significant main effect of group *F* (1,176) = 6.87, *p* =.01. No significant difference was found between groups for hunger, impulsivity, usual SSB consumption, gender χ^2 (1) = .38, *p* =.53, and time last consumed food or fluid χ^2 (2) = 0.18, *p* =.91. A gender difference was found in volume consumed under experimental conditions with men (*M* = 445.21, *SD* = 167.78) consuming more water than women (*M* = 350.58, *SD* = 130.39), *t* (82) = 2.76, *p* =.004) and men (*M* =242.39, *SD* = 92.28) consuming more SSB than women (*M* =194.37, *SD* = 84.01), *t* (92) = 2.31, *p* =.012.

Table 1

Paired samples t-test: Hunger and thirst before versus after testing (N = 178)

	Before Testing *M* (*SD*)	Post Testing *M* (*SD*)	Difference *t (df)*	*p*
Hunger	50.89 (24.06)	32.27(20.70)	13.17 (177)	<.001
Thirst	61.79 (20.50)	25.78 (21.65)	19.46 (177)	<.001

Table 2

Independent t-test Between Group Comparisons for Continuous Variables: Age, Waist, BMI, Impulsivity, Usual SSB consumption, Hunger, Thirst

	Group					
	Water *M (SD)*	SSB *M (SD)*	*df*	*t*	*p*	*Cohen's d*
N	84	94	-	-	-	-
Age (years)	18.56 (1.16)	18.56 (1.31)	176	-.02	.98	.003
BMI	22.85 (4.02)	22.72 (4.06)	176	.20	.84	.03
Waist (cm)	79.69 (10.46)	79.38 (11.20)	176	.19	.85	.03
Impulsivity	68.69 (7.43)	66.63 (8.42)	176	1.72	.09	.26
Usual SSB consumption (ml/d)	135.84 (173.33)	184.84 (218.23)	173.67	-1.66	.11	-.25
Volume consumed	377.62 (147.43)	206.12 (88.57)	132.84	9.27	<.001	1.43
Hunger before	51.43 (22.87)	50.43 (25.18)	176	.28	.78	.04
Hunger after	31.78 (18.63)	33.51 (22.47)	175.06	-.56	.58	-.08
Thirst before	61.07(19.76)	62.45 (21.23)	176	-.45	.66	-.07
Thirst After	19.52 (17.48)	31.38 (23.49)	170.60	-3.85	<.001	-.57

Note: BMI = Body Mass Index.

To determine the impact of experimental condition on the relationship between impulsivity and choice, a moderated multiple regression was tested using the PROCESS macro model 1. Binary logistic regression analysis revealed a non-significant main effect of self-report impulsivity Odds Ratio = 0.95; 95% CI [-.21 - 0.07], SE =.07, Wald χ^2 (1) = -1.00, *p* = .31, and a non-significant main effect of group on choice of immediate over delayed reward, Odds Ratio = 0.95; 95% CI [-6.93 – 4.30], SE =2.87, Wald χ^2 (1) = -.46 *p* = .65. As expected, there was no interaction of group allocation and impulsivity on choice of immediate over delayed reward χ^2 (1) =.11, *p* =.74, indicating that group allocation to receive either SSB or water did not influence choice.

Table 3

Experimental Group Correlations

	Water Group							SSB Group						
	M (SD)	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist	M (SD)	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist
Impulsivity	68.69 (7.43)	-	-	-	-	-	-	66.63 (8.42)	-	-	-	-	-	-
Volume	377.62 (147.43)	-.09	-	-	-	-	-	206.12 (88.57)	.05	-	-	-	-	-
Choice N wait	54	-.19	.01	-	-	-	-	55	-.17	.07	-	-	-	-
Usual SSB	135.84 (173.33)	.08	-.12	-.01	-	-	-	184.84 (218.23)	.10	.26*	-.03	-	-	-
BMI	22.84 (4.02)	.03	.02	.03	.15	-	-	22.72 (4.06)	-.15	.18	-.05	.12	-	-
Waist	79.69 (10.46)	.04	.05	.05	.22*	.85***	-	79.38 (11.12)	-.17	.19	-.06	.12	.88***	-
Women N (%)	60 (71)	.05	-.29**	-.03	-.07	-.04	-.38***	71 (76)	.05	-.23*	.07	-.09	-.18	-.42***

Note. * p <.05, ** p < .01, *** p < .001

3.3 Inferential Statistics

Gender was entered into step one of a regression analysis and was predictive of experimental SSB consumed F (1, 92) = 5.35, p = .023 with men (M =242.39, SD = 92.28) consuming more SSB than women (M =194.37, SD = 84.01). After controlling for gender in step one, self-report impulsivity was entered into step two with the overall model non-significant F (2,91) = 2.58, p =.06. Contrary to hypothesis one, gender was the most predictive of volume consumed under experimental conditions accounting for 5.6% of the unique variance with men consuming more than women.

In support of hypothesis one, Binary logistic regression analysis revealed that self-report impulsivity significantly contributed to the choice of immediate over delayed reward, Odds Ratio = 0.95; 95% CI [0.91 - 0.99], SE =.02, Wald χ^2 (1) = 4.93, p = .026, with more impulsive individuals choosing immediate over delayed reward.

Hypothesis two stated that impulsivity would predict usual SSB consumption and measures of obesity. Gender was entered into step one of a regression analysis and was not a significant predictor of usual SSB consumption, F (1,176) = .90, p = .34. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis which revealed that self-report impulsivity remained a non-significant predictor of usual SSB consumption in this cohort, F (2,175) = .99, p = .37.

To test that impulsivity was predictive of waist circumference and BMI, separate regression analyses were carried out with waist circumference and BMI as outcome variables. Gender was entered into step one of a regression analysis and was not a significant predictor of BMI, F (1,176) = 2.29, p =.13. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis. The model remained non-significant F (2,175) = 1.55, p =.22. Similarly, gender was entered into step one of regression analyses and was a significant predictor of waist circumference, F (1,176) = 34.31, p <.001. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis which revealed that although the overall model was significant, F (2,175) = 17.54, p <.001, self-report impulsivity was a non-significant predictor of waist circumference contributing 0.4% of the unique variance. Gender remained responsible for 16.1% of the total 16.7% variance for waist circumference but not BMI in this cohort.

Tests of Moderation

One of the primary aims of the research was to investigate the relationship between impulsivity, usual SSB consumption and obesity. As waist circumference was significantly associated with usual SSB consumption, further analysis was performed on this variable.

A moderated regression using the PROCESS macro Model 1 on SPSS was performed to test the moderating effect of usual SSB consumption on impulsivity and measures of obesity. See Figure 2 for the proposed model. As shown in Table 4, no main effect or interaction was found with usual SSB consumption. No association was found between impulsivity and waist circumference.

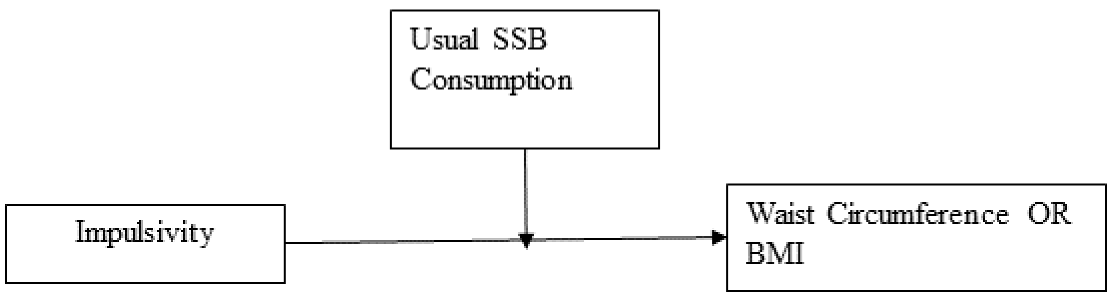


Figure 2

Proposed Moderation Model of Usual SSB consumption on Impulsivity and Waist Circumference or BMI.

Table 4

Moderated multiple regression between usual SSB consumption, trait impulsivity on waist circumference and BMI.

Predictor	*B*	*SE (B)*	*t*	*p*	*LLCI*	*ULCI*
Impulsivity	-.09	.12	-.78	.43	-.34	.15
Usual SSB	.02	.03	.63	.53	-.05	.09
Impulsivity x Usual SSB	<.001	<.001	-.38	.71	-.001	.001
Impulsivity	-.02	.05	-.48	.63	-.12	.07
Usual SSB	.01	.01	.94	.35	-.01	.04
Impulsivity x Usual SSB	<.001	<.001	-.73	.46	-.001	.001

Note. LLCI and ULCI denote lower and upper confidence intervals respectively. Non-mean centred scores were used.

Contrary to the hypothesis that usual SSB consumption will moderate the relationship between impulsivity and waist circumference, with more impulsive participants who consume more usual SSB will have larger waist circumferences, no significant relationship was found between impulsivity usual SSB consumption and waist circumference, $F(3,174) = 2.00$, $p = .11$ and between impulsivity usual SSB consumption and BMI, $F(3,174) = 1.59$, $p = .19$.

Tests of Mediation

Significant direct and indirect mediation effects between impulsivity, usual SSB consumption and both measures of obesity were tested using the PROCESS macro on SPSS. The model was tested using the PROCESS Macro model 4 bootstrap method with 95% confidence intervals (*n*=10,000) for SPSS. Figure 3 below represents the overview of the model with path *a* representing the association between impulsivity and usual SSB consumption, path *b* representing the association between usual SSB consumption and waist circumference after controlling for impulsivity, and path *c* representing the direct effect of impulsivity on waist circumference. Indirect effects refer to path *a* by path *b* via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals. Figure 4 represents the overview of the model with path a_1 representing standardised coefficients for the association between impulsivity and usual SSB consumption, path b_1 representing the association between usual SSB consumption and BMI after controlling for impulsivity, and path c_1 representing the direct effect of impulsivity on BMI. Indirect effects refer to path a_1 by path b_1 via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals.

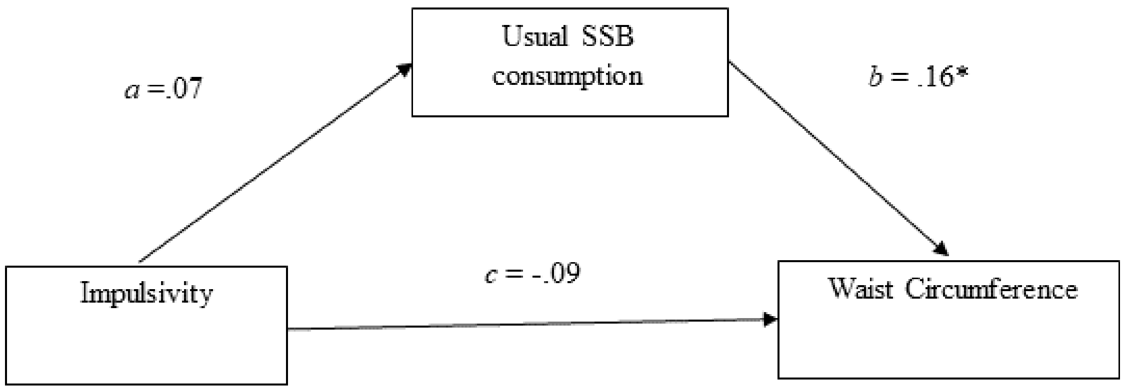


Figure 3

Standardised Coefficients Showing the Relationship Between Impulsivity and Waist Circumference via Usual SSB Consumption

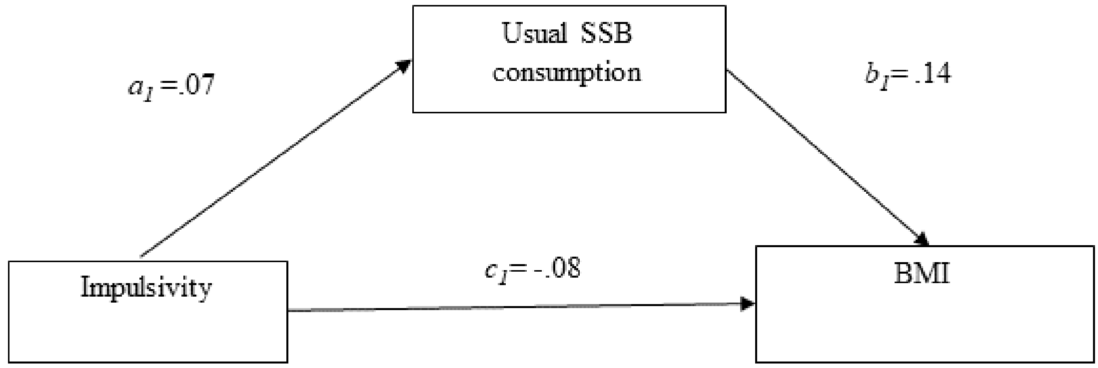


Figure 4

Standardised Coefficients showing the Relationship between Impulsivity and BMI via Usual SSB Consumption.

Impulsivity was not significantly associated with usual SSB consumption (path a), Usual SSB consumption was significantly associated with waist circumference (path b) while the direct path from impulsivity (path c) was not significant (Table 5). Impulsivity therefore, was unrelated to usual SSB consumption but usual SSB consumption was related to waist circumference. Similarly, there was no significant association between impulsivity and usual SSB consumption (path a_1), usual SSB consumption and BMI (path b_1) and the direct effect of impulsivity on BMI was also not significant (path c_1).

Table 5

Unstandardised Direct Effects of Impulsivity, Usual SSB Consumption on Waist Circumference and BMI.

		Effect	
Outcome Variable	Variable	Bootstrap Estimate (SE)	BC 95% CI
Usual SSB Consumption	Impulsivity (path a)	1.86 (1.86)	-1.83, 5.55
Waist Circumference	Usual SSB (path b)	.009 (.004)*	.009, .017
Waist Circumference	Impulsivity (path c)	-.12 (.10)	-.32, .08
Usual SSB Consumption	Impulsivity (path a_1)	1.86 (1.86)	-1.83, 5.55
BMI	Usual SSB (path b_1)	.003 (.001)	-.0002, .006
BMI	Impulsivity (path c_1)	-.04 (.04)	-.116, .033

Note. * p <.05. BC = biased corrected; CI = Confidence Interval.

Mediation analysis revealed a non-significant indirect effect of impulsivity on waist circumference through usual SSB consumption (See Table 6). Similarly, no direct or indirect associations were found using BMI as an outcome variable. The variable BMI was not explored further.

Table 6

Unstandardised Indirect Effects of Impulsivity on Waist Circumference and BMI Through the Mediator Usual SSB Consumption

		Effect	
Outcome Variable	Mediator	Bootstrap Estimate (SE)	BC 95% CI
Waist Circumference	Usual SSB Consumption	.02 (.02)	-.014, .071
BMI	Usual SSB Consumption	.01 (.01)	-.004, .023

Note: * p<.05, indicates a significant indirect effect. BC = biased corrected; CI = Confidence Interval.

As no significant mediating effect of impulsivity on waist circumference through usual SSB consumption was found, further regression analysis was performed on waist circumference with gender, impulsivity and usual SSB consumption as predictors. Gender was entered into step one of a regression analysis and was a significant predictor of waist circumference, F (1,176) = 30.31, $p < .001$. After controlling for gender in step 1, usual SSB consumption was entered into step 2 with the regression model remaining significant, F (2,175) = 19.13, $p <.001$. Impulsivity was entered into step 3 with the overall regression model remaining significant, F (3,174) = 13.13, $p <.001$. Altogether the model represented 18.5% of the variability in waist circumference. However, gender was the strongest predictor of waist circumference in this cohort accounting for 15% of the unique variance. As expected, females (M = 76.92, SD = 9.31), had significantly smaller waist circumference than men (M = 86.81, SD = 11.52), t (176) = 5.86, $p <.001$. Usual SSB consumption and impulsivity non-significant predictors together accounting for only 2% of the unique variance (Table 7). Therefore, the results suggest that the pathway to obesity does not lie between impulsivity and SSB consumption in this cohort.

Table 7

Hierarchical regression of gender, usual SSB consumption and Impulsivity on waist circumference.

Variable	B	SE B	β	sr^2
Female	-9.59***	1.68	-.39	.15
Usual SSB consumption	.007	.004	.13	.02
Impulsivity	-.098	.093	-.07	.005

Note. R^2 = .185. ***$p < .001$.

When the results were broken down into experimental group allocation, a significant correlation, which warranted further investigation, were found between the volume of SSB consumed under experimental conditions with usual SSB consumption. After controlling for gender in step 1, usual SSB consumption was entered into step 2 and remained a significant predictor of experimental SSB consumption, F (2,90) = 5.66, p =.005 accounting for 5.6% of the unique variance. Altogether the model represented 11.1% of the variability in experimental SSB consumption with gender contributing 4.5% of the total variance (Table 8).

Table 8

Hierarchical regression of gender and usual SSB consumption on experimental SSB consumption.

Variable	*B*	SE *B*	β	sr^2
Female	-43.88*	20.34	-.21	.04
Usual SSB consumption	.096*	.04	.23	.06

Note. R^2 = .111. **p* < .05.

No further correlations of note were found in the water group, therefore no further analyses were carried out on this group.

4.0 Discussion

As hypothesised the BIS-11 predicted the first behavioural measure of impulsivity, the monetary delay of gratification, but not the second behavioural measure, the predicted increase in SSB consumption under experimental conditions. Hypothesis two predicted that self-report impulsivity would predict usual SSB consumption and obesity. The BIS-11 was not predictive of either usual SSB consumption nor measures of obesity. Hypothesis three predicted that usual SSB consumption would mediate the relationship between impulsivity and waist circumference and was not supported in this study. However, gender was the strongest predictor of waist circumference, BMI and also volume of SSB consumed under experimental conditions. The specific findings are discussed below.

The current study aimed to investigate the predictive capacity of a self-report measure of impulsivity in emerging adults over two behavioural measures of impulsivity, one an experimental SSB consumption and the other a monetary delay of gratification. Research (Lumley et al., 2016; Melbye et al., 2016) indicated that increased SSB consumption is linked with impulsivity with more impulsive individuals consuming more SSB. There is currently no behavioural measure of impulsivity involving SSB consumption directly. A premise of this study was that use of a behavioural measure specific to the context being assessed (SSB consumption under thirst conditions) would provide a more accurate measure of how trait impulsivity influenced SSB consumption.

A possibility is that even though the participant was left alone and encouraged to consume as much as they desired, demand characteristics may have influenced the volume of SSB consumed under experimental conditions. In a review of relevant literature around demand characteristics in laboratory settings, Robinson et al., (2015), identified that a heightened awareness of participants towards their eating behaviour, led to reduced food consumption. This would be relevant in this case as the study invitation indicated that SSB was a construct under investigation. Therefore, participants may have wished to appear in a favourable light by consuming less SSB than they would under natural settings.

The second behavioural measure of impulsivity, a monetary delay of gratification, was hypothesised to significantly correlate with self-report impulsivity. This hypothesis was supported with more impulsive individuals choosing the immediate over the delayed reward. Therefore, the delay of gratification measure demonstrated a suitability to measure trait impulsivity. This, in combination with the lack of association between the BIS-11 and behavioural SSB consumption, may be due to the cohort of predominantly older teenage women actively exerting cognitive dietary restraint over the experimental SSB consumption part of the study. Experimental consumption of SSB may correlate with self-report impulsivity in a more diverse target cohort.

Either the SSB behavioural measure is not a sensitive indicator of impulsivity, or the cohort used in the study was not sufficiently impulsive to demonstrate a behavioural change. However, given that the monetary measure was associated with impulsivity, it is likely that the experimental SSB measure was not a sensitive measure. McGreen, Kemps and Tiggemann (2022) reported a gender difference in the relationship between self-control and experimental SSB consumption with those who had less self-control consuming more SSB under experimental conditions, however, this relationship was found in men only. When this was tested in the current study, no significant interaction was found between gender and impulsivity for volume consumed, so this possibility was not supported. However, it should be noted, that only 23 men participated in the SSB experimental group. A larger sample size would illuminate this finding further.

Additionally, and in contrast to hypothesis two, a non-significant relationship was found between impulsivity and usual SSB consumption. This is in contrast to previous research demonstrating a relationship between the two variables (Ames et al., 2014; Lumley et al., 2016; Melbye & Helland, 2018). This current result fits with the premise that university attendance requires a degree of self-control to achieve positive outcomes, and therefore would fit with normative impulsivity scores. Stanford et al., (2009) reported normative impulsivity scores of 62 with a total score of 74 or above categorising as impulsive. This indicates that this cohorts fit the norm for impulsivity. Additionally, Kulbida, Kemps and Tiggemann (2022) reported a significant interaction between reward sensitivity, impulsivity and increased usual SSB consumption such that only those high in both reward sensitivity and impulsivity consumed the most usual SSB. Reward sensitivity was not measured in the current study and may be a determinant for further investigation.

One of the aims of the study was to explore the relationship between impulsivity, usual SSB consumption and obesity. The third hypothesis stated that usual SSB consumption would either moderate (such that those higher in impulsivity and high SSB consumption would have a higher incidence of obesity) or mediate (such that impulsivity predicts obesity through increased SSB consumption) the relationship between impulsivity and measures of obesity. Additionally, the relationship between SSB consumed under experimental conditions, usual SSB consumption, self-report impulsivity, and measures of obesity were explored. Contrary to existing research (Bennet & Blissett, 2019; Giel et al. 2017; Goldschmidt et al, 2019), no significant association was found between impulsivity and either BMI, or waist circumference. This was an unexpected finding and once again points to the lack of diversity of impulsivity within the university cohort.

Also, and contrary to expectations, neither a moderating nor mediating effect of usual SSB consumption was found between impulsivity and measures of obesity. This is a novel finding as no research to date has explored the interrelationship between these variables. Although it was expected that the variables would be interrelated, this again speaks to the lack of diversity within the cohort tested and warrants further investigation within a broader, more diverse community. It remains unclear if trait impulsivity promotes excess SSB consumption and then high SSB consumption promotes further state related impulsivity and whether the effect of obesity perpetuates the cycle. There is evidence that obesity itself, may promote poor decision-making capacity in vulnerable individuals (Brooks et al., 2013). Future research is needed to replicate the current study to further understand the relationship.

Other findings from the study included a positive relationship found between usual SSB and experimental SSB consumption, suggesting that SSB consumption under experimental conditions reflects usual consumption. However, there were significant gender differences, with women consuming significantly less SSB under experimental conditions than men, and consistent with ABS (2018) data, women having a significantly smaller waist circumference than men and men generally consuming more SSB than women (ABS,2018).

4.1 Strengths and Limitations

The greatest strength of the current study was the experimental design nature in that it allowed direct manipulation of thirst to then measure actual SSB or control beverage consumption under controlled conditions. In addition, the study was able to estimate actual SSB consumption under those conditions, as well as self-reported estimates of usual SSB consumption. This was a novel approach as most research has relied predominantly on self-report data of SSB consumption which was then investigated in relation to unrelated behavioural measures of impulsivity. This was the first study of this kind that directly used SSB consumption as a behavioural indicator of impulsivity.

A further strength of the research was the in-person experimental design rather than a media distributed survey design. Survey designs distributed via social media are outside experimenter controls and as such can be subject to confounds such as participants not answering honestly, or the survey being answered by others with different or conflicting interests (Coughlan, Cronin, & Ryan, 2009). Likewise, online survey designs do not offer the capacity for real-time clarification of questions. One of the strengths of the experimental design in this research was the capacity for participants to ask clarifying questions of the researcher to better understand questions. Similarly, the in-person experimental nature of the research ensured that participants matched the requirements in terms of age. Likewise, potential confounds such as food and fluid consumption prior to participation were eliminated using the in-person design, as were any possible errors in following the research protocol.

Volume of the water consumed under experimental conditions was significantly greater than that of the SSB provided which was an unexpected outcome of this study. It was anticipated that participants would consume more of the SSB as the advertising material targeted those who enjoyed SSB to participate. Although there was no difference between the groups in thirst at the commencement of the experiment, those allocated to the SSB group reported significantly greater levels of thirst at the conclusion, indicating that thirst was not as quenched by the SSB consumed. All other variables between the groups were similar, leading to the possibility that the difference lay in the texture and mouthfeel of the control (plain bottled water) versus the carbonated SSB (lemonade). This may be presented as a limitation of the study as the two liquids did not match in consistency. Although participants demonstrated reduced likability of the SSB, it was chosen to be colourless to best match the water. A popular flavour was chosen in order to appeal to most tastes. It is possible that the presence of bubbles inhibited intake over the relatively short tasting period. It is possible that SSB did not quench thirst to the same extent as the water. It was also possible that participants demonstrated constraint in SSB consumption due to demand characteristics or that laboratory conditions did not match real life scenarios where SSB is usually consumed

Potentially a follow up study could use carbonated water as the control substance to better match the texture and mouth feel of the soft drink. Even though a requirement for participation was that no food or fluid be consumed at least one hour prior to the experiment, a further limitation was that testing occurred throughout the day and was not limited to a specific time such as late afternoon or evening when it could be argued that most SSB would be consumed. However, due to time constraints, it was not possible to limit data collection to evenings or late afternoons. Therefore, time of day was a potential limitation. It is also possible that seasonal variations in SSB consumption may have been a further limitation, with data collected throughout the year. Once again, time constraints prevented season specific data collection.

In addition, the number of participants who did not return to collect the delayed reward was unexpected. It was assumed and hoped, that those who chose the delayed reward would return in the week to collect their reward. Although a reminder was sent to all participants at the end of the data collecting period, a significant number (11%) of participants did not return to collect their reward. It was anticipated that students would be highly motivated for money. It was postulated that they may have forgotten, hence the reminder. However, it was also possible that the participants who did not complete the reward component may have responded to demand bias by choosing the delayed reward but then also been sufficiently impulsive as to forgo the greater effort of pursuing the delayed reward. It is equally possible that participants experienced demand bias of a different sort, making them reluctant to collect the reward so not to appear greedy or non-altruistic.

4.2 Conclusion

In summary, this study demonstrated that the trait BIS-11 successfully predicted the monetary behavioural measure of impulsivity but was not predictive of volume of SSB consumed under experimental conditions. This suggests that either the second state measure of increased SSB consumption under induced thirst conditions may not have been a sensitive measure of trait self-report impulsivity, or that the cohort of participants was not sufficiently diverse in impulsivity to demonstrate change. Contrary to expectations in this cohort of university emerging adults, impulsivity and usual SSB consumption were not related to obesity, with gender being the strongest predictor of obesity. Usual SSB consumption was a significant predictor of experimental SSB consumption. These results extend existing research by further substantiating the use of a simple naturalistic delay of gratification tool as a measure of impulsivity in emerging adults. The results also add a template for further investigation of the use of the experimental SSB measure of behavioural impulsivity with a more diverse cohort of participants. Further research to replicate and extend upon these findings is warranted.

References

Allom, V., & Mullan, B. (2014). Individual differences in executive function predict distinct eating behaviours. *Appetite, 80,* 123 – 130. doi. org/10.1016/j.appet.2014.05.007.

Ames, S., Kisbu-Sakarya, Y., Reynolds, K., Boyle, S., Cappelli, C., Cox, M.. . Stacy, A. (2014). Inhibitory control effects in adolescent binge eating and consumption of sugar-sweetened beverages and snacks. *Appetite, 81*, 180-192. doi:10.1016/j.appet.2014.06.013.

Anokhin, A. P., Golosheykin, S., Grant, J. D., & Heath, A. C. (2011). Heritability of delay discounting in adolescence: A longitudinal twin study. *Behavior Genetics, 41*(2), 175-183. doi:10.1007/s10519-010-9384-7.

Attuquayefio, T., Stevenson, R. J., Boakes, R. A., Oaten, M. J., Yeomans, M. R., Mahmut, M., & Francis, H. M. (2016). A high-fat high-sugar diet predicts poorer hippocampal-related memory and a reduced ability to suppress wanting under satiety. *Journal of Experimental Psychology: Animal Learning and Cognition*, 42(4), 415-428. doi:10.1037/xan0000118.

Australian Bureau of Statistics (ABS). (2018). *4364.0.55.001 National Health Survey, first results, 2017-2018*. Australian Government.

Bhat, N. A., Roopesh, B. N., Bhaskarapillai, B., & Benegal, V. (2018). Validation of the Barratt Impulsiveness Scale – short form among Indian adolescents. *Asian Journal of Psychiatry, 37,* 172-177. https://doi.org/10.1016/j.ajp.2018.10.009.

Blanco-Gómez, A., Ferré, N., Luque, V., Cardona, M., Gispert-Llauradó, M., Escribano, J., . . . Canals-Sans, J. (2015). Being overweight or obese is associated with inhibition control in children from six to ten years of age. *Acta Paediatrica, 104*(6), 619-625. doi:10.1111/apa.12976.

Brannigan, M., Stevenson, R. J., & Francis, H. (2015). Thirst interoception and its relationship to a Western-style diet. *Physiology & Behavior, 139*, 423-429. doi:10.1016/j.physbeh.2014.11.050.

Brooks, S. J., Cedernaes, J., & Schioth, H. B. (2013). Increased prefrontal and parahippocampal activation with reduced dorsolateral prefrontal and insular cortex activation to food images in obesity: A meta-analysis of fMRI studies. *PLoS One, 8*(4), e60393. doi:10.1371/journal.pone.0060393.

Burger, K. S., & Stice, E. (2014). Neural responsivity during soft drink intake, anticipation, and advertisement exposure in habitually consuming youth. *Obesity, 22*(2), 441-450. doi:10.1002/oby.20563.

Cyders, M. A., & Coskunpinar, A. (2011). Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? *Clinical Psychology Review, 31*(6), 965-982. doi:10.1016/j.cpr.2011.06.001

Cyders, M. A., & Coskunpinar, A. (2012). The relationship between self-report and lab task conceptualizations of impulsivity. *Journal of Research in Personality, 46*(1), 121-124. doi:10.1016/j.jrp.2011.11.005

Dawe, S., & Loxton, N.J. (2004). The role of impulsivity in the development of substance use and eating disorders. *Neuroscience and Biobehavioral Reviews, 28,* 343-351. doi:10.1016/j.neubiorev.2004.03.007.

Della Torre, S. B., Keller, A., Depeyre, J.L., & Kruseman, M. (2016). Sugar-sweetened beverages and obesity risk in children and adolescents: A systematic analysis on how methodological quality may influence conclusions. *Journal of the Academy of Nutrition and Dietetics, 116,* 638-659. http://dx.doi.org/10.1016/j.jand.2015.05.020.

Doidge, J. L., Flora, D. B., & Toplak, M. E. (2021). A meta-analytic review of sex differences on delay of gratification and temporal discounting tasks in ADHD and typically developing samples. *Journal of Attention Disorders, 25 (4),* 540- 561. doi: 10.1177/1087054718815588.

Dougherty, D. M., Mathias, C. W., Marsh, D. M., & Jagar, A. A. (2005). Laboratory behavioral measures of impulsivity. *Behavior Research Methods, 37*(1), 82-90. doi:10.3758/BF03206401.

Enticott, P. G., Ogloff, J. R. P., & Bradshaw, J. L. (2006). Associations between laboratory measures of executive inhibitory control and self-reported impulsivity. *Personality and Individual Differences, 41*(2), 285-294. doi:10.1016/j.paid.2006.01.011.

Falbe, J., Thompson, H.R., Patel, A., & Madsen, K.A. (2019). Potentially addictive properties of sugar-sweetened beverages among adolescents. *Appetite, 133*, 130-137. https://doi.org/10.1016/j.appet.2018.10.032.

Fossati, A., Barratt, E. S., Acquarini, E., & Di Ceglie, A. (2002). Psychometric properties of an adolescent version of the Barratt Impulsiveness Scale-11 for a sample of Italian high school students. *Perceptual and Motor Skills, 95*(2), 621-635.

Francis, H. M., & Stevenson, R. J. (2011). Higher reported saturated fat and refined sugar intake is associated with reduced hippocampal-dependent memory and sensitivity to interoceptive signals. *Behavioral Neuroscience, 125*(6), 943-955. doi:10.1037/a0025998.

