Reducing Soft Drink Consumption Using Nudges

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ABSTRACT

The overconsumption of soft drink is an emerging health issue due to its high sugar content. This has led several countries to implement strategies to reduce soft drink consumption, such as taxation, restricting access to soft drinks in certain environments, and introducing health-related warning labels. While each of these strategies has shown varying levels of success, an alternative strategy could have more success without limiting freedom of choice, nor financially disadvantaging those who choose to drink soft drink. One such strategy is a behaviour change strategy called nudging, which has shown success in promoting healthier eating behaviours. The overarching aim of the present thesis was to investigate the socio-cognitive factors associated with soft drink consumption, and design interventions that use nudges to increase healthy beverage choices. The present thesis contained five studies, collated in three chapters.

Study 1 (Chapter 1) presents a systematic literature review and meta-analysis that aimed to identify the socio-cognitive determinants associated with the amount and frequency of sugar-sweetened beverage consumption. The results from the meta-analysis showed that the determinants most strongly associated with sugar-sweetened beverage consumption were those that were part of the Theory of Planned Behaviour (i.e., attitudes, subjective norms, and perceived behavioural control) as well as habits. It was suggested that nudging interventions should be based on the components of the theory and target habits to be maximally effective at reducing sugar-sweetened beverage consumption.

Studies 2 and 3 (Chapter 2) investigated whether subtle wrap-based nudges on a vending machine could influence beverage choices in both a laboratory (Study 2) and an online study (Study 3). Across three types of wrap-based nudges (cues, branding, and colour), there was no significant influence on beverage choice. However, the control vending machine (coloured black) in Study 3 significantly increased caffeine-based choices.

Study 4 (Chapter 3) investigated whether featuring a traffic light system on a vending machine could influence beverage choices. Results showed that it did not. Study 5 expanded the design to include a condition that increased the range of healthy beverages, plus a condition that combined this with traffic lights. Increasing the healthy range resulted in a small but significant increase in healthy beverage choices, and when combined with traffic lights produced a larger increase in healthy beverage choices; in fact, it was the only condition that showed more healthy than unhealthy choices.

Overall, the present thesis provides promising interventions to reduce soft drink consumption by offering a practical and effective approach based on nudging consumers towards healthier beverage choices. The thesis provides evidence that subtle nudges (i.e., branding, pictured

beverages, or colours) may be less effective at reducing soft drink choices, whereas using more explicit nudges (i.e., featuring traffic lights, and increasing the healthy range) or combining nudges are likely a more successful approach towards reducing soft drink choices.

DECLARATION

I certify that this thesis:

1. does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university

2. and the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and

3. to the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: Ryan Calabro

Date: 17/11/2022

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CHAPTER 1: GENERAL INTRODUCTION

Chapter Overview

This opening chapter aims to provide relevant background information about soft drink consumption, outline several strategies that have been used to reduce its consumption, and propose an alternative strategy based on an approach used to encourage healthier eating behaviour. In particular, the average levels of soft drink consumption and related health issues are detailed, and strategies such as taxing soft drinks, changing the accessibility to soft drinks, and featuring warning labels on soft drinks are discussed. Nudging is then outlined and proposed as a potential alternative strategy for reducing soft drink consumption. The Theory of Planned Behaviour is also introduced, with a proposal that the most effective nudges should focus on each of the components of the theory. Finally, the chapter presents the overall aim of the thesis and its specific sub-aims addressed in the subsequent chapters.

Soft Drink Consumption and Health Concerns

Soft drinks are a commonly consumed beverage across the world (Grand View Research, 2021), with the majority of people in many different countries consuming at least one soft drink every day (Ferreira et al., 2022). Soft drinks are defined as carbonated beverages which usually contain large amounts of added sugar, up to 60 grams per serving (Australian Bureau of Statistics, 2022). Due to the high amount of sugar contained in soft drinks, a single serving (i.e., one glass, bottle, or can) will usually exceed the daily limit of 50 grams of added sugar proposed by the World Health Organisation (World Health Organization, 2015). This overconsumption of sugar puts many individuals at an elevated risk of developing health problems such as diabetes, tooth decay, cancer, and obesity (Bassett et al.,

2020; Basu et al., 2013; Tahmassebi & BaniHani, 2019). Importantly, the core consumers of soft drink are young people, who are more at risk of developing lifelong unhealthy habits (Ferreira et al., 2022). It should also be noted that there are diet and sugar-free varieties of soft drink, which contain alternatives to sugar. These were not the focus of the current thesis, which was to reduce health issues associated with consuming high amounts of added sugar.

Many people do not know the amount of sugar contained within one serving of soft drink, and thus are unaware of the health risks associated with the overconsumption of sugar from soft drinks (Miller et al., 2019). There are many places where soft drinks are available for purchase, such as supermarkets, fast food outlets, convenience stores, and petrol stations, but one significant source of soft drinks is vending machines (Grand View Research, 2019). Vending machines are a worldwide market that continues to grow every year, with an expected compound annual growth rate of 9.4% until 2025 (Grand View Research, 2019). This growth is due to an increasing demand for on-the-go snacks and drinks, with vending machines able to provide easy 24/7 access in commercial and public areas (Grand View Research, 2019).

Approaches for Reducing Soft Drink Consumption

To combat the health problems related to the overconsumption of soft drink, many countries have implemented strategies aimed at reducing consumption (Fernandes, 2008; Teng et al., 2019; Terry-McElrath et al., 2013). One of the most popular strategies that has been used across various countries is the introduction of an additional tax on soft drinks (Teng et al., 2019), which has shown to be successful in reducing average daily intake (Teng et al., 2019). However, research has shown that a soft drink tax is only supported by the majority of the public under very specific

circumstances, namely when the tax is used as a strategy to reduce obesity or when the revenue is used for health initiatives (Eykelenboom et al., 2019). It has also been reported that a soft drink tax may disadvantage lower sociodemographic groups (Backholer et al., 2016). Another potential issue with a soft drink tax is that other high sugar items (e.g., chocolate and lollies) that do not have an additional tax may be purchased instead (Nakhimovsky et al., 2016).

Another strategy for reducing soft drink consumption that has been implemented in several countries, is changing the availability of soft drinks in certain environments. For example, soft drinks have been removed for purchase from locations such as schools (Fernandes, 2008; Terry-McElrath et al., 2013), universities (Howse et al., 2017), and hospitals (Tinney et al., 2021). In the case of removing soft drinks from schools, studies have reported mixed success in reducing overall soft drink consumption (Fernandes, 2008; Terry-McElrath et al., 2013). One of the problems identified with this approach, is that the soft drink consumption at school can be replaced with consumption outside of the school environment where access to soft drinks is not restricted (Fernandes, 2008; Terry-McElrath et al., 2013). In addition, the removal of soft drinks from school and work environments has been found to be unsupported by the public as it is considered an infringement on freedom of choice (Howse et al., 2017).

Yet another strategy that has been adopted in a number of countries is featuring warning labels on soft drinks (Bollard et al., 2016; Donnelly et al., 2018; Mantzari et al., 2020). For example, Chile recently introduced a mandatory labelling system that requires high sugar items to have large and easily identifiable warning labels on the front of the packaging that clearly indicate the high sugar content

(Taillie et al., 2020). Research has suggested that this system may be successful in reducing sugar sweetened beverage consumption (Taillie et al., 2020). However, it is possible that results may not be maintained beyond the initial introduction of the labelling requirement and consumption may eventually return to levels before its introduction.

All the above-mentioned approaches mostly rely on explicitly changing policy related to soft drink consumption, which usually requires the government to change policy that potentially erodes freedom of choice. These approaches also rely on the public responding positively to the change and not coming up with ways to circumvent them. An alternative style of approach to reducing soft drink consumption, is to implicitly guide people to resist purchasing soft drinks and encourage them to purchase healthier beverages instead.

Nudging and Soft Drink Consumption

One such approach to implicitly steer consumers is by way of a behaviour change strategy called nudging. Nudging typically involves implicit methods designed to procure a desired behaviour without removing choice or changing economic incentives (Hummel & Maedche, 2019). Nudging is based on the idea of 'libertarian paternalism', where freedom of choice is respected but behaviour is purposely influenced towards a desired behaviour, as people's preferences and choices are often ill-formed because they are often influenced by the default position (Sunstein & Thaler, 2003). A recent review of nudging interventions by Mertens et al. (2022) found that those which target the structure of alternative choices (e.g., changing range or composition of options or changing the default option) outperform interventions that focus on the reinforcement of behavioural intentions (e.g.,

encouraging self-control) or the description of alternative choices (e.g., including relevant information about choices).