Giel, K. E., Teufel, M., Junne, F., Zipfel, S., & Schag, K. (2017). Food-related impulsivity in obesity and binge eating disorder - A systematic update of the evidence. *Nutrients, 9,* 1170. doi:10.3390/nu9111170.

Hong, M. Y., Shepanski, T. L., & Gaylis, J. B. (2016). Majoring in nutrition influences BMI of female college students. *Journal of Nutritional Science, 5, e8,* 1-7. doi:10.1017/jns.2015.24.

Isen, J. D., Sparks, J. C., & Iacono, W. G. (2014). Predictive validity of delay discounting behavior in adolescence: a longitudinal twin study. *Experimental Clinical Psychopharmacology, 22*(5), 434-443. doi:10.1037/a0037340.

Johansen, C. M., Reynolds, K. D., Xie, B., Unger, J. B., & Ames, S. L. (2019). Acculturation and sugar-sweetened beverage consumption among Hispanic adolescents: The moderating effect of impulsivity. *Appetite, 134,* 142 – 147. https://doi.org/10.1016/j.appet.2018.12.026.

Langer, S.L., Seburg, E., JaKa, M.M., & Sherwood, N. E. (2017). Predicting dietary intake among children classified as overweight or at risk for overweight: Independent and interactive effects of parenting practices and styles. *Appetite, 110,* 72 -79. http://dx.doi.org/10.1016/j.appet.2016.12.011.

Laverty, A. A., Magee, L., Monteiro, C. A., Saxena, S., & Millett, C. (2015). Sugar and artificially sweetened beverage consumption and adiposity changes: National longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity, 12,* 137-147. DOI 10.1186/s12966-015-0297-y.

Liu, Y., Zhao, J., Zhang, X., Gao, X., Xu, W., & Chen, H. (2019). Overweight adults are more impulsive than normal weight adults: Evidence from ERPs during a chocolate-related delayed discounting task. *Neuropsychologica, 133,* 107181. https://doi.org/10.1016/j.neuropsychologia.2019.107181.

Lumley, J., Stevenson, R. J., Oaten, M. J., Mahmut, M., & Yeomans, M. R. (2016). Individual differences in impulsivity and their relationship to a Western-style diet. *Personality and Individual Differences, 97*, 178-185. doi:10.1016/j.paid.2016.03.055.

Kanoski, S. E., & Davidson, T. L. (2011). Western diet consumption and cognitive impairment: Links to hippocampal dysfunction and obesity. *Physiology & Behavior, 103*(1), 59-68. doi:10.1016/j.physbeh.2010.12.003.

Kulbida, M., Kemps, E., & Tiggemann, M. (2022). The role of rash impulsivity and sensitivity to reward in soft drink consumption. *Appetite, 173,* 105977. https://doi.org/10.1016/j.appet.2022.105977.

Meule, A., & Blechert, J. (2017). Interactive and indirect effects of trait impulsivity facets on body mass index. *Appetite, 118,* 60-65. http://dx.doi.org/10.1016/j.appet.2017.07.023.

Melbye, E. L., Bergh, I. H., Hausken, S. E. S., Sleddens, E. F. C., Glavin, K., Lien, N., & Bjelland, M. (2016). Adolescent impulsivity and soft drink consumption: The role of parental regulation. *Appetite, 96*, 432-442. doi:http://dx.doi.org/10.1016/j.appet.2015.09.040.

Melbye, E. L., & Helland, M. H. (2018). Soft drinks for lunch? Self-control, intentions and social influences. *British Food Journal, 120 (8),* 1735 – 1748. doi:10.1108/BFJ-11-2017-0605.

Millar, L., Rowland, B., Nichols, M., Swinburn, B., Bennett, C., Skouteris, H., & Allender, S. (2014). *Obesity, 22*, E96-E103. doi:10.1002/oby.20665.

Miller, A. L., Lee, H. J., & Lumeng, J. C. (2015). Obesity-associated biomarkers and executive function in children. *Pediatric research, 77*(1-2), 143-147. doi:10.1038/pr.2014.158.

Mischel,W., & Ebbesen, E. B. (1970). Attention in delay of gratification. *Journal of Personality and Social Psychology, 16*(2), 329-337. doi:10.1037/h0029815.

Moran A., & Mullan, B. (2020). Exploring temporal self-regulation theory to predict sugar-sweetened beverage consumption. *Psychology and Health, 36,* 334 -350. https://doi.org/10.1080/08870446.2020.1774055.

National Health & Medical Research Council (NHMRC). 2013. *Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children in Australia.* Australian Government.

Nelson, L. H., & McNamara Barry, C. (2005). Distinguishing features of emerging adulthood: The role of self-classification as an adult. *Journal of Adolescent Research, 20 (5),* 242-262. https://doi.org/10.1177/0743558404273074

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology, 51*(6), 768-774. doi:10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1.

Reichelt, A. C., Killcross, S., Hambly, L. D., Morris, M. J., & Westbrook, R. F. (2015). Impact of adolescent sucrose access on cognitive control, recognition memory, and parvalbumin immunoreactivity. *Learning and Memory, 22*(4), 215-224. doi:10.1101/lm.038000.114.

Reynolds, B., Ortengren, A., Richards, J. B., & de Wit, H. (2006). Dimensions of impulsive behavior: Personality and behavioral measures. *Personality and Individual Differences, 40*(2), 305-315. doi:10.1016/j.paid.2005.03.024.

Reynolds, B., & Schiffbauer, R. (2005). Delay of gratification and delay discounting: A unifying feedback model of delay-related impulsive behavior. *Psychological Record, 55*(3), 439-460.

Robinson, E., Hardman, C. A., Halford, J. C.G., & Jones, A. (2015). Eating under observation: A systematic review and meta-analysis of the effect that heightened awareness of observation has on laboratory measured energy intake. *American Journal of Clinical Nutrition, 102,* 324 – 337. doi: 10.3945/ajcn.115.111195.

Romine, C. B., & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190.

Sparks, J. C., Isen, J.D., & Iacono, W. G. (2014). Preference on cash-choice task predicts externalizing outcomes in 17-year-olds. *Behaviour Genetics, 44,* 102 – 112. Doi http://dx.doi.org/10.1007/s10519-013-9638-2.

Stanford, M.S., Mathias, C.W., Dougherty, D.M., Lake, S.L., Anderson N.E., &Patton, J.H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47,* 385-395. doi:10.1016/j.paid.2009.04.008.

Tabachnick, B. G., & Fiddell, L.S. (2013). Using multivariate statistics. EsGender, United Kingdom: Pearson Education Limited.

Wulfert, E., Block, J. A., Santa Ana, E., Rodriguez, M. L., & Colsman, M. (2002). Delay of gratification: Impulsive choices and problem behaviors in early and late adolescence. *Journal of Personality, 70*(4), 533-552. doi:10.1111/1467-6494.05013.

Xu, S., Xiao, Z., & Rao, H. (2019). Hypothetical versus real monetary reward decrease the behavioral and affective effects in the balloon analogue risk task. Experimental Psychology, 66 (3), 221-230. doi: 10.1027/1618-3169/a000447.

Yau, P. L., Kang, E. H., Javier, D. C., & Convit, A. (2014). Preliminary evidence of cognitive and brain abnormalities in uncomplicated adolescent obesity. *Obesity, 22*(8), 1865-1871. doi:10.1002/oby.20801.

CHAPTER 5

Study 2: Impulsivity and Behavioural Measurement of Impulsivity using SSB in Emerging Adults

Introduction

One of the findings from the previous study was that the volume of the control beverage (water) consumed was significantly greater than that of SSB, and that the control beverage was more thirst quenching. This may have impacted the results by differences in the drink texture influencing consumption. It was proposed that this may have been due to differences in texture, bubble content and mouth feel. Therefore, Study 2 was designed to use a carbonated control (soda water) to better match the texture and mouthfeel of the SSB and thus design rigour around this factor. Another concern from Study 1 was the number of participants (10.9% of the total) who did not return to collect their $10 reward. There were a number of reasons proposed to explain this, including demand bias both in choosing the delayed reward in the first place and then reluctance to collect the reward once chosen. It was decided to increase the reminder process in Study 2 to counter any demand characteristics and improve collection rate.

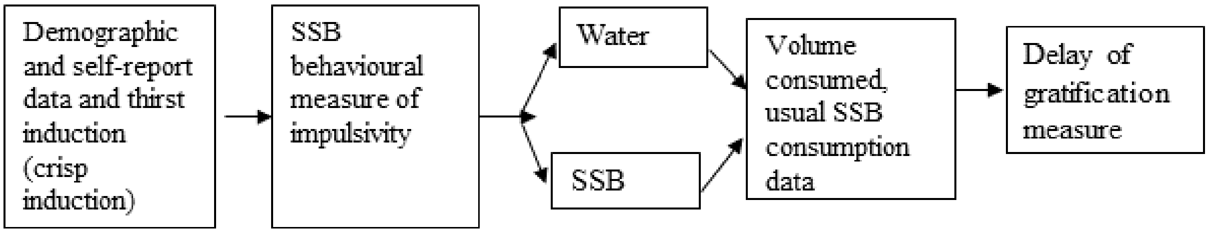
The aim of Study 2, therefore, was to replicate Study 1 using soda water as the control beverage and increased effort to remind participants to collect their final reward. As with Study 1, Study 2 further investigated two behavioural measures of impulsivity, one being a SSB measure whereby it is expected that after inducing thirst, more impulsive adolescents will consume a greater volume of SSB than less impulsive individuals as well as those assigned to receive a control substance. The second behavioural measure of impulsivity is Wulfert’s (2002) monetary delay of gratification measure whereby more impulsive individuals are expected to choose the immediate over the delayed reward. Both behavioural measures will be correlated with the self-report Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995). In addition, usual SSB consumption as determined by self-report questions was used to further test the links between self-report impulsivity, habitual SSB consumption and obesity.

Similarly to Study 1, Study 2 utilised an older group of adolescents and emerging adults recruited from a pool of first year University students using advertising targeting those who were interested in soft drink. Participants were made to feel thirsty by first consuming a predetermined quantity of salted potato crisps as per Brannigan et al. (2015), and then later having access *ad libitum* to either soda water or SSB. Volume of either soda water or SSB consumed was measured. Hypothesis one proposed that the BIS-11 self-report measure of impulsivity would predict behavioural impulsivity by (i) an increase in SSB compared to soda water consumed under experimental conditions and (ii) choice of immediate over delayed gratification. Hypothesis two proposed that self-report impulsivity would predict usual SSB consumption and obesity in this group of emerging adults.

Design

The study employed an experimental manipulation of condition (SSB v control, between subjects) with fluid consumption (see Figure 1). Thirst was used to induce impulsivity (as per Brannigan, Stevenson, & Francis, 2015). The outcome variables were volume of fluid consumed after inducing thirst, choice of monetary reward, BMI, waist circumference and usual SSB consumption. The predictor variables were self-reported impulsivity, and group (SSB vs Soda water). Participants were randomly assigned to one of two experimental conditions using the randomisation function of the *Qualtrics* online survey tool. Ethical approval was granted by the Griffith University Human Ethics Committee (GU Ref No: 2016/777).

Figure 5.1. *Experimental Design Demonstrating Impulsivity with Fluid Consumption, Preceded by Self-Report Questionnaire and Followed by a Delay of Gratification Test.*



Note. SSB = Sugar Sweetened Beverage

Participants

The total sample comprised of 137 participants (67% women, mean age 18.15 years, *SD* = 1.10 years) with a mean BMI of 23.38 (*SD* = 4.79) and mean waist circumference of 81.15 cm (*SD* = 11.39). Participants were recruited from the first year Griffith University Subject Pool with the opportunity to gain course credit points. Participants were invited to the study via advertising on the University SONA website (refer Appendix A). Participants aged 21years of age or younger were targeted, as this age group fits the general demographic required. Additional participants aged between 18 and 21 years were also recruited from the general student population via the Griffith University monthly volunteer broadcast emails. Additional participants recruited via the Griffith University monthly volunteer broadcast emails were eligible to enter a draw for a $50 Coles/Myer gift card via email submission of the study code (Refer Appendix B). Advertising information advised those who may experience a negative reaction to consuming soft drink and salted potato chips not to proceed to the booking phase. All participants attended the behavioural psychology laboratory at the Griffith University Gold Coast campus for the experimental phase. Of the 137 participants recruited, eight participants (5.8%) did not complete the follow up collection of monetary delay of gratification and were subsequently removed from the analyses. A further 21 participants identified as not consuming SSB or artificially sweetened SSB and were removed from analyses leaving a total of 107 participants.

Procedure

Participants were asked not to consume any food or liquid for at least 60 minutes prior to commencement of the study, to limit potential confounding variables. Prior to commencement of the protocol, participants were sent a reminder email not to eat or drink anything (including water) for at least one hour before their appointment. Upon arrival they were again screened to exclude those who may experience a negative reaction to exposure to soft drink or salted potato crisps. Participants were then asked when they last had something to eat or drink (including water) where response options included "*In the last hour*", "*In the last 2 hours*", "*In the last 3 hours*", and "*More than 3 hours ago*". Participants were excluded from further participation if they consumed food or drink in the past hour. Successful participants provided informed consent, and their weight, height and waist circumference were measured.

Thirst was induced via a small measure of salted potato chips (as per Brannigan et al., 2015). Participants were asked to consume the chips prior to completing the self-report questionnaires. Participants rated their current hunger and thirst levels, then completed a series of online questions containing the Barratt self-report measure of impulsivity using the online *Qualtrics* survey tool before commencing the first behavioural experimental task of drink consumption.

Participants were randomly allocated to either the experimental group (soft drink) or the control group (soda water) and asked to drink as much as they wished to rate the drink under the guise of taste and rate "pleasantness". Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room.

Upon completion of first behavioural impulsivity measure, participants were again asked to rate their hunger and thirst, then completed questions to ascertain usual soft drink consumption before the monetary delay of gratification measure. Participants were given the opportunity to choose $7 immediately or $10 in one week's time (as per emerging adults in Wulfert et al., 2002). Participants were then thanked for participation and allowed to leave.

Measures

Demographic Data. Participants completed the following demographic questions: age, gender, ratings of hunger and thirst prior and post experiment, and when they last drank fluid (Refer to Appendix C). BMI was determined from actual height and weight measurements. Waist measurement was determined using a measuring tape checked monthly for stretching and replaced if stretched. The participant was requested to remove heavy outer garments, to stand with their feet fairly close together (about 12–15 cm) with their weight equally distributed and to breathe normally as per NHMRC guidelines (2013). The participant was then asked to wrap the measuring tape around their waist at the natural waist level in line with their umbilicus with the tape neither tight nor loose (NHMRC, 2013). Overweight and obesity are generally defined as a BMI greater than 25 and 30 respectively, with waist circumference over 80cm and 88 cm respectively for women and 94cm and 102cm for men (NHMRC, 2013). Thirst and hunger were measured using a 10cm Visual Analogue Scale pre and post the experimental condition. Participants were asked to rate the statements "How hungry are you right now?" and "How thirsty are you right now?" (0 = *not at all*, 10 = *very much).*

Usual SSB Consumption. Frequency of SSB consumption was measured after the experimental phase via a self-report question of "How often do you usually drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks" with a 9-point Likert scale (1 = every day to 9 = never). Quantity consumed per occasion was measured by "When you do drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks, how many glasses do you have?" using an 8-point Likert scale (1 = 1 glass to 7 = 7 glasses, 8 = 0 glasses) and with a guide as to what comprises a 250ml glass. Average daily SSB consumption (ml/day) was calculated by multiplying the number of glasses per occasion by the number of days per week that SSB was consumed, divided by 7 and multiplied by 250ml. SSB included soft drink, cordial, energy drinks, iced teas, fruit type drinks and flavoured mineral water drinks.

Barratt Impulsivity Scale-11 Adolescents. The Barratt Impulsiveness Scale – Adolescent (BIS-11-A) is a 30 item, 4-point Likert scale (1 = rarely/never to 4 = almost always/always) self-report questionnaire of impulsivity adapted from the adult BIS-11 (Fossati, Barratt, Acquarini, & Di Ceglie, 2002; Patton, Stanford, & Barratt, 1995). The adolescent version was deemed most appropriate for this age group as they have yet to fully establish adult responsibilities and behaviours (Nelson & Barry, 2005). Items include, "I act on the spur of the moment" with higher total scores representing greater levels of impulsivity. Scores were summed and ranged from 30 to 120 with higher scores indicating higher levels of impulsivity. The BIS-11-A demonstrated adequate internal consistency in this study (α = .78; Refer Appendix D).

Soft Drink Measure of Impulsivity. Thirst was induced by providing 19g of salted potato chips (equivalent to 0.28g of salt) prior to provision of the drink, and whilst participants completed the demographic questions. Participants were randomly allocated to either the experimental group (soft drink) or the control (water) group. The soft drink provided was a chilled 1.25l bottle of Lemonade with labels removed, whilst the control was a 1.25l bottle of chilled store-bought soda water with labels removed. Soda water was chosen as the control drink to best match the texture and mouth feel of the soft drink for the current study. Participants were provided with sufficient drink as to satisfy thirst and to compensate for any potential ceiling effect from insufficient drink and were asked to taste-test and rate the pleasantness of the drink. Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room. It was anticipated that the sensation of thirst tested normal inhibition responses, such that more impulsive individuals would consume more than would normally be sufficient to quench their thirst (Brannigan et al., 2015). Beverage type and quantity consumed was measured upon completion of the experiment.

Monetary Delay of Gratification. Participants participated in the monetary delay of gratification at the completion of testing. The monetary delay of gratification offered a choice whereby emerging adults choose either $7 (smaller and immediate reward) now or $10 (larger and delayed reward) to be collected from the Department of Applied Psychology reception in a week's time (as per Wulfert et al., 2002; Refer to Appendix E). Each participant was thanked for their participation, and the following instructions were verbally delivered by the experimenter:

> "We are interested in how people make decisions, so we are going to ask you to make a choice. As a token of our appreciation for your participation, we would like to offer you a cash bonus. You can either choose to have $7 right now [show cash to participant] or wait. If you wait, you will receive $10 in one week when you can come and collect it from Psychology reception [show cash and envelope to participant]. What would you like to do?"

If the participant chose the immediate reward, they were provided with $7 cash immediately. If the participant chose the delayed reward, they were asked to write their name and student number on an envelope. The experimenter placed the $10 inside the envelope, sealed the envelope, put the future date for collection on it and set the envelope aside. Participants were provided with directions to psychology reception and advised to collect their money in one week's time. Envelopes were taken to reception at the end of each day of testing, where staff were briefed on the collection criteria. To ensure completion of the entire gratification protocol, students were provided with weekly reminders to collect their money, if they had not already done so. The monetary delay of gratification was chosen as it has been previously validated against externalising behaviours of impulsivity in adolescents and has the benefits of being naturalistic and modelling real life decision-making (Anokhin et al., 2011; Isen et al., 2014; Sparks et al., 2014; Wulfert et al., 2002). Monetary incentives were considered the most suitable stimulus to induce impulsivity in this group of emerging adults.

Results

Data Screening and Assumptions

Prior to analyses, data were screened using SPSS 25.0. The original dataset contained responses from 136 participants, of whom eight participants (5.8%) did not collect the final part of the study and were removed from further analysis. A further 21 participants identified as not consuming SSB or artificially sweetened SSB and were removed from analysis. Otherwise, the experiment was performed such that there was no missing data. Data was assessed for normality using skewness and kurtosis statistics (Field, 2009). As expected, when sampling a non-clinical sample of young university students, usual SSB consumption and BMI were positively skewed. All other variables were normally distributed. Data was screened for outliers. Three statistically significant univariate outliers were identified in the variable usual SSB consumption using a p = .001 cut off. Removal did not change the nature of the results, therefore, they were included in the final analysis. One multivariate outlier was identified using Mahalanobi's distance cut off p =.001 χ^2 = 18.47 (Tabachnick and Fiddell, 2013). The variables Waist, BMI, experimental volume consumed and usual SSB consumption were significantly positively skewed with skew to SE rates greater than 3.29 using a cut-off of p =.001. Log transformations did not significantly alter the results, so were not used in the final analysis. One hundred and seven participants with a mean age of 18.1years (*SD* =.99), mean waist circumference 80.72 (*SD* = 10.56), mean BMI 23.04 (*SD* =

4.13) and 72 (67%) women were included in the final analysis. Calculation of *A priori* power analyses using GPower revealed a minimum sample of 138 participants to achieve a moderate effect size (d=.30) for correlational analyses and 119 participants were required to detect a medium effect (f^2=.15) for multiple regression with three predictors at 0.95 probability level.

Group Comparison and Descriptive Statistics

To test whether participants experienced reductions in both self-reported thirst and hunger after the testing period, a paired samples t-test was conducted. As expected, hunger and thirst reduced significantly post testing compared to before testing (see Table 5.1). To check for successful randomisation, investigation of the two groups was conducted. Continuous variables were tested using independent t-test and categorical variables tested using chi-square tests. A significant difference was found between likability of Control group drink type (M =3.06, SD = 2.60) and SSB group drink type (M =5.92, SD = 2.08) group with those in the control group liking the drink less than the SSB group t (97.64) = -6.28, p <.001). Informal feedback from participants revealed that the choice of soda water as a control was not well received. No significant difference was found between conditions for demographic variables, Impulsivity, usual SSB consumption hunger or thirst, and time food or fluid was last consumed (see Table 5.2 & Table 5.3).

Table 5.1

Paired samples t-test: Hunger and thirst before versus after testing

	Before Testing *M* (*SD*)	Post Testing *M* (*SD*)	Change *t (df)*	*p*
Hunger	5.35 (2.09)	3.26 (2.16)	11.96 (106)	<.001
Thirst	6.49 (1.99)	3.26 (2.41)	13.75 (106)	<.001

Table 5.2

Independent t-test Between Group Comparisons for Continuous Variables: Age, Waist, BMI, Impulsivity, Usual SSB consumption, Hunger, Thirst (N =107)

	Group				
	Control *M (SD)*	SSB *M (SD)*	*df*	*t*	*p*
N	52	55	-	-	-
Age (years)	18.06 (0.99)	18.15 (0.99)	105	-.45	.65
BMI	22.98 (3.59)	23.10 (4.61)	105	-.15	.88
Waist (cm)	81.38 (9.93)	80.10 (11.17)	105	.62	.55
Impulsivity	69.56 (8.18)	68.45 (9.87)	105	.63	.53
Usual SSB consumption (ml/d)	234.20 (270.41)	174.68 (168.69)	84.62	1.36	.18
Volume consumed	207.69 (153.12)	244.09 (127.20)	105	-1.34	.18
Hunger before	5.48 (2.07)	5.22 (2.11)	105	.65	.52
Hunger after	3.44 (2.31)	3.09 (2.01)	105	.84	.40
Thirst before	6.42 (2.21)	6.56 (1.78)	98.04	-.35	.72
Thirst After	3.30 (2.53)	3.21 (2.31)	105	.19	.85

Note: BMI = Body Mass Index.

Chi-Square test

Table 5.3

χ^2 Between Group Comparisons for Categorical Demographic Variables;, Female, Time last ate

	Group				
	Control	SSB			
	f	*f*	*df*	χ^2	*p*
Female (%)	32 (62%)	40 (73%)	1	1.52	.22
Time last ate/drank	-	-	2	3.26	.20
In the last 2 hours	32	37			
In the last 3 hours	9	13			
More than 3 hours	11	5			

To determine the impact of experimental condition on the relationship between impulsivity and choice, a moderated multiple regression was tested using the PROCESS macro model 1. Binary logistic regression analysis revealed a non -significant main effect of self-report impulsivity, Odds Ratio = 0.95; 95% CI [-.26 - .13], SE =.10, Wald χ^2 (1) = -.64, $p = .52$, and a non-significant main effect of group on choice of immediate over delayed reward, Odds Ratio = 0.95; 95% CI [-9.79 – 5.73], SE =3.96, Wald χ^2 (1) = -.51 $p = .61$. As expected, there was no interaction of group allocation and impulsivity on choice of immediate over delayed reward χ^2 (1) =.06, p =.81, indicating that group allocation to receive either SSB or control did not influence choice of immediate over delayed gratification.

Inferential Statistics

There was no significant correlation between self-report impulsivity and SSB consumed under experimental conditions (Table 5.4). Gender was entered into step one of a regression analysis and was not predictive of experimental SSB consumed F (1, 53) = 2.18, p = .15. After controlling for gender in step one, self-report impulsivity was entered into step two with the overall model non-significant F (2,52) = 2.00, p =.15. Contrary to hypothesis one, impulsivity was not predictive of volume of SSB consumed under experimental conditions. This suggests that the self-report measure was not predictive of this behavioural measure of impulsivity in this cohort of emerging adults.

There was also no significant correlation between self-report impulsivity and choice of immediate over delayed gratification (Table 5.5). Also contrary to hypothesis one, Binary logistic regression analysis revealed that self-report impulsivity did not significantly contribute to the choice of immediate over delayed reward, Odds Ratio = 0.95; 95% CI [0.92 -1.01], SE =.03, Wald χ^2 (1) = 2.21, p = .14.

Table 5.4

Test Group Correlation Table

	Control Group (N=52)						SSB Group (N=55)					
	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist
Impulsivity	-	-	-	-	-	-	-	-	-	-	-	-
Volume	-.05	-	-	-	-	-	.16	-	-	-	-	-
Choice	-.15	.04	-	-	-	-	-.17	.03	-	-	-	-
Usual SSB	-.04	-.24	.08	-	-	-	.05	.14	-.03	-	-	-
BMI	.24	.14	-.12	-.02	-	-	-.17	-.25	.04	.05	-	-
Waist	.20	.32*	-.12	-.12	.81***	-	-.11	-.20	.10	.10	.93***	-
Female	.07	-.31*	.06	.07	-.07	-.47***	.08	-.20	-.04	-.15	-.24	-.42**

Note. * p <.05, ** p < .01, *** p < .001

Table 5.5

Correlations all participants (N = 107)

	M	*SD*	Age	Waist	BMI	Female	Choice	Impulsivity
Age	18.10	0.99	-	-	-	-	-	-
Waist	80.72	10.56	.14	-	-	-	-	-
BMI	23.04	4.13	.12	.88***	-	-	-	-
Female N (%)	72 (67%)	-	-.07	-.44***	-.16	-	-	-
Choice N now	29 (27%)	-	<.001	.03	-.03	-.02	-	-
Impulsivity	68.99	9.06	-.04	.02	-.02	.07	-.15	-
Usual SSB	203.61	224.89	-.03	-.01	.01	-.03	.06	.01

Note. ***$p < .001$

Hypothesis two stated that impulsivity would predict usual SSB consumption and measures of obesity. Gender was entered into step one of a regression analysis and was not a significant predictor of usual SSB consumption, F (1,105) = .09, p = .77. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis which revealed that self-report impulsivity remained a non-significant predictor of usual SSB consumption in this cohort, F (2,104) = .05, p = .95.

To test that impulsivity was predictive of waist circumference and BMI, separate regression analyses were carried on with waist circumference and BMI as outcome variables. Gender was entered into step one of a regression analysis and was not a significant predictor of BMI, F (1,105) = 2.72, p =.10. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis. The model remained non-significant F (2,104) = 1.35, p =.26. Similarly, gender was entered into step one of regression analyses and was a significant predictor of waist circumference, F (1,105) = 25.68, p <.001. After controlling for gender in step one, self-report impulsivity was entered into step two of the regression analysis which revealed that although the overall model was significant, F (2,104) = 12.93, p <.001, self-report impulsivity was a non-significant predictor of waist circumference, contributing 0.2% of the unique variance. Gender remained responsible for 19.9% of the total 19.9% variance for waist circumference but not BMI in this cohort.

Tests of Moderation

One of the primary aims of the research was to investigate the relationship between impulsivity, usual SSB consumption and obesity. A moderated regression using the PROCESS macro Model 1 on SPSS was performed to test the moderating effect of usual SSB consumption on impulsivity and measures of obesity. See Figure 5.2 for the proposed model.

As shown in Table 5.6, no main effect or interaction was found with usual SSB consumption. No association was found between impulsivity and waist circumference or BMI.

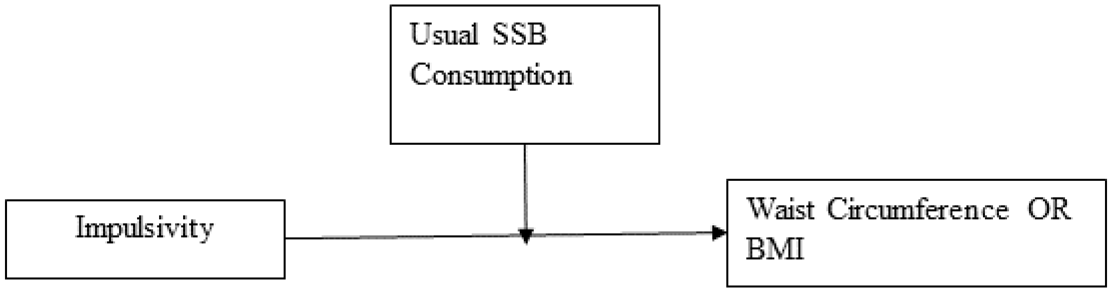


Figure 5.2

Proposed Moderation Model of Usual SSB consumption on Impulsivity and Waist Circumference or BMI.

Table 5.6

Moderated multiple regression between usual SSB consumption, trait impulsivity on waist circumference or BMI.

Predictor	*B*	*SE (B)*	*t*	*p*	*LLCI*	*ULCI*
Impulsivity	.04	.17	.24	.81	-.29	.38
Usual SSB	.004	.04	.10	.92	-.08	.08
Impulsivity x Usual SSB	<.001	<.001	-.11	.91	-.001	.001
Impulsivity	-.01	.07	-.15	.88	-.14	.12
Usual SSB	<.001	.01	-.03	.97	-.03	.03
Impulsivity x Usual SSB	<.001	<.001	.04	.96	<-.001	<.001

Note. LLCI and ULCI denote lower and upper confidence intervals respectively. Non-mean centred scores were used.

Contrary to the hypothesis that usual SSB consumption would moderate the relationship between impulsivity and waist circumference, with more impulsive participants who consume more usual SSB predicted to have larger waist circumferences, no significant relationship was found between impulsivity, usual SSB consumption and waist circumference, $F(3,103) = .03$, $p = .99$ nor between impulsivity usual SSB consumption and BMI, $F(3,103) = .01$, $p = .99$.

Tests of Mediation

Significant direct and indirect mediation effects between impulsivity, usual SSB consumption and both measures of obesity were tested using the PROCESS macro on SPSS. The model was tested using the PROCESS Macro model 4 bootstrap method with 95% confidence intervals (n=10,000) for SPSS. Figure 5.3 below represents the overview of the model with path *a* representing the association between impulsivity and usual SSB consumption, path *b* representing the association between usual SSB consumption and waist circumference after controlling for impulsivity, and path *c* representing the direct effect of impulsivity on waist circumference. Indirect effects refer to path *a* by path *b* via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals. Figure 5.4 represents the overview of the model with path a_1 representing standardised coefficients for the association between impulsivity and usual SSB consumption, path b_1 representing the association between usual SSB consumption and BMI after controlling for impulsivity, and path c_1 representing the direct effect of impulsivity on BMI. Indirect effects refer to path a_1 by path b_1 via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals.