Nudging has been used successfully across various domains to elicit more responsive road use behaviour (Rubaltelli et al., 2021), promote sustainable energy use (Gillingham & Tsvetanov, 2018), and encourage healthier eating (Kroese et al., 2016). Over recent years, nudging has grown in popularity in the food domain. Indeed, a recent review by Mertens et al. (2022) found that food choices are most responsive to nudging, with effect sizes up to 2.5 times larger than nudges in other behavioural domains. While introducing mandatory labelling could be an effective approach to increasing healthy eating behaviour, there are more implicit approaches that could be just as effective. For example, some successful nudging methods used to encourage healthy eating behaviours include repositioning healthy food items closer to the consumer in different contexts (Bucher et al., 2016; Kroese et al., 2016), such as placing healthy food items at eye level shelf locations in a supermarket (Bucher et al., 2016), listing healthy food at the top of menus and online food ordering apps (Keegan et al., 2019; Stuber et al., 2022), or serving food on different coloured plates (Akyol et al., 2018; Genschow et al., 2012).

While nudging has shown success in reducing unhealthy food consumption, at present relatively few studies have tested whether nudging can have the same success for reducing soft drink consumption, and some of the methods used for food consumption may prove successful for reducing soft drink consumption. The research to date that has focussed on using nudges for soft drinks has focussed on listing diet soft drinks before regular soft drinks at fast food kiosks (Schmidtke et al., 2019), signposting tax increases for soft drinks in a simulated online supermarket

(Zizzo et al., 2021), moving soft drinks to the bottom shelf of fridges in a school canteen (Mikkelsen et al., 2021), and using red glasses to reduce soft drink consumption (Akyol et al., 2018; Genschow et al., 2012).

As vending machines are a common source of soft drinks (Grand View Research, 2019), nudges that focus on vending machines may prove to be an important approach for reducing soft drink consumption. One potential avenue for using nudges on vending machines is by altering the appearance of the machine. Vending machines typically have wraps (the outside design of the vending machine) which usually feature an advertisement for a particular beverage that is available in the machine. The vending machine wrap offers a potential way to include a nudge to influence the choice of a beverage from the machine. For example, many vending machines are wrapped in promotional material that advertises a particular brand available in the machine (e.g., Coke) which may influence the purchase of a soft drink. By featuring a promotional material that advertises a healthier brand available in the machine (e.g., Mt. Franklin – a popular brand of water in Australia), this could influence consumers to purchase a beverage consistent with the advertising (i.e., purchasing water instead of a soft drink). It is also possible that the wrap does not need to explicitly advertise a product, but could instead feature a representation of the product without any cues to the brand name (e.g., a picture of a brown fizzy beverage in a glass representing Coke) and still exert the same influence on beverage choice. Therefore, featuring a representation of a healthier product on the wrap (e.g., a glass of water) could promote healthier beverage choices. Another potential influence on choice could simply be the colour of the vending machine representing a particular brand that the colour is associated with (e.g., a red vending machine representing Coke). Therefore, a blue vending machine (i.e., the same

colour as the popular Australian brand of water – Mt. Franklin) could promote healthier choices (e.g., water choices) from the vending machine.

The Theory of Planned Behaviour and Soft Drink Consumption

While subtle nudges like the ones mentioned above may prove effective at reducing soft drink consumption, an alternative approach could be to target the socio-cognitive components that lead to the resultant consumption behaviour. One theory that has been used to investigate the socio-cognitive precursors to a range of consumption and other health behaviours is the Theory of Planned Behaviour (Ajzen, 1991). This theory proposes that there are three main components that precede and lead to the intention to perform a behaviour. One of these three preceding components is an individual's attitude towards the behaviour. This represents whether an individual thinks positively or negatively about performing a certain behaviour. For example, for soft drink consumption, if someone thinks consuming soft drink is a good thing, they would be more likely to have a positive attitude towards soft drink, and therefore be more likely to consume it. The next socio-cognitive component is the norms pertaining to the behaviour. There are different types of norms that may be related to the target behaviour: descriptive norms, injunctive norms, and social norms. Descriptive norms represent the perception of how often others are perceived to be performing the behaviour. For example, if an individual thinks that others often consume soft drink, then they may be more likely to consume it themselves. Injunctive norms represent the perception of what others think about whether someone should be performing the behaviour or not. For example, if someone perceives that others think that they should limit their soft drink consumption, then they may be more likely to limit their own consumption. Finally, social norms represent the perception of what attitudes others have about

performing the behaviour. For example, if someone thinks others have a positive attitude towards soft drink consumption, then they might be more likely to consume it. The final component is perceived behavioural control, which relates to how well someone thinks they can control the behaviour. For example, how well someone thinks that they can control their soft drink consumption.

Although nudges are generally thought to act on the automatic decision-making process, they could also affect the more explicit and reflective decision-making process (Mertens et al., 2022). Nudges designed to target components of the Theory of Planned Behaviour may be more likely to affect this latter system. While the components of the Theory of Planned Behaviour typically require actions that would reflect the explicit and conscious decision-making process, these components may equally be influenced by the implicit, unconscious decision-making process (Evans & Stanovich, 2013).

The Theory of Planned Behaviour has been shown to explain a significant amount of variance in soft drink consumption behaviour (studies report ranges from 27–68%), with attitude found to be the strongest component leading to the intention of consuming soft drinks (studies report correlations ranging from r = .38 – .76), followed by perceived behavioural control (r = .38 – .57), and subjective norms (r = .18 – .42) (Kassem & Lee, 2004; Kassem et al., 2003; Seyed Mortaza et al., 2019; Zoellner et al., 2012). The theory has also been used to design interventions that have successfully reduced unhealthy food consumption (McDermott et al., 2015), and soft drink consumption (Gregorio-Pascual & Mahler, 2020). For example, Gregorio-Pascual and Mahler (2020) designed an intervention that targeted all three components of the theory. In particular, they provided information about the health

risks of consuming such beverages (attitudes), implemented action plans about consuming healthy beverages and resisting tempting situations to consume unhealthy beverages (perceived behavioural control), and provided accurate social and injunctive norms about soft drink consumption (subjective norms). They found that each component of the intervention resulted in greater intentions to reduce soft drink consumption, with those who used the action plan (perceived behaviour control) reporting significantly lower soft drink consumption at follow-up than a control group.

Based on the Theory of Planned Behaviour, nutritional labelling is a potential intervention that could target the attitude and perceived behavioural control components of the theory. There are many different types of nutritional labelling systems that have been used, such as a health warning (e.g., warning of health risk associated with consumption), nutrient warning (e.g., warning about high levels of a specific nutrient), nutritional score (e.g., A to E rating system for overall nutrition), and the traffic light system (Song et al., 2021). The traffic light system involves visual cues based on traffic light colours (green, amber, and red) to represent the overall nutritional value of food and beverages, and thus offers an easy-to-understand way to identify healthy and unhealthy beverages. Within the context of the Theory of Planned Behaviour, it could target the attitude component by invoking negative attitudes towards beverages that are classified unfavourably (e.g., amber, or red) or the perceived behavioural control component by providing an easy-to-understand reference for choosing a healthy beverage that increases the confidence of the consumer to make a more informed healthier choice. The effectiveness of the traffic light system was recently supported by a review of nutritional labelling systems, which found the traffic light system to be one of the best at nudging consumers

towards purchasing healthier food products (Song et al., 2021). However, the traffic light system on its own does not provide any normative information. One way of providing such information could involve restocking a vending machine to give the impression that particular items (e.g., green) are more popular than other items (e.g., amber or red). This could be achieved by filling the vending machine with a higher ratio of healthy items and placing them in the most noticeable locations (e.g., eye-level), and placing unhealthy items more peripherally (e.g., at the bottom of the machine). These alterations to proportions and locations were proposed by recent guidelines from the Victorian Healthy Eating Advisory Service for stocking vending machines to promote healthier choices (2022).

Aims and Overview of the Present Thesis

The overarching aim of the thesis was to determine the socio-cognitive determinants that are most associated with soft drink consumption, and to examine the use of nudging to reduce soft drink consumption by targeting some of these determinants. Each individual study in the thesis had its own specific aims. In particular, Study 1 (Chapter 2) evaluated existing research on the socio-cognitive determinants associated with sugar sweetened beverage consumption by performing a systematic literature review and meta-analysis. Studies 2 and 3 (Chapter 3) evaluated the effectiveness of using wrap-based nudges (branding, cueing, and colour) on vending machines to reduce soft drink choices from a digital vending machine. Studies 4 and 5 (Chapter 4) investigated the effectiveness of featuring a traffic light system and increasing the healthy range of beverages in a vending machine on reducing soft drink choices. While Study 1 (Chapter 2) focused on individual factors, Studies 2-5 (Chapters 3 and 4) focused on factors outside of the individual. Chapter 5 draws together the entire body of work and presents a general

discussion of the main findings from each study as well as practical and theoretical implications, limitations, and recommendations for future research. Apart from Chapter 1 and Chapter 5, all chapters presented in the current thesis are formatted as manuscripts for publication. Specifically, Chapter 2 (Study 1) has been published, Chapter 3 (Studies 2 and 3) is currently under revision, and Chapter 4 (Studies 4 and 5) is currently under review. As these are manuscripts prepared for publication, there is some repetition of the background information included in the introductions of each of the corresponding chapters.

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CHAPTER 2: SOCIO-COGNITIVE DETERMINANTS OF SUGAR-SWEETENED BEVERAGE CONSUMPTION AMONG YOUNG PEOPLE: A SYSTEMATIC REVIEW AND META-ANALYSIS

For the published version of this chapter, see:

Calabro, R., Kemps, E., & Prichard, I. (2022). Socio-cognitive determinants of sugar-sweetened beverage consumption among young people: A systematic review and meta-analysis. *Appetite*, *180*, 106334. https://doi.org/10.1016/j.appet.2022.106334

Abstract

The overconsumption of sugar sweetened beverages is an increasing public health concern. Understanding the socio-cognitive determinants that drive such consumption could inform the development of interventions to reduce sugar sweetened beverage consumption. The aim of the present review and meta-analysis was to determine the strength of associations between socio-cognitive determinants and the amount and frequency of sugar sweetened beverage consumption among young people. A systematic review was conducted in accordance with PRISMA guidelines. A search was performed using the following databases: PsycINFO, MEDLINE, Scopus, ProQuest, and PubMed. The key search terms were: (1) children, adolescents, young adults; (2) sugar sweetened beverage consumption, choice or purchasing behaviour; and (3) socio-cognitive determinants related to sugar sweetened beverage consumption. The search identified 4325 papers, with 22 papers remaining after screening. Two separate meta-analyses were performed, one for amount (n = 14) and one for frequency (n = 8) of consumption. The most strongly associated determinants with amount of sugar sweetened beverage consumed were habit, intention to consume, and attitudes, whereas the most strongly associated determinants with frequency of consumption were intentions, injunctive norms, and

descriptive norms. Comparisons between the meta-analyses revealed two distinct differences: injunctive norms were more strongly correlated with frequency of consumption, and self-efficacy with amount consumed. It was suggested that interventions that focus on multiple determinants, including components of the Theory of Planned Behaviour may result in the largest reductions in consumption. Specifically, focussing on changing attitudes, norms and habits, and increasing perceived behavioural control related to sugar sweetened beverages may be maximally effective in reducing consumption behaviour.
Keywords: sugar sweetened beverages; consumption; socio-cognitive determinants; Theory of Planned Behaviour; young people; meta-analysis

Introduction

The overconsumption of sugar sweetened beverages is an increasing public health concern worldwide (Tahmassebi & BaniHani, 2020). Sugar-sweetened beverages are drinks that contain free sugar, that is, any sugar that is added during the manufacturing process. This includes soft drinks, some fruit juices, energy drinks, and some caffeinated beverages, but not diet or sugar-free variants of these types of beverages. Due to their high sugar content, the overconsumption of sugar sweetened beverages can lead to health problems, such as tooth decay, diabetes, and heart disease (Basu et al., 2013; Çetinkaya & Romaniuk, 2020). Of particular concern is that the core consumers of sugar sweetened beverages are young adults and adolescents (Australian Bureau of Statistics, 2018), who are particularly sensitive to developing lifelong habits. The World Health Organization (WHO) (2015) recently halved the recommended daily intake of free sugars in their guidelines from 10% down to 5% of total daily energy intake. This change puts people in many

countries at risk of over-consumption of free sugars, of which sugar sweetened beverages are one of the largest sources (Australian Bureau of Statistics, 2018).

Many determinants have been correlated with consumption of sugar sweetened beverages. These can broadly be divided into two types: (1) demographic determinants and (2) behavioural determinants. Demographic determinants are those that are mostly outside of one's behavioural control, such as age, gender, education, and socio-economic status. Behavioural determinants are more often within one's behavioural control, such as intentions, attitudes, and perceived behavioural control. Both types of determinants are important to consider in identifying the drivers of sugar sweetened beverage consumption. While some demographic determinants such as age, gender and socio-economic status can be strong drivers of sugar sweetened beverage consumption, these cannot easily be changed. Hence, most previous research has focussed on targeting behavioural determinants as part of interventions to decrease sugar sweetened beverage consumption (Gregorio-Pascual & Mahler, 2020; Zoellner et al., 2012; Zoellner et al., 2016). For example, changing an individual's attitudes toward sugar sweetened beverages is possible by providing information about the health risks of consuming such beverages (Gregorio-Pascual & Mahler, 2020).

The literature to date has mostly focussed on behavioural determinants that are related to the Theory of Planned Behaviour. This theory links an individual's beliefs to resultant behaviour through three components, namely attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991). Attitudes refer to an individual's thoughts about an action being favourable or unfavourable. In relation to sugar sweetened beverage consumption, if an individual's attitudes towards sugar

sweetened beverages are positive (i.e., they generally think of sugar sweetened beverages as a good thing), then they may be more likely to consume sugar sweetened beverages. Subjective norms are an individual's beliefs about whether others would approve or disapprove of an action. Applied to sugar sweetened beverage consumption, this relates to whether an individual thinks most people would approve of drinking sugar sweetened beverages, and if they do, then they may be more likely to consume sugar sweetened beverages. Perceived behavioural control is an individual's evaluation of the difficulty or ease of performing a certain action. In the context of sugar sweetened beverage consumption, this is whether an individual believes they would find it easy to limit their consumption, and if they do believe that it is easy, then they may be less likely to consume sugar sweetened beverages.