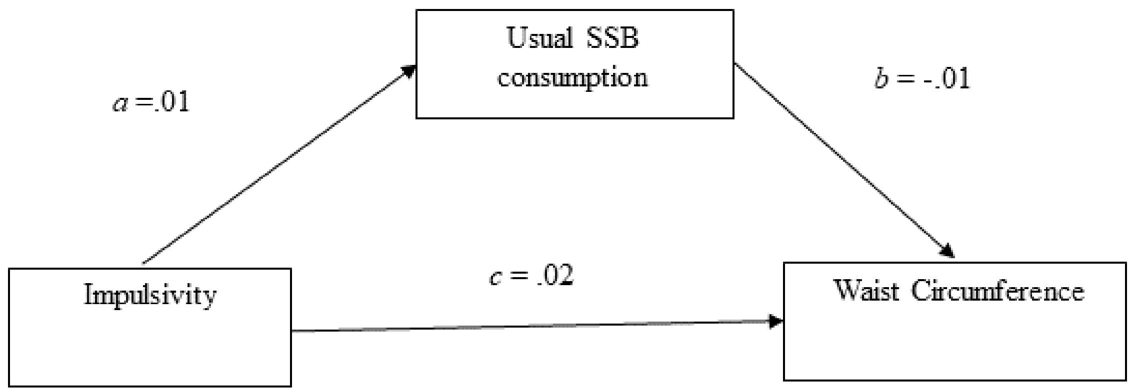


Figure 5.3

Standardised Coefficients Showing the Relationship Between Impulsivity and Waist Circumference via Usual SSB Consumption

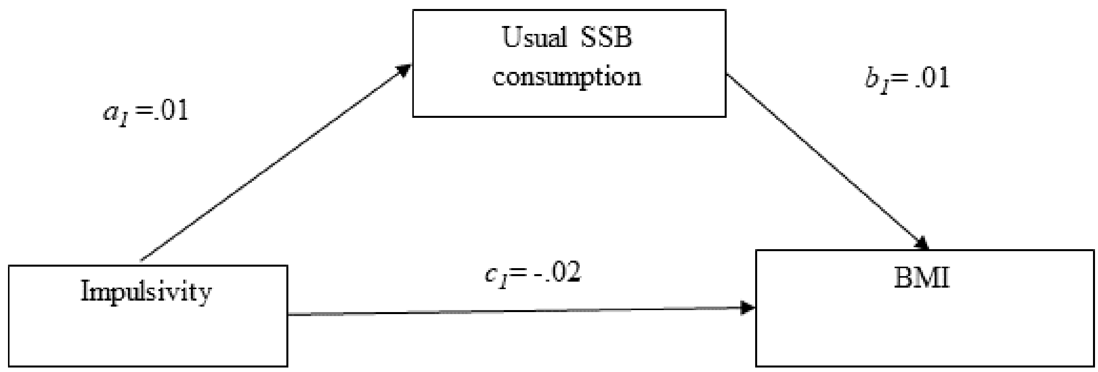


Figure 5.4

Standardised Coefficients showing the Relationship between Impulsivity and BMI via Usual SSB Consumption.

Impulsivity was not significantly associated with Usual SSB consumption (path a), Usual SSB consumption was not significantly associated with waist circumference (path b) while the direct path from impulsivity (path c) was not significant (Table 5.7). Therefore, impulsivity was unrelated to usual SSB consumption, and usual SSB consumption was not related to waist circumference. Similarly, there was no significant association between impulsivity and usual SSB consumption (path a_1), usual SSB consumption and BMI (path b_1) and the direct effect of impulsivity on BMI was also not significant (path c_1).

Table 5.7

Unstandardised Direct Effects of Impulsivity, Usual SSB Consumption on Waist Circumference and BMI.

		Effect	
Outcome Variable	Variable	Bootstrap Estimate (SE)	BC 95% CI
Usual SSB Consumption	Impulsivity (path a)	.21 (2.42)	-4.59, 5.01
Waist Circumference	Usual SSB (path b)	<-.001 (.005)	-.009, .008
Waist Circumference	Impulsivity (path c)	.03 (.11)	-.20, .25
Usual SSB Consumption	Impulsivity (path a_1)	.21 (2.42)	-4.59, 5.01
BMI	Usual SSB (path b_1)	<.001 (.002)	-.0034, .0038
BMI	Impulsivity (path c_1)	-.008 (.04)	-.10, .08

Note. * p <.05. BC = biased corrected; CI = Confidence Interval.

Mediation analysis revealed a non-significant indirect effect of impulsivity on waist circumference through usual SSB consumption (See Table 5.8). Similarly, no direct or indirect associations were found using BMI as an outcome variable. The variable BMI was not explored further.

Table 5.8

Unstandardised Indirect Effects of Impulsivity on Waist Circumference and BMI Through the Mediator Usual SSB Consumption

Outcome Variable	Mediator	Effect	
		Bootstrap Estimate (SE)	BC 95% CI
Waist Circumference	Usual SSB Consumption	<-.001 (.01)	-.014, .032
BMI	Usual SSB Consumption	<.0011 (.005)	-.005, .014

Note: * p<.05, indicates a significant indirect effect. BC = biased corrected; CI = Confidence Interval.

As no significant mediating effect of impulsivity on waist circumference through usual SSB consumption was found, further regression analysis was performed on waist circumference with gender, impulsivity and usual SSB consumption as predictors. Gender was entered into step one of a regression analysis and was a significant predictor of waist circumference, F (1,105) = 25.68, p < .001. After controlling for gender in step 1, usual SSB consumption was entered into step 2 with the overall regression model remaining significant, F (2,104) = 12.77, p <.001. Impulsivity was entered into step 3 with the overall regression model remaining significant, F (3,103) = 8.57, p <.001. Altogether the model represented 20.0% of the variability in waist circumference. However, gender was the strongest predictor of waist circumference in this cohort accounting for 19.9% of the unique variance. As expected, women (M = 77.47, SD = 8.22), had significantly smaller waist circumference than men (M = 87.40, SD = 11.75), t (50.72) = 4.49, p <.001. Usual SSB consumption and impulsivity were non-significant predictors, together accounting for only 0.1% of the unique variance (Table 5.9). Therefore, the results suggest that the pathway to obesity does not lie between impulsivity and SSB consumption in this cohort.

Table 5.9

Hierarchical regression of gender, usual SSB consumption and Impulsivity on waist circumference.

Variable	*B*	SE *B*	β	sr^2
Female	-10.02***	1.98	-.45	.19
Usual SSB consumption	-.001	.004	-.03	<.001
Impulsivity	.06	.10	.05	.002

Note. R^2 = .200. ***p < .001.

No significant correlations in the control group which warranted further investigation, were found. Therefore, no further analyses were carried out on the control group.

Discussion

Contrary to hypothesis one, impulsivity was not predictive of either delay of gratification or volume of SSB consumed under experimental conditions. Also contrary to hypothesis two, impulsivity was not predictive of usual SSB consumption nor measures of obesity in this cohort of emerging adults. Furthermore, no mediating or moderating effect of usual SSB consumption with impulsivity and measures of obesity was found. Regression analysis demonstrated a gender effect, as expected, with women having larger waist circumferences than men.

Similarly to Study 1 and Robinson et al., (2015), demand characteristics may have influenced the volume of SSB consumed under experimental conditions. The study invitation indicated that SSB was a construct under investigation. Therefore, participants may have wished to appear in a favourable light by consuming less SSB than they would under natural settings. Additionally, and as per the findings from Study 1, either the SSB behavioural measure is not a sensitive indicator of impulsivity, or the experimental paradigm did not encourage more impulsive participants to engage in compulsive drinking of SSB. Laboratory conditions do not replicate naturalistic conditions where distractions such as television or social media may induce the temptation to consume beyond satiety (Bradbury et al, 2019; Mittal et al, 2011; Scully et al, 2017). Such distracted overconsumption of SSB may be especially relevant for more impulsive individuals. Future studies should consider television viewing or other similar background distractions to better mimic naturalistic settings similar to those used by Mittal et al (2011).

In contrast to hypothesis two and previous research (Ames et al., 2014; Lumley et al., 2016; Melbye & Helland, 2018) but concurrent with the findings from Study 1, a non-significant relationship was found between impulsivity and usual SSB consumption. This current result fits with the premise that university attendance requires a degree of self-control to achieve positive outcomes and therefore would fit with normative impulsivity scores. Stanford et al., (2009) reported normative impulsivity scores of 62 with a total score of 74 or above categorising as impulsive. It is likely that self-selection bias impacted the study, whereby mainly those who were health motivated, consumed little SSB usually and were naturally low in impulsivity expressed interest in participating, thereby limiting access to more diverse, impulsive individuals. This is consistent with existing research (Finlayson, 2012; Foscarini-Craggs 2021;). Haynes and Robinson (2019) reported that health-conscious individuals who participate in research may do so to reinforce their self-perception of health. Manson and Robbins (2017) reported those who volunteered in a psychology study were more conscientious while Van Lange (2011) reported more pro-social behaviour among volunteer participants.

The third hypothesis stated that usual SSB consumption would either moderate (such that those higher in impulsivity and high SSB consumption would have a higher incidence of obesity) or mediate (such that impulsivity predicts obesity through increased SSB consumption) the relationship between impulsivity and measures of obesity. Additionally, the relationship between SSB consumed under experimental conditions, usual SSB consumption, self-report impulsivity, and measures of obesity were explored. Contrary to existing research (Refer Table 1), and the hypothesis, no significant association was found between impulsivity and either BMI or waist circumference. This once again points to the lack of diversity of impulsivity within the university cohort.

Also, and contrary to expectations, neither a moderating nor mediating effect of usual SSB consumption was found between impulsivity and measures of obesity. Although it was expected that the variables would be interrelated, this again speaks to the lack of diversity within the cohort tested.

Strengths and Limitations

A small number of participants limits the generalisability of these findings. The relatively small sample size likely resulted in the occurrence of Type II errors due to a decrease in power, given that the actual sample size in this study was smaller than the sample size required to find an affect based on a priori power calculations (actual sample size =107, required sample size for a medium effect = 138).

Strengths and limitations in Study 2 remained similar to those of Study 1 with two exceptions as learnings from Study 1. The greatest strength of Study 2 over Study 1 was the change in type of control fluid to better match the mouthfeel and consistency of SSB. Whereas Study 1 demonstrated a difference in thirst quenching ability and volume of experimental liquid consumed between SSB and water, no such difference existed in the current study. However, the use of soda water as the control may have introduced a further confound into the study results as the soda water was significantly less liked by participants and may have influenced their reporting of usual SSB.

Unlike Study 1, Study 2 presented no significant findings. This may be attributed to two major differences between this study and the first study. The first difference was in the use of soda water as the control. Study one showed that participants in the SSB group consumed significantly less drink than those in the control. Soda water was chosen as the control drink in Study two to compensate for a potentially confounding factor of mouth feel and bubble content from the first study that may have influenced quantity consumed in Study 1. The second difference was the increase in participants collecting the delayed reward as the final part of the study. Compared to the previous study, the experimenter sent out regular reminders to increase the number of participants collecting the delayed gratification reward. This potentially created an unexpected confound whereby some possibly impulsive participants chose a delayed gratification due to demand bias. Unlike those in Study 1 who failed to collect the reward, thereby eliminating that confound, those in Study 2 were regularly reminded to collect the reward.

As stated previously *a priori* power analysis indicated a minimum sample of 138 participants to achieve a moderate effect size. Thus, insufficient power remains as the most likely factor in the lack of significant associations. Additionally, the experimental paradigm may not have encouraged more impulsive participants to engage in compulsive drinking of SSB and participant bias particularly as the study deliberately targeted participants interested in health. Future studies could target an audience where impulsive behaviours might be a pre-requisite for participation and, as suggested, use distraction techniques to better mimic naturalistic settings.

Furthermore, the experimental laboratory design of the study attempted to control for many environmental factors such as previous food and drink consumption and induction of thirst to ensure similar thirst across participants. Plus ensuring participants came to the laboratory eliminated distractions and ensured direct measurement of the volume consumed within a set timeframe. However, laboratory conditions do not mimic home or social occasions where SSB may be consumed more freely.

In addition, and as with Study 1, the cohort used was emerging adult first year university students with women making up a majority of participants. Perceptions of body image may also have factored into the volume of SSB consumed with participants exercising restraint over the volume of SSB consumed and reluctant to consume as much as they wished. Disordered perceptions of body image unrelated to actual weight or dietary restraint has been demonstrated in first year women university students in the USA and Australia (Delinsky & Wilson, 2008; Rodgers, et al., 2011), implying that body image may be particularly important for older female adolescents. It could be argued that this level of restraint implies that for young women, dietary restraint may be uppermost in their priorities. Other research indicates that impulsivity and dietary restraint are separate factors that may interact and compete for priority (Bennett & Blissett, 2020). Contrary to expectations, Meule, Lukito, Vogele and Kubler (2011) found in a group of women university students, that those high in dietary restraint exhibited greater inhibitory control over food intake, suggesting likewise for this current cohort, a long-term high priority goal of dietary restraint may override the short-term impulsive reward of SSB consumption. Dietary restraint was not measured in this study but warrants further investigation in future research.

In summary, trait impulsivity was not predictive of volume of SSB consumed under experimental conditions, and choice of immediate over delayed reward. This suggests that the measure of increased SSB consumption under induced thirst conditions may not have been a sensitive measure of trait self-report impulsivity or that the cohort of participants was not sufficiently diverse in impulsivity to demonstrate an effect. Contrary to expectations in this cohort of university emerging adults, impulsivity and usual SSB consumption were not related to obesity, with gender being the strongest predictor of waist circumference. Usual

SSB consumption was not a significant predictor of experimental SSB consumption. These results extend existing research by demonstrating a lack of clear association between impulsivity, SSB consumption and obesity in emerging adults.

Conclusion

Overall, the results from this study demonstrate that first, soda water was not a suitable control choice of fluid and second, reminders to complete the delay of gratification aspect created an additional confound. The final study, Study 3, replicates Studies 1 and 2 but in a cohort of younger participants drawn from the wider community. Children were the cohort of interest in the final study as it is expected that children have yet to be affected by any potential neurological consequences of long-term SSB consumption (Ferreira et al., 2018, Francis & Stevenson, 2011; Weinstein et al., 2015). This then was aimed to provide a clear indication of the impact of impulsivity on SSB consumption and obesity in a younger cohort. In addition, the protocol returned to the use of plain water as the control substance. Additionally, the responsibility to provide the reward for those who chose the delayed choice was with the parent, and as such, the confound of reminders was eliminated. Finally, parental impulsivity and parenting style were examined with a view that these factors would also influence their child's SSB consumption. Parenting factors are discussed in the following chapter.

CHAPTER 6

The following chapter discusses the role that parents play in their child's impulsivity and SSB consumption. It examines the relationship between parental impulsivity, parenting style and child impulsivity with a view that more impulsive parents, via a negative parenting style, may enable more impulsive behaviours in their offspring. The reciprocal relationship between heritability, parenting and child behaviour is multifactorial and complex. For instance, more impulsive children may elicit negative interactions from their parents which in turn further elicit negative responses and behaviours in the children (Ahmad & Hinshaw, 2016). Similarly, an individual who has inherited a vulnerability from their parents to impulsivity may not engage in high-risk impulsive behaviour in adulthood if their parents adopted a positive parenting style. However, this outcome also depends on other family practices and environmental influences (Beauchaine & McNulty, 2013). The focus of this chapter then leads to a discussion that the combination of impulsivity and parenting style may influence SSB consumption and thus obesity in their children.

Parenting style and Impulsivity

Beauchaine and McNulty (2013) proposed a developmental model of impulsivity whereby a genetic vulnerability to impulsivity may later develop into impulsive behavioural issues such as ADHD and conduct type disorders. The authors argued that individual differences in midbrain dopamine activity at birth provide the basis of trait impulsivity early in life and that environmental factors such as parenting, coercive family practices, peer group violent or criminal behaviour, and other environmental factors influence the degree of progression to less desirable behaviours in adulthood. They proposed that heritability is less important than the environmental influences and that parenting style or quality, in particular, harsh or inconsistent parenting is the most important determinant of progression to impulsivity (Beauchaine &McNulty, 2013). In addition, the authors argued that chronic stress (such as resulting from engaging in high risk behaviours or poor parenting practice) may cause further structural and functional changes within the PFC thereby diminishing the ability of the inhibitory network to work effectively (for a review see Beauchaine et al. 2011). Beauchaine and McNulty (2013) proposed that those individuals with a predisposition towards impulsivity and under adverse environmental conditions may then be on a trajectory of increasingly impulsive behaviours. Although the behavioural issues discussed above represent the extreme of impulsivity-related disorders, the impact of parenting on impulsive behaviour is relevant in regards to obesity. That is, more impulsive individuals who experience a negative parenting style may also be at greater risk of obesity.

To test Beauchaine and McNulty's (2013) developmental model of impulsivity, Ahmad and Hinshaw, (2016) investigated the longitudinal effect of authoritarian parenting style on childhood impulsivity and externalising behaviours from childhood to adulthood on a sample of 216 girls. Parents completed a 70-item self-report Ideas about Parenting measure that identified Authoritarian, Authoritative and Overwhelmed parenting styles. Parent and teacher-reported childhood behaviours were obtained via interviews and questionnaires with adolescent behaviours reported via self-report and parental questionnaires. Hyperactivity or impulsivity at age 9 years was predictive of parent and teacher reported conduct problems, aggression and delinquency at adolescence (mean age 14.2 years). Childhood behaviours of impulsivity or hyperactivity was also predictive of criminal records, self-reported antisocial behaviour, and conduct problems as young adults (mean age 19.6 years). The results provide further evidence that impulsivity in childhood can progress into behavioural issues as the child matures through adolescence. In addition, maternal self-reported authoritarian parenting style moderated the relationship between childhood hyperactivity and delinquent behaviour in adolescence, such that high levels of authoritarian parenting was associated with a stronger association between childhood hyperactivity and more reported delinquent behaviours

(Ahmad & Hinshaw, 2016). This implies that a harsher parenting style, rather than tempering hyperactive children's behaviours, will increase the risk of future adolescent delinquent behaviour.

Hentges et al. (2017) also looked at the longer term longitudinal effects of parenting on early childhood impulsivity and impulsive behaviour during adolescence and early adulthood in 310 mothers and their sons from the age of 2 to 22 years. A rejecting parenting style emerged as a significant predictor of impulsive behaviours at all ages, while child impulsivity also further moderated parenting. For those more impulsive children, a rejecting parenting style was associated with later high risk taking behaviours at ages 15 and 22 years. Thus, the evidence supports the developmental model as proposed by Beauchaine and McNulty (2013), suggesting that a vulnerability to impulsivity, in addition to a negative parenting style, has the potential to lead to increased impulsive behaviours during adolescence. Although parental impulsivity was not measured in Hentges et al. (2017), it is possible that parental impulsivity may have further exaccerbated children's behaviour via parenting style. It is possible that high parental impulsivity may tend towards negative parenting practices which in turn further elicited impulsive behaviour in their children which then exaccerbated the behavioural trajectory at adolescence. Therefore, it is important to examine the role that parental impulsivity and SSB may play in child impulsivity.

Although the heritability of impulsivity has been established using twin studies (Anokhin, Grant, Mulligan &Heath, 2015; Bezdjian, Baker, & Tuvblad, 2011), little research has examined the relationship between parental impulsivity and behavioural aspects of child impulsivity. To address this, Takeda (2010) utilised self-report and structured interview information from the biological parents of 323 children aged six to 18 years who were diagnosed with attention deficit hyperactivity disorder (ADHD). Inattentiveness, hyperactivity or impulsivity behaviours were reported in 41% of one or both biological parents of children with diagnosed ADHD signifying a link between parental and child impulsivity (Takeda, 2010). Together, the results are indicative of a dynamic relationship between child and parent impulsivity and environmental influences. As discussed earlier, impulsive children may elicit more negative parenting behaviours. Similarly, more impulsive parents may use more negative parenting styles. In a sample of 101 mothers and their infants aged 12 to 23 months, Gratz et al. (2015) investigated the role of self-reported maternal impulsivity, on infant vulnerability to impulsivity (as measured by a maternal reported measure of infant inhibitory control, a laboratory task of inhibitory control plus observed fear in infants in response to novel situations). The results revealed a positive association between maternal impulsivity and infant vulnerability to impulsivity (Gratz et al., 2015), providing a further link between parent and child impulsivity.

In addition, parents influence their children's behaviour through a gene-environment interaction. Harold et al. (2013) investigated the relationship between adopted child trait impulsivity and ADHD symptoms with biological parent impulsive behaviour and adoptive parent hostility in 320 sets of children and their biological and adoptive mothers. Significant positive associations were found between biological maternal impulsive behaviour and their child's trait impulsivity and between child trait impulsivity and their impulsive behaviour. Furthermore, the authors reported a significant mediating effect of adoptive mother hostility on the relationsship between child trait impulsivity and their impulsive behaviour, indicating that child impulsivity leads to impulsive behaviour through negative parenting practices (Harold et al., 2013).

Elam et al. (2017) further developed this concept of parenting practice influencing the expression of a genetic predisposition towards impulsivity. The authors proposed that a child's genetic predisposition towards impulsivity will influence the type of parenting they receive, such that impulsive parents have genetically predisposed impulsive children who, in turn, evoke a specific type of parenting in response that further exaccerbates the child's impulsivity. The authors used specific genetic markers to identify parents and children genetically at risk of impulsivity and then examined parent-reported child impulsivity and parental monitoring in 359 children longitudinally from middle childhood (mean age 6.35 years) to middle adolescence (mean age 13.37 years) (Elam et al., 2017). The authors reported a significant positive association between child impulsivity (as determined by both genetic susceptability and parent report) with parental genetic risk scores for impulsivity, thereby implying a generational genetic link for impulsivity. In addition, child impulsive behaviour in middle childhood mediated the relationship between child trait impulsivity and parental monitoring in that impulsive children who engaged in more impulse driven behaviour resulted in poorer parenting. This then translated to greater impulsive risk taking behaviour in middle adolescence (Elam et al., 2017). In addition, more impulsive parents engaged less with their impulsive children. Overall, the results outlined above demonstrate a complex interaction between parental impulsivity, parenting behaviour and child impulsivity with the resaerch demonstrating that parenting style has both a mediating and a moderating role (see Table 6.1 for a summary).

Table 6.1

Summary of Studies Demonstrating Complex Relationships Between Parenting, Child and Parent Impulsivity

Study	Predictor Variable	Moderator/Mediator/Direct Association	Outcome Variable
Ahmed & Hinshaw, (2016)	Child Hyperactivity	Direct Association	Impulsive Behaviour in Adolescence
Ahmed & Hinshaw, (2016)	Child Hyperactivity	Authoritarian Parenting as Moderator	Impulsive Behaviour in Adolescence
Hentges et al. (2017)	Rejecting Parenting	Direct Association	Child Impulsive Behaviour
Hentges et al. (2017)	Rejecting Parenting	Child Impulsivity as Moderator	Impulsive Behaviour in Adolescence
Takeda, (2010)	Parent Impulsivity	Direct Association	Child Impulsive Behaviour
Gratz et al. (2015)	Parent Impulsivity	Direct Association	Child Impulsive Behaviour
Harold et al. (2013)	Child Impulsivity	Direct Association	Child Impulsive Behaviour
Harold et al. (2013)	Parent Impulsivity	Direct Association	Child Impulsivity
Harold et al. (2013)	Child Impulsivity	Adoptive Parent Hostility as Mediator	Child Impulsive Behaviour
Elam et al. (2017)	Parent Impulsivity	Direct Association	Child Impulsive Behaviour
Elam et al. (2017)	Child Impulsivity	Child Impulsive Behaviour as Mediator	Less Parental Monitoring

The evidence presented above summarises the research investigating the relationship between parenting practice, parental impulsivity, and their child's impulsive behaviour. No research has examined the impact of parental impulsivity on childhood impulsivity and impulsive dietary behaviour. It is yet to be determined what role parental impulsivity plays in determining childhood obesity, and what role child impulsivity driven behaviours might play. Therefore, there is a gap within the literature directly linking parental and child impulsive behaviours as a pathway to obesity.

The evidence above demonstrates both a mediating and moderating influence of parenting style on child impulsive behaviours. This may then influence more impulsive driven food choices. For example, children and adolescents lack maturity in executive function and rely on their parents to teach and model positive self-regulatory behaviour particularly in relation to food choices. However, late childhood and adolescence is also a period of developing autonomy and risk-taking behaviour (Golan & Crow, 2004). As a result, hedonistic driven unhealthy food choices and positive parental influences for healthy eating may compete for dominance (Golan & Crow, 2004). Therefore, positive parenting styles may teach self-regulation and influence the food choices adolescents make thereby offsetting more impulsive tendencies. The following section will demonstrate a role of parental influence over children and adolescents' dietary habits, SSB consumption, and obesity.

Parenting, SSB and obesity

Reid, Worsley, and Mavondo (2015) identified parents as dietary gatekeepers for their children by influencing family eating structure, interaction patterns, television, and snack food rules. The authors proposed that parental attitudes, perceived social norms, family support and perceived parental control over their children were primary indicators of children's dietary quality and subsequently, BMI. Three hundred and twenty-six United States and 323 Australian parents completed an online questionnaire to determine the influence of nutritional knowledge, convenience food acquisition, shopping practices, and parental BMI on nutritional satisfaction with current diet (Reid et al., 2015). Parent's nutritional capabilities, control and confidence influenced the family food practice and food availability, such that increased knowledge and confidence was positively associated with better food practices within the home. Not surprisingly, parental BMI was positively associated with less healthy food practice (Reid et al., 2015), providing support that obesity is related to unhealthy dietary practices. Although child BMI was not determined, it might follow that like their parents, child BMI might be similarly associated with food choices.

Parenting practice and modelling may also influence childhood eating behaviours of less healthy items such as SSB. Grimm et al. (2004) investigated factors influencing soft drink consumption within a sample of 560 young adolescents aged 8 to 13 years using self-report questionnaires. Children whose friends regularly consumed SSB, and those who reported a strong liking of the taste of SSB, reported more SSB intake. Similarly, children whose parents regularly consumed soft drinks were three times more likely to consume soft drinks, indicating an influence of peer and parental modelling of behaviour. In a further online survey study by Pettigrew et al. (2015), 1302 parents of children aged 8 to 14 years were asked about their own attitudes towards SSB, parenting style and their children's SSB consumption. Fifty-five percent of parents reported that their child consumed SSB at least weekly. Parental attitude towards SSB was the strongest influence over their child's SSB consumption, such that parental attitudes mediated the relationship between external influences such as television advertising, children's desire to consume SSB, perceived social norms around SSB and children's SSB consumption. In addition, desire by the child to consume SSB, and positive social norms around acceptability of SSB, not only influenced parental attitudes, but were independently associated with greater SSB consumption. That is, the more children requested SSB, in conjunction with increased perceived social acceptability of SSB, the more favourably parents perceived and allowed their child to consume SSB. Although parental consumption of SSB was not reported in this study, when considered in combination with the results from Grimm, et al. (2004), it demonstrates a role of parent attitude toward SSB and consumption of SSB in determining children's attitudes and behaviour towards SSB.

Furthermore, using a self-report survey with 742 adolescents (mean age 13 years), SSB consumption was influenced by parental modelling and accessibility, with those reporting fewer parental rules and increased SSB availability, consuming more SSB (Gebremariam et al., 2016). Similarly, a self-report study examined the role of perceived parental regulation on SSB consumption with a sample of 383 adolescents aged 12 to 17 years (van der Horst et al., 2007). Adolescents who perceived their parents as being either moderately strict, or more highly involved, reported less SSB consumption (van der Horst et al., 2007). The results suggest that parents influence their child's SSB consumption through parental attitude and SSB availability.

Relatedly, a systematic review of 13 observational studies explored correlations between parenting style, SSB availability and consumption in 10-to-12-year-old children (Verloigne et al., 2012). Parental SSB consumption, SSB availability and a permissive parenting style was associated with increased consumption in this age group, while having parental behavioural rules was negatively associated with SSB consumption. Conversely, a sample of 421 parents of overweight children aged between 5 and 10 years completed a series of questionairres on parenting styles, feeding practices in conjunction with a 24 hour recall of their child's food intake (Langer et al., 2017). Increased SSB consumption was related to BMI, with a higher authoritarian style of parenting associated with more restrictive feeding style with subsequent lower SSB intake, indicating that authoritarian parents who restrict their child's intake also restrict their child's SSB intake. However, a restrictive feeding style had no effect on SSB consumption when authoritarianism was low. The authors also reported a negative association between parental monitoring and SSB consumption such that the more that parents monitored (rather than restricted) their child's intake, the less SSB the child consumed (Langer et al., 2017). The results sugest that other than being overly permissive, restrictive or authoritarian, parents who are actively involved and monitor their child's intake may instill healthy dietary practices in their child.

Melbye et al. (2016) proposed that parental regulation would play an important role in youth impulsivity and SSB consumption. They proposed that parenting style would influence adolescent self-regulation, with a controlling style associated with more impulsive behaviour. The hypotheses that impulsivity was associated with higher SSB consumption, and that impulsivity, SSB consumption, and parenting style were related, were investigated with 2765 adolescents aged 13 to 15 years using self-report questionnaire data (Melbye et al., 2016). The results demonstrated that impulsivity was predictive of increased SSB consumption, and that parental regulation mediated the relationship between adolescent self-reported impulsivity and SSB consumption. That is, the more impulsive the adolescent, the more SSB consumed, but adolescents who perceived their parents as legitimate rule makers were better able to limit their SSB consumption compared to those who saw their parents as controlling (Melbye et al., 2016). Positive parenting practices helped adolescents regulate their own dietary behaviour. Although not reported in this study, it is possible that parental impulsivity may similarly influence child impulsivity and SSB consumption. That is, impulsive adolescents may consume more SSB, but those with more impulsive parents may drink more than those with less impulsive parents. The evidence highlights the importance of parenting style and impulsivity on their child's SSB consumption, and that more impulsive adolescents were better able to control their SSB consumption when their parents had legitimacy (See Table 6.2 for a summary of the evidence).

Table 6.2

Summary of Studies Demonstrating the Relationships Between Parenting, and Child SSB Consumption

Study	Predictor Variable	Moderator/Mediator/ Direct Association	Outcome Variable
Reid et al., (2015)	Family Practice	Direct Association	Child Obesity
Grimm et al., (2004)	Parent SSB consumption	Direct Association	Child SSB consumption
Pettigrew et al. (2015)	Parental Attitude to SSB	Direct Association	Child SSB consumption
Pettigrew et al. (2015)	Child desire consume SSB	Direct Association	Parent attitudes
Pettigrew et al. (2015)	Child desire to consume SSB	Direct Association	Child SSB consumption
Pettigrew et al. (2015)	Environment SSB influences	Parental SSB Attitude as Mediator	Child SSB consumption
Gebremariam et al., (2016)	Parental modelling SSB behaviour	Direct Association	Child SSB consumption
van der Horst et al., (2007)	Involved parenting	Direct Association	Reduced Child SSB consumption
Verloigne et al., (2012)	Parent SSB consumption	Direct Association	Child SSB consumption
	Permissive parenting style	Direct Association	Child SSB consumption
Langer et al., (2017)	SSB consumption	Direct Association	BMI
Melbye et al., (2016)	Child Impulsivity	Direct Association	Child SSB consumption
Melbye et al., (2016)	Child Impulsivity	Parental Regulation as Mediator	Child SSB consumption

Taken together, the evidence presented argues (i) parental impulsivity predicts child trait impulsivity, (ii) child trait impulsivity then promotes more impulsive behaviour (SSB consumption), (iii) parenting style influences child SSB consumption and risk of obesity, and (iv) parenting style may have either a moderating or a mediating effect on the relationship between child impulsivity and SSB consumption. The issue raised based on the literature, and which is the focus of this final study, is the role of parental impulsivity and parenting style on child impulsivity, SSB consumption and obesity. The previous studies in this thesis have investigated emerging adults' impulsive behaviour as it relates to SSB consumption. These cohorts represented emerging adults, who although may be living independent lives, still engage in potentially high-risk impulsive behaviours (Kim-Spoon et al., 2016; Steinberg, 2010). The following study will represent a shift towards a younger cohort, that is, children aged 10-12 years. This age group was chosen as they are more vulnerable to the effects of excess SSB and are dependent upon their parent's influence for important dietary choices and thus parenting style remains an important factor in their decision-making process.