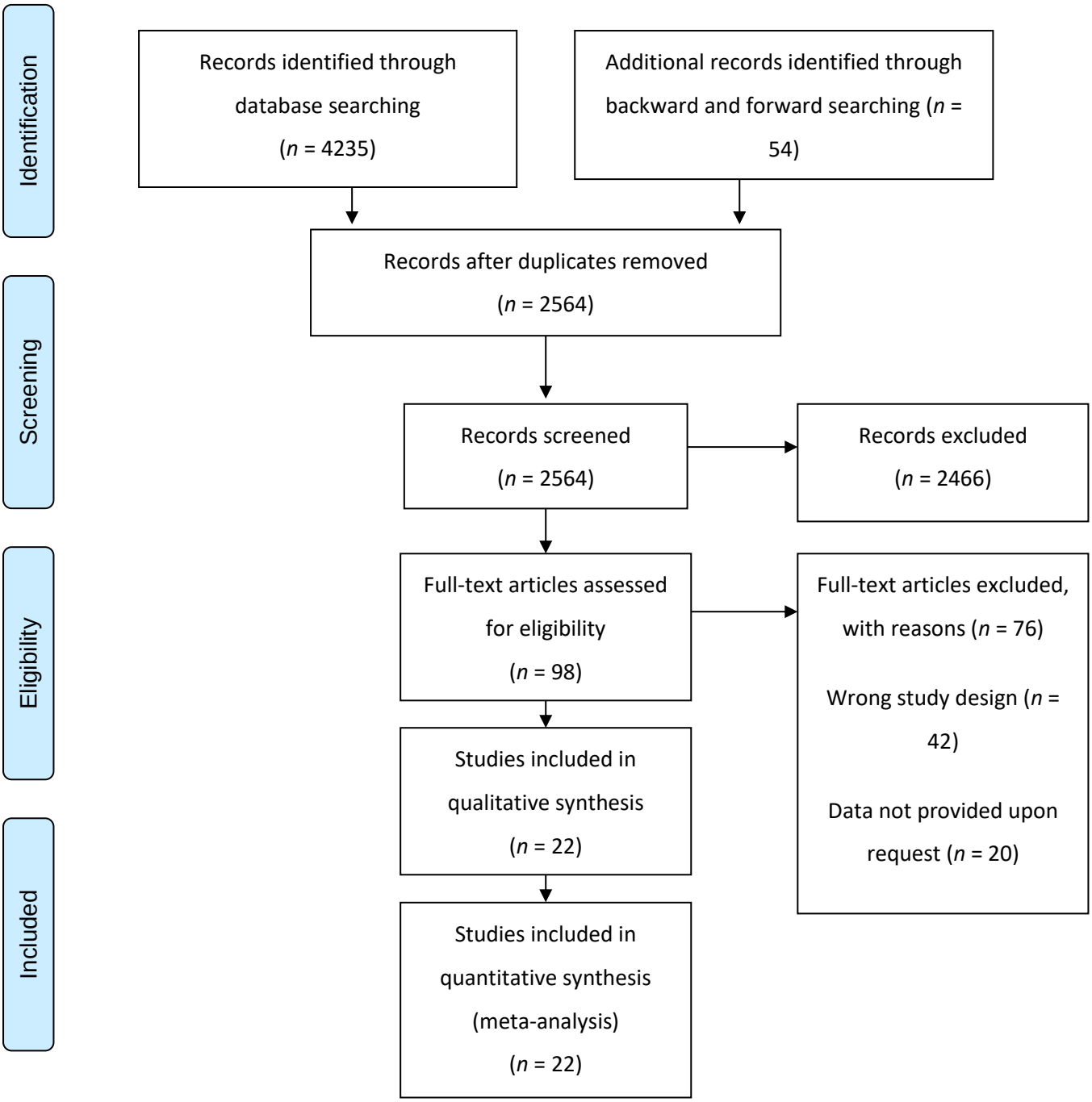
The Theory of Planned Behaviour has been researched extensively in relation to sugar sweetened beverage consumption, with most of the literature focussing on particular components of the theory, and some literature investigating all three components (Choy & Isong, 2018; de Bruijn & van den Putte, 2009; Kassem & Lee, 2004; Kassem et al., 2003; Riebl et al., 2015; Riebl et al., 2016; Zoellner et al., 2012). However, to date there has been no comprehensive analysis of this research to determine which components of the theory are the most strongly correlated with sugar sweetened beverage consumption. In addition, there is literature (Gesualdo & Yanovitzky, 2019; Robinson et al., 2016; Stroebele-Benschop et al., 2018; Tak et al., 2011) that has investigated components that are not included in the theory, which are also important to consider in understanding the determinants that drive sugar sweetened beverage consumption, such as habits. Habits represent already formed behaviours that are automatically performed without much conscious thought.

Applied to sugar sweetened beverage consumption, habits relate to automatically choosing to consume a sugar sweetened beverage in certain contexts (e.g., with friends, while watching television, or with a meal). In order to provide a comprehensive evaluation of these determinants, we included any determinants that could be considered cognitive and within behavioural control (e.g., attitudes, norms, self-efficacy and habitual behaviour) in our review and defined these as socio-cognitive determinants.

Thus, the aim of the present review was to determine which socio-cognitive determinants are most strongly associated with sugar sweetened beverage consumption among young people (~10 – 24 years), who are the core consumers (Australian Bureau of Statistics, 2018; Drewnowski & Rehm, 2014). To this end, we conducted a systematic review and meta-analysis of the existing literature that has investigated the link between socio-cognitive determinants and sugar sweetened beverage consumption. In particular, we sought to ascertain which socio-cognitive determinants predict the *amount* and *frequency* of sugar sweetened beverage consumption, and how strongly each determinant is associated with these outcomes. The results from this review will provide useful knowledge about the socio-cognitive determinants that most strongly drive sugar sweetened beverage consumption behaviour. This knowledge could then be used to design targeted interventions focussing on the most strongly associated socio-cognitive determinants, with the aim of reducing sugar sweetened beverage consumption among young people.

Method

Figure 1
PRISMA flowchart



Design

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The protocol for the review was pre-registered with Open Science Framework (Registration code: 7puhd).

Search Strategy

The search strategy was developed with the assistance of two academic librarians at Flinders University. The key search terms and thesaurus terms included in the search strategy were: (1) children, adolescents, young adults; (2) soft drink consumption, choice or purchasing behaviour; and (3) socio-cognitive determinants related to soft drink consumption (e.g., intentions, attitudes, descriptive norms, social norms, perceived behavioural control, habits, and self-efficacy). Searches were completed on the 28th of May 2020 from the following five databases: PsycINFO, MEDLINE, PubMed, Scopus, ProQuest. An updated search was run on the 25th of January 2022 to find any additional papers that were published since the original search. The search was limited to published peer-reviewed articles in the English language with human subjects. The full search strategy is provided in Appendix A.

Eligibility Criteria

To be included in the review, studies had to meet the following criteria: (1) a child, adolescent or young adult sample (approximately 10 – 24 years old; papers with an age range a few years lower or higher than this were also included to capture those papers which had age ranges that were within the classification of young people), (2) a measurement of sugar-sweetened beverage consumption (e.g.,

amount, frequency, choice or purchasing behaviour), and (3) a measurement of any socio-cognitive determinant related to sugar-sweetened beverage consumption (e.g., intentions, attitudes, descriptive norms, social norms, perceived behavioural control, habits, and self-efficacy).

Data Screening

Endnote and Covidence (an online systematic review platform) were used to remove duplicate entries. The titles and abstracts of eligible papers were independently screened for suitability by two reviewers. Any conflicts were discussed until an agreement was reached. The full texts of the remaining eligible papers were then screened (see Figure 1). At this stage, backward (references that are cited within the article) and forward (references that have since cited the article) searching was also conducted to ensure all suitable papers were identified.

Any missing data was requested from authors on two separate occasions. On the first occasion, authors were given three weeks to provide the requested data. On the second occasion, any authors who had not yet provided the data were sent a reminder and given an additional three weeks to do so. Data requests (and reminders) were sent to 30 authors as well as co-authors, with 10 responding with the requested data which were subsequently included in the review. Of the 20 authors who did not respond, only one had provided a “data available on request” statement in their article.

Data Extraction

Data extraction was completed using Microsoft Excel, customised to suit the purpose of this review. The extracted data included: sample characteristics, study

design, study methodology, study setting, country, primary outcome (consumption amount or frequency), key socio-cognitive determinants related to the primary outcome, correlations, and sample size.

Quality Assessment

The Mixed Methods Appraisal Tool (Hong et al., 2018) was used to evaluate the study quality and risk of bias. The quality assessment of the included full-text articles was completed by two independent reviewers. Each included study was appraised according to the checklist criteria for the relevant study type. For example, for a non-comparative study this included criteria assessing the clarity of the research question, appropriateness of the data collection and sample used, correctly used measurements and statistical analysis, and successful identification and control of potential sources of bias. Studies were rated from 1 (low quality) to 5 stars (high quality) based on the percentage of the quality criteria they met.

Statistical Analysis

The relevant socio-cognitive determinants from each study were identified, and relevant studies were grouped together for each determinant. In some cases, measures that captured very similar determinants/constructs were combined into a single group (e.g., social norms). We used Comprehensive Meta-Analysis (CMA) version 3 (Biostat, 2022) to conduct the meta-analyses and determine the overall correlation for each determinant. The meta-analyses were split into two groups based on the outcome measured. The two outcomes were: (1) amount of sugar sweetened beverages consumed, and (2) frequency of sugar sweetened beverage consumption. CMA calculated the correlation (r), lower and upper limit (r), Z-value (z)

and p-value (*p*) for each determinant and outcome measure. Because some of the included studies measured how much certain determinants decreased consumption rather than increased consumption, these determinants were converted so all correlations were consistently measuring how much each determinant increased sugar sweetened beverage consumption. The results were entered into Excel to produce forest plots for each determinant. These were then combined into a single forest plot with relevant determinants for each outcome measure.

Results

Study Selection

As shown in Figure 1, 2564 articles were identified for review after removing duplicates. These were imported into Covidence for title and abstract screening. After title and abstract screening, and backward and forward searching, 98 articles remained for full-text screening. During full text-screening, 76 articles were excluded for various reasons (see Figure 1). These included: wrong study design (*n* = 42), authors did not provide the data requested (*n* = 20), wrong population (*n* = 7), or the study used parental reporting (*n* = 7). This resulted in a total of 22 articles that were included in the meta-analysis.

Study Characteristics

The mean sample size of the included studies was 1090 (*SD* = 1601, range = 100 – 7811). The mean percentage of males in the included studies was 44% (*SD* = 8%, range = 26% – 54%). The mean age across all studies was 15 years (*SD* = 3, range = 10 – 26 years). The most common countries the studies were conducted in were the Netherlands (*n* = 5), the United States (*n* = 5), and the United Kingdom (*n* =

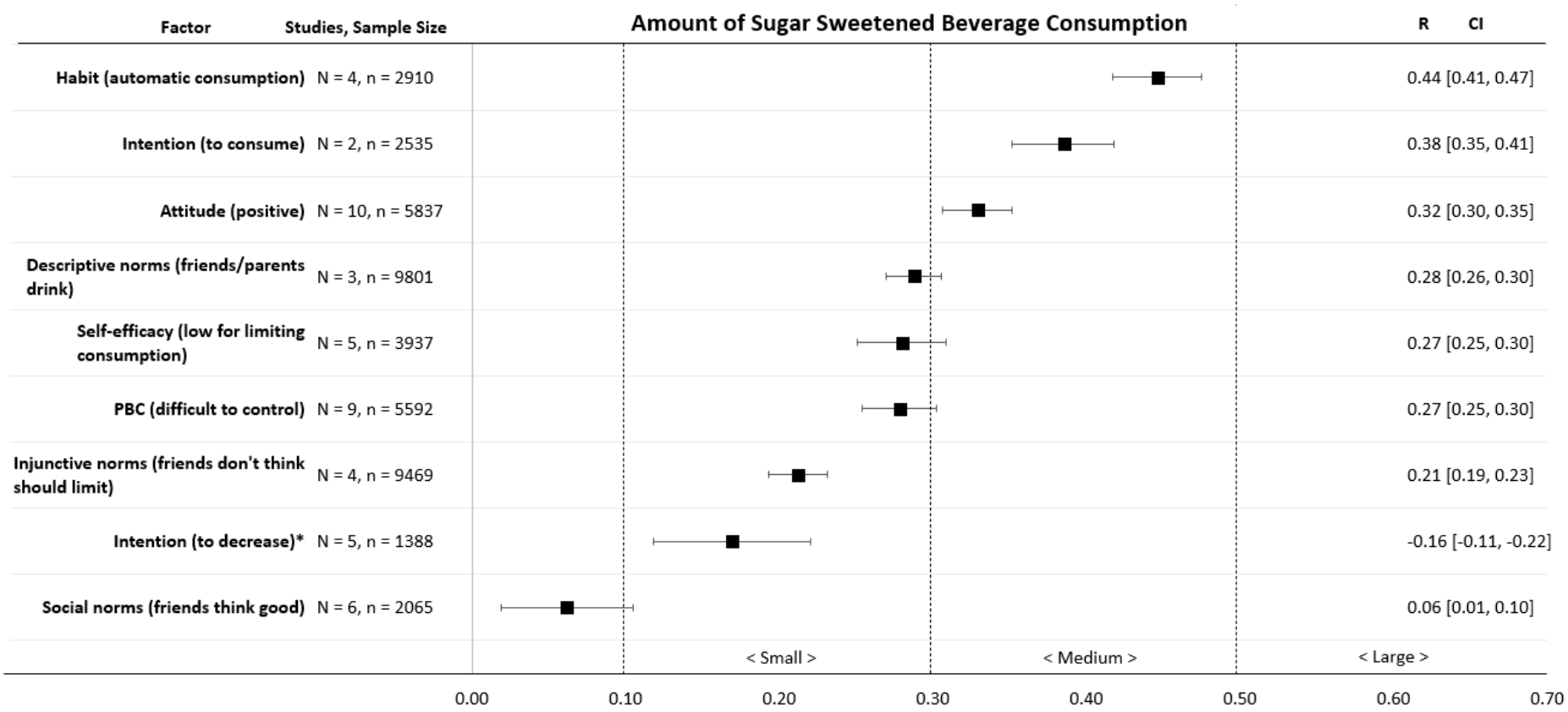
4). Most studies were cross-sectional by design (*n* =19), with one longitudinal, one randomised controlled trial, and one cohort study. Most studies were completed within a school setting (*n* = 12), followed by a university (*n* = 7), and online (*n* = 3). The most commonly measured socio-cognitive determinants were attitudes (*n* = 14), perceived behavioural control (*n* = 10), descriptive norms (*n* = 8), social norms (*n* = 6), injunctive norms (*n* = 7), self-efficacy (*n* = 7), intention to decrease (*n* = 5), habits (*n* = 3) and intention to consume (*n* = 4). See Table 1 for a summary of each of the studies included in the meta-analyses.

Meta-analyses

All 22 studies were included in the correlational meta-analyses. Of these, 14 studies were included in the analysis of the amount of sugar sweetened beverages consumed and 8 studies were included in the analysis of the frequency of sugar sweetened beverage consumption.

Figure 2

Meta-analysis of the socio-cognitive determinants associated with amount of sugar sweetened beverage consumption.



Note. *Intention (to decrease) is negatively correlated

Determinants Associated with Amount of Sugar Sweetened Beverage Consumption

The first meta-analysis showed that the determinants fell within three separate clusters related to strength for the amount of sugar sweetened beverages consumed. As shown in Figure 2, the first cluster included habits, intentions, and attitudes toward consumption. The determinant most associated with amount consumed was habit (automaticity) of consumption, with a meta-analysis of four studies (n = 2910) producing a correlation of r = .44 (lower = .41, upper = .47), Z = 28.65, p < .001. The next strongest determinant was intention to consume sugar sweetened beverages, with a meta-analysis of two studies (n = 2535) producing a correlation of r = .38 (lower = .35, upper = .41), Z = 20.44, p < .001. Finally, the last determinant in this cluster was positive attitudes toward sugar sweetened beverages, with a meta-analysis of ten studies (n = 5837) producing a correlation of r = .32 (lower = .30, upper = .35), Z = 26.04, p < .001.

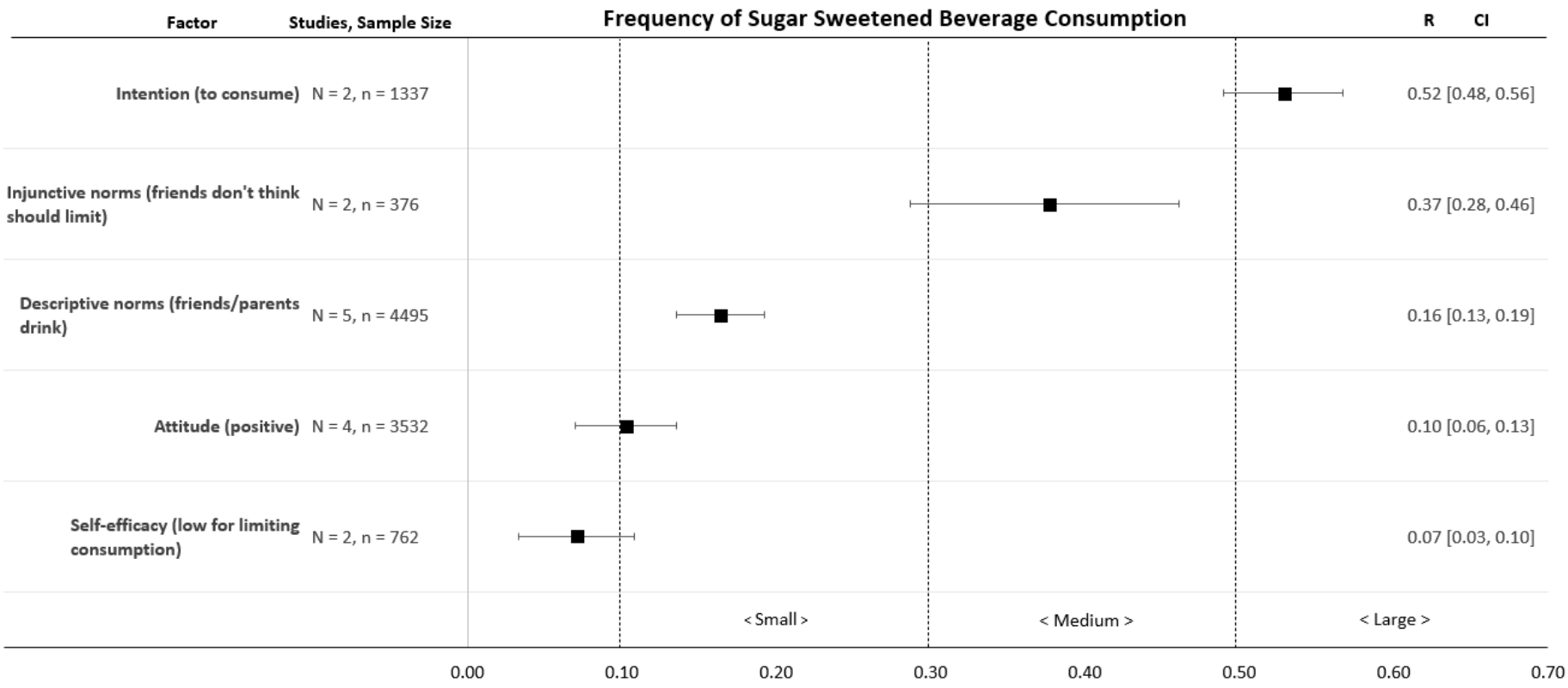
The second cluster of determinants associated with amount of sugar sweetened beverages consumed included descriptive norms, self-efficacy, and perceived behavioural control. The determinant most associated with amount consumed in this cluster was descriptive norms regarding how much parents or friends drink sugar sweetened beverages, with a meta-analysis of three studies (n = 9801) producing a correlation of r = .28 (lower = .26, upper = .30), Z = 26.04, p < .001. The next strongest determinant in this cluster was low self-efficacy pertaining to limiting consumption or low self-efficacy in general, with a meta-analysis of five studies (n = 3937) producing a correlation of r = .27 (lower = .25, upper = .30), Z = 18.01, p < .001. Finally, the last determinant in this cluster was perceived