CHAPTER 7

Study 3: The role of impulsivity on soft drink consumption in children aged 10-12 years

Introduction

Study 1 produced valuable information around study design and identified potential confounds, specifically the difference in the mouth feel of water versus SSB and incomplete collection by all participants who chose the monetary delayed gratification. Study 2 introduced further methodological rigour to test the findings from Study 1, including soda water as the control substance to better match mouth feel plus additional reminders to collect the monetary delayed gratification. Therefore, Study 3 replicates Study 1 in that water was used as the control drink, and reminders to collect the delayed reward were not used.

Additionally, Study 3 now represents a developmental shift from emerging adults to a younger cohort in a move that tests the primary aim of this thesis, that is, the role of child trait impulsivity on SSB consumption and subsequent obesity in children aged 10-12 years. The main aim of Study 3 was first, to investigate the association between child impulsivity as determined by the self-report with two behavioural measures, usual SSB consumption, and obesity. The second aim of Study 3 was to investigate the relationship between parental impulsivity and parenting style on their child's impulsivity, usual SSB consumption and obesity. In addition, the two behavioural measures of impulsivity, SSB consumption under experimental conditions and the Wulfert (2002) monetary delay of gratification were investigated together with the Barratt self-report measure of impulsivity in this cohort of children aged 10-12 years.

As with Study 1, the SSB behavioural measure of impulsivity expected that after inducing thirst, more impulsive adolescents would consume a greater volume of SSB than either less impulsive individuals and those assigned to receive the control (water) drink. The second behavioural measure of impulsivity being investigated in the younger cohort was related to Wulfert's (2002) monetary delay of gratification measure whereby more impulsive individuals were expected to choose the immediate over the delayed reward. It will be expected that trait impulsivity, as determined by the self-report Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995), would predict impulsive behaviour with greater SSB consumption under experimental conditions and the choice of immediate over delayed gratification. In addition, usual SSB consumption as determined by self-report questions was used to further explore the relationship between self-report impulsivity, habitual SSB consumption and obesity. Hypothesis one states that the BIS-11 self-report measure of impulsivity will predict behavioural impulsivity by (i) an increase in SSB compared to control consumed under experimental conditions and (ii) choice of immediate over delayed gratification in younger children aged 10-12 years. Hypothesis two extends from Melbye et al. (2016) and states that self-report impulsivity would predict usual SSB consumption and measures of obesity in this group of children. Hypothesis three states that usual SSB consumption would predict SSB consumption under experimental conditions, in that, those who engage in more impulsive behaviour at home will also engage in the same behaviour under experimental conditions. Concurrent with Elam et al. (2017) and Gratz et al. (2015), hypothesis four predicts that parental impulsivity will be associated with their child's impulsivity, with more impulsive parents having more impulsive children.

In addition, the involvement of parenting style on the relationship between parent and child impulsivity, SSB consumption and obesity in children was explored. Hypothesis five proposed that, like Ahmed and Hinshaw (2016), a negative parenting style would moderate the relationship between child trait impulsivity and child SSB consumption, with more impulsive children consuming more usual SSB when parents have a more negative parenting style. Hypothesis six refers to an exploration of the relationship between impulsive parents, their parenting style and the effect on their child. Similar to Harold et al. (2013), Hypothesis six proposed that parenting style would mediate the relationship between parent impulsivity and child impulsive behaviour. That is, it was predicted that a poorer parenting style would result in more impulsive parents providing a less supportive environment, thereby facilitating more impulsive behaviours from their children, in this case, increased usual SSB consumption. Hypothesis seven referred to an exploration of the relationship between child trait impulsivity, SSB consumption and obesity. It proposed that increased obesity (waist circumference or BMI) would result from child trait impulsivity through increased SSB consumption.

Design

The study was an experimental manipulation of condition (SSB v Water, between subjects) with fluid consumption (see Figure 1). Thirst was used to induce impulsivity (as per Brannigan, Stevenson, & Francis, 2015). The outcome variables were volume of fluid consumed after inducing thirst, choice of monetary reward, BMI, waist circumference and usual SSB consumption. The predictor variables were self-reported impulsivity, parenting style and group (SSB vs water). Participants were randomly assigned to one of two experimental conditions. Ethical approval for this study was granted by the University Human Ethics Committee (GU Ref No: 2018/781).

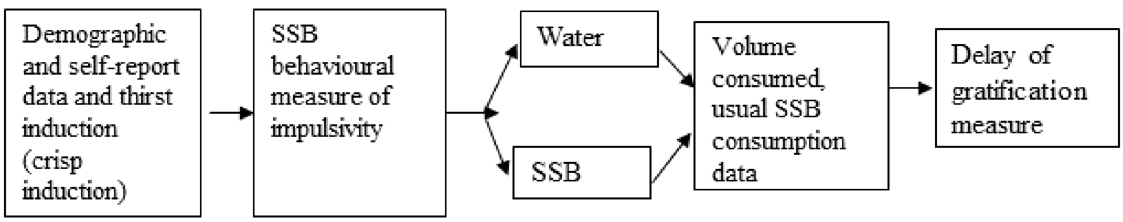


Figure 7.1. *Experimental Design Demonstrating Impulsivity with Fluid Consumption, Preceded by Self-Report Questionnaire and Followed by a Delay of Gratification Test.*

Note. SSB = Sugar Sweetened Beverage

Participants

The sample comprised of 69 children (60% girls) with a mean age 10.85 years (*SD* = .95 years), a mean waist circumference of 71.90 cm (*SD* = 11.81 cm), mean BMI of 19.05 (*SD* = 3.78) and one of their parents (90% women), with a mean age 42.32 years (*SD* = 5.72) mean parental BMI = 26.87 (*SD* = 4.93). Participants were recruited from advertisements placed in school newsletters across the local areas in Brisbane and Gold Coast. Additional participants were also recruited from the general student population via the Griffith University monthly volunteer broadcast emails, via flyers across University campus, and flyers distributed to letter boxes in the local vicinity. Advertising information advised those who may experience a negative reaction to consuming soft drink or salted potato chips not to proceed to the booking phase. All participants attended either the behavioural psychology laboratory at the Griffith University Gold Coast or the research participation room Mt Gravatt campuses for the experimental phase (Refer Appendix K, L). Data collection occurred during school terms from September 2019 prior to COVID-19 to March 2020, then from August 2020 until March 2021. Data collection ceased due to ongoing Government health restrictions and community COVID-19 concerns.

Procedure

Participants were asked not to consume any food or liquid for 60 minutes prior to study commencement, to limit potential confounding variables. Prior to commencement of the protocol, parents of participants were sent a reminder email not to eat or drink anything (including water) for at least one hour before their appointment. Upon arrival they were again screened to exclude those who may experience a negative reaction to exposure to soft drink or salted potato crisps. Participants were then asked when they last had something to eat or drink (including water) where response options included "*In the last hour*", "*In the last 2 hours*", "*In the last 3 hours*", and "*More than 3 hours ago*". Participants were excluded from further participation if they consumed food or drink in the past hour. Successful participants provided informed consent, with their weight, height and waist circumference measured.

Thirst was induced via a small measure of salted potato chips (as per Brannigan et al., 2015). Participants were asked to consume the chips prior to completing the self-report questionnaires. Participants rated their current hunger and thirst levels, then completed a series of online questions containing the Alabama parenting scale and the Barratt self-report measure of impulsivity initially using *Qualtrics* and then the *REDcap* (Harris et al., 2009; 2019) online survey tool, before commencing the first behavioural experimental task of drink consumption. Parents were asked to complete a pen and paper informed consent and survey with demographic details, height, weight and the *Parent Alabama Parenting Questionnaire* and the *Adult Barratt Impulsivity* Scale (refer Appendix G, H, and I).

Participants were randomly allocated to either the experimental group (soft drink) or the control (water) group and asked to drink as much as they wished to rate the drink under the guise of taste and rate "pleasantness". Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room. Random group allocation occurred initially via the *Qualtrics* software. When *REDcap* became the preferred university software, randomisation occurred using a mobile phone randomisation application (Randomiser Version 7.1, robertsammons.com).

Upon completion of the first behavioural impulsivity measure, participants were again asked to rate their hunger and thirst, then completed questions to ascertain usual soft drink consumption before the monetary delay of gratification measure. Participants were given the opportunity to choose $5 immediately or $7 in one week's time (as per younger adolescents in Wulfert et al., 2002). If the participant chose the immediate reward, the cash was provided.

If the participant chose the delayed reward, the cash was placed in an envelope, sealed then given to their parent to provide in one weeks' time. Both participants and their parent each received a $10 gift card to thank them for their time. Participants were then thanked for participation and allowed to leave.

Measures

Demographic Data. Participants completed the following demographic questions: age, gender, ratings of hunger and thirst prior and post experiment, and when they last drank fluid (Refer to Appendix C). BMI was determined from actual height and weight measurements. Waist measurement was determined using a measuring tape checked monthly for stretching and replaced if stretched. The participant was requested to remove heavy outer garments, to stand with their feet fairly close together (about 12–15 cm) with their weight equally distributed and to breathe normally as per NHMRC guidelines (2013). The participant was then asked to wrap the measuring tape around their waist at the natural waist level in line with their umbilicus with the tape neither tight nor loose (NHMRC, 2013). Parents were asked questions about height and weight. Overweight and obesity are generally defined as a BMI greater than 25 and 30 respectively, with waist circumference of 80cm and 88 cm respectively for women and 94cm and 102cm for men (NHMRC, 2013). For children, overweight and obesity was defined as a waist circumference to height ratio of greater than 0.5, or a waist circumference greater than the 75th percentile based on age and gender (Eisenmann, 2005; NHMRC, 2013). Thirst and hunger were measured using a 10cm Visual Analogue Scale pre and post the experimental condition. Participants were asked to rate the statements "How hungry are you right now?" and "How thirsty are you right now?" (0 = *not at all*, 10 = *very much).*

Usual SSB Consumption. Frequency of SSB consumption was measured after the experimental phase via two self-report question of "How often do you usually drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks" on a 9-point Likert scale (1 = every day to 8= special occasions only to 9 = never). Quantity consumed per occasion was measured by "When you do drink soft drink, cordial, energy, iced tea, fruit type or flavoured mineral water drinks, how many glasses do you have?" using an 8-point Likert scale (1 = 1 glass to 7 = 7 glasses, 8 = 0 glasses) and with a guide as to what comprises a 250ml glass. Average daily SSB consumption (ml/day) was calculated by multiplying the number of glasses per occasion by the number of days per week that SSB was consumed, divided by 7 and multiplied by 250ml. SSB included soft drink, cordial, energy drinks, iced teas, fruit type drinks, flavoured mineral water drinks and artificially sweetened beverages.

Barratt Impulsivity Scale -11 Adolescent. The Barratt Impulsiveness Scale – Adolescent (BIS-11-A) is a 30-item, 4-point Likert scale (1 = rarely/never to 4 = almost always/always) self-report questionnaire of impulsivity adapted from the adult BIS-11 (Fossati et al., 2002; Patton, Stanford, & Barratt, 1995) and has been validated for use in children aged 10 years and over (Cosi et al., 2008; Hartmann et al., 2011). Items include "I act on the spur of the moment" with higher total scores representing greater levels of impulsivity. Scores were summed and ranged from 30 to 120 with higher scores indicating higher levels of impulsivity. The BIS-11-A demonstrated adequate internal consistency in this study (α = .79; Refer Appendix D).

Adult Barratt Impulsivity Scale -11. The adult Barratt Impulsivity Scale (BIS-11) is a 30-item, 4-point Likert scale (1 = rarely/never to 4 = almost always/always) self-report questionnaire of impulsivity (Patton, Stanford, Barratt, 1995). Items include "I act on impulse" with higher total scores representing greater levels of impulsivity. Scores were summed and ranged from 30 to 120 with higher scores indicating higher levels of impulsivity. The Parent BIS-11 demonstrated adequate internal consistency in this study (α = .81; Refer Appendix H).

Alabama Parenting Scale. To account for parenting factors which may impact upon children's soft drink consumption, the Alabama Parenting Questionnaire (adolescent form), was administered to participants prior to the experimental phase. Parents completed the parent version separately. The Alabama Parenting Questionnaire assesses five aspects of parenting (i) positive parenting, (ii) supervision and monitoring, (iii) involved parenting, (iv) consistent parenting and (v) use of corporal punishment (Shelton, 1996). The questionnaire comprises both a parent and child version and has been validated against parents of children aged 6-18 years and children aged 6-18 years (Frick 1996). A brief 15-question version has been validated using a sample of 208 children and adolescents between 9 to 17 years and their parents and was used in the current study (Scott, Briskman, & Dadds, 2011). The internal reliability of the five subscales for the adolescent version in the current study was α = .80 (positive parenting), α = .56 (involvement), α = .68 (inconsistent parenting), α = .25 (poor supervision), and *α* = .91 (corporal punishment; Refer Appendix F). Of these, only the positive parenting and corporal punishment scale were considered acceptable reliability. The internal reliability of the subscales for the parent version in the current study was α = .80 (positive parenting), α = .29 (involvement), α = .54 (inconsistent parenting), α = .65 (poor supervision), and *α* = .73 (corporal punishment; Refer Appendix I). Similarly to the adolescent version, only positive parenting and corporal punishment were of acceptable reliability.

Soft Drink Measure of Impulsivity. Thirst was induced by providing 19g of salted potato chips (equivalent to 0.28g of salt) prior to provision of the drink, and whilst participants completed the demographic questions. Participants were randomly allocated to either the experimental group (soft drink) or the control (water) group. The soft drink provided was a chilled 1.25 l bottle of Lemonade with labels removed, whilst the water was a 1.5l bottle of chilled store purchased plain water with labels removed. Participants were provided with sufficient drink as to satisfy thirst and to compensate for any potential ceiling effect from insufficient drink and asked to taste-test and rate the pleasantness of the drink. Participants were allowed *ad libitum* access to the drink over approximately 4 minutes while the experimenter left the room. It was anticipated that the sensation of thirst tested normal inhibition responses, such that more impulsive individuals would consume more than would normally be sufficient to quench their thirst (Brannigan et al., 2015). Beverage type and quantity consumed was measured upon completion of the experiment.

Monetary Delay of Gratification. Participants participated in the monetary delay of gratification at the completion of testing. The monetary delay of gratification offered a choice whereby young adolescents choose either $5 (smaller and immediate reward) now or $7 (larger and delayed reward) in a week's time (as per Wulfert et al., 2002; Refer to Appendix J). Each participant was thanked for their participation, and the following instructions verbally delivered by the experimenter:

> "We are interested in how people make decisions, so we are going to ask you to make a choice. As a token of our appreciation for your participation, we would like to offer you a cash bonus. You can either choose to have $5 right now [show cash to participant] or wait. If you wait, you will receive $7 in one week [show cash and envelope to participant]. What would you like to do?"

If the participant chose the immediate reward, they were provided with $5 cash immediately. If the participant chose the delayed reward, the experimenter placed the $7 inside the envelope, sealed the envelope, wrote the future date for collection and placed the envelope aside. This envelope was provided to parents with instructions to give to their child in one week's time. The monetary delay of gratification was chosen as it had been previously validated against externalising behaviours of impulsivity in adolescents and has the benefits of being naturalistic and modelling real life decision-making (Anokhin et al., 2011; Isen et al., 2014; Sparks et al., 2014; Wulfert et al., 2002). Monetary incentives were considered a suitable stimulus to induce impulsivity in this group of adolescents.

Results

Data Screening and Assumptions

Prior to analyses, data were screened using SPSS 27.0. The original dataset contained responses from 69 child participants and their parent. Thirteen participants identified as drinking either no SSB or artificially sweetened SSB and were subsequently removed from analysis. One parent did not complete the parent version of the Alabama Parenting scale and was excluded from the parenting analysis but was included in the impulsivity analysis. Otherwise, the experiment was performed such that there was no missing data. Data was assessed for normality using skewness and kurtosis statistics (Field, 2009). Except for Usual SSB consumption, all relevant variables were normally distributed. Data was screened for outliers. One statistically significant univariate outlier was identified as consuming an unusually large amount of usual SSB consumption using a $p = .001$ cut off. Removal changed the nature of the results; therefore, they were excluded in the final analysis (Tabachnick and Fiddell, 2013). No multivariate outliers were identified using Mahalanobis distance cut off $p = .00$, $\chi^2 = 18.47$ (Tabachnick and Fiddell, 2013). Usual SSB consumption was significantly positively skewed with skew to SE rates greater than 3.29 using a cut-off of $p = .001$. A log transformation did not significantly alter the results, so the original data is reported. The final sample for analysis comprised of 56 participants (61% girls) mean age 10.92 years (*SD* = .94 years) with a mean waist circumference of 71.96 cm (*SD* = 11.76 cm), mean BMI of 18.92 (*SD* = 3.64) and one parent (91% women), with a mean age of 42.4 years (*SD* = 5.96) and mean parental BMI = 27.05 (*SD* = 5.15). Using the criteria of overweight or obesity as a waist/height ratio of >.5 (NHMRC, 2013), 20% of children met the criteria for being overweight. Calculation of *A priori* power analyses using GPower revealed a minimum sample of 138 participants to achieve a moderate effect size (*d*=.30) for correlational analyses and 119 participants were required to detect a medium effect (f^2=.15) for multiple regression with three predictors at 0.95 probability level. However, the logistics of obtaining sufficient parent and child pairs to attend the University campus, plus the onset of COVID and ongoing restrictions relating to COVID, prevented ongoing participant data collection.

Group Comparison and Descriptive Statistics

To test whether participants experienced reductions in both self-reported thirst and hunger after the testing period, a paired samples t-test was conducted. As expected, hunger and thirst reduced significantly post-testing compared to before testing (see Table 7.1). To check for successful randomisation, investigation of the two groups was conducted using chi-square and t-tests. Continuous variables were tested using independent t-test and categorical variables tested using chi-square tests. There were no significant differences between the control and soft drink group for the variables examined (see Table 7.2). No significant difference was found between the likability of the control group drink type and SSB drink type group with those in the SSB drink group liking the drink similarly to the control group. Unlike studies 1 and 2, it was possible that for this age group, participants did not demonstrate demand-related constraint in SSB preference or consumption. No significant difference was found between conditions for gender and time last consumed food or fluid (see Table 7.3). Parental descriptive statistics are presented in Table 7.4.

Table 7.1

Paired samples t-test: Hunger and thirst before versus after testing (N = 56)

	Before Testing *M* (*SD*)	Post Testing *M* (*SD*)	Difference *t (df)*	*p*
Hunger	40.21 (22.11)	32.50 (22.78)	2.45 (55)	.018
Thirst	59.93 (23.65)	23.29 (20.78)	11.68 (55)	<.001

Table 7.2

Independent t-test Between Group Comparisons for Continuous Variables: Age, Waist, BMI, Impulsivity, Usual SSB consumption, Hunger, Thirst

	Group				
	Control	SSB			
	M (SD)	*M (SD)*	*df*	*t*	*p*
N	29	27	-	-	-
Age (years)	10.95 (0.93)	10.89 (.97)	54	.23	.82
BMI	18.98 (3.74)	19.86 (3.60)	54	.12	.90
Waist (cm)	72.66 (12.45)	71.22 (11.16)	54	.45	.65
Impulsivity	66.03 (8.99)	66.63 (10.87)	54	-.22	.82
Usual SSB consumption (ml/d)	131.71 (148.59)	110.45 (107.50)	54	.61	.54
Volume consumed	292.24 (147.46)	247.22 (154.79)	54	1.11	.27
Like Drink Provided	49.86 (29.22)	57.37 (34.15)	54	-.89	.38
Hunger before	39.03 (20.25)	41.48 (24.27)	54	-.41	.68
Hunger after	37.86 (21.35)	26.74 (23.24)	54	1.87	.07
Thirst before	58.72 (20.82)	63.37 (26.31)	54	-1.05	.30
Thirst After	24.86 (20.62)	21.59 (21.22)	54	.59	.56

Note: BMI = Body Mass Index.

Table 7.3

χ^2 Between Group Comparisons for Categorical Demographic Variables, Female, Time last ate

	Group				
	Control	SSB			
	f	*f*	*df*	χ^2	*p*
Girls	18	16	1	.05	.83
Time last ate/drank	-	-	1	2.90	.09
In the last 2 hours	22	25			
In the last 3 hours	7	2			
More than 3 hours	0	0			

Table 7.4

Parent Demographics (N = 56)

	M (SD)	N (%)
Age	42.40 (5.96)	-
Women	-	51 (91)
BMI	27.06 (5.14)	-
Impulsivity	54.55 (8.99)	-

Inferential Statistics

Contrary to hypothesis one, there was no significant correlation between self-report impulsivity and SSB consumed under experimental conditions. Gender was entered into step one of a regression analysis and was not predictive of experimental SSB consumed F (1, 25) = 3.49, p = .07 with boys (M =311.36, SD = 193.44) consuming similar SSB under experimental conditions as girls (M =203.13, SD = 107.19) t (14.24) = 1.69, p =.11. After controlling for gender in step one, self-report impulsivity was entered into step two with the overall model non-significant F (2,24) = 1.98, p =.16. Hypothesis one was not supported with impulsivity not predictive of volume of SSB consumed under experimental conditions. This is consistent across studies and suggests that the self-report measure was not predictive of this behavioural measure of impulsivity (Table 7.5). Contrary to hypothesis one and Study 1 findings, there was also no significant correlation between self-report impulsivity and choice of immediate over delayed gratification (Table 7.6). Binary logistic regression analysis revealed that self-report impulsivity did not significantly contribute to the choice of immediate over delayed reward, Odds Ratio = 0.95; 95% CI [0.91 – 1.08], SE =.04, Wald χ^2 (1) = .03, p = .86.

Hypothesis two stated that impulsivity would predict usual SSB consumption and measures of obesity. Gender was entered into the first step of a regression analysis and was not a significant predictor of usual SSB consumption, F (1,54) = .15, p = .70. In contrast to hypothesis two, in this cohort, and after controlling for gender, self-report impulsivity was entered into step two of the regression analysis and was not a significant predictor of usual SSB consumption in this cohort, F (2,53) = .21, p = .81. Unlike Study 1, there was also no significant correlation between usual SSB consumption and measures of obesity.

Table 7.5

Experimental Group Correlations

	Control Group						SSB Group					
	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist	Impulsivity	Volume	Choice	Usual SSB	BMI	Waist
Impulsivity	-	-	-	-	-	-	-	-	-	-	-	-
Volume	-.01	-	-	-	-	-	-.07	-	-	-	-	-
Choice	-.01	.15	-	-	-	-	-.05	-.29	-	-	-	-
Usual SSB	.11	.14	.15	-	-	-	.21	.06	-.19	-	-	-
BMI	.08	.29	.16	.08	-	-	-.21	-.04	-.21	.10	-	-
Waist	-.05	.20	.08	.13	.89***	-	-.22	.05	-.14	-.01	.90***	-
Female	.08	.01	-.26	-.20	.02	-.24	-.30	-.40*	.02	-.15	.08	-.004

Note. * p <.05, *** p < .001

Table 7.6

Correlations all participants (*N* = 56)

	M	*SD*	Age	Waist	BMI	Female	Choice	Impulsivity
Age	10.92	.94	-	-	-	-	-	-
Waist	71.96	11.76	.03	-	-	-	-	-
BMI	18.92	3.64	.03	.89***	-	-	-	-
Female N (%)	34 (61%)	-	-.11	-.04	.08	-	-	-
Choice N wait (%)	50 (89%)	-	.09	.04	.03	-.16	-	-
Impulsivity	66.32	9.86	-.02	-.11	-.06	-.11	-.02	-
Usual SSB	121.49	129.68	.11	.02	.06	-.05	-.04	.08

Note. *** $p < .001$

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When the results were broken down into experimental groups, the variables influencing the volume of SSB consumed under experimental conditions were further explored. Hypothesis three expected that usual SSB consumption would predict experimental SSB consumption. This was not supported as usual SSB was not associated with experimental SSB consumption. (Table 7.5). After controlling for gender in step one, regression analysis revealed that self-reported usual SSB consumption did not significantly predict the volume of SSB consumed during experimental conditions F (2,24) = 1.75, p = .20 (Table 7.7).

Table 7.7

Hierarchical regression of gender and usual SSB consumption on experimental volume SSB consumed in children aged 10-12 years.

Variable	*B*	SE *B*	β	sr^2
Female	-109.34	59.02	-.35	.12
Usual SSB consumption	.10	.28	.07	.004

Note. R^2 = .13. $^*p < .05$.

In contrast to hypothesis four, there was no significant correlation between child and parent impulsivity. However, parents overall (M =54.55, SD = 8.99) were significantly less impulsive than children (M = 66.32, SD = 9.86). A paired samples t-test demonstrated a significant difference between parent and their own child impulsivity, t (55) = 7.22, p < .001.

Tests of Moderation

Hypothesis five examined the relationship between parenting style, impulsivity, and usual SSB consumption (Table 7.8).

Table 7.8

Correlations between Parent and Child Scores on the Alabama Parenting Scale, Usual SSB consumption and Impulsivity.

	Child Positive Parenting	Child Involved Parenting	Child Inconsistent Parenting	Child Poor Supervision	Parental Positive Parenting	Parent Involved Parenting	Parent Inconsistent Parenting	Parent Poor Supervision	Parent Impulsivity	Child Impulsivity	Usual SSB (ml/day)
Child Positive	-	-	-	-	-	-	-	-	-	-	-
Child Involved	.54***	-	-	-	-	-	-	-	-	-	-
Child Inconsistent	.06	-.02	-	-	-	-	-	-	-	-	-
Child Poor Supervision	.21	.24	.22	-	-	-	-	-	-	-	-
Parental Positive	.14	.09	.05	-.09	-	-	-	-	-	-	-
Parent Involved	-.13	.06	-.19	.02	.13	-	-	-	-	-	-
Parent Inconsistent	.11	-.02	.27*	-.11	.04	.04	-	-	-	-	-
Parent Poor Supervision	-.01	-.10	.13	.12	-.20	-.23	.10	-	-	-	-
Parent Impulsivity	-.09	-.16	.08	.01	-.09	-.49***	.11	.28*	-	-	-
Child Impulsivity	-.20	-.23	.21	.16	-.20	-.10	.14	.41**	.17	-	-
Usual SSB (ml/day)	.05	.09	.12	.03	-.05	.07	.18	.10	-.22	.08	-
Waist (cm)	-.11	.005	-.17	-.13	-.03	.01	-.14	-.05	-.12	-.11	.02

Note. *$p<.05$, ** $p<.01$, ***$p<.001$

A moderated regression using the PROCESS macro-Model 1 on SPSS was performed to test the moderating effect of child scores of negative parenting style on child impulsivity and resultant SSB consumption. See Figure 7.2 for the proposed model. As shown in Table 7.9, no main effect or interaction was found with either inconsistent parenting or poor supervision.

Table 7.9

Moderated multiple regression between negative parenting style, trait impulsivity on usual SSB consumption

Predictor	*B*	*SE (B)*	*t*	*p*	*LLCI*	*ULCI*
Impulsivity	4.11	4.79	.86	.39	-5.50	13.73
Inconsistent Parenting	43.59	49.32	.88	.38	-55.37	142.56
Impulsivity x Inconsistent Parenting	-.55	.71	-.77	.44	-1.98	0.88
Impulsivity	.43	5.09	.09	.93	-9.79	10.66
Poor Supervision	-6.03	72.13	-.08	.93	-150.78	138.72
Impulsivity x Poor Supervision	.11	1.04	.11	.91	-1.97	2.21

Note. LLCI and ULCI denote lower and upper confidence intervals respectively. Non-mean centred scores were used.

Contrary to the hypothesis that a negative parenting style would moderate the relationship between child trait impulsivity and child SSB consumption, with more impulsive children consuming more usual SSB when parents have a more negative parenting style, no significant relationship was found between child impulsivity usual SSB consumption and child scores for inconsistent parenting style, $F(3,52) = 0.51$, $p = .68$, or between child impulsivity usual SSB consumption and child scores for poor supervision, $F(3,52) = 0.11$, $p = .95$.

Tests of Mediation

Hypothesis six proposed that a negative parenting style would mediate the relationship between parent impulsivity and child impulsive behaviour. That is, a poorer parenting style will result in those more impulsive parents providing a less supportive environment, thereby facilitating more impulsive behaviours from their children. Although the BIS-11 measures trait vulnerability to impulsivity, it does so by asking questions relating to typical behaviour and as such can be a determinant of usual behaviours. A significant positive association was found between parent scores for poor supervision and both parent and child impulsivity (Table 7.8). This suggests that more impulsive parents who provide less supervision allow more impulsive children to express impulsive behaviour. Furthermore, a significant negative correlation found between parent impulsivity and parent scores for involved parenting (*p* <.001) implies that more impulsive parents were less involved with their child.

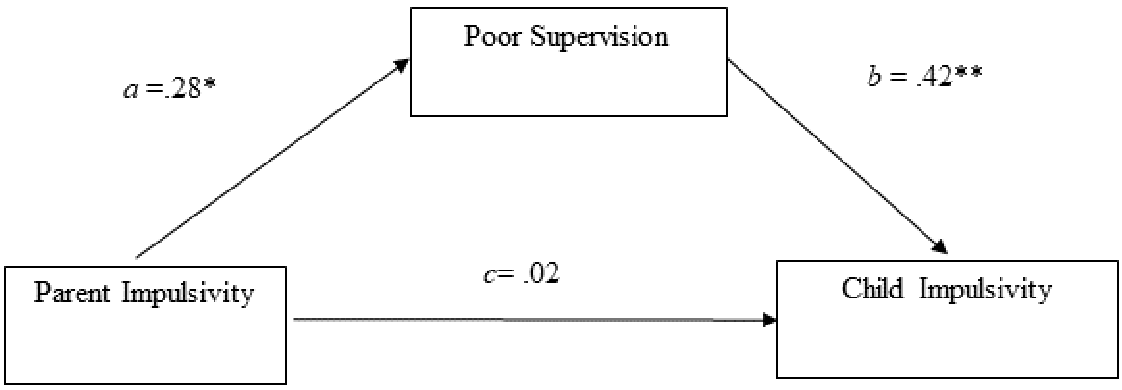

Figure 7.2

Standardised Coefficients showing the Relationship between Parent and Child Impulsivity via Parent Scores for Poor Supervision

Parent impulsivity was significantly associated with parent scores of poor supervision (path a), parent scores for poor supervision was significantly associated with child impulsivity (path b) while the direct path from parent impulsivity (path c) was not significant (Table 7.10). Therefore, parent impulsivity was related to higher parent scores for poor supervision which was then related to child impulsivity.

Table 7.10

Unstandardised Direct Effects of Parent Impulsivity, Child Impulsivity and Parent scores for Poor Supervision.

		Effect	
Outcome Variable	Variable	Bootstrap Estimate (SE)	BC 95% CI
Poor Supervision	Parent Impulsivity (path a)	.05 (.02)*	.003, .10
Child Impulsivity	Poor Supervision (path b)	2.55 (.81)**	.92, 4.20
Child Impulsivity	Parent Impulsivity (path c)	.02 (.15)	-.28, .33

Note. * *p* <.05, ***p* <.01. BC = biased corrected; CI = Confidence Interval.

Mediation analysis revealed a significant indirect effect of parental impulsivity on child impulsivity through parental poor supervision, (See Table 7.11). This supports an indirect mediating link whereby more impulsive parents facilitate more impulsive children through poor supervision.

Table 7.11

Unstandardised Indirect Effects of Parental Impulsivity on Child Impulsivity Through the Mediator Parent Scores of Poor Supervision.

	Effect	
Mediator	Bootstrap Estimate (SE)	BC 95% CI
Poor Supervision	0.13 (0.08)*	0.01, 0.34

Note: * p<.05, indicates a significant indirect effect. BC = biased corrected; CI = Confidence Interval.