behavioural control of the difficulty to control consumption, with a meta-analysis of nine studies (n = 5592) producing a correlation of r = .27 (lower = .23, upper = .31), Z = 21.34, p < .001.

The third cluster of determinants associated with the amount of sugar sweetened beverages consumed included injunctive norms of friends thinking they should not limit consumption, intention to decrease consumption, and social norms of friends thinking the drink was good. The determinant most associated with amount consumed in this cluster was injunctive norms of friends thinking the participant should not limit consumption, with a meta-analysis of four studies (n = 9469) producing a correlation of r = .21 (lower = .19, upper = .23), Z = 20.97, p < .001. The next strongest determinant in this cluster was intention to decrease consumption, with a meta-analysis of five studies (n = 1388) producing a correlation of r = -.16 (lower = -.11, upper = -.22), Z = 6.34, p < .001. Finally, the last determinant in this cluster was social norms of friends thinking the drink was good, with a meta-analysis of six studies (n = 2065) producing a correlation of r = .06 (lower = .01, upper = .10), Z = 6.34, p < .001.

Figure 3

Meta-analysis of the socio-cognitive determinants associated with frequency of sugar sweetened beverage consumption



Determinants Associated with Frequency of Sugar Sweetened Beverage Consumption

The second meta-analysis showed that the determinants fell within two separate clusters related to strength for the weekly frequency of sugar sweetened beverage consumption. As shown in Figure 3, the first cluster included intention to consume and injunctive norms. The determinant most associated with frequency of consumption was intention to consume sugar sweetened beverages, with a meta-analysis of two studies (n = 1337) producing a correlation of r = .52 (lower = .48, upper = .56), Z = 21.50, p < .001. The second determinant in this cluster was injunctive norms of friends thinking they should not limit consumption of sugar sweetened beverages, with a meta-analysis of two studies (n = 376) producing a correlation of r = .37 (lower = .28, upper = .46), Z = 7.63, p < .001.

The second cluster of determinants associated with frequency of sugar sweetened beverages consumption included descriptive norms, attitudes, and self-efficacy. The determinant most associated with the frequency of consumption in this cluster was descriptive norms related to how often friends and parents drink sugar sweetened beverages, with a meta-analysis of five studies (n = 4495) resulting in a correlation of r = .16 (lower = .14, upper = .19), Z = 11.08, p < .001. The next strongest determinant was positive attitudes towards sugar sweetened beverage consumption, with a meta-analysis of four studies (n = 3532) producing a correlation of r = .10 (lower = .06, upper = .13), Z = 6.11, p < .001. Finally, the last determinant in this cluster was low self-efficacy of limiting sugar sweetened beverage consumption, with a meta-analysis of two studies (n = 762) producing a correlation of r = .07 (lower = .03, upper = .11), Z = 3.69, p < .001.

Study Quality

The assessment of the study quality is available in Table S1 (see supplementary material). Quality assessment ratings ranged from 43% (2 stars) to 100% (5 stars), with a mean of 82.9%. Of the included studies, most studies scored 5 stars (*n* = 9) or 4 stars (*n* = 7), with some studies scoring 3 stars (*n* = 2) or 2 stars (*n* = 4). Most of the two-star studies scored poorly due to their limited age range and limited representativeness of the target population (e.g., assessing adolescents but only including participants aged between 12 – 15 years).

Discussion

The present review and meta-analysis aimed to determine which socio-cognitive determinants are most associated with the amount and frequency of sugar sweetened beverage consumption among young people. This was achieved by performing a comprehensive meta-analysis of studies that investigated links between socio-cognitive determinants (e.g., attitudes, norms, habits) and these consumption outcomes. The analysis revealed varying levels of strength for associations between different socio-cognitive determinants with the amount versus frequency of sugar sweetened beverage consumption. For amount consumed, the most associated determinant was habit (automaticity) of consumption, followed by intention to consume sugar sweetened beverages, and positive attitudes toward sugar sweetened beverages. For frequency of consumption, the most associated determinant was intention to consume sugar sweetened beverages, followed by injunctive norms (friends do not think should limit) and descriptive norms (friends/parents drink).

The meta-analysis showed that for amount consumed the determinants could be grouped into three different clusters based on the strength of association. Perhaps not surprisingly, the strongest determinant in the first cluster was habit (automaticity) of consumption, as a habit represents an already formed tendency to consume (Zhen et al., 2011). However, there are some instances where habit does not necessarily predict consumption, such as a habit towards healthy eating (de Vries, 2014) or specifically drinking water (Papies et al., 2021). The next strongest determinant in this cluster was intention to consume. According to the Theory of Planned Behaviour, intentions are preceded by other determinants (attitudes, subjective norms, and perceived behavioural control) (Ajzen, 1991), which could have contributed to the strength of the association. The next strongest determinant in this cluster was positive attitudes towards sugar sweetened beverages. In the Theory of Planned Behaviour, attitudes are one of three components that precede the intention to perform a behaviour (Ajzen, 1991). The present results show that positive attitudes towards sugar sweetened beverages were the strongest of these three preceding components leading to resultant sugar sweetened beverage consumption. Previous research has also found positive attitudes to be the most strongly associated with resultant sugar sweetened beverage consumption (Zoellner et al., 2012).

The strongest determinant in the second cluster for the amount consumed was descriptive norms (friends/parents drink). This determinant represents the idea that knowing or thinking others consume sugar sweetened beverages means that you may be more likely to consume sugar sweetened beverages yourself. A potential source of this norm is the consumption behaviour of parents, which has been shown to significantly influence the consumption behaviour of children and adolescents

(Gaar et al., 2017). Another potential source is the consumption behaviour of peers, which is often overestimated (Perkins et al., 2010), resulting in a misperceived norm regarding how much peers consume, which in turn leads to greater sugar sweetened beverage consumption. The second strongest determinant in this cluster was low self-efficacy of limiting consumption, which was closely followed by low perceived behavioural control. Both determinants represent a similar aspect of behaviour, namely how well an individual thinks they can control the amount of sugar sweetened beverages they consume. Perceived behavioural control in particular has been shown to significantly affect consumption behaviour, with interventions designed to increase perceived behavioural control found to be effective at long-term reductions in sugar sweetened beverage consumption (Gregorio-Pascual & Mahler, 2020).

The third and final cluster represented the weakest correlated determinants for amount consumed. The strongest determinant within this cluster was injunctive norms (friends do not think should limit). However, the link between injunctive norms and amount consumed was weaker than that of descriptive norms (i.e., how much friends/parents drink), suggesting that how much others are perceived to consume is more important than what others are perceived to think about consuming sugar sweetened beverages The second strongest determinant in this cluster was intention to reduce consumption. However, intention to reduce sugar sweetened beverage consumption was much less strongly associated with the resultant consumption of sugar sweetened beverages than was intention to consume. This could be because individuals may not necessarily follow through on their intention to reduce their consumption, because of barriers such as breaking an existing habitual behaviour (Zhen et al., 2011). The weakest determinant in this cluster and the weakest

determinant overall was social norms (i.e., friends thinking good). This determinant was very weakly associated with sugar sweetened beverage consumption, much weaker than injunctive norms (i.e., friends/parents not thinking should limit). One reason might be that injunctive norms represent more of an active view ‘for’ or ‘against’ consumption, whereas social norms relate to whether peers think it is ‘good’ or ‘bad’ to consume sugar sweetened beverages. Of the different types of norms, descriptive norms were the most strongly associated with amount of sugar sweetened beverage consumed. This result suggests that sugar sweetened beverage consumption may be more sensitive to behaviour performed by friends or parents, rather than the thoughts or views of friends or parents about sugar sweetened beverage consumption. It also supports previous research showing descriptive norms to be a stronger predictor of sugar sweetened beverage consumption than injunctive norms (Lally et al., 2011).