Hypothesis seven proposed that usual SSB consumption would mediate the relationship between child self-report impulsivity and obesity as determined by waist circumference in that trait impulsivity will result in obesity through increased SSB consumption. Significant direct and indirect effects between usual SSB consumption, child impulsivity, and waist circumference were tested using the PROCESS macro on SPSS. The model was tested using the PROCESS Macro model 4 bootstrap method with 95% confidence intervals (n=10,000) for SPSS. Figure 7.3 below represents the overview of the model with path a_1 representing the association between child impulsivity and usual SSB consumption, path b_1 representing the association between usual SSB consumption and waist circumference after controlling for child impulsivity, and path c_1 representing the direct effect of child impulsivity on waist circumference. Indirect effects refer to path *a* by path *b* via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals.

Figure 7.4 represents the overview of the model with path a_2 representing standardised coefficients for the association between child impulsivity and usual SSB consumption, path b_2 representing the association between usual SSB consumption and BMI after controlling for child impulsivity, and path c_2 representing the direct effect of child impulsivity on BMI. Indirect effects refer to path a_2 by path b_2 via the mediator usual SSB consumption with significant indirect effects evident by an absence of zero within the confidence intervals.

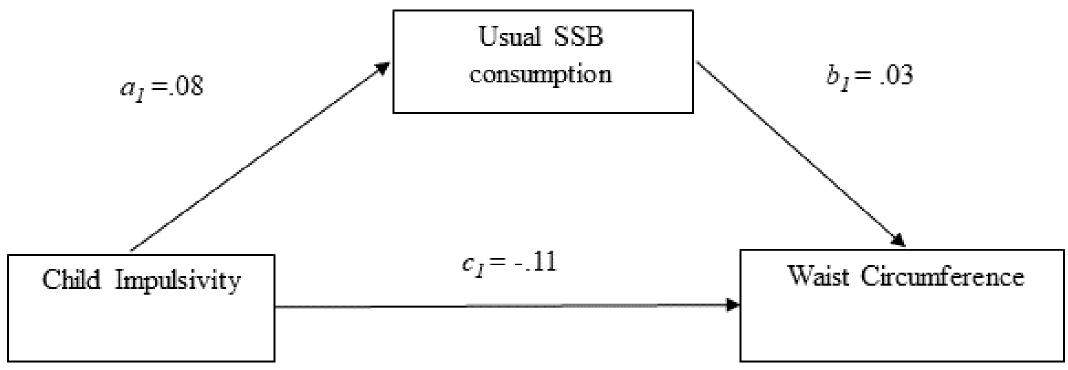

Figure 7.3

Standardised Coefficients Showing the Relationship Between Child Impulsivity and Waist Circumference via Usual SSB Consumption

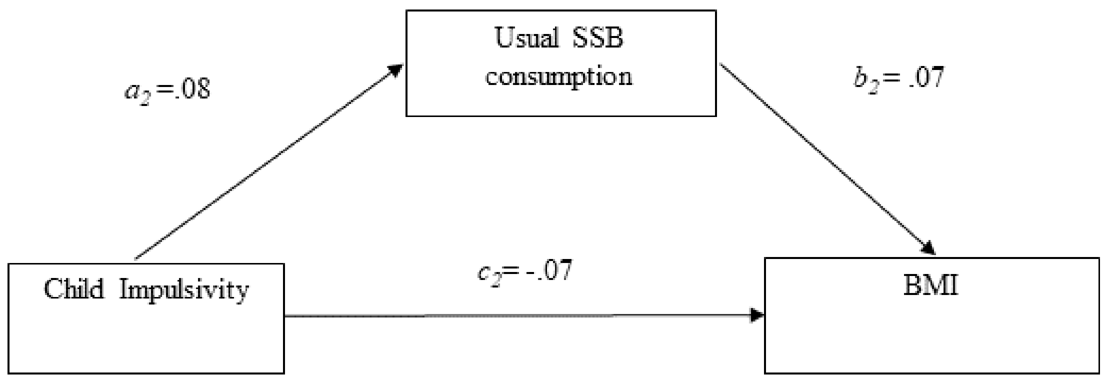

Figure 7.4

Standardised Coefficients Showing the Relationship Between Child Impulsivity and BMI via Usual SSB Consumption.

There was no significant association between child impulsivity and usual SSB consumption (path a_1), usual SSB consumption and waist circumference (path b_1) and the direct effect of child impulsivity on waist circumference was also not significant (path c_1) (Table 7.12). Similarly, there was no significant association between child impulsivity and usual SSB consumption (path a_2), usual SSB consumption and BMI (path b_2) and the direct effect of child impulsivity on BMI was also not significant (path c_2).

Table 7.12

Unstandardised Direct Effects of Child Impulsivity and Usual SSB consumption on Waist Circumference and BMI

		Effect	
Outcome Variable	Variable	Bootstrap Estimate (SE)	BC 95% CI
Usual SSB consumption	Child Impulsivity (path a_1)	1.00 (1.78)	-2.58, 4.58
Waist Circumference	Usual SSB consumption (path b_1)	.002 (.01)	-.02, .03
Waist Circumference	Child Impulsivity (path c_1)	-.13 (.16)	-.46, .19
Usual SSB consumption	Child Impulsivity (path a_2)	1.00 (1.78)	-2.58, 4.58
BMI	Usual SSB consumption (path b_2)	.002 (.004)	-.006, .01
BMI	Child Impulsivity (path c_2)	-.02 (.05)	-.13, .08

Note. BC = biased corrected; CI = Confidence Interval.

Mediation analysis revealed a non-significant indirect effect of child impulsivity on waist circumference through usual SSB consumption (See Table 7.13). Similarly, no direct nor indirect associations were found using BMI as an outcome variable. These were not explored further. Therefore, the results suggest that the pathway to obesity does not lie between child impulsivity and SSB consumption. No further associations were found with waist circumference, or BMI as a measure of obesity and any of the child or parent measures of parenting style.

Table 7.13

Unstandardised Indirect Effects of Child Impulsivity on Waist Circumference and BMI Through the Mediator Usual SSB Consumption

Outcome Variable	Mediator	Effect	
		Bootstrap Estimate (SE)	BC 95% CI
Waist Circumference	Usual SSB Consumption	0.002 (0.02)	-.04, .06
BMI	Usual SSB Consumption	.002 (.01)	-.01, .02

Note: * p<.05, indicates a significant indirect effect. BC = biased corrected; CI = Confidence Interval.

Discussion

In contrast with hypothesis one and Study 1, self-report impulsivity was neither a significant predictor of volume of SSB consumed under experimental conditions nor choice of immediate over delayed gratification. The lack of association between self-report impulsivity and volume of SSB consumed under experimental conditions is consistent across all three studies and raises the possibility of participant bias where the study deliberately targeted participants interested in health. It is also likely that the thirst induction paradigm, similar to Brannigan et al., (2015), whereby inducing thirst related overconsumption for more impulsive individuals, was not successful. In their study, Brannigan et al., (2015) found that those who consumed a high fat, high sugar diet were less able to stop overconsumption when thirst was induced. Although Brannigan et al., (2015) did not investigate overconsumption due directly to impulsivity, their premise was that those who consume a high sugar diet would be less sensitive to thirst satiety cues and would then overconsume. It also follows that these individuals would be less able to cease overconsumption of SSB compared to water.

One possibility raised from their study was that those who regularly consume a high fat and sugar diet may also be more impulsive, that is, less able to stop overconsumption, once started. The rationale for the studies in this thesis was that more impulsive individuals would overconsume SSB after thirst was induced. Future studies can determine if the thirst induction methodology was insufficient to induce impulsive overconsumption or if targeting more impulsive participants would yield the desired outcome.

Additionally, the experimental laboratory setting may not have been conducive for those more impulsive participants to engage in compulsive overconsumption of SSB. Laboratory conditions do not replicate naturalistic conditions where distractions such as television or social media induce the temptation to consume beyond satiety (Bradbury et al, 2019; Mittal et al, 2011; Scully et al, 2017). Such distracted overconsumption of SSB may be especially relevant for more impulsive individuals. Future studies should consider television viewing or other similar background distractions to better mimic naturalistic settings and induce distracted overconsumption. Additionally, the current studies only offered one flavour of SSB, chosen to match in colour the control fluid. It is likely that, although participants liked the drink provided, a choice of popular SSB flavours, such as cola and orange, could be offered, with the participant to choose their preferred flavour to further encourage overconsumption. Future studies could also target an audience where impulsive behaviours might be a pre-requisite for participation.

Perceptions of body image may have played a significant role limiting participants from consuming as much SSB as desired under experimental conditions. Schuck et al. (2018) investigated body image perceptions among children and adolescents aged 11-17 years. The authors reported that girls aged 13-14 years were most influenced by body image perceptions, however, this perception was also present in the younger (11-12 years) age group (Schuck et al., 2018). In a recent review, Pursey et al., (2021) reported body image dissatisfaction in children as young as six years of age, with almost a third of girls aged 10-14 years reported wanting to lose weight. Rodgers et al., (2019) investigated negative body image and dietary restraint in 261 children aged seven years with perfectionism and perceived reward of thinness being directly associated with higher dietary restraint. Bennett and Blissett (2020) reported an interaction of dietary restraint with impulsivity in 7 to 11-year-old children with those high in both dietary restraint and impulsivity consuming more in an experimental setting. Therefore, it is also likely that restraint related to body image may have been present in this group of children tested, resulting in less SSB consumption than they would under naturalistic conditions. Although body image perceptions and dietary restraint were limitations of this study, it also represents potential for further investigation in future research.

One of the interesting observations in this study is that only six participants chose the immediate gratification reward. In contrast, previous research using a similar young group demonstrated a significant percentage of participants choosing the immediate over delayed reward (Wulfert, 2002), with more impulsive individuals choosing the immediate reward. Gollner et al. (2018) suggested that age differences in the ability to self-regulate and thus choosing an immediate over a delayed reward, were due to differences in being able to view future scenarios such as career options and life choices, with middle aged adults more practised than young adolescents. The authors, however, found that children aged 9 to 14 years were no different to adults in their choice of immediate over delayed reward (Gollner et al., 2018). This would suggest that this current cohort of participants overall, were well within the accepted norms for impulsivity, and is further supported by norms for the BIS-11 by Stanford et al (2009) as being between 52 to 71. Hartmann et al. (2011) reported norms between 55 to 73 for the Adolescent BIS-11 for children and adolescents over 10 years.

Similar across Study 1 to Study2, and in contrast to hypothesis two, self-report impulsivity predicted neither usual SSB consumption nor measures of obesity. This contrasts with previous research as presented in Chapter 3 and with Melbye et al., (2016). It is likely that self-selection bias impacted the study, whereby mainly those who were health motivated, consumed little SSB usually and were naturally low in impulsivity expressed interest in participating, thereby limiting access to more diverse, impulsive individuals. This is consistent with other existing research (Finlayson, 2012; Foscarini-Craggs 2021;). Haynes and Robinson (2019) reported that health-conscious individuals who participate in research may do so to reinforce their self-perception of health. Manson and Robbins (2017) reported those who volunteered in a psychology study were more conscientious while Van Lange (2011) reported more pro-social behaviour among volunteer participants. In this study, although 20% of children met the criteria for overweight or obesity (NHMRC, 2013), obesity was not related to any variables. Future studies could utilise an advertising strategy targeting decision-making processes rather than interest in SSB consumption to obtain a more diverse cohort.

It is also possible that a cross-sectional analysis as carried out by this study is not indicative of the longer-term effect of SSB consumption on measures of obesity. Laverty et al., (2015) conducted a longitudinal study into SSB consumption and obesity with 13,000 UK children aged 7 to 11 years and reported a long-term increase in obesity over the four years associated with increased SSB intake. Millar et al., (2014) reported a similar result from a longitudinal study over six years on the effect of SSB consumption on obesity in 4,000 Australian children aged 4 to 10 years. The authors reported that actual SSB consumption did not increase over time with the children, thus highlighting a potential cumulative effect of SSB on obesity. Therefore, although the results obtained from the current study did not demonstrate an association between SSB intake and obesity, it does not rule out the potential negative impact over time.

Hypothesis three expected that for more impulsive children, usual SSB consumption as indicative of impulsive behaviour would translate across to SSB consumption in experimental conditions. In contrast to Study 1, but supporting the findings of Study 2, usual SSB consumption did not predict experimental SSB consumption. Nor was usual SSB consumption related to either measure of obesity. Therefore, it is possible that, again, the methodology of the laboratory setting limiting subsequent distracted overconsumption, lack of choice of preferred SSB, plus a non-effect of expected thirst induction were likely responsible for this result. In the most recent ABS survey (2020), average consumption of SSB for all age groups of adults and children was approximately 158 ml/day.. However, although children aged 9-13 years were previously reported to be the largest consumers of SSB (ABS, 2018), children from the current study reported less than the average usual SSB consumption. This is consistent with self-selection of more health aware parents and participants and may explain the absence of relationship between usual SSB and other constructs of interest in this group.

Unlike Study 1 but similar to Study 2, gender was not a significant predictor of experimental SSB consumption with boys and girls being similar consumers of SSB. This is not consistent with ABS data, where boys aged 2-17 years were likely to consume more SSB than girls (ABS, 2018). Schneider, Mata and Kadel (2020) followed longitudinal SSB consumption over 6 years in a sample of 11,691 children and adolescents aged 0 to 17 years and reported boys consuming more SSB overall with consumption increasing across adolescence. The finding of no gender difference in SSB consumption is likely due to the small sample size, insufficient power and the advertisement encouraging those with an interest in SSB to apply. Generally, girls are encouraged to be more focused on body image and appearance (Kagesten et al., 2016; Schneider et al.,2020). It is also possible that social acceptability plays a role in gender differences in SSB consumption, with it being acceptable for boys to consume more SSB (Deslippe et al., 2022; Kagesten et al., 2016).

Hypothesis four stated that parental impulsivity would be positively associated with child trait impulsivity. This was not supported, however, as children were overall more impulsive than their parents. According to the dual systems model of development (Gillebaart, 2018), increased reward-seeking and risk-taking behaviours of adolescence are a result of a rapidly maturing subcortical brain region overriding less mature executive cortical processes. To discern the relationship between risk taking behaviour and brain processing, Mills et al. (2014) followed a sample of children longitudinally from early adolescence through to adulthood. The authors used MRI data plus measures of risk-taking behaviours and impulsivity. Their findings were in keeping with early maturation of the areas involved in impulsivity and later development of the overarching executive control. However, they did not find evidence linking that finding with behavioural measures. The authors reported that the lack of evidence was more due to insufficient numbers in the study (24 participants) with relatively few exhibiting high-risk behaviour or impulsivity (Mills et al, 2014). In support of the dual systems brain development model and behavioural outcomes, Defoe et al., (2015) performed a meta-analysis of existing studies that used a variety of behavioural and computerised risk-taking measures. Defoe et al. (2015) found that very young adolescents take significantly more risks than do late adolescents and adults. Therefore, a maturation effect of impulsivity may be at play with the difference in impulsivity between children and their parents.

In a more recent study, Kray et al. (2021) investigated risk taking behaviour and impulsivity across a range of developmental periods from 9 to 17 years and, parallel with the findings of Defoe et al. (2015), found no increase in risky behaviours in late adolescence.

Kray et al. (2021) found children aged 9 to 11 years were less risk averse than middle (12-14 years) or older adolescents (15-17 years) across a series of behavioural and self-report measures. The authors proposed that the differences were in line with developmental cognitive aspects of working memory, with the children less able to process and hold all required information to make an informed decision around risk. The authors likewise found no correlation of age with self-report impulsivity. As a result, they concluded that differences in risk taking behaviour was related to cognitive development rather than differences in trait impulsivity. Kray et al. (2021) clarified however, that not only are behavioural and self-report measures of impulsivity poorly correlated, but also behavioural measures depend on the characteristic of the decision type, with time pressured decisions more likely to result in more impulsive choices (Kray et al., 2021). In the current study, the decision process to take immediate over delayed reward was not time pressured, therefore, participants may have lacked a sense of urgency which otherwise may have resulted in an immediate choice.

It may also be the case in the current study that this group of children were less able to process longer term consequences than the older group of emerging adults in Study 1 and 2. However, it should be noted again that the child mean impulsivity score was still considered within the “normal range” as described by Stanford et al. (2009) and Hartmann et al. (2011). This implies that although this group of children were higher in impulsivity than their parents, overall, they were still within acceptable norms on the BIS-11 scale. This once more highlights that the experimental paradigm did not encourage more impulsive participants to engage in compulsive drinking of SSB and self-selection bias where only individuals who were more health conscious and less impulsive responded to the recruitment process (Finlayson, 2012; Foscarini-Craggs, 2021; Haynes, 2019). It should be noted that the request for participation was predominantly through participating school newsletter and although the author received participation requests from children, it was parents who offered themselves and their children to participate. It stands to reason that the parents who offered to participate were therefore less impulsive and more involved with their children.

Hypotheses five and six explored parenting and associations with impulsivity, and SSB consumption. Hypothesis five proposed that a negative parenting style would moderate the relationship between child trait impulsivity and child impulsive behaviour as determined by SSB consumption, with more impulsive children consuming more usual SSB when parents have a more negative parenting style. No moderating relationship was found. This does not support the findings of Ahmed and Hinshaw (2016) who identified authoritarian parenting as the moderator between childhood impulsivity and later impulsive behaviours. Authoritarianism was not a variable in this study. Authoritarian parenting is associated with high demands from their child, strict control and discipline (Hosokawa & Katsura, 2019). These factors are more extreme than the negative parenting aspects of poor supervision and inconsistent parenting which were tested in this current model. Therefore, it is likely that authoritarian parenting may be more related to a harsher discipline style than was tested currently.

Hypothesis six was that a negative parenting style would mediate the relationship between parent impulsivity and child trait impulsivity. This hypothesis was supported with parental impulsivity, facilitating child impulsive behaviour through poor parenting style as determined by parent score of poor supervision (but not child scores). However, this did not carry over to SSB consumption, as no mediating effect of poor supervision between parent impulsivity and child impulsive behaviour was found. Impulsive parents via poor supervision, although translated to more impulsive children, did not translate to increased SSB consumption in those children. This finding speaks to the complexity of the relationship between parenting, impulsivity and behavioural outcomes and warrants further future investigation to include more measures of parenting style that include authoritarianism.

These results around parenting style, the impact on child impulsivity, and their child's subsequent SSB consumption is reflected in the literature. Although a significant proportion of research focuses on the detrimental effects of an overly restrictive style, the results from this study demonstrate the impact of a less involved parenting style. Langer et. al., (2017) demonstrated increased SSB consumption associated with a less restrictive parenting style, while parents who actively monitored their child's intake associated with less SSB consumption. An involved parenting style was also associated with better dietary practices around SSB consumption (Melbye et al., 2016). Similarly, Melbye et al. (2018) proposed that self-control is dependent on other mechanisms such as parental modelling and monitoring which reinforce restraint over desired outcomes such as SSB consumption. The results from this current study demonstrate that parenting style is a factor in tempering their child's behaviour with an uninvolved parenting style potentially just as detrimental as an overly restrictive style.

The lack of correlation between child and parent scores on parenting style contrasts with previous reports (Scott, et al., 2011) but in support of Esposito, et al. (2016) and Gross et al., (2017) who similarly demonstrated poor correlations between child and parent parenting styles. Gross et al., (2107) indicated that youth may interpret the questions and conceptualise parenting differently to their parents. Esposito, et al. (2016) proposed that parents may have a more positive bias in their own perceptions of parenting which does not transcend to their children's perceptions. Janssens et al. (2015) suggested that parents may see themselves aspiring to be good parents whereas their child may perceive parenting less favourably as a means to exert autonomy, independence and separation. This perception is upheld in the current study, however, only a small number of participants limits the generalisability. The relatively small sample size likely resulted in the occurrence of Type II errors due to a decrease in power, given that the actual sample size in this study was smaller than the sample size required to find an effect based on a priori power calculations (actual final sample size = 56, required sample size for a medium effect = 138).

It should also be noted the poor internal reliabilities of involved parenting and poor supervision for the child version and involved parenting, inconsistent parenting and poor supervision for the parent version further limits the interpretation of the results. Although the brief 15-question version has been previously validated using a sample of 208 children and adolescents between 9 to 17 years and their parents (Scott, Briskman, & Dadds, 2011), Badahdah and Trung Le (2016) reported low internal reliabilities for parental involvement and poor supervision subscales. The authors suggested that some questions around children “being out with friends they don’t know” or “not leaving a note to inform parents where they are” may not be appropriate for younger children (Badahdah & Trung Le, 2016). Anecdotally, although the age group of children in the current study was somewhat older than Badahdah and Trung Le (2016), children in the current study also stated these items as things they did not do. This highlights the need for more diverse cohorts of participants in future studies. In addition, Badahdah and Trung Le (2016) suggested that poor reliability may be related to only having a few items in each subscale. Similarly, Gross et al., (2107) also reported low internal reliabilities on the inconsistent and poor supervision subscales and proposed that their items were not representative of the actual construct being measured, however, the authors used a 9-question scale. Lohan, Morawska and Mitchell (2017) combined the subscales to create a single scale with adequate internal consistency, but once again suggested that some questions around poor supervision may not be appropriate to younger participants. The Alabama Parenting Scale was chosen in that it offered both a child and parent version and, being short, placed less cognitive load on the participants when combined with the remainder of the survey questions. This scale should be further tested on a larger sample size in future studies to explore the relationship between a less involved parenting style and comparison to a parenting style measure based on authoritarian style to ascertain possible overlap.

Finally, hypothesis seven proposed a mediating effect of usual SSB consumption between child trait impulsivity and measures of obesity, in that impulsivity would translate to obesity via increased SSB consumption. This hypothesis was not supported with no significant indirect effect found. Previous research demonstrated a significant link between SSB consumption and obesity with children (Cantoral et al., 2016; Della Torre et al., 2016; Zheng et al., 2015) while other research has demonstrated a link between SSB consumption and impulsivity (Ames et al. 2014), impulsivity and obesity risk (Blanco-Gomez et al., 2015) and reward drive, obesity and SSB consumption in children (De Decker et al., 2016). Therefore, it was an unexpected finding not to have the three variables related and is discussed further below.

Limitations

The most significant limitation impacting this study was the onset of COVID-19. This resulted in prevention of data collection for periods of time due to Government restrictions and then ultimately community concerns around heath and disease avoidance leading to a dearth of willing participants. As stated previously *a priori* power analysis indicated a minimum sample of 138 participants to achieve a moderate effect size. Thus, insufficient power remains as a factor in the lack of significant associations. Additionally, the study deliberately targeted parents and children interested in health, thereby attracting participants who were naturally less impulse driven. The study required participants and one of their parents to go to considerable effort to respond to the advertisement, make an appointment and then attend campus to participate, implying a more conscientious, less impulsive cohort overall. Future studies could target an audience where impulsive behaviours might be a pre-requisite for participation plus include distraction techniques to better mimic natural settings and encourage overconsumption in those more impulsive individuals.

Furthermore, the experimental laboratory design of the study attempted to control for many environmental factors such as previous food and drink consumption and induction of thirst to ensure similar thirst across participants. Also, ensuring participants came to the laboratory eliminated distractions and ensured direct measurement of the volume consumed within a set timeframe. However, as discussed earlier, laboratory conditions do not mimic home or social occasions where SSB may be consumed more freely particularly when participants are distracted.

A further consideration of the design of the study was thirst induction whereby it was expected that more impulsive individuals would overconsume SSB rather than water once thirst was induced, due to limited capacity to recognise satiety and then cease consuming the desired product, SSB. It is possible that the thirst induction protocol was not successful. Brannigan et al., (2015) proposed that in their study, overconsumption was related to poor cognitive awareness and hippocampal learning as a result of long-term consumption of the high sugar fat diet. Perhaps in the targeted cohorts, this was not a factor as long-term consequences of a high sugar diet have yet to emerge. However, one of the reasons for targeting emerging adults and children was that any effect observed would be due to impulsivity rather than long term consequences of diet. Therefore, it remains that the thirst induction protocol on its own was unsuccessful. Perhaps when combined with a more naturalistic setting with appropriate distraction techniques, and a choice of desired SSB beverage, the desired effect may be observed. Therefore, an aim for future research may be to include a take-home task whereby SSB or water intake in a specified home setting and monitored by a parent are measured.

Additionally, researchers did not obtain data on the socio-economic status of families. Advertisements for participation were placed in school newsletters across a predominantly middle-class section of the community. Future studies could target communities within a range of socio-economic status to determine the impact if any on impulsivity and SSB consumption. Similarly, future studies should include measures of body image and dietary restraint which were identified as potential confounds influencing consumption.

Poor internal reliabilities of involved parenting and poor supervision for the child version and involved parenting, inconsistent parenting and poor supervision for the parent version also was a limitation. Anecdotally, children in the current study also stated some items on the parenting scale as things they did not do. This highlights the need for a larger sample size plus comparison with a measure of parenting that explores an authoritarian parenting style.

Strengths

The greatest strength of the current study was the experimental design nature in that it allowed direct manipulation of thirst to then measure actual SSB or control beverage consumption under controlled conditions. In addition, the study was able to estimate actual SSB consumption under those conditions, as well as self-reported estimates of usual SSB consumption. This was a novel approach as most research has relied predominantly on self-report data of SSB consumption which was then investigated in relation to unrelated behavioural measures of impulsivity. The current study was the first of this kind to directly use SSB consumption as a behavioural indicator of impulsivity. Another of the main strengths of the study was the capacity to use children's self-report rather than parents reporting their child's impulsivity, parenting style or usual SSB consumption. This means that children were able to directly report their own behaviour, eliminating potential biases or misreporting from their parents.

A further strength of the research was the in-person experimental design rather than an online survey design. Survey designs distributed via social media are outside experimenter controls and as such can be subject to confounds such as participants not answering honestly, or the survey being answered by others with different or conflicting interests (Coughlan, Cronin, & Ryan, 2009). Likewise, online survey designs do not offer the capacity for real-time clarification of questions. One of the strengths of the experimental design in this research was the capacity for participants to ask clarifying questions of the researcher to better understand questions. Similarly, the in-person, experimental nature of the research ensured that participants matched the requirements in terms of age. Likewise, potential confounds such as food and fluid consumption prior to participation were eliminated using the in-person design, as were any possible errors in following the research protocol.

Implications

Obesity related health care costs in the US amount to a significant proportion of government spending with SSB related health consequences contributing to a considerable budgetary load (Marriott & Dillard, 2021). As a result, taxation on SSB has been suggested as a way to discourage reducing SSB consumption. Taxation of SSBs offers benefits in that it contributes to the revenue to offset healthcare related costs, plus discourages consumption, like tobacco related taxes. In addition, taxation of SSB provides clear messaging to consumers that SSB may not be healthy food choices. Where taxation of SSB has been implemented, reduced consumption of SSB, particularly among those in poorer economic circumstances has been significant (Marriott & Dillard, 2021). However, experience in the USA convincing voters to support tax reforms legislating tax on SSB has been mixed, with many consumers viewing tax as a violation of human rights and messages failing to convince the public that taxation benefits outweigh the negative health consequences (Marriott & Dillard, 2020). In a recent article canvassing expert nutrition and public health opinions (van der Bend, Jakstas, Van Kleef, Shewsbury & Bucher, 2022), numerous challenges were identified when targeting young people's food choices. These include negating the effect of social media influencers and emotional engagement of adolescents by food advertising, plus adolescents' need for social approval, identity and independence all influencing food choices (van der Bend et al, 2022). Intervention strategies could be considered to either minimise access to SSB for the most vulnerable age groups or increase education targeting at risk groups and their parents to promote healthier choices or improve self-control.

Therefore, it remains incumbent upon parents and caregivers to provide an environment that promotes beneficial health behaviours for their children. Braid et al. (2021) interviewed a sample of 19 community leaders and community members from a predominantly low income, high incidence of obesity population in the USA to understand public perception around policies and strategies to reduce SSB intake. The predominant message received was that although taxation strategies would reduce access to SSB, conversely it would create another burden and stress on an already vulnerable population group. Participants overwhelming supported a strategy of reducing access to SSB in restaurants and childcare facilities, along with targeted programs to educate parents on the effect of SSB on obesity and health (Braid et al., 2021).

This study further demonstrates the role of parenting on children's behaviour. Although children of this age are beginning to assert independence and make their own decisions, it is incumbent upon parents to guide their behaviour. This study demonstrated that an uninvolved parenting style in conjunction with impulsive parents then leads to increased impulsive behaviour in their children. Although in the current study, this behaviour did not then translate to increased SSB consumption or obesity, future studies with more power could further elucidate the relationship with SSB consumption. This finding speaks to the complexity of the relationship between parenting, impulsivity and behavioural outcomes and warrants further future investigation using a more naturalistic setting to induce overconsumption in those more impulsive individuals and with a larger diverse sample size, as well as measurement of authoritarian parenting style, body image and dietary restraint.

Although this study did not yield expected outcomes, it paves the way for further refinements to the protocol and a direct behavioural measure of impulsivity using SSB. Future studies could utilise the learnings from this study by offering a choice of SSB flavours to better provide participants their preferred beverage, utilising distractions in combination with the thirst induction protocol and including measures of dietary restraint and body image to better capture the factors that drive SSB consumption.

Conclusion

In summary, this study demonstrated that the BIS-11 did not predict either the monetary behavioural measure of impulsivity or volume of SSB consumed under experimental conditions. One possibility is self-selection bias whereby only health conscious, low in impulsivity participants responded to the advertising. It is also possible that the SSB experimental protocol was not successful. This would benefit from further follow up studies which incorporates the refinements suggested above. Usual SSB consumption did not predict experimental SSB consumption or either measure of obesity. Similarly, to Studies 1 and 2, gender remained the significant predictor of experimental SSB consumption with boys consuming more SSB than girls. Also, similarly to Studies 1 and 2, self-report impulsivity did not predict either usual SSB consumption or measures of obesity. Obesity was not related to any of the variables tested, adding further weight to the possibility that self-selection of health-conscious participants was at play.

This study explored child and parent aspects of parenting and associations with impulsivity, SSB consumption and obesity. A significant indirect mediating relationship was established between self-report parental impulsivity, parental scores of poor supervision (but not child scores) and child self-report impulsivity. Impulsive parents enable more impulsive children through poor supervision. Overall, the results suggest that negative aspects of parenting style such as poor supervision may act as increased risk factors in facilitating their child's impulsivity and SSB consumption. The results warrant further exploration with a larger target audience, improved experimental design as suggested above, including measures of dietary restraint and body image and with a further measure of parenting style encompassing authoritarian parenting style in addition to the current measure.

CHAPTER 8

Overall Discussion

The overall aims of the research were to address limitations in the literature surrounding SSB consumption, impulsivity, and obesity in emerging adults and children; plus explore the effect of parenting factors on their child's SSB behaviour, impulsivity and obesity. First, a behavioural measure of impulsivity involving actual SSB consumption under experimental conditions was measured against both a monetary behavioural measure and a self-report measure of impulsivity in emerging adults (Studies 1, 2) and children aged 10-12 years (Study 3). Second, the association between impulsivity, parenting style, SSB consumption and obesity was investigated in a sample of children aged 10-12 years (Study 3). Third, the association between parent and child impulsivity was explored to further understand the factors involved in SSB consumption in children (Study 3). In the following sections the findings will be discussed in relation to the overall implications for limiting SSB consumption in younger populations, followed by strengths and limitations of the research and future directions for research in this field.

Findings

Relationship between self-report impulsivity and SSB behavioural measure of impulsivity

Studies 1 to 3 hypothesised that when thirst was induced, the desire to consume more SSB than required to satisfy thirst would exceed participants' ability to stop drinking once thirst had been quenched. The studies predicted that more impulsive individuals would consume more SSB than control participants due to the desire to overconsume once satiated over-rode participants impulse control mechanism. This hypothesis was not supported and was a consistent finding across the studies. As reported earlier, behavioural measures of impulsivity generally to poorly associate with self-report trait measures of impulsivity. The inclusion of an SSB specific state-based measure was hypothesised to better relate to the

Barratt scale as it was naturalistic and more likely to reflect trait impulsive driven usual behaviour. Although SSB consumption under experimental conditions did not relate significantly to the self-report Barratt measure, this was a consistent finding across all studies and supports the existing literature presented in Chapter 1. Self-report questionnaires require a level of insight which more impulsive individuals may not possess, thereby providing a potential confound. (Reynolds et al., 2006). Overall, the results speak to the complexity of measuring impulsivity under experimental conditions and the multifactorial nature of trait-based decision making. The findings across all three studies confirm Meule and Blechert (2017). It is likely that the SSB measure for state-based impulsivity reflects an aspect of trait impulsivity not represented by a self-report questionnaire. Future studies could incorporate a variety of existing state-based impulsivity measurements, including the SSB measure, to better understand the association of thirst driven SSB consumption with state-based impulsivity. Future studies could also improve the experimental protocol design as discussed below.

Demand characteristics may have influenced participants to consume less than they would under more natural settings. Studies 1 and 2 involved emerging adults during their first year of university where body image and dietary restraint may be most relevant and impact findings (Delinsky & Wilson, 2008; Rodgers et al., 2011). Similarly, the protocol design may have been insufficiently sensitive to demonstrate an effect. The thirst induction experimental paradigm was based on that of Brannigan et al., (2015). In their study, Brannigan et al., (2015) found that those who consumed a high fat, high sugar diet were less able to stop overconsumption when thirst was induced. Although Brannigan et al., (2015) did not investigate overconsumption due directly to impulsivity, the premise was that those who consume a high sugar diet would be less sensitive to thirst satiety cues and would therefore overconsume. It also follows that these individuals would be less able to cease overconsumption of SSB compared to water. One possibility raised from their study was that those who regularly consume a high fat and sugar diet may also be more impulsive, that is, less able to stop overconsumption, once started. The rationale for the studies in this thesis was that more impulsive individuals would overconsume SSB after thirst was similarly induced. It is yet to be determined whether the thirst induction methodology was insufficient to induce impulsive overconsumption or rather that targeting more impulsive participants would have yielded the desired outcome.

Additionally, the experimental laboratory setting may not have been conducive for more impulsive participants to engage in compulsive overconsumption of SSB. Laboratory conditions do not replicate naturalistic conditions where distractions such as television or social media induce the temptation to consume beyond satiety (Bradbury et al, 2019; Mittal et al, 2011; Scully et al, 2017). Such distracted overconsumption of SSB may be especially relevant for more impulsive individuals. Future studies should consider television viewing or other similar background distractions to better mimic naturalistic settings and induce distracted overconsumption. Additionally, the current studies only offered one flavour of SSB, chosen to match in colour the control fluid. It is likely that, although participants liked the drink provided, a choice of popular SSB flavours, such as cola and orange, could be offered, with the participant to choose their preferred flavour, to further encourage overconsumption. Future studies could also target an audience where impulsive behaviours might be a pre-requisite for participation. Further, conducting a take-home component of the studies to assess effects in a naturalistic setting may be useful in future studies.

Impulsivity and dietary restraint have been demonstrated as separate constructs that may compete for priority in any given setting (Bennett & Blissett, 2020). Other research demonstrated that women university students high in dietary restraint demonstrated greater inhibitory control over food intake under experimental conditions (Meule et al., 2011).

Together this research suggests that for the university cohorts used in Studies 1 and 2, women may particularly have been highly influenced by dietary restraint and body image resulting in lesser than expected SSB consumption under experimental conditions.

Perceptions of body image may have played a significant role limiting participants from consuming as much SSB as desired under experimental conditions in study 3 as well. Schuck et al. (2018) investigated body image perceptions among children and adolescents aged 11 to 17 years. The authors reported that girls aged 13 to 14 years were most influenced by body image perceptions, however, this perception was also present in the younger (11 to 12 years) age group (Schuck et al., 2018). In a recent review, Pursey et al., (2021) reported body image dissatisfaction in children as young as six years of age, with almost a third of girls aged 10 to 14 years reporting that they wanted to lose weight. Rodgers et al., (2019) investigated negative body image and dietary restraint in 261 children aged seven years with perfectionism and perceived reward of thinness being directly associated with higher dietary restraint. Bennett and Blissett (2020) reported an interaction of dietary restraint with impulsivity in 7–11-year-old children with those high in both dietary restraint and impulsivity consuming more in an experimental setting. Therefore, it is also likely that restraint related to body image may have been present across all groups, resulting in less SSB consumption than they would under naturalistic conditions. Although body image perceptions and dietary restraint were limitations of this study, it also represents potential for further investigation in future research.

Relationship between self-report impulsivity and monetary behavioural measure of impulsivity

Studies 1 to 3 hypothesised that more impulsive individuals would be less able to delay gratification, particularly with regards to a high-value incentive. The monetary delay of gratification was chosen as it was a naturalistic behavioural measure of impulsivity and the high salience of this type of reward to students. This was supported across Study 1 but not with Study 2 or 3. Existing literature supporting the monetary delay of gratification has related it to more extreme impulsive behaviours such as problem behaviours, conduct disorder, attention deficit hyperactivity disorder and substance use (Anokhin et al., 2011; Doidge et al., 2019; Wulfert et al., 2002). Therefore, it is likely that although the measure is robust and highlights those highly impulsive individuals, it may not distinguish lesser impulsive differences. Additionally, the sample sizes across studies was insufficient to demonstrate significant differences across a more normal population. As suggested by Dougherty et al. (2005) and Meule and Blechert (2017), a combination of different behavioural tasks may better complement each other and offer unique contributions thus providing more of a complete picture of the impulsivity construct. Although delay discounting with hypothetical rewards may be too complex for children, future studies could a variety of simpler age appropriate tasks such as the go/no-go, door opening, and circle drawing tasks similar to Bennett and Blissett (2019) for children.

As discussed in Chapter 7, a very small number of children chose the immediate reward in Study 3, which resulted in insufficient power to determine significant findings. As previously emphasised, Study 2 introduced additional confounds which potentially changed the nature of results. It is also possible that self-selection bias was at play across all studies with potentially only less impulsive and more health-conscious participants expressing interest in the study. Future research would perhaps target a larger, different audience focusing more on decision-making processes in the advertising material to capture both more impulsive participants and individuals who are less health conscious.

Association between impulsivity, SSB consumption and obesity in emerging adults and children

Across all three studies, no significant relationship was found between SSB consumed under experimental conditions and self-reported measure of impulsivity. Similarly, no significant relationship was found between the measures of obesity, waist circumference and BMI and usual SSB consumption. In all studies, obesity was not related to SSB consumption or impulsivity. It is probable that a cross-sectional analysis, as carried out by these studies, is not indicative of the longer-term effect of SSB consumption on measures of obesity. In separate longitudinal studies involving children, Laverty et al., (2015) and Millar et al., (2014) each reported a long-term increase in obesity associated with increased SSB intake. Millar et al., (2014) further reported that actual SSB consumption did not increase over time, thus highlighting the cumulative effect of SSB on obesity. This effect may also have impacted the lack of association with the studies involving emerging adults. Future studies should consider a longitudinal approach to determine the cumulative effect of the relationship between SSB consumption, impulsivity and obesity.

It is also possible that lack of association between usual SSB consumption and obesity could be related to self-selection bias or lack of power due to the small sample sizes, as discussed earlier. This is consistent with other existing research (Finlayson, 2012; Foscarini-Craggs 2021;). Haynes and Robinson (2019) reported that health-conscious individuals who participate in research may do so to reinforce their self-perception of health. Manson and Robbins (2017) reported those who volunteered in a psychology study were more conscientious while Van Lange (2011) reported more pro-social behaviour among volunteer participants.

Interestingly, across all studies, no significant relationship was found between usual SSB consumption and impulsivity scores on the BIS-11. It should be noted that across all studies, average scores for impulsivity were similar and, according to Stanford (2009), were well within limits considered normal. Therefore, reaching a target audience of more impulsive participants may yield different results that are more consistent with expected outcomes. All studies included in this thesis advertised for individuals with an interest in soft drinks, thereby indirectly targeting individuals wanting to reinforce their positive their self-perception of health (Haynes& Robinson, 2019). Future studies could specifically target more impulsive individuals through an advertising strategy aimed more at decision-making processes rather than those with an interest in SSB. Moran & Mullen, (2020) reported a significant relationship between increased SSB consumption and reduced self-control. However, in that study, after accounting for habit, intention and environmental cues, self-control was no longer a significant predictor of usual SSB consumption (Moran & Mullen, 2020).

This finding along with the current findings implies that the SSB consumption protocol used in the studies may be confounded by other factors including distractions, environmental, body image, dietary restraint and thirst induction as discussed earlier. Therefore, eliminating or accounting for these confounds is a challenge for future research. Future studies could also utilise an advertising strategy targeting decision-making processes rather than interest in SSB consumption to obtain a more diverse cohort.

It has previously been reported (ABS, 2018) that average SSB consumption of children and adolescents (2-17 years) who are regular consumers of SSB is approximately 600ml/day. In the most recent ABS survey (2020), average consumption of SSB for all age groups of adults and children was approximately 158 ml/day. Average reported usual SSB intake across Study 1 to Study 3 was consistent with this ABS data. However, although children aged 9-13 years were previously reported to be the largest consumers of SSB (ABS, 2018), participants from Study 3 reported the least average usual SSB consumption. This is consistent with self-selection of more health aware parents and participants in Study 3 and may explain the absence of a relationship between usual SSB and other constructs of interest in this group.

Association between child and parental impulsivity in children

Children aged 10 to 12 years were significantly more impulsive than their respective parents. This finding was discussed in Chapter 7 in relation to differences in cognitive development more than differences in trait impulsivity being responsible for this discrepancy. Additionally, the relationships between child and parent scores on parenting styles and impulsivity were also investigated. Parental impulsivity predicted child impulsivity through poor parental supervision. This implies that parental impulsivity translates to child impulsive behaviour only when it is accompanied by poor supervision.

Furthermore, the study hypothesised that more impulsive parents would have more impulsive children who would then consume more SSB both usually and under experimental conditions. This finding is in contrast with previous research which supports a relationship between parent and child impulsivity (Elam et al., 2017; Gratz et al., 2015; Takeda, 2010). As discussed earlier, this finding is most likely due to insufficient power resulting from a small sample size. Further research using a larger, more diverse participant group may provide insight into this discrepancy.

Relationship between parenting style, SSB consumption and obesity in children

Interestingly and in addition to above, the evidence surrounding the impact of parenting style presented mixed findings. Poor supervision mediated the relationship between parental impulsivity and their child’s impulsivity indicating that more impulsive parents provide a less supportive environment thereby facilitating more impulsive behaviours from their child. This is a novel and significant finding. Previous research demonstrated a negative impact on impulsive behaviour from an overly restrictive parenting style (Ahmed & Hinshaw, 2016; Hentges, 2017; Langer et al, 2017). This is a novel finding demonstrating the impact of a less involved parenting style and indicates that a less involved parenting style can be just as detrimental as an overly restrictive one. However, this should be interpreted with caution due to the low internal reliability of the parenting subscales.

No moderating effect of a negative parenting style on impulsivity and SSB consumption in children and no parenting style impacting obesity was found in this cohort. As discussed in Chapter 7, child and their parent scores for parenting style were not related suggesting that parents and their child see parenting very differently. Parents may view their own style as more positive, and children may see their parents less favourably (Esposito et al., 2016; Janssens et al., 2015). However, due to the small sample size, and resultant poor internal reliability of the parenting subscales, this cannot be generalised. Once again, a larger sample size may elucidate this more fully with another measure of parenting style to include authoritarian parenting style.

Additionally, and in contrast with previous research, (Ames et al. 2014; Blanco-Gomez et al., 2015; Cantoral et al., 2016; De Decker et al., 2016; Della Torre et al., 2016; Zheng et al., 2015), no association nor mediating effect of usual SSB consumption between child impulsivity and obesity was found. This was an unexpected finding and speaks to the lack of power of the sample size and recruitment strategy targeting more health-conscious participants. Future studies could target a more diverse cohort using a generalised recruitment strategy utilising decision-making as the key phrase within the advertisements as well as considering longitudinal research.

Strengths of the Research

The greatest strength of the current research was the experimental design nature in that it allowed direct manipulation of thirst to then measure actual SSB or control beverage consumption under controlled conditions. In addition, the research was able to estimate actual SSB consumption under those conditions, as well as self-reported estimates of usual SSB consumption. This was a novel approach as most research has relied predominantly on self-report data of SSB consumption which was then investigated in relation to unrelated behavioural measures of impulsivity. This was the first study of this kind that directly used SSB consumption as a behavioural indicator of impulsivity.

A further strength of the research was the in-person experimental design rather than a media distributed survey design. Survey designs distributed via social media are outside experimenter controls and as such can be subject to confounds such as participants not answering honestly, or the survey being answered by others with different or conflicting interests (Coughlan, Cronin, & Ryan, 2009). Likewise, online survey designs do not offer the capacity for real-time clarification of questions. One of the strengths of the experimental design in this research was the capacity for participants to ask clarifying questions of the researcher to better understand questions. Similarly, the in-person, experimental nature of the research ensured that all participants for each study matched the requirements in terms of age and student status. Likewise, potential confounds such as food and fluid consumption prior to participation were eliminated using the in-person design, as were any possible errors in following the research protocol.

Another of the main strengths of the research was the large number of emerging adult participants across different cohorts, providing a good cross-section of first year university students. Another strength of the research was the ability to capture a cohort of young adolescents to provide a broad picture of SSB consumption across the realm of both younger and emerging adults. A further strength of the current research was the capacity to use children's self-report rather than parents reporting their child's impulsivity or usual SSB consumption. This means that the researchers were able to directly have children report their own behaviour, eliminating potential biases or misreporting from the parent.

The final strength of the research was the novel and significant finding demonstrating the impact of poor supervisory parenting style on children's SSB consumption. Previous research has demonstrated the effect of a restrictive or authoritarian parenting style. This research has directly linked less involved parenting style with increased SSB consumption.

Limitations

Like any research, there are limitations involved in this research. The small number of participants in the final study led to a lack of power and potentially further significant findings. As stated previously, laboratory conditions do not replicate naturalistic conditions where distractions such as television or social media may induce the temptation to consume beyond satiety (Bradbury et al, 2019; Mittal et al, 2011; Scully et al, 2017). Such distracted overconsumption of SSB may be especially relevant for more impulsive individuals. Future studies should consider television viewing or other similar background distractions to better mimic naturalistic settings and encourage more distracted consumption.

Across all the studies, the researcher actively recruited participants who were interested in SSB consumption and thus, health-related behaviour. Therefore, as discussed previously, self-selection bias may have been a strong factor influencing the results. Similarly, the emerging adults were recruited from the university population and firstly, would not be representative of the wider population, and secondly, may be naturally less impulsive. This population may have already developed strategies either to modify or override impulsive traits or were naturally less impulsive, simply by the nature of being university students.

Likewise, as discussed earlier, demand characteristics may have played a greater role than expected across all studies. This would have resulted in participants across all studies being reluctant to consume as much SSB as desired to portray a favourable image. Perceptions of body image likely played a significant role across all studies, implying that dietary restraint may have prevented some participants from consuming as much SSB as desired under experimental conditions. Disordered perceptions of body image unrelated to actual weight or dietary restraint has been demonstrated in first year women university students in the USA and Australia (Delinsky & Wilson, 2008; Rodgers, et al., 2011), implying that body image is particularly important for older women adolescents. Schuck et al. (2018) investigated body image perceptions among children and adolescents aged 11-17 years. The authors reported that girls aged 13-14 years were most influenced by body image perceptions, however, this perception was also present in some of the younger (11-12 years) age group (Schuck et al., 2018). It could be argued that dietary restraint may be uppermost in girls and women's priorities. It is possible that dietary restraint related to body image may also have been present in all participants tested, resulting in less SSB consumption than they would under naturalistic conditions. Although dietary restraint measurement and body image perceptions were key limitations of this current research, they also represent the potential for further investigation in future research.

Although the strength of an experimental design was to minimise environmental confounds and ensure consistent conditions as much as possible, consuming SSB in a laboratory was not the same as consuming at home or socially under naturalistic conditions. Laboratory conditions do not replicate naturalistic conditions where distractions such as television or social media may induce the temptation to consume beyond satiety (Bradbury et al, 2019; Mittal et al, 2011; Scully et al, 2017). Such distracted overconsumption of SSB may be especially relevant for more impulsive individuals. Future studies should consider television viewing or other similar background distractions to better mimic naturalistic settings similar to those used by Mittal et al (2011). Therefore, the amount of drink consumed under laboratory conditions may not be representative of normal consumption for these participants. Despite the above-mentioned limitations, the research represents some important implications for future which will be discussed below.

Implications and Future Directions

As stated above, future research could investigate the effect of body image and restrained eating behaviour on these groups of younger and emerging adults to further understand and account for the ramifications on consuming food or fluid under experimental conditions. This was an important, yet unconsidered implication of the current research. One of the main aims of the current research was to explore actual SSB consumption under experimental conditions and the role of impulsivity. Impulsivity and its role in dietary behaviour is multidimensional with the current research demonstrating the complexity involved in isolating single factors. It would therefore be anticipated that once body image and restrained eating behaviours were accounted for, and once the methodological protocol were further refined, SSB overconsumption under experimental conditions would demonstrate adequate acceptability as a behavioural outcome of impulsivity. Rather than relying upon indirect methods of relating impulsivity to SSB consumption, future research would be able to have a direct and accurate measure to illustrate the relationship and thus determine causality. Once the nature of association between impulsivity, parenting style and SSB consumption could be further teased apart, intervention strategies could be considered to either minimise access to SSB for most vulnerable age groups and increase education targeting at-risk groups and their parents to promote healthier choices or improve self-control.

As discussed in Chapter 7, obesity and SSB related health consequences contribute a considerable budgetary load in the US (Marriott & Dillard, 2021) with taxation on SSB suggested as a way to discourage SSB consumption. However, experience in the USA convincing voters to support tax reforms legislating tax on SSB has been mixed, with many consumers viewing tax as a violation of human rights and messages failing to convince the public that taxation benefits outweigh the negative health consequences (Marriott & Dillard, 2020). Van der Bend, Jakstas, Van Kleef, Shewsbury & Bucher, (2022) reported numerous challenges when targeting younger adolescent food choices, including the effect of social media and food advertising, plus adolescents' need for social approval, identity and independence (van der Bend et al, 2022).

Therefore, it remains incumbent upon parents and caregivers to provide an environment that promotes beneficial health behaviours for their children. Braid et al. (2021) interviewed a sample of 19 community leaders and community members from a predominantly low income, high incidence of obesity population in the USA to understand public perception around policies and strategies to reduce SSB intake. The predominant message received was that although taxation strategies would reduce access to SSB, conversely it would create another burden and stress on an already vulnerable population group. Participants overwhelmingly supported a strategy of reducing access to SSB in restaurants and childcare facilities, along with targeted programs to educate parents on the effect of SSB on obesity and health (Braid et al., 2021). Future research and education could target parents, schools, restaurants, and childcare facilities to advocate healthier choices and reduce SSB intake.

In addition, the research presented in this thesis demonstrates the role of parenting behaviours on influencing children's SSB consumption with strategies targeting programs highlighting the importance of involving parents more in their child's life via supervision and involvement. The most significant and novel finding from this research is that less involved parenting style may be just as impactful as an overly restrictive or hostile parenting style in influencing impulsive behaviours. Future research could investigate the effect of positive parenting programs in assisting parents be more involved in their child's dietary choices.

Summary and Concluding Comments

This thesis aimed to extend existing research by firstly exploring a behavioural measure of impulsivity as it relates directly to SSB consumption, and secondly, investigation of the relationship between SSB consumption, impulsivity and obesity in parents and their children. Study 1 through to Study 2 examined the SSB behavioural measure of impulsivity in emerging adults. Study 3 not only examined this behavioural measure of impulsivity in younger adolescents, but also examined the parent-child relationship with impulsivity. Additionally, Study 3 specifically investigated the role of impulsivity and parenting style in SSB consumption and obesity in children. Although the behavioural measures of impulsivity using the monetary delay of gratification and SSB consumption across cohorts of children and emerging adults yielded ambiguous outcomes, results investigating the relationship between parenting style and parental impulsivity on their child impulsivity, SSB consumption and obesity yielded interesting findings. Parental impulsivity predicted child impulsivity through parental poor supervision, implying that parental impulsivity translates to increased child impulsivity when it is accompanied by poor supervision. This means that interventions targeting parental involvement may have a positive impact on child impulsivity. Also, impulsivity in children was not related to an increase in usual SSB consumption or obesity with no parenting style impacting obesity in this cohort. As suggested earlier, this is likely related to lack of power, self-selection bias of participants who may already be health conscious, and methodological limitations of the experimental design. Regardless, the results infer that encouraging parental involvement in their child's food choices is worthy of a targeted intervention. The results of this thesis provide a promising basis for future research to target at risk children and emerging adults, plus encourage health information to parents to become more active participants in their child's food choices.

References

Abargouei, A. S., Kalantari, N., Omidvar, N., Rashidkhani, B., Rad, A. H., Ebrahimi, A. A., . . . Esmaillzadeh, A. (2012). Refined carbohydrate intake in relation to non-verbal intelligence among Tehrani schoolchildren. *Public Health Nutrition, 15*(10), 1-7. doi:10.1017/S1368980011003302.

Abbott K. N., Morris, M. J., Westbrook, R. F., & Reichelt, A. C. (2016). Sex-specific effects of daily exposure to sucrose on spatial memory performance in male and female rats, and implications for estrous cycle stage. *Physiology and Behaviour, 162*, 52-60. http://dx.doi.org/10.1016/j.physbeh.2016.01.036.

Ahmad, S. I., & Hinshaw, S. P. (2016). Attention-deficit/hyperactivity disorder, trait Impulsivity, and externalizing behavior in a longitudinal sample. *Journal of Abnormal Child Psychology*, 1-13. doi:10.1007/s10802-016-0226-9.

Aichert, D. S., Wostemann, N. M., Costa, A., Macare, C., Wenig, J. R., Moller, H-J., Rubia, K., & Ettinger, U. (2012). Associations between trait impulsivity and prepotent response inhibition. *Journal of Clinical and Experimental Neurobiology, 34 (10),* 1016 – 1032. http://dx.doi.org/10.1080/13803395.2012.706261.

Allom, V., & Mullan, B. (2014). Individual differences in executive function predict distinct eating behaviours. *Appetite, 80,* 123 – 130. doi. org/10.1016/j.appet.2014.05.007.

Ames, S., Kisbu-Sakarya, Y., Reynolds, K., Boyle, S., Cappelli, C., Cox, M.. . Stacy, A. (2014). Inhibitory control effects in adolescent binge eating and consumption of sugar-sweetened beverages and snacks. *Appetite, 81*, 180-192. doi:10.1016/j.appet.2014.06.013.

Anokhin, A. P., Golosheykin, S., Grant, J. D., & Heath, A. C. (2011). Heritability of delay discounting in adolescence: A longitudinal twin study. *Behavior Genetics, 41*(2), 175-183. doi:10.1007/s10519-010-9384-7.

Anokhin, A. P., Grant, J. D., Mulligan, R.C., & Heath, A. C. (2015). The genetics of impulsivity: Evidence for the heritability of delay discounting. *Biological Psychiatry, 77 (10),* 887- 894. doi:10.1016/j.biopsych.2014.10.022.

Attuquayefio, T., Stevenson, R. J., Boakes, R. A., Oaten, M. J., Yeomans, M. R., Mahmut, M., & Francis, H. M. (2016). A high-fat high-sugar diet predicts poorer hippocampal-related memory and a reduced ability to suppress wanting under satiety. *Journal of Experimental Psychology: Animal Learning and Cognition, 42*(4), 415-428. doi:10.1037/xan0000118.

Australian Bureau of Statistics (ABS). (2020). *Apparent Consumption of Selected Foodstuffs, Australia.* Australian Government.

Australian Bureau of Statistics. (2018). *4364.0.55.001 National Health Survey, first results, 2017-2018*. Australian Government.

Australian Bureau of Statistics. (2014). *4364.0.55.007 Australian Health Survey: Nutrition first results – food and nutrients, 2011-2012*. Australian Government.

Badahdah, A., & Trung Le, K. (2016). Parenting young Arab children: Psychometric properties of an adapted arabic brief version of the Alabama Parenting Questionnaire. *Child Psychiatry and Human Development, 47, (3)*, 486-493. https://doi-org.libraryproxy.griffith.edu.au/10.1007/s10578-015-0581-8.

Bahrami, F., Kelishadi, R., Jafari, N., Kaveh, Z., & Isanejad, O. (2013). Association of children's obesity with the quality of parental–child attachment and psychological variables. *Acta Paediatrica, 102*(7), e321-e324. doi:10.1111/apa.12253.

Basu, S., McKee, M., Galea, G., & Stuckler, D. (2013). Relationship of soft drink consumption to global overweight, obesity, and diabetes: a cross-national analysis of 75 countries. *American Journal of Public Health, 103*(11), 2071-2077. doi:10.2105/AJPH.2012.300974.

Batterink, L., Yokum, S., & Stice, E. (2010). Body mass correlates inversely with inhibitory control in response to food among adolescent girls: An fMRI study. *NeuroImage, 52*(4), 1696-1703. doi:10.1016/j.neuroimage.2010.05.059

Baym, C. L., Khan, N. A., Monti, J. M., Raine, L. B., Drollette, E. S., Moore, R. D., . . . Cohen, N. J. (2014). Dietary lipids are differentially associated with hippocampal-dependent relational memory in prepubescent children. *The American Journal of Clinical Nutrition, 99*(5), 1026 - 1033. doi:10.3945/ajcn.113.079624.

Beauchaine, T. P., & McNulty, T. (2013). Comorbidities and continuities as ontogenic processes: Toward a developmental spectrum model of externalizing psychopathology. *Development and Psychopathology, 25*(4), 1505-1528. doi:10.1017/S0954579413000746.

Beauchaine, T. P., Neuhaus, E., Zalewski, M., Crowell, S. E., & Potapova, N. (2011). The effects of allostatic load on neural systems subserving motivation, mood regulation, and social affiliation. *Development and Psychopathology, 23(4*), 975-999. doi:10.1017/S0954579411000459.

Beilharz, J. E., Maniam, J., & Morris, M. J. (2016). Short-term exposure to a diet high in fat and sugar, or liquid sugar, selectively impairs hippocampal-dependent memory, with differential impacts on inflammation. *Behavioural Brain Research, 306,* 1-7. http://dx.doi.org/10.1016/j.bbr.2016.03.018.

Bennett, C., & Blissett, J. (2019). Multiple measures of impulsivity, eating behaviours and adiposity in 7-11- year-olds. *Appetite, 133,* 217- 222. https://doi.org/10.1016/j.appet.2018.11.002.

Bennett, C., & Blissett, J. (2020). Interactive effects of impulsivity and dietary restraint over snack intake in children. *Appetite, 146,* 104496 - 104502. https://doi.org/10.1016/j.appet.2019.104496.

Benton, D., Maconie, A., & Williams, C. (2007). The influence of the glycaemic load of breakfast on the behaviour of children in school. *Physiology & Behavior, 92*(4), 717-724. doi:10.1016/j.physbeh.2007.05.065.

Berridge, K. C. (2009). 'Liking' and 'wanting' food rewards: Brain substrates and roles in eating disorders. *Physiology & Behavior, 97(5*), 537-550. doi:10.1016/j.physbeh.2009.02.044.

Bezdjian, S., Baker, L. A., & Tuvblad, C. (2011). Genetic and environmental influences on impulsivity: A meta-analysis of twin, family and adoption studies. *Clinical Psychology Review, 31*(7), 1209-1223. doi:10.1016/j.cpr.2011.07.005.

Bhat, N. A., Roopesh, B. N., Bhaskarapillai, B., & Benegal, V. (2018). Validation of the Barratt Impulsiveness Scale – short form among Indian adolescents. *Asian Journal of Psychiatry, 37,* 172-177. https://doi.org/10.1016/j.ajp.2018.10.009.

Blanco-Gómez, A., Ferré, N., Luque, V., Cardona, M., Gispert-Llauradó, M., Escribano, J., . . . Canals-Sans, J. (2015). Being overweight or obese is associated with inhibition control in children from six to ten years of age. *Acta Paediatrica, 104*(6), 619-625. doi:10.1111/apa.12976.

Bleich,S.N., Vercammen, K. A, Koma, J.W., & Li,Z. (2018). Trends in beverage consumption among children and adults, 2003-2014. *Obesity, 26 (2)*, 432-441. . doi:10.1002/oby.22056.

Bradbury, K.M., Turel, O., & Morrison, K. M. (2019). Electronic device use and beverage related sugar and caffeine intake in US adolescents. *PLoS ONE, 14(10),*e0223912. https://doi.org/10.1371/ journal.pone.0223912

Braid, L., Olivia, R., Nichols, K., Reyes, A., Guzman, J., Goldman, R. E., & Woo Baidel, J. A. (2021). Community perceptions in New York City: Sugar-sweetened beverage policies and programs in the first 1000 days. *Maternal and Child Health Journal, 25,* (12), 1-12. https://doi.org/10.1007/s10995-021-03255-8.

Brannigan, M., Stevenson, R. J., & Francis, H. (2015). Thirst interoception and its relationship to a Western-style diet. *Physiology & Behavior, 139*, 423-429. doi:10.1016/j.physbeh.2014.11.050.

Brooks, S. J., Cedernaes, J., & Schioth, H. B. (2013). Increased prefrontal and parahippocampal activation with reduced dorsolateral prefrontal and insular cortex activation to food images in obesity: A meta-analysis of fMRI studies. *PLoS One, 8*(4), e60393. doi:10.1371/journal.pone.0060393.

Burger, K. S., & Stice, E. (2014). Neural responsivity during soft drink intake, anticipation, and advertisement exposure in habitually consuming youth. *Obesity, 22*(2), 441-450. doi:10.1002/oby.20563.

Burke, M. V., & Small, D. M. (2015). Physiological mechanisms by which non-nutritive sweeteners may impact body weight and metabolism. *Physiology and Behaviour, 152,* 381-388. http://dx.doi.org/10.1016/j.physbeh.2015.05.036.

Cantoral, A., Tellez-Rojo, M. M., Ettinger, A. S., Hu, H., Hernandez-Avila, M., & Peterson, K. (2016). Early introduction and cumulative consumption of sugar-sweetened beverages during the pre-school period and risk of obesity at 8–14 years of age. *Pediatric Obesity, 11*, 68-74. doi:10.1111/ijpo.12023.

Caleza, C., Yanez-Vico, R. M., Mendoza, A., & Igiesias-Linares, A. (2016). Childhood obesity and delayed gratification behavior: A systematic review of experimental studies. *Journal of Paediatrics, 169*, 201-201. doi:10.1016/j.jpeds.2015.10.008.

Casperson, S. L., Johnson, L., & Roemmich, J. N. (2017). The relative reinforcing value of sweet versus savory snack foods after consumption of sugar- or non-nutritive sweetened beverages. *Appetite, 112,* 143 – 149. http://dx.doi.org/10.1016/j.appet.2017.01.028.

Cherbuin, N., Sachdev, P., & Anstey, K. J. (2012). Higher normal fasting plasma glucose is associated with hippocampal atrophy: The PATH Study. *Neurology, 79*(10), 1019-1026.

Clifton, P. M., Chan, L., Moss, C. L., Miller, M. D., & Cobiac, L. (2011). Beverage intake and obesity in Australian children. *Nutrition and Metabolism, 8*(1), 87-87. doi:10.1186/1743-7075-8-87.

Colantuoni, C., Schwenker, J., McCarthy, J., Rada, P., Ladenheim, B., Cadet, J. L., . . . Hoebel, B. G. (2001). Excessive sugar intake alters binding to dopamine and mu-opioid receptors in the brain. *Neuroreport, 12*(16), 3549-3552. doi:10.1097/00001756-200111160-00035.