For frequency of consumption, the meta-analysis revealed two clusters of determinants based on the strength of correlation. In the first cluster, intentions to consume was the strongest correlated determinant. This is again in line with the Theory of Planned Behaviour which proposes that intentions are preceded by other determinants (attitudes, subjective norms, and perceived behavioural control) (Ajzen, 1991), which likely contributed to the strength of the association. The second strongest determinant in this cluster was injunctive norms (friends do not think should limit). This is different from the associations with amount consumed where it was the weakest. One reason for this difference may be the differential measurement of injunctive norms between the two meta-analyses for amount and frequency, i.e., promoting versus limiting, respectively.

In the second cluster, the strongest correlation was for descriptive norms (friends/parents drink), followed closely by positive attitudes towards sugar sweetened beverages. This differs from the associations with amount consumed, where attitudes were slightly more strongly correlated than descriptive norms. One reason may be that individuals are more likely to drink sugar sweetened beverages more often when they are around their peers than they are to change the amount they drink on any one occasion. However, it could also reflect differences in the measurement of this variable between studies focused on frequency of consumption versus those that investigated amount consumed. Finally, self-efficacy was the weakest correlating determinant in this cluster and the weakest overall. The finding that self-efficacy was more strongly correlated with amount consumed than with frequency of consumption could be because how often an individual drinks may be controlled more by external determinants (e.g., how often friends drink) whereas how much they choose to drink may be controlled more by internal determinants (e.g., self-efficacy).

The results of this meta-analysis have some important implications for the development of interventions to reduce sugar sweetened beverage consumption. Specifically, using the Theory of Planned Behaviour shows that there are certain determinants that may be particularly important to focus on when designing interventions for reducing sugar sweetened beverage consumption, with some potential differences for reducing the amount versus frequency of consumption. For example, positive attitudes were shown to be one of the strongest predictors of the amount of sugar sweetened beverage consumed. Therefore, interventions that promote less positive attitudes towards sugar sweetened beverages should be maximally effective in reducing sugar sweetened beverage consumption. Attitudes

towards sugar sweetened beverage consumption have been shown to be mostly linked to their perceived healthiness (Bombak et al., 2021). Therefore, effective interventions should seek to change health perceptions. One approach to effectively change health perceptions towards sugar sweetened beverages is to provide nutritional information that is simple, and easy-to-understand highlighting how unhealthy sugar sweetened beverages are (such as a traffic light labelling system) (Dillard et al., 2018; Gupta et al., 2021; Teng et al., 2021).

Another avenue could be to focus on the various norms related to consuming sugar sweetened beverages. We analysed three types of norms, with descriptive norms (friends/parents drinking) found to the most strongly related to sugar sweetened beverage consumption, followed by injunctive norms (friends do not think should limit) and social norms (friends think good). Research has shown that descriptive norms related to sugar sweetened consumption are often overestimated, and this overestimation can lead to increased consumption behaviour (Perkins et al., 2010). Therefore, an intervention that focusses on providing accurate descriptive norms could correct such overestimation and potentially decrease consumption behaviour (Perkins et al., 2010). In contrast, injunctive norms and social norms may be more reliant on existing attitudes towards sugar sweetened beverages, which likely control what someone thinks about sugar sweetened beverages and how strongly they believe other people should limit their consumption. Therefore, interventions that focus on creating more negative attitudes towards sugar sweetened beverages (i.e., thinking sugar sweetened beverages are unhealthy) could have the flow-on effect of producing more negative injunctive norms (i.e., friends more strongly thinking should limit consumption) and social norms (i.e., friends more likely to think are bad).

Finally, although perceived behavioural control was the least strongly associated with sugar sweetened beverage consumption, previous research has shown that it is nevertheless an important determinant (Billich et al., 2018; Gregorio-Pascual & Mahler, 2020). In particular, making people feel more confident in their ability to choose healthy beverages has been shown to reduce the amount of sugar sweetened beverages consumed. One way of increasing perceived behavioural control is the aforementioned provision of nutritional labels to help consumers more easily identify the healthier options by highlighting which beverages are unhealthy (e.g., using a traffic light system or warning label) (Billich et al., 2018). Another approach would be to enhance motivation and provide support to reduce consumption. This could be achieved by way of action plans about consuming healthy beverages (e.g., planning to consume healthy beverages in the next two weeks), and resisting tempting situations (e.g., when offered a sugar sweetened beverage) (Gregorio-Pascual & Mahler, 2020).

While interventions could focus on just one of the Theory of Planned Behaviour determinants, it is likely that focussing on more than one determinant may be more effective. For example, Gregorio-Pascual and Mahler (2020) designed several interventions that targeted a varying number of the three components of the Theory of Planned Behaviour. They found that an intervention that focussed on all three components (attitudes, norms, and perceived behavioural control) produced the greatest reduction in intentions to consume sugar sweetened beverages. In addition, as habit was one of the strongest correlating determinants of amount of sugar sweetened beverages consumed, it is another important variable, not included in the Theory of Planned Behaviour to consider in the design of future interventions. Although habits represent behaviours that have already been formed, there is some

recent evidence showing that habitual behaviour can be changed successfully. In particular, Judah et al. (2020) investigated the effectiveness of a habit and implementation intention-based intervention in which regular sugar sweetened beverage consumers formed implementation intentions to substitute sugar sweetened beverages with either water or diet drinks over a period of two months. They found that substituting sugar sweetened beverages with water or diet drinks were both effective in reducing sugar sweetened beverage consumption as well as self-reported sugar sweetened beverage habits. Finally, interventions that focus on determinants both within (e.g., attitudes) and outside of the Theory of Planned Behaviour (e.g., habits) may prove maximally effective for reducing sugar sweetened beverage consumption. Further research is needed to determine the optimal mix of targeted determinants.

There are a number of limitations of the present review and meta-analysis. First, there were relatively few studies overall for the meta-analyses, with 14 for the amount of consumption and 8 for the frequency of consumption. Consequently, fewer determinants could be compared between amount and frequency of consumption. Relatedly, a substantial number of studies (n = 20) were excluded on account of missing data, despite repeated efforts to obtain these from authors. As these studies were clearly relevant and similar to those included in the analyses, their inclusion would have allowed for a more comprehensive analysis of some of the determinants. As a result, some of the analyses were based on a small number of studies. For example, there were only two studies in the correlation between intention to consume and amount of sugar sweetened beverage consumed, and which were of lower quality (scoring two stars). Hence, these results should be interpreted with caution. Second, the variables of interest were often defined

differently across studies. This resulted in variables with varying definitions being grouped together under similar constructs to conduct the meta-analysis. However, we clearly defined the determinants in the present review to ensure consistency in the grouping for each determinant. Third, many studies on sugar sweetened beverage consumption in young people were based on the Theory of Planned Behaviour. Consequently, there is an inherent bias towards Theory of Planned Behaviour components (intentions, attitudes, subjective norms, perceived behavioural control) to the exclusion of other determinants of sugar sweetened beverage consumption. Future research should seek to ensure comprehensive measurement of the drivers of such consumption. Finally, the current review focused on correlations between determinants and sugar-sweetened beverage consumption, and thus the reported relationships should not be interpreted as causation.

In conclusion, the present review provides a comprehensive evaluation of the socio-cognitive determinants associated with the frequency and amount of sugar-sweetened beverage consumption in young people. The results of meta-analysis provide a useful indication of the determinants to focus on in future interventions aimed at reducing sugar sweetened beverage consumption in this cohort.

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Author Contributions

All authors contributed to the design of the study and writing of the manuscript. Ryan Calabro was responsible for conducting the systematic literature review under supervision of Eva Kemps. Ryan Calabro conducted the meta-analysis and wrote the first draft of the manuscript, with all other authors editing subsequent drafts of the manuscript. All authors have approved the final manuscript.

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Declaration of Interest

None.

Data and code availability

All data used in the meta-analyses are available from the lead author (Ryan Calabro) who has full access to the data.

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Table 1

Studies included in the meta-analysis of socio-cognitive determinants and consumption of soft drink/SSBs.

Reference	**Sample Characteristics**	**Study Setting / Country**	**Study Design**	**Consumption Measure (Grouping)**	**Relevant Determinants Measured**	**Reported Correlation (r)**	**Quality Assessment**
Beaulieu et al. (2020)	*n* = 311 Age Range = 13-18 (*M* = N/A, *SD* = N/A) Male = 48%, Female = 52%	School Canada	Questionnaire Cross-sectional	Amount	Social Norms Attitude PBC	*r* = 0.19 *r* = 0.28 *r* = 0.42	*****
Chin A Paw et al. (2008)	*n* = 854 Age Range = 12-13 (*M* = 12.7, *SD* = 0.5)	Secondary Schools Netherlands	Intervention/Questionnaire RCT	Amount	Injunctive Norms Attitude	*r* = 0.03 *r* = 0.17	***

	Male = 49%, Female = 51%				PBC Habit	*r* = 0.17 *r* = 0.23	
de Bruijn and van den Putte (2009)	*n* = 312 Age Range = N/A (*M* = 14.62, *SD* = 1.26) Male = 34%, Female = 65%	Vocational and Secondary Schools Netherlands	Questionnaire Correlational	Amount	Social Norms Attitude Intention (to decrease) Self-efficacy Habit	*r* = 0.01 *r* = 0.18 *r* = -0.13 *r* = 0.29 *r* = 0.46	*****

de Bruijn et al. (2007)	*n* = 208 Age Range = 12-18 (*M* = 15.2, *SD* = 1.9) Male = 38%, Female = 62%	Homes Netherlands	Questionnaire Correlational	Amount	Social Norms Attitude PBC Intention (to decrease)	*r* = 0.03 *r* = 0.23 *r* = 0.16 *r* = -0.20	****
Deliens et al. (2015)	*n* = 816 Age Range = N/A (*M* = 21.2, *SD* = 2.1) Male = 40%, Female = 60%	University Belgium	Questionnaire Cross-sectional	Amount	Social Norms Descriptive Norms Attitude PBC	*r* = 0.01 *r* = 0.36 *r* = 0.32 *r* = 0.42	****

					Self-efficacy	*r* = 0.40	
Figueroa et al. (2019)	*n* = 1225 Age Range = 12-17 (*M* = 14.5, *SD* = 1.6) Male = 49%, Female = 50%	Internet US	Questionnaire Cross-sectional	Frequency	Intention (to consume)	*r* = 0.51	*****
Gan et al. (2019)	*n* = 421 Age Range = N/A (*M* = 13.3, *SD* = 1.3)	School Malaysia	Questionnaire Cross-sectional	Amount	Injunctive Norms	*r* = 0.02	****

	Male = 41%, Female = 58%						
Geers et al. (2017)	*n* = 1499 Age Range = 13 - 18 (*M* = 15, *SD* = 1.29) Male = 44%, Female = 56%	University US	Questionnaire Cross-sectional	Frequency	Attitude	*r* = 0.14	*****
Gesualdo and Yanovitzky (2019)	*n* = 1657 Age Range = 12-17 (*M* = 14, *SD* = 1.6) Male = 50%, Female = 50%	US Health Survey US	Questionnaire Correlational	Frequency	Descriptive Norms Attitude Self-efficacy	*r* = 0.09 *r* = 0.04 *r* = 0.02	*****

Ickes and Sharma (2012)	*n* = 318 Age Range = 12-17 (*M* = 13.18, *SD* = 0.756) Male = 44%, Female = 55%	Middle School US	Questionnaire Cross-sectional	Amount	Social Norms Attitude PBC Intention (to decrease)	*r* = 0.05 *r* = 0.11 *r* = 0.40 *r* = -0.14	****
Jones and Robinson (2017)	*n* = 340 Age Range = N/A (*M* = 21.7, *SD* = 4.5) Male = 26%, Female = 74%	University UK	Questionnaire Longitudinal	Frequency	Descriptive Norms	*r* = 0.08	****

Lally et al. (2011)	*n* = 264 Age Range = 16-17 (*M* = 16.9, *SD* = 0.5) Male = 46%, Female = 54%	High School UK	Questionnaire Cross-sectional	Frequency	Injunctive Norms Attitude	*r* = 0.40 *r* = 0.16	**
Riebl et al. (2016)	*n* = 100 Age Range = 12-18 (*M* = 14, *SD* = 0.2) Male = 52%, Female = 48%	University US	Questionnaire Cross-sectional	Amount	Social Norms Attitude PBC Intention (to decrease)	*r* = 0.34 *r* = 0.11 *r* = 0.01 *r* = -0.36	*****

Robinson et al. (2016)	*n* = 1056 Age Range = N/A (*M* = 21.68, *SD* = 4.49) Male = 29%, Female = 71%	University (Online) UK	Questionnaire Cross-sectional	Frequency	Descriptive Norms Self-efficacy	*r* = 0.08 *r* = 0.15	****
Smith et al. (2008)	*n* = 112 Age Range = 17-26 (*M* = 18.33, *SD* = 1.89) Male = 38%, Female = 62%	University UK	Questionnaire Longitudinal	Frequency	Injunctive Norms Descriptive Norms Attitude PBC	*r* = 0.32 *r* = 0.36 *r* = 0.38 *r* = 0.10	***

					Intention (to consume)	*r* = 0.71	
Tak et al. (2011)	*n* = 1361 Age Range = 12-15 (*M* = 14.1, *SD* = 1.2) Male = 54%, Female = 46%	Primary and Secondary Schools Netherlands	Questionnaire Cross-sectional	Amount	Attitude PBC Intention (to consume) Habit	*r* = 0.46 *r* = 0.26 *r* = 0.39 *r* = 0.55	**
te Velde et al. (2014)	*n* = 7811 Age Range = 10-12 (*M* = 11.6, *SD* = 0.7)	Primary Schools Europe	Questionnaire Cross-sectional	Amount	Injunctive Norms Descriptive Norms	*r* = 0.35 *r* = 0.29	**

	Male = 48%, Female = 52%						
van der Horst et al. (2007)	*n* = 383 Age Range = 12-17 (*M* = 13.5, *SD* = 0.62) Male = 44%, Female = 55%	Secondary Schools Netherlands	Questionnaire Cross-sectional	Amount	Injunctive Norms Attitude Self-efficacy Habit	*r* = 0.03 *r* = 0.38 *r* = 0.26 *r* = 0.48	*****
Van der Horst et al. (2008)	*n* = 1174 Age Range = 12-15 (*M* = 14.1, *SD* = 1.2)	Secondary School Netherlands	Questionnaire Cross-sectional	Amount	Descriptive Norms Attitude	*r* = 0.22 *r* = 0.46	**

	Male = 52%, Female = 47%				PBC Intention (to consume)	*r* = 0.27 *r* = 0.38	
Wouters et al. (2010)	*n* = 1330 Age Range = 12-18 (*M* = 14.9, *SD* = N/A) Male = 51%, Female = 49%	Secondary School Netherlands	Questionnaire Cross-sectional	Frequency	Descriptive Norms	*r* = 0.32	****
Xu et al. (2017)	*n* = 1976	University	Questionnaire	Amount	Self-efficacy	*r* = 0.28	*****

	Age Range = 16-26 (*M* = 20.14, *SD* = 1.32) Male = 34%, Female = 65%	China	Cross-sectional				
Zhang et al. (2019)	*n* = 450 Age Range = 12-17 (*M* = N/A, *SD* = N/A) Male = 50%, Female = 49%	Secondary School Hong Kong	Questionnaire Correlational	Amount	PBC Intention (to decrease) Self-efficacy	*r* = 0.20 *r* = -0.16 *r* = 0.05	*****

Note. PBC = perceived behaviour control

Appendix A

Search Strategies

PsycINFO	
Sample	1. (child* or adolescen* or teenage* or young people or young person* or young adult* or youth* or youngster* or teen* or pediatric or paediatric or student* or school* or universit* or college*).ti,ab,id. 2. adolescent attitudes/ or adolescent behavior/ or child attitudes/ or child behavior/ 3. 1 or 2
Consumption or Purchasing Behaviour Related Words	4. ((consumption or consume* or intake* or drink* or preference* or habit* or decision* or choice* or decide* or inclin* or like* or choose* or select* or pick* or purchas* or buy* or sale* or vend* or sell* or frequenc* or amount