Cosi, S., Vigil-Colet, A., Canals, J., & Lorenzo-Seva, U. (2008). Psychometric properties of the Spanish adaptation of the Barratt Impulsiveness Scale 11A for children. *Psychological Reports, 103,* 336 -346.

Coughlan, M., Cronin, P., & Ryan, F. (2009). Survey research: Process and limitations, *International Journal of Therapy and Rehabilitation, 16, (1),* 9 – 15. https://doi.org/10.12968/ijtr.2009.16.1.37935.

Cyders, M. A., & Coskunpinar, A. (2011). Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? *Clinical Psychology Review, 31*(6), 965-982. doi:10.1016/j.cpr.2011.06.001

Cyders, M. A., & Coskunpinar, A. (2012). The relationship between self-report and lab task conceptualizations of impulsivity. *Journal of Research in Personality, 46*(1), 121-124. doi:10.1016/j.jrp.2011.11.005

Davis, C. (2009). Psychobiological traits in the risk profile for overeating and weight gain. *International Journal of Obesity, 33*(S2), S49-S53. doi:10.1038/ijo.2009.72.

Davis, C., & Carter, J. C. (2009). Compulsive overeating as an addiction disorder. A review of theory and evidence. *Appetite, 53*(1), 1-8. doi:http://dx.doi.org/10.1016/j.appet.2009.05.018.

Dawe, S., Gullo, M. J., & Loxton, N. J. (2004). Reward drive and rash impulsiveness as dimensions of impulsivity: Implications for substance misuse. *Addictive Behaviours, 29*, 1389-1405. doi:10.1016/j.addbeh.2004.06.004.

Dawe, S., & Loxton, N.J. (2004). The role of impulsivity in the development of substance use and eating disorders. *Neuroscience and Biobehavioral Reviews, 28,* 343-351. doi:10.1016/j.neubiorev.2004.03.007.

De Decker, A., Sioen, I., Verbeken, S., Braet, C., Michels, N., & De Henauw, S. (2016). Associations of reward sensitivity with food consumption, activity pattern, and BMI in children. *Appetite, 100*, 189-196. doi:10.1016/j.appet.2016.02.028.

Defoe, I. N, Dubas, J. S., Figner, B., & Van Aken, M. A. G. (2015). A meta-analysis on age differences in risky decision making: Adolescents versus children and adults. *Psychological Bulletin, 141, (1),* 48 – 84. http://dx.doi.org/10.1037/a0038088

Delinsky, S. S., & Wilson, G. T. (2008). Weight gain, dietary restraint, and disordered eating in the freshman year of college. *Eating Behaviours, 9,* 82-90. doi:10.1016/j.eatbeh.2007.06.001.

Della Torre, S. B., Keller, A., Depeyre, J.L., & Kruseman, M. (2016). Sugar-sweetened beverages and obesity risk in children and adolescents: A systematic analysis on how methodological quality may influence conclusions. *Journal of the Academy of Nutrition and Dietetics, 116,* 638-659.

Deslippe, A.L., O'Connor, T.M., Brussoni, M., & Masse,L. (2022). The association of food parenting practices with adolescents' dietary behaviors differ by youth gender, but not by parent gender. *Appetite, 169*, 105846. https://doi.org/10.1016/j.appet.2021.105846.

DiMeglio, D. P., & Mattes, R. D. (2000). Liquid versus solid carbohydrate: effects on food intake and body weight. *International Journal of Obesity, 24*(6), 794-800. doi:10.1038/sj.ijo.0801229.

Doidge, J. L., Flora, D. B., & Toplak, M. E. (2021). A meta-analytic review of sex differences on delay of gratification and temporal discounting tasks in ADHD and typically developing samples. *Journal of Attention Disorders, 25 (4),* 540- 561. doi: 10.1177/1087054718815588.

Dougherty, D. M., Mathias, C. W., Marsh, D. M., & Jagar, A. A. (2005). Laboratory behavioral measures of impulsivity. *Behavior Research Methods, 37*(1), 82-90. doi:10.3758/BF03206401.

Eisenmann, J. C. (2005). Waist circumference percentiles for 7- to 15-year-old Australian children. *Acta Pediatrica, 94,* 1182 -1185. DOI: 10.1080/08035250510029352.

Elam, K. K., Chassin, L., Lemery- Chalfant, K., Pandika, D., Wang, F. L., Bountress, K., Dick, D., Agrawal, A. (2017). Affiliation with substance-using peers: Examining gene-environment correlations among parent monitoring, polygenic risk, and children's impulsivity. *Developmental Psychobiology, 59,* 561-573. doi: 10.1002/dev.21529.

Enticott, P. G., Ogloff, J. R. P., & Bradshaw, J. L. (2006). Associations between laboratory measures of executive inhibitory control and self-reported impulsivity. *Personality and Individual Differences, 41*(2), 285-294. doi:10.1016/j.paid.2006.01.011.

Esposito, A., Servera, M., Garcia-Banda, G., Del Giudice. (2016). Factor analysis of the Italian version of the Alabama Parenting Questionnaire in a community sample. *Journal Child and Family Studies, 25*, 1208 – 1217. Doi: 10.1007/s10826-015-0291-7.

Falbe, J., Thompson, H.R., Patel, A., & Madsen, K.A. (2019). Potentially addictive properties of sugar-sweetened beverages among adolescents. *Appetite, 133*, 130-137. https://doi.org/10.1016/j.appet.2018.10.032

Feldstein Ewing, S. W., Claus, E. D., Hudson, K. A., Filbey, F. M., Jiminez, E. Y., Lisdahl, K. M., & Kong, A. S. (2017). Overweight adolescents' brain response to sweetened beverages mirrors addiction pathways. *Brain Imaging and Behaviour, 11,* 925 – 935. doi: 10.1007/s11682-016-9564-z.

Ferreira, A., Castro, J. P., Andrade, J. P., Madeira, M. D., & Cardoso, A. (2018). Cafeteria-diet effects on cognitive functions, anxiety, fear response and neurogenesis in the juvenile rat. *Neurobiology of Learning and Memory, 155*, 197 – 207. doi: 10.1016/j.nlm.2018.07.014.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed). Sage Publications.

Finlayson, G., Cecil, J., Higgs, S., Hill, A., & Hetherington, M. (2012). Susceptibility to weight gain. Eating behaviour traits and physical activity as predictors of weight gain during the first year of university. *Appetite, 58,* 1091 – 1098. http://dx.doi.org/10.1016/j.appet.2012.03.003.

Folkvord, F., Nederkoorn, C., Westerik, H., Buijzen, M. A., & Anschutz, D. J. (2014). Impulsivity, "advergames," and food intake. *Pediatrics, 133*(6), 1007-1012. doi:10.1542/peds.2013-3384.

Foscarini-Craggs, P., Lowe, R., & Lee, M. (2021). Changes over time in the relationship between weight, body fat, motivation, impulsivity and eating behaviour. *BMC Public Health, 121 (1),* 1353. https://doi.org/10.1186/s12889-021-11402-7.

Fossati, A., Barratt, E. S., Acquarini, E., & Di Ceglie, A. (2002). Psychometric properties of an adolescent version of the Barratt Impulsiveness Scale-11 for a sample of Italian high school students. *Perceptual and Motor Skills, 95*(2), 621-635.

Francis, H. M., & Stevenson, R. J. (2011). Higher reported saturated fat and refined sugar intake is associated with reduced hippocampal-dependent memory and sensitivity to interoceptive signals. *Behavioral Neuroscience, 125*(6), 943-955. doi:10.1037/a0025998.

Gebremariam, M. K., Lien, N., Torheim, L. E., Andersen, L. F., Melbye, E. L., Glavin, K., . . . Bjelland, M. (2016). Perceived rules and accessibility: measurement and mediating role in the association between parental education and vegetable and soft drink intake. *Nutrition Journal, 15*(1), 76. doi:10.1186/s12937-016-0196-3.

Giel, K. E., Teufel, M., Junne, F., Zipfel, S., & Schag, K. (2017). Food-related impulsivity in obesity and binge eating disorder - A systematic update of the evidence. *Nutrients, 9,* 1170. doi:10.3390/nu9111170.

Gillebaart, M. (2018).The ‘operational’ definition of self-control. *Frontiers in Psychology, 9,* 1231. doi: 10.3389/fpsyg.2018.01231.

Golan, M., & Crow, S. (2004). Parents are key players in the prevention and treatment of weight-related problems. *Nutrition Reviews, 62*(1), 39-50. doi:10.1301/nr.2004.jan.39-50.

Goldschmidt, A. B., Smith, K. E., Lavender, J. M., Engel, S. G., & Haedt-Matt, A. (2019). Trait-level facets of impulsivity and momentary, naturalistic eating behavior in children and adolescents with overweight/obesity. *Journal of Psychiatric Research, 110,* 24-30. https://doi.org/10.1016/j.jpsychires.2018.12.018.

Goldstein, R. Z., & Volkow, N. D. (2002). Drug addiction and its underlying neurobiological basis: neuroimaging evidence for the involvement of the frontal cortex. *The American Journal of Psychiatry, 159*(10), 1642-1652. doi:10.1176/appi.ajp.159.10.1642.

Gollner, L. M., Ballhausen, N., Kliegel, M., & Forstmeler, S. (2018). Delay of gratification, delay discounting and their associations with age, episodic future thinking, and future time perspective. *Frontiers in Psychology, 8,* 2304. doi: 10.3389/fpsyg.2017.02304.

Gomez-Smith, M., Karthikeyan, S., Jeffers, M. S., Janik, R., Thomason, L. A., Stefanovic, B., & Corbett, D. (2016). A physiological characterization of the cafeteria diet model of metabolic syndrome in the rat. *Physiology & Behavior, 167,* 382-391. doi.org/10.1016/j.physbeh.2016.09.029.

Gratz, K. L., Kiel, E. J., Latzman, R. D., Moore, S. A., Elkin, T. D., Megason, G. C., & Tull, M. T. (2015). Complex interrelations of trait vulnerabilities in mothers and their infants. *Infancy, 20*(3), 306-338. doi:10.1111/infa.12075.

Grimm, G. C., Harnack, L., & Story, M. (2004). Factors associated with soft drink consumption in school-aged children. *Journal of the American Dietetic Association, 104*(8), 1244-1249. doi:10.1016/j.jada.2004.05.206.

Gross, L. S., Li, L., Ford, E. S., & Liu, S. (2004). Increased consumption of refined carbohydrates and the epidemic of type 2 diabetes in the United States: An ecologic assessment. *The American Journal of Clinical Nutrition, 79*(5), 774.

Gross, T. J., Fleming, C. B., Mason, W. A., & Haggerty, K .P. (2017). Alabama Parenting Questionnaire–9: Longitudinal measurement invariance across parents and youth during the transition to high school. *Assessment, 24, (5),* 646 – 659. doi: 10.1177/1073191115620839.

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2007). How impulsiveness and variety influence food intake in a sample of healthy women. *Appetite, 48*(1), 119-122. doi:10.1016/j.appet.2006.06.004.

Guerrieri, R., Jansen, A. T. M., & Nederkoorn, C. (2008). The interaction between impulsivity and a varied food environment: its influence on food intake and overweight. *International Journal of Obesity, 32*(4), 708-714. doi:10.1038/sj.ijo.0803770

Guerrieri, R., Nederkoorn, C., Stankiewicz, K., Alberts, H., Geschwind, N., Martijn, C., & Jansen, A. (2007). The influence of trait and induced state impulsivity on food intake in normal-weight healthy women. *Appetite, 49*(1), 66-73. doi:10.1016/j.appet.2006.11.008.

Gullo, M. J., Ward, E., Dawe, S., Powell, J., & Jackson, C. J. (2011). Support for a two-factor model of impulsivity and hazardous substance use in British and Australian young adults. *Journal of Research in Personality,45*, 10-18. doi:10.1016/j.jrp.2010.11.002.

Harold, G.T., Leve, L.D., Barrett, D., Elam. K., Neiderhiser, J.M., Natsuaki, M. N., Shaw, D.S., Reiss, D. & Thapar, A. (2013). Biological and rearing mother influences on child ADHD symptoms: Revisiting the developmental interface between nature and nurture. *Journal of Child Psychology and Psychiatry, 54,* 1038 – 1046. doi:10.1111/jcpp.12100.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42 (2),* 377- 381.

Harris, P. A., Taylor, R., Minor, R. L., Elliott, V., Fernandez, M., O'Neal, L., McLeod, L., Delacqua, G., Delacqua, F., Kirby, J., Duda, S. N., & REDCap consortium. (2019). The REDCap consortium: Building an international community of software partners. . *Journal of Biomedical Informatics, 95*, 103208. doi: 10.1016/j.jbi.2019.103208.

Hartmann, A. S., & Rief, W. (2011). Psychometric properties of the German version of the Barratt Impulsiveness Scale, version 11 (BIS-11) for adolescents. *Perceptual and Motor Skills, 112, (2)*, 353-368. DOI 10.2466/08.09.10.PMS.112.2.353-368.

Haynes, A. & Robinson, E. (2019). Who are we testing? Self-selection bias in laboratory-based eating behaviour studies. *Appetite, 141,* 104330. https://doi.org/10.1016/j.appet.2019.104330.

Hentges, R. F., Shaw, D. S. & Wang, M-T. (2017). Early childhood parenting and child impulsivity as precursors to aggression, substance use, and risky sexual behavior in adolescence and early adulthood. Development and Psychopathology, 30 (4), 683 – 698. doi: 10.1007/s10802-007-9126-3.

Hong, M. Y., Shepanski, T. L., & Gaylis, J. B. (2016). Majoring in nutrition influences BMI of female college students. *Journal of Nutritional Science, 5, e8,* 1-7. doi:10.1017/jns.2015.24.

Hosokawa, R., & Katsura, T. (2019). Role of parenting style in children's behavioral problems through the transition from preschool to elementary school according to gender in Japan. *International Journal of Environmental Research and Public Health, 16,* 21. http://dx.doi.org/10.3390/ijerph16010021.

Houben, K., Nederkoorn, C., & Jansen, A. (2014). Eating on impulse: The relation between overweight and food-specific inhibitory control: Food-specific inhibition and overweight. *Obesity, 22(5*), E6-E8. doi:10.1002/oby.20670.

Hsu, T. M., Konanur, V. R., Taing, L., Usui, R., Kayser, B. D., Goran, M. I., & Kanoski, S. E. (2015). Effects of sucrose and high fructose corn syrup consumption on spatial memory function and hippocampal neuroinflammation in adolescent rats. *Hippocampus, 25*(2), 227-239. doi: 10.1002/hipo.22368.

Isen, J. D., Sparks, J. C., & Iacono, W. G. (2014). Predictive validity of delay discounting behavior in adolescence: a longitudinal twin study. *Experimental Clinical Psychopharmacology, 22*(5), 434-443. doi:10.1037/a0037340.

Janssens, A., Goossens, L., Van Den Noortgate, W., Colpin, H., Verschueren, K., & Van Leeuwen, K. (2015). Parents' and adolescents' perspectives on parenting: Evaluating conceptual structure, measurement invariance and criterion validity. *Assessment, 22 (4)* 473-489. DOI: 10.1177/1073191114550477.

Johansen, C. M., Reynolds, K. D., Xie, B., Unger, J. B., & Ames, S. L. (2019). Acculturation and sugar-sweetened beverage consumption among Hispanic adolescents: The moderating effect of impulsivity. *Appetite, 134,* 142 – 147. https://doi.org/10.1016/j.appet.2018.12.026.

Johnson, R. K., Appel, L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H., . . . Prevention. (2009). Dietary sugars intake and cardiovascular health: A scientific statement from the American Heart Association. *Circulation, 120*(11), 1011-1020. doi:10.1161/CIRCULATIONAHA.109.192627.

Kagesten, A., Gibbs, S., Blum, R. W., Moreau, C., Chandra-Mouli,V., Herbert, A., & Amin A. Understanding factors that shape gender attitudes in early adolescence globally: A mixed-methods systematic review. *PLoS ONE, 11 (6)*, e0157805. doi:10.1371/journal.pone.0157805.

Kanoski, S. E., & Davidson, T. L. (2011). Western diet consumption and cognitive impairment: Links to hippocampal dysfunction and obesity. *Physiology & Behavior, 103*(1), 59-68. doi:10.1016/j.physbeh.2010.12.003.

Kim-Spoon, J., Kahn, R., Deater-Deckard, K., Chiu, P., Steinberg, L, & King-Casas, B. (2016). Risky decision making in a laboratory driving task is associated with health risk behaviors during late adolescence but not adulthood. *Journal of Behavioural Development, 40 (1),* 58-63. doi: 10.1177/0165025415577825.

Kray, J., Kreis, K., & Lorenz, C. (2021). Age differences in decision making under known risk: The role of working memory and impulsivity. *Developmental Psychology, 57, (2)*, 241 – 252. https://doi.org/10.1037/dev0001132.

Kulbida, M., Kemps, E., & Tiggemann, M. (2022). The role of rash impulsivity and sensitivity to reward in soft drink consumption. *Appetite, 173,* 105977. https://doi.org/10.1016/j.appet.2022.105977.

Lange, F., & Eggert, F. (2015). Mapping self-reported to behavioral impulsiveness: The role of task parameters. *Scandinavian Journal of Psychology, 56,* 115 – 123. doi: 10.1111/sjop.12173.

Langer, S. L., Seburg, E., JaKa, M.M., Sherweood, N. E., & Levy, R. L. (2017). Predicting dietary intake among children classified as overweight or at risk for overweight: Independent and interactive effects of parenting practices and styles. *Appetite, 110,* 72-79. http://dx.doi.org/10.1016/j.appet.2016.12.011.

Laverty, A. A., Magee, L., Monteiro, C. A., Saxena, S., & Millett, C. (2015). Sugar and artificially sweetened beverage consumption and adiposity changes: National longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity, 12,* 137-147. DOI 10.1186/s12966-015-0297-y.

Lim,J-E., Kim, S., Seo, S., Kang, W., Kim, A., Kang, Y., Woo Choi, K., Tae, W-S., Ham,B.J., & Han, K-M. (2021). Association of prefrontal cortex thinning with high impulsivity in healthy adults. *Psychiatry Investigations, 18 (6),* 570-579. https://doi.org/10.30773/pi.2020.0404.

Liu, Y., Zhao, J., Zhang, X., Gao, X., Xu, W., & Chen, H. (2019). Overweight adults are more impulsive than normal weight adults: Evidence from ERPs during a chocolate-related delayed discounting task. *Neuropsychologica, 133,* 107181. https://doi.org/10.1016/j.neuropsychologia.2019.107181.

Lohan, A., Morawska A., & Mitchell, A. (2017). Associations between parental factors and child Diabetes-management–related behaviors. *Journal of Developmental and Behavioural Pediatrics, 38,* 330-338. doi: 10.1097/DBP.0000000000000447.

Ludwig, D. S., Peterson, K. E., & Gortmaker, S. L. (2001). Relation between consumption of sugar-sweetened drinks and childhood obesity: A prospective, observational analysis. *The Lancet, 357*(9255), 505-508.

Lumley, J., Stevenson, R. J., Oaten, M. J., Mahmut, M., & Yeomans, M. R. (2016). Individual differences in impulsivity and their relationship to a Western-style diet. *Personality and Individual Differences, 97*, 178-185. doi:10.1016/j.paid.2016.03.055.

Maayan, L., Hoogendoorn, C., Sweat, V., & Convit, A. (2011). Disinhibited eating in obese adolescents is associated with orbitofrontal volume reductions and executive dysfunction. *Obesity, 19*(7), 1382-1387. doi:10.1038/oby.2011.15.

Macintyre, A. K., Marryat, L., & Chambers, S. (2018). Exposure to liquid sweetness in early childhood: Artificially-sweetened and sugar-sweetened beverage consumption at 4–5 years and risk of overweight and obesity at 7–8 years. *Pediatric Obesity, 13*, 755-765. doi:10.1111/ijpo.12284.

Malik, V. S., Pan, A., Willett, W. C., & Hu, F. B. (2013). Sugar-sweetened beverages and weight gain in children and adults: A systematic review and meta-analysis. *The American Journal of Clinical Nutrition, 98*(4), 1084. doi:10.3945/ajcn.113.058362.

Malik, V. S., Popkin, B. M., Bray, G. A., Després, J.-P., Willett, W. C., & Hu, F. B. (2010). Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: A meta-analysis. *Diabetes Care, 33*(11), 2477-2483. doi:10.2337/dc10-1079.

Manson, J.H., & Robbins, M. L. (2017). New evaluation of the Electronically Activated Recorder (EAR): Obtrusiveness, compliance and participant self- selection effects. *Frontiers in Psychology, 8,* 658. doi: 10.3389/fpsyg.2017.00658.

Marriott, R.W & Dillard, J.P. (2021). Sweet talk for voters: a survey of persuasive messaging in ten U. S. sugar-sweetened beverage tax referendums. *Critical Public Health, 31*(4), 477-486. doi: https://doi.org/10.1080/09581596.2020.1724263.

Marsh, S., Mhurchu, C. N., & Maddison, R. (2013). The non-advertising effects of screen-based sedentary activities on acute eating behaviours in children, adolescents, and young adults. A systematic review. *Appetite, 71*, 259 -273. http://dx.doi.org/10.1016/j.appet.2013.08.017.

Medic, N., Ziauddeen, H., Ersche, K. D., Farooqi, I. S., Bullmore, E. T., Nathan, P. J., Ronan, L., & Fletcher, P. C. (2016). Increased body mass index is associated with specific regional alterations in brain structure. *International Journal of Obesity, 40,* 1177 – 1182. doi:10.1038/ijo.2016.42.

Melbye, E. L., Bergh, I. H., Hausken, S. E. S., Sleddens, E. F. C., Glavin, K., Lien, N., & Bjelland, M. (2016). Adolescent impulsivity and soft drink consumption: The role of parental regulation. *Appetite, 96*, 432-442. doi:http://dx.doi.org/10.1016/j.appet.2015.09.040.

Melbye, E. L., & Helland, M. H. (2018). Soft drinks for lunch? Self-control, intentions and social influences. *British Food Journal, 120 (8),* 1735 – 1748. doi:10.1108/BFJ-11-2017-0605.

Meule, A., & Blechert, J. (2017). Interactive and indirect effects of trait impulsivity facets on body mass index. *Appetite, 118,* 60-65. http://dx.doi.org/10.1016/j.appet.2017.07.023.

Meule, A., Hofmann, J., Weghuber, D., & Blechert, J. (2016). Impulsivity, perceived self-regulatory success in dieting, and body mass in children and adolescents: A moderated mediation model. *Appetite, 107*, 15-20. http://dx.doi.org/10.1016/j.appet.2016.07.022.

Meule, A., Lukito, S., Vogele, C., & Kubler, A. (2011). Enhanced behavioural inhibition in restrained eaters. *Eating Behaviours, 12,* 152- 155. doi:10.1016/j.eatbeh.2011.01.006.

Millar, L., Rowland, B., Nichols, M., Swinburn, B., Bennett, C., Skouteris, H., & Allender, S. (2014). Relationship Between Raised BMI and Sugar Sweetened Beverage and High Fat Food Consumption Among Children. *Obesity, 22*, E96-E103. doi:10.1002/oby.20665.

Miller, A. L., Lee, H. J., & Lumeng, J. C. (2015). Obesity-associated biomarkers and executive function in children. *Pediatric research, 77*(1-2), 143-147. doi:10.1038/pr.2014.158.

Mills, K. L., Goddings, A-L., Clasen, L. S., Giedd, J. N., & Blakemore, S-J. (2014). The developmental mismatch in structural brain maturation during adolescence. *Developmental Neuroscience, 36,* 147 – 160. DOI: 10.1159/000362328

Mischel,W., & Ebbesen, E. B. (1970). Attention in delay of gratification. *Journal of Personality and Social Psychology, 16*(2), 329-337. doi:10.1037/h0029815.

Molteni, R., Barnard, R. J., Ying, Z., Roberts, C. K., & Gómez-Pinilla, F. (2002). A high-fat, refined sugar diet reduces hippocampal brain-derived neurotrophic factor, neuronal plasticity, and learning. *Neuroscience, 112*(4), 803-814. doi:10.1016/S0306-4522(02)00123-9.

Moran A., & Mullan, B. (2020). Exploring temporal self-regulation theory to predict sugar-sweetened beverage consumption. *Psychology and Health, 36,* 334 -350. https://doi.org/10.1080/08870446.2020.1774055.

Morris, M. J., Beilharz, J. E., Maniam, J., Reichelt, A. C., & Westbrook, R. (2015). Why is obesity such a problem in the 21st century? The intersection of palatable food, cues and reward pathways, stress, and cognition. *Neuroscience and Biobehavioral Reviews, 58*, 36-45.

National Health & Medical Research Council (NHMRC). 2013. *Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children in Australia.* Australian Government.

Nederkoorn, C., Dassen, F. C. M., Franken, L., Resch, C., & Houben, K. (2015). Impulsivity and overeating in children in the absence and presence of hunger. *Appetite, 93*, 57. doi:10.1016/j.appet.2015.03.032.

Nederkoorn, C., Houben, K., Guerrieri, R., Jansen, A., & Coelho, J. S. (2012). Specificity of the failure to inhibit responses in overweight children. *Appetite, 59*(2), 409-413. doi:10.1016/j.appet.2012.05.028.

Nederkoorn, C., Jansen, A., Jansen, E., & Mulkens, S. (2007). Impulsivity predicts treatment outcome in obese children. *Behaviour Research and Therapy, 45(5)*, 1071-1075. doi:10.1016/j.brat.2006.05.009.

Nelson, L. H., & McNamara Barry, C. (2005). Distinguishing features of emerging adulthood: The role of self-classification as an adult. *Journal of Adolescent Research, 20 (5),* 242-262. https://doi.org/10.1177/0743558404273074

Northstone, K., Joinson, C., Emmett, P., Ness, A., & Paus, T. (2012). Are dietary patterns in childhood associated with IQ at 8 years of age? A population-based cohort study. *Journal of Epidemiology and Community Health (1979-), 66*(7), 624-628. doi:10.1136/jech.2010.111955.

Nyaradi, A., Foster, J. K., Hickling, S., Li, J., Ambrosini, G. L., Jacques, A., & Oddy, W. H. (2014). Prospective associations between dietary patterns and cognitive performance during adolescence. *Journal of Child Psychology and Psychiatry, 55*(9), 1017-1024. doi:10.1111/jcpp.12209.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology, 51*(6), 768-774. doi:10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1.

Pecherro, P., Ayala-Nunes, L., Ray, J. V., Nunes, C., & Goncalves, R. A. (2016). The Barratt Impulsiveness Scale -11 among a school sample of Portugese male and female adolescents. *Journal of Child and Family Studies, 25,* 2753-2764. DOI 10.1007/s10826-016-0453-2.

Pender, S., Stevenson, R. J., Francis, H. M., & Oaten, M. J. (2019). Wanting and liking for sugar sweetened beverages and snacks differ following depletion and repletion with energy and fluids. *Appetite, 137,* 81-89. doi:https://doi.org/10.1016/j.appet.2019.02.014.

Pettigrew, S., Jongenelis, M., Chapman, K., & Miller, C. (2015). Factors influencing the frequency of children's consumption of soft drinks. *Appetite, 91*, 393-398. doi:http://dx.doi.org/10.1016/j.appet.2015.04.080.

Pietrzak, R. H., Sprague, A., & Snyder, P. J. (2008). Trait impulsiveness and executive function in healthy young adults. *Journal of Research in Personality, 42*(5), 1347-1351. doi:10.1016/j.jrp.2008.03.004.

Pursey K. M., Burrows, T.L., Barker, D., Hart, M., & Paxton S. J. (2021). Disordered eating, body image concerns, and weight control behaviors in primary school aged children: A systematic review and meta-analysis of universal–selective prevention interventions. *International Journal of Eating Disorders, 54,* 1739 – 1765. DOI: 10.1002/eat.23571.

Rada, P., Avena, N.M., & Hoebel, B. G. (2005). Daily bingeing on sugar repeatedly releases dopamine in the accumbens shell. *Neuroscience, 134, (3)*, 737-744. doi: 10.1016/j.neuroscience.2005.04.043

Reichelt, A. C., Killcross, S., Hambly, L. D., Morris, M. J., & Westbrook, R. F. (2015). Impact of adolescent sucrose access on cognitive control, recognition memory, and parvalbumin immunoreactivity. *Learning and Memory, 22*(4), 215-224. doi:10.1101/lm.038000.114.

Reid, M., Worsley, A., & Mavondo, F. (2015). The Obesogenic Household: Factors Influencing Dietary Gatekeeper Satisfaction with Family Diet. *Psychology & Marketing, 32*(5), 544-557. doi:10.1002/mar.20799.

Reicks, M., Baltaci, A., Alvarez de Davilla, S., Druziako,S., Hurtado, G. A., Overcash, F., Peralta, A. R., and Zhang, Y. Latino fathers promoting healthy behaviours. *Journal of Nutrition Education and Behaviour, 51, 7S,* NP16.

Reynolds, B., Ortengren, A., Richards, J. B., & de Wit, H. (2006). Dimensions of impulsive behavior: Personality and behavioral measures. *Personality and Individual Differences, 40*(2), 305-315. doi:10.1016/j.paid.2005.03.024.

Reynolds, B., Penfold, R. B., & Patak, M. (2008). Dimensions of impulsive behavior in adolescents: Laboratory behavioral assessments. *Experimental And Clinical Psychopharmacology, 16*(2), 124-131. doi:10.1037/1064-1297.16.2.124.

Reynolds, B., & Schiffbauer, R. (2005). Delay of gratification and delay discounting: A unifying feedback model of delay-related impulsive behavior. *Psychological Record, 55*(3), 439-460.

Reynolds, E. K., & Mayes, L. C. (2011). Impulsivity in Adolescents (Vol. 1): Oxford University Press. doi: 10.1093/oxfordhb/9780195389715.013.0132.

Robinson, E., Hardman, C. A., Halford, J. C.G., & Jones, A. (2015). Eating under observation: A systematic review and meta-analysis of the effect that heightened awareness of observation has on laboratory measured energy intake. *American Journal of Clinical Nutrition, 102,* 324 – 337. doi: 10.3945/ajcn.115.111195.

Rodgers, R., Chabroi, H., & Paxton, S. J. (2011). An exploration of the tripartite influence model of body dissatisfaction and disordered eating among Australian and French college women. *Body Image, 8,* 208-215. doi:10.1016/j.bodyim.2011.04.009.

Rodgers, R. F., Nichols, T. E., Damiano, S. R., Wertheim, E. H., & Paxton, S. J. (2019). Low body esteem and dietary restraint among 7-year old children: The role of perfectionism, low self-esteem, and belief in the rewards of thinness and muscularity. *Eating Behaviours, 32,* 65-68. https://doi.org/10.1016/j.eatbeh.2018.12.004

Romine, C. B., & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190.

Ross, A. P., Darling, J. N., & Parent, M. B. (2013). High energy diets prevent the enhancing effects of emotional arousal on memory. *Behavioral Neuroscience, 127*(5), 771-779. doi:10.1037/a0033732.

Ross, N., Yau, P. L., & Convit, A. (2015). Obesity, fitness, and brain integrity in adolescence. *Appetite, 93*, 44. doi:10.1016/j.appet.2015.03.033.

Schneider, S., Mata, J., & Kadel, P. (2020). Relations between sweetened beverage consumption and individual, interpersonal, and environmental factors: A 6-year longitudinal study in German children and adolescents. *International Journal of Public Health,65(5),* 559-570. https://doi.org/10.1007/s00038-020-01397-0.

Schuck, K., Munsch, S., & Schneider, S. (2018). Body image perceptions and symptoms of disturbed eating behavior among children and adolescents in Germany. *Child and Adolescent Psychiatry and Mental Health, 12 (10),* 1-11. https://doi.org/10.1186/s13034-018-0216-5.

Schulze, M. B., Manson, J. E., Ludwig, D. S., Colditz, G. A., Stampfer, M. J., Willett, W. C., & Hu, F. B. (2004). Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *Journal of the American Medical Association, 292*(8), 927-934. doi:10.1001/jama.292.8.927.

Scully, M., Morley, B., Niven, P., Crawford, D., Pratt, I. S., Wakefield, M. (2017). Factors associated with high consumption of soft drinks among Australian secondary-school students. *Public Health Nutrition, 20 (13),* 2340 – 2348. doi:10.1017/S1368980017000118.

Sheludiakova, A., Rooney, K., & Boakes, R. A. (2012). Metabolic and behavioural effects of sucrose and fructose/glucose drinks in the rat. *European Journal of Nutrition, 51*(4), 445-454. doi:10.1007/s00394-011-0228-x.

Shott, M. E., Cornier, M. A., Mittal, V. A., Pryor, T. L., Orr, J. M., Brown, M. S., & Frank, G. K. W. (2015). Orbitofrontal cortex volume and brain reward response in obesity. *International Journal of Obesity, 39*(2), 214-221. doi:10.1038/ijo.2014.121.

Smith, D. G., & Robbins, T. W. (2013). The neurobiological underpinnings of obesity and binge eating: A rationale for adopting the food addiction model. *Biological Psychiatry, 73*, 804-810. doi.org/10.1016/j.biopsych.2012.08.026.

Sparks, J. C., Isen, J.D., & Iacono, W. G. (2014). Preference on cash-choice task predicts externalizing outcomes in 17-year-olds. *Behaviour Genetics, 44,* 102 – 112. Doi http://dx.doi.org/10.1007/s10519-013-9638-2.

Stanford, M.S., Mathias, C.W., Dougherty, D.M., Lake, S.L., Anderson N.E., &Patton, J.H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47,* 385-395. doi:10.1016/j.paid.2009.04.008.

Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Sciences, 9*(2), 69-74. doi:10.1016/j.tics.2004.12.005.

Steinberg, L. (2010). A dual systems model of adolescent risk-taking. *Developmental Psychology, 52,* 216-224. doi 10.1002/dev.20445.

Tabachnick, B. G., & Fiddell, L.S. (2013). Using multivariate statistics. EsGender, United Kingdom: Pearson Education Limited.

Takeda, T. (2010). Parental ADHD status and its association with proband ADHD subtype and severity. *Journal of Pediatrics, 157*(6), 995-1000.e1001. doi:10.1016/j.jpeds.2010.05.053.

The Royal Australian College of General Practitioners. (2016). *General practice management of type 2 diabetes: 2016 -18*. East Melbourne, Vic: RACGP.

Unterwald, E. M., Kreek, M. J., & Cuntapay, M. (2001). The frequency of cocaine administration impacts cocaine-induced receptor alterations. *Brain Research, 900(1)*, 103-109. doi:http://dx.doi.org/10.1016/S0006-8993(01)02269-7.

Van der Horst, K., Kremers, S., Ferreira, I., Singh, A., Oenema, A., & Brug, J. (2007). Perceived parenting style and practices and the consumption of sugar-sweetened beverages by adolescents. *Health Education Research, 22*(2), 295-304. doi:10.1093/her/cyl080.

Van Lange, P.A.M, Schippers, M., & Balliet, D. (2011). Who volunteers in psychology experiments? An empirical review of prosocial motivation in volunteering. *Personality and Individual Differences, 51,* 279 – 284. doi:10.1016/j.paid.2010.05.038.

Van Opstal, A. M., Kaal, I., van den Berg-Huysmans, A.A., Blonk, C., Pijil, H., Rombouts, S. A. R.B., &van der Grond, J. (2019). Dietary sugars and non-caloric sweeteners elicit different homeostatic and hedonic responses in the brain *Nutrition ,60,* 80-85. https://doi.org/10.1016/j.nut.2018.09.004.

Vanderschuren, L. J. M. J., & Kalivas, P. W. (2000). Alterations in dopaminergic and glutamatergic transmission in the induction and expression of behavioral sensitization: a critical review of preclinical studies. *Psychopharmacology, 151(2*), 99-120. doi:10.1007/s002130000493

Verloigne, M., Van Lippevelde, W., Maes, L., Brug, J., & De Bourdeaudhuij, I. (2012). Family- and school-based correlates of energy balance-related behaviours in 10–12-year-old children: a systematic review within the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) project. *Public Health Nutrition, 15*(8), 1-16. doi:10.1017/S1368980011003168.

Volkow, N. D., Wang, GJ., Baler, R. D. (2011). Reward, dopamine and the control of food intake: Implications for obesity. *Trends in Cognitive Sciences, 15, (10),* 37-46.

Weinstein, G., Maillard, P., Himali, J. J., Beiser, A. S., Au, R., Wolf, P. A., . . . DeCarli, C. (2015). Glucose indices are associated with cognitive and structural brain measures in young adults. *Neurology, 84*(23), 2329-2337. Doi:10.1212/WNL.0000000000001655.

Whittingham, K., Sanders, M. R., McKinlay, L., & Boyd, R.N. Parenting intervention combined with acceptance and commitment therapy: Process of change. *Journal of Child and Family Studies, 28,* 1673 – 1680. https://doi.org/10.1007/s10826-019-01386-9.

Wulfert, E., Block, J. A., Santa Ana, E., Rodriguez, M. L., & Colsman, M. (2002). Delay of gratification: Impulsive choices and problem behaviors in early and late adolescence. *Journal of Personality, 70*(4), 533-552. doi:10.1111/1467-6494.05013.

Xu, T. J., & Reichelt, A. C. (2018). Sucrose or sucrose and caffeine differentially impact memory and anxiety-like behaviours, and alter hippocampal parvalbumin and doublecortin. *Neuropharmacology, 137*, 24-32. https://doi.org/10.1016/j.neuropharm.2018.04.012

Xu, S., Xiao, Z., & Rao, H. (2019). Hypothetical versus real monetary reward decrease the behavioral and affective effects in the balloon analogue risk task. Experimental Psychology, 66 (3), 221-230. doi: 10.1027/1618-3169/a000447.

Yau, P. L., Kang, E. H., Javier, D. C., & Convit, A. (2014). Preliminary evidence of cognitive and brain abnormalities in uncomplicated adolescent obesity. *Obesity, 22*(8), 1865-1871. doi:10.1002/oby.20801.

Zheng, M., Allman-Farinelli, M., Heitmann, B.L., Toelle, B., Marks, G., & Rangan, A. (2015). Liquid versus solid energy intake in relation to body composition among Australian children. *Journal of Human Nutrition and Dietetics, 28 (Supp 2),* 70-79. doi:10.1111/jhn.12223.

Appendices

Appendix A –Informed Consent first Year Psychology Students

Factors contributing to soft drink consumption

INFORMATION SHEET

Who is conducting the research

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Why is the research being conducted?
This research is interested in the relationship between food and beverage consumption. The aim of this research is to develop a greater understanding of what drives soft drink consumption. This research is funded by a grant from the Australian Research Council.

What you will be asked to do
You will be asked not to drink anything for 60 minutes prior to participation. You will be provided with a small sample of potato crisps while you complete some questionnaires asking questions about your age, usual soft drink consumption and personality. You will then be provided with some drink and asked to make ratings about that drink. The study will take approximately 30 minutes to complete.

The expected benefits of the research
This study should take approximately 30 minutes to complete. As a result, first year psychology pool participants will receive 0.5 participation credits for participating in this study (1 credit point = 1 hour of participation). The information participants provide will contribute to the existing literature by making an empirical link between factors involved in soft drink consumption.

The basis by which participants will be selected or screened
Participants must be aged between 17-21 years.

Risks to you
The risks involved in participating in this research are no greater than that arising from daily living. **Please notify the experimenter if you have diabetes or any medical condition that prevents you from consuming potato crisps and soft drink.**

Your confidentiality
Any information or personal details gathered in the course of the study are confidential. No individual will (or could) be identified in any publication of the results. Only the named investigators will have access to the data for the purposes of analysis and reporting.

Information containing registrations for course credit will be stored separately from the completed questionnaire responses. All research data (survey responses and analysis) will be retained in a password protected electronic file at Griffith University for a period of five years before being destroyed.

Your participation is voluntary

Participation is in this research is entirely voluntary. You are not obliged to participate and if you decide to participate you are free to withdraw at any time without having to give a reason and without consequence.

Questions / further information

All questions regarding this research should be directed to the investigator:
Robyn Stumm [email: robyn.stumm@griffithuni.edu.au]

The ethical conduct of this research

This project has been granted ethical approval through Griffith University Human Research Ethics Committee (GU ref no: 2016/777). Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research (2007). If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 3735 4375 or research-ethics@griffith.edu.au.

Feedback to you

A summary of results of the data will be available to participants on email request.

Expressing consent

Please complete the consent form attached.

Factors contributing to soft drink consumption

CONSENT FORM

Research Team

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By signing below, I confirm that I have read and understood the information package and in particular have noted that:

- I understand that my involvement in this research will include eating a small sample of potato crisps while I complete some questionnaires. I will then be provided with some drink and asked to make ratings about that drink, and then asked some more questions
- I do not have diabetes or any medical condition that prevents me from eating potato crisps and soft drink
- I have had any questions answered to my satisfaction;
- I understand the risks involved;
- I understand that there will be no direct benefit to me from my participation in this research;
- I understand that my participation in this research is voluntary and I can withdraw at any time without penalty or explanation;
- I understand that if I have any additional questions I can contact the research team;
- I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 4375 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and

☐ I agree to participate in the project.

☐ I agree to reporting of the results from this research.

Name	
Signature	
Date	

Appendix B- Informed Consent Prize Draw Griffith Undergraduate students

Factors contributing to soft drink consumption

INFORMATION SHEET

Who is conducting the research

Ms Robyn Stumm (PhD Candidate)
robyn.stumm@griffithuni.edu.au
School of Applied Psychology
Griffith University

Dr Megan Oaten (Primary Supervisor)
(07) 5678 0831
m.oaten@griffith.edu.au

Dr Stefano Occhipinti (Associate Supervisor)
s.occhipinti@griffith.edu.au

Why is the research being conducted?

This research is interested in the relationship between food and beverage consumption. The aim of this research is to develop a greater understanding of what drives soft drink consumption. This research is funded by a grant from the Australian Research Council.

What you will be asked to do

You will be asked not to drink anything for 60 minutes prior to participation. You will be provided with a small sample of potato crisps while you complete some questionnaires asking questions about your age, usual soft drink consumption and personality. You will then be provided with some drink and asked to make ratings about that drink. The study will take approximately 30 minutes to complete.

The expected benefits of the research

This study should take approximately 30 minutes to complete. As a result, participants recruited from the wider Griffith University population will go into a draw to receive a $50 gift voucher to be drawn on completion of the study. The information participants provide will contribute to the existing literature by making an empirical link between factors involved in soft drink consumption.

The basis by which participants will be selected or screened

Participants will be recruited from the Griffith University population. Participants must be aged between 18-21 years in order to participate.

Risks to you

The risks involved in participating in this research are no greater than that arising from daily living. **Please notify the experimenter if you have diabetes or any medical condition that prevents you from consuming potato crisps and soft drink.**

Your confidentiality

Any information or personal details gathered in the course of the study are confidential. No individual will (or could) be identified in any publication of the results. Only the named investigators will have access to the data for the purposes of analysis and reporting. Information containing registrations for course credit will be stored separately from the completed questionnaire responses. All research data (survey responses and analysis) will be retained in a password protected electronic file at Griffith University for a period of five years before being destroyed.

Your participation is voluntary

Participation is in this research is entirely voluntary. You are not obliged to participate and if you decide to participate you are free to withdraw at any time without having to give a reason and without consequence. Participants will still be eligible to enter into the prize draw even if they withdraw.

Questions / further information

All questions regarding this research should be directed to the investigator:
Robyn Stumm [email: robyn.stumm@griffithuni.edu.au]

The ethical conduct of this research

This project has been granted ethical approval through Griffith University Human Research Ethics Committee (GU ref no: 2016/777). Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research (2007). If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 3735 4375 or research-ethics@griffith.edu.au.

Feedback to you

A summary of results of the data will be available to participants on email request.

Expressing consent

Please complete the consent form attached.

How to enter

Thank you for participating in this study. Please email this code **SD12017** to the account *onlineprizedraw@gmail.com* so that you may enter the $50 Myer gift card prize draw to be drawn on study completion.

Terms and Conditions of Entry to Prize Draw

1. The prize draw is being run by Robyn Stumm (supervised by Dr Megan Oaten and Dr Stefano Occhipinti), of Griffith University to encourage participation in "Factors contributing to soft drink consumption" study.
2. By electing to participate, you accept these terms and conditions as governing the prize draw. Instructions on how to enter the prize draw and details advertising the survey form part of the conditions. Any personal information you provide to us in the course of entering the prize draw will be dealt with by us in accordance with our privacy policy.
3. One prize will be awarded in the prize draw, being a Myers voucher and being worth $50. Should the advertised prize become unavailable as a result of circumstances beyond our control, we are free (at our sole discretion) to substitute a cash prize equivalent to the value of the prize advertised.
4. Entry is free (other than the cost of accessing the website, which is your responsibility). Entry is open between 1st May 2017 and 30th of June 2017. Entries received after the closing date will not be accepted.
5. To enter the prize draw, you must:
    a. Be between 18-21 years of age;
    b. Be a participant in the study "Factors contributing to soft drink consumption" and
    c. Supply a valid email address.
6. You may not enter the prize draw if you are: i) a member of the research team, ii) employed by the research team; iii) an immediate family member (i.e. a spouse-partner, child or sibling) of the research team.

7. You may only submit one entry in the prize draw.
8. All survey and other materials provided by you become our property. No responsibility is taken for late, lost or misdirected surveys or entries.
9. Following the closing date, the prize winner will be selected randomly from valid entries received. Each entry can only be drawn once.
10. Subject to system malfunction, the draw will occur on 1st August 2017. If the systems supporting the draw are not functioning as they should when the draw is due, the draw will be held as soon as possible once the systems become functional again. Prize winners do not need to be present at the time of the draw.
11. Prize winner names will not be published.
12. The relevant prize will be sent to each prize winner at the email address provided with the prize draw entry. If an address has not been supplied, the entry will be treated in accordance with Clause 14. The prize will be emailed within two weeks of the draw.
13. The right to a prize is not transferable or assignable to another person.
14. If any prize winner cannot be contacted within three (3) months of the draw, then that person's right to the prize is forfeited and the prize will be treated as an unclaimed prize.
15. Only one redraw of unclaimed prizes will take place, and other existing prizes are not affected. The redraw prize winner(s) will be randomly selected from remaining valid entries and notified within two (2) weeks of the redraw. If the redraw prize winner(s) cannot be contacted within three (3) months of the redraw, then we may determine that the relevant prize(s) will not be awarded.
16. Prizes cannot be substituted for another prize at the election of the prize-winner.
17. We are not liable for any loss, expense, damage or injury sustained by any entrant in connection with this prize draw, the prize or redemption of the prize, except for any liability which cannot be excluded by law (in which case, that liability is limited to the minimum allowable by law).
18. We may suspend the promotion if we determine that the integrity or administration of the promotion has been adversely affected due to circumstances beyond its control. We may disqualify any individual who tampers with the entry process.

Factors contributing to soft drink consumption

CONSENT FORM

Research Team

Ms Robyn Stumm (PhD Candidate)
Robyn.stumm@griffithuni.edu.au

Dr Megan Oaten (Primary Supervisor)
(07) 5678 0831
m.oaten@griffith.edu.au

Dr Stefano Occhipinti (Associate Supervisor)
s.occhipinti@griffith.edu.au

By signing below, I confirm that I have read and understood the information package and in particular have noted that:

- I understand that my involvement in this research will include eating a small sample of potato crisps while I complete some questionnaires. I will then be provided with some drink and asked to make ratings about that drink, and then asked some more questions
- I do not have diabetes or any medical condition that prevents me from eating potato crisps and soft drink
- I have had any questions answered to my satisfaction;
- I understand the risks involved;
- I understand that there will be no direct benefit to me from my participation in this research;
- I understand that my participation in this research is voluntary and I can withdraw at any time without penalty or explanation;
- I understand that if I have any additional questions I can contact the research team;
- I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 4375 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and

☐ I agree to participate in the project.

☐ I agree to reporting of the results from this research.

Name	
Signature	
Date	

Appendix C- Participant Demographic Information

1. What is your age? (years) ____________
2. We will measure your weight (kg) ___________
3. We will measure your height (cm) ______________
4. Are you: (please tick)
   - ☐ Male
   - ☐ Female
5. When was the last time you had something to drink?
   - ☐ In the last hour
   - ☐ In the last two hours
   - ☐ 3 hours ago
   - ☐ More than 3 hours ago

For the following questions, please circle out of 10 (where 0 is not at all and 10 is very much)

6. (Prior to testing) How hungry are you right now?

   0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

7. (Prior to testing) How thirsty are you right now?

   0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

TO BE COMPLETED AFTER THE EXPERIMENT

For the following questions, please circle out of 10 (where 0 is not at all and 10 is very much)

8. How hungry are you right now?

   0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

9. How thirsty are you right now?

   0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

10. How much did you like the drink provided?

0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

11. How much do you like soft drink?

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

12. What is the name of your favourite soft drink ___________________

13. How much do you like cordial (e.g., concentrated syrup like raspberry or lime that you add water to)

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

14. How much do you like flavoured fruit drinks (e.g., fruit poppers like apple or orange?

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

15. How much do you like flavoured energy drinks (e.g., Powerade, Gatorade, V, Red Bull, Mother)?

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

16. How much do you like flavoured water drinks (e.g., vitamin water, iced teas or sparkling mineral water with fruit flavour)?

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

17. How much do you like plain unflavoured water?

    0(not at all)_1_2_3_4_5_6_7_8_9_10 (very much)

18. How often do you drink soft drink, cordial, energy, fruit type or flavoured mineral water drinks? (please tick one only)

    - ☐ every day
    - ☐ 6 days a week
    - ☐ 5 days a week
    - ☐ 4 days a week
    - ☐ 3 days a week
    - ☐ 2 days a week
    - ☐ 1 day a week

☐ only on special occasions

☐ never

19. When you drink soft drink, cordial, energy, fruit or flavoured mineral water drinks, how many glasses do you usually have each day?

(**NOTE. A standard glass is 250 ml, one popper equals 1 glass, one can of soft drink (375ml) equals 1.5 glasses, 1 bottle (6ooml) equals 2.5 glasses**)

☐ 1 glass

☐ 2 glasses

☐ 3 glasses

☐ 4 glasses

☐ 5 glasses

☐ 6 glasses

☐ 7 or more glasses

☐ none

20. What type of soft drinks or cordial do you usually drink?

☐ diet or sugar free

☐ regular

Appendix D- Barratt Impulsivity Scale – 11 Adolescent (BIS-11A)

Please circle the number that best matches your agreement with the following statements.

	Rarely/never	Occasionally	Often	Almost always/ always
1. I plan what I have to do	1	2	3	4
2. I do things without thinking	1	2	3	4
3. I make up my mind quickly	1	2	3	4
4. I am happy-go-lucky	1	2	3	4
5. I do not "pay attention"	1	2	3	4
6. My thoughts are racing too fast	1	2	3	4
7. I plan my spare time	1	2	3	4
8. I am self-controlled	1	2	3	4
9. I concentrate easily	1	2	3	4
10. I am a "saver"	1	2	3	4
11. I cannot stand still at movies or school	1	2	3	4
12. I like to think carefully about things	1	2	3	4
13. I plan for my future	1	2	3	4
14. I say things without thinking	1	2	3	4
15. I like to think about complex problems	1	2	3	4
16. I change my mind about what I will do when I grow up	1	2	3	4
17. I act "on impulse"	1	2	3	4
18. I get easily bored when solving 'thought' problems	1	2	3	4
19. I act on the spur of the moment	1	2	3	4
20. I am a great thinker	1	2	3	4
21. I change friends	1	2	3	4
22. I buy things on impulse	1	2	3	4
23. I can think about one problem at a time	1	2	3	4

	Rarely/never	Occasionally	Often	Almost always/ always
24. I change hobbies and sports	1	2	3	4
25. I spend more than I should	1	2	3	4
26. When I think about something, other thoughts pop up in my mind	1	2	3	4
27. I am more interested in the present than the future	1	2	3	4
28. I am restless at movies or lectures	1	2	3	4
29. I like to play chess or checkers	1	2	3	4
30. I am future oriented	1	2	3	4

Appendix E- Delay of Gratification Protocol

1. To be administered at the end of testing. Participants will be presented with the following instructions:
2. "We are interested in how people make decisions, so we are going to ask you to make a choice. As a token of our appreciation for your participation, we would like to offer you a cash bonus. You can either choose to have $7 right now [show cash to participant] or wait. If you wait, you will receive $10 in one week when you can come and collect it from Psychology reception [show cash and envelope to participant] to you. What would you like to do?"
3. If the participant chose the delayed reward, they were asked to write their name and student number on an envelope. The experimenter placed the $10 inside the envelope, sealed the envelope, put the future date for collection and put the envelope aside. Participants were provided with directions to Psychology reception and advised to collect their money in one week's time. Envelopes were taken to reception at the end of each day of testing
4. If the participant chooses $7, give them $7 cash.
5. Thank participant for participation and provide receipt for course credit if appropriate, or invited to enter the prize draw.
6. For participants who chose the delayed reward, Envelopes were taken to reception at the end of each day of testing.

Appendix F Alabama Parenting Survey (Child form)

Please circle the number that best matches your agreement with the following statements.

	Never	Almost Never	Sometimes	Often	Always
Positive parenting 1. Your parents let you know when you do a good job with something	1	2	3	4	5
10. Your parents praise you if you behave well	1	2	3	4	5
9. Your parents compliment you when you do something well	1	2	3	4	5
Inconsistent Discipline 2. Your parents threaten to punish you and then do not actually punish you	1	2	3	4	5
12. Your parents let you out of a punishment early (Like lift restrictions earlier than originally said)	1	2	3	4	5
5. You can talk your parents out of punishing you after doing something wrong	1	2	3	4	5
Poor Supervision 3. You don't leave a note or tell your parents where you are going	1	2	3	4	5
7. You stay out in the evening past the time you are supposed to be home	1	2	3	4	5
11. You go out with friends your parents don't know	1	2	3	4	5
Involvement 6. Your parents asked you about your day in School	1	2	3	4	5
8. Your parents helped you with homework	1	2	3	4	5
4. Your parents played games or do fun things with you	1	2	3	4	5
Corporal Punishment 15. Your parents hit you with a belt or other object when you did something wrong	1	2	3	4	5
13. Your parents spanked you when you did something wrong	1	2	3	4	5

	Never	Almost Never	Sometimes	Often	Always
14. Your parents slapped you when you did something wrong	1	2	3	4	5

Appendix G Parental Consent

Factors contributing to soft drink consumption

INFORMATION SHEET

Who is conducting the research

Ms Robyn Stumm (PhD Candidate)
robyn.stumm@griffithuni.edu.au
School of Applied Psychology
Griffith University

Dr Megan Oaten (Primary Supervisor)
(07) 5678 0831
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Dr Stefano Occhipinti (Associate Supervisor)
s.occhipinti@griffith.edu.au

Why is the research being conducted?

This research is interested in the relationship between food and beverage consumption. Young adolescents are the biggest consumers of soft drink. There is a strong link between soft drink consumption and obesity. Understanding what drives this behaviour is an important step in the process of combating obesity. The aim of this research is to develop a greater understanding of what drives soft drink consumption. This research is funded by a grant from the Australian Research Council and is being conducted at the Griffith University campus, Department of Applied Psychology behavioural laboratory.

What you will be asked to do

If you decide to take part, you will be with your son or daughter at all times. Your child will be provided with a small sample of potato crisps while they complete some questions about age, usual soft drink consumption and answering a personality type and parenting style questionnaire. They will then be provided with some drink and asked to make ratings about that drink. The study will take approximately 30 minutes to complete.

You will participate by answering some questions about age, usual soft drink consumption and a personality type and parenting style questionnaire.

The expected benefits of the research

You and your child will contribute to some valuable research and will each receive a $10 gift card as a 'thank you'

Risks to you

The risks involved in participating in this research are no greater than that arising from daily living.

Please notify the experimenter if your child has diabetes or any medical condition that stops them from eating potato crisps and drinking soft drink.

One of the questionnaires asks about parenting style, including discipline style. You do not have to answer any questions that make you feel uncomfortable.

Your confidentiality

Any information or personal details gathered in the course of the study are confidential. No individual will (or could) be identified in any publication of the results. Only the named investigators will have access to the data for the purposes of analysis and reporting**.** All research data will be stored in a password protected electronic file at Griffith University for a period of five years before being destroyed.

Your participation is voluntary

Participation is in this research is entirely voluntary. You are under no obligation to take part and if you decide to participate you are free to withdraw from the study at any time without having to give a reason and without consequence.

Questions / further information

All questions regarding this research should be directed to the investigator:
Robyn Stumm [email: robyn.stumm@griffithuni.edu.au]
Results from this research will be reported in an academic thesis and disseminated via journal articles and conference presentations.

The ethical conduct of this research

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research (2007). If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 3735 4375 or research-ethics@griffith.edu.au.

Privacy Statement

The conduct of this research involves the collection, access and/or use of your de-identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information consult the University's Privacy Plan at http://www.griffith.edu.au/about-griffith/plans-publications/griffith-university-privacy-plan or telephone (07) 3735 4375.

Feedback to you

A summary of results of the data will be available on email request at project completion.

Expressing consent

Please complete the consent below.

Factors contributing to soft drink consumption

PARENT CONSENT FORM

Research Team

Ms Robyn Stumm (PhD Candidate)
Robyn.stumm@griffithuni.edu.au

Dr Megan Oaten (Primary Supervisor)
(07) 5678 0831
m.oaten@griffith.edu.au

Dr Stefano Occhipinti (Associate Supervisor)
s.occhipinti@griffith.edu.au

By signing below, I confirm that I have read and understood the information package and in particular have noted that:

- I understand that my child's involvement in this research will include eating a small sample of potato crisps while they complete some questionnaires around age, usual soft drink consumption and personality type and parenting style. They will be provided with some drink and asked to make ratings about that drink, and then asked some more questions
- My child does not have diabetes or any medical condition that prevents them from eating potato crisps and soft drink
- I have explained the experiment to my child and they understand what will be required of them and they consent to participating in the study
- I understand my participation will involve answering questions around age, usual soft drink consumption, and a personality type and parenting style questionnaire
- I have had any questions answered to my satisfaction;
- I understand the risks involved;
- I understand that there will be no direct benefit to me from participation in this research;
- I understand that my participation in this research is voluntary and I can withdraw my child at any time without penalty or explanation;
- I understand that if I have any additional questions I can contact the research team;
- I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 4375 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project
- I provide consent for my child to participate in this research
- I agree to participate in this research
- I agree to reporting of results from this research in an academic thesis and disseminated via journal articles and conference presentations.

Name	
Signature	
Relationship to child	
Date	

Please complete all the questions below:

Number of children participating today______________________________

Q1 What is your age in years?

____

2 What is your gender?

O Male (1)

O Female (2)

Q3 What is your height in cm?

____

Q4 What is your weight in Kg?

____

Appendix H Parent Barratt Impulsiveness Scale

Barratt Impulsiveness Scale – 11 Adult

(BIS-11A)

Please circle the number that best matches your agreement with the following statements.

	Rarely/n ever	Occa sionally	ften	Al most always/ always
31. I plan tasks carefully	1	2		4
32. I do things without thinking	1	2		4
33. I make up my mind quickly	1	2		4
34. I am happy-go-lucky	1	2		4
35. I do not “pay attention”	1	2		4
36. I have “racing” thoughts	1	2		4
37. I plan trips well ahead of time	1	2		4
38. I am self-controlled	1	2		4
39. I concentrate easily	1	2		4
40. I save regularly	1	2		4
41. I “squirm” at plays or lectures	1	2		4
42. I am a careful thinker	1	2		4
43. I plan for job security	1	2		4
44. I say things without thinking	1	2		4
45. I like to think about complex problems	1	2		4
46. I change jobs	1	2		4
47. I act “on impulse”	1	2		4
48. I get easily bored when solving ‘thought’ problems	1	2		4
49. I act on the spur of the moment	1	2		4

	Rarely/n ever	Occa sionally	ften	Al most always/ always
50. I am a steady thinker	1	2		4
51. I change residences	1	2		4
52. I buy things on impulse	1	2		4
53. I can only think about one problem at a time	1	2		4
54. I change hobbies	1	2		4
55. I spend more than I earn	1	2		4
56. I often have extraneous thoughts when thinking	1	2		4
57. I am more interested in the present than the future	1	2		4
58. I am restless at theatres or lectures	1	2		4
59. I like puzzles	1	2		4
60. I am future oriented	1	2		4

Appendix I Parent Alabama Parenting Scale

Please circle the number that best matches your agreement with the following statements.

	Never	Almost Never	Sometimes	Often	Always
1. You let your child know when he/she is doing a good job with something	1	2	3	4	5
2. You threaten to punish your child and then do not actually punish them	1	2	3	4	5
3. Your child fails to leave a note or tell you where they is going	1	2	3	4	5
4. You play games or do fun things with your child	1	2	3	4	5
5. Your child can talk you out of punishing them after doing something wrong	1	2	3	4	5
6. You ask your child about their day at school	1	2	3	4	5
7. Your child stays out in the evening past the time they are supposed to be home	1	2	3	4	5
8. You help your child with their homework	1	2	3	4	5
9. You compliment your child when they do something well	1	2	3	4	5
10. You praise your child if they behave well	1	2	3	4	5
11. Your child goes out with friends you don't know	1	2	3	4	5
12. You let your child out of a punishment early (Like lift restrictions earlier than originally said)	1	2	3	4	5
13. You spank your child when he/she has done something wrong	1	2	3	4	5
14. You slap your child when he/she has done something wrong	1	2	3	4	5
15. You hit your child with a belt or other object when he/she has done something wrong	1	2	3	4	5

Please give this to the researcher and wait for your child to finish. Thank you again for participating in this research project.

Appendix J- Delay of Gratification Protocol (Child)

1. To be administered at the end of testing. Participants will be presented with the following instructions:
2. "We are interested in how people make decisions, so we are going to ask you to make a choice. As a token of my appreciation for your participation, I would like to offer you a cash bonus. You can either choose to have $5 right now or wait. If you wait, you will receive $7 in one week. What would you like to do??"
3. If the participant chose the delayed reward, the experimenter placed the $7 inside the envelope, sealed the envelope, put the future date for collection and put the envelope aside.
4. If the participant chooses $5, give them $5 cash.
5. Thank participant and parent for participation and envelope to parent for provision to child in one weeks time.

Appendix K Advertising Flyer Study 3

Soft Drink Consumption Study

We want to develop a better understanding of why people drink soft drink.

If you are the parent of a child/adolescent aged between 10 and 12 years and are able to accompany your son or daughter to Griffith University –campus for 30 minutes of research testing, we need you.

Please contact Robyn Stumm (Email: robyn.stumm@griffithuni.edu.au), School of Applied Psychology, Griffith University, for more details.

(GU Ref No. : 2018/781)

ALL PARTICIPANTS WILL BE FINANCIALLY COMPENSATED FOR THEIR TIME.

Thanks for your help

robyn.stumm@griffithuni.edu.au

Appendix K School Newsletter Article Study 3

Griffith University Soft Drink Consumption Study

We want to develop a better understanding of why people drink soft drink.

If you are the parent of a child/adolescent aged between 10 and 12 years and are able to accompany your son or daughter to Griffith University – Mt Gravatt Campus for 30 minutes of research testing, please contact Robyn Stumm (Email: robyn.stumm@griffithuni.edu.au), School of Applied Psychology, Griffith University, for more details.

ALL PARTICIPANTS WILL BE FINANCIALLY COMPENSATED FOR THEIR TIME.

Thanks very much!

robyn.stumm@griffithuni.edu.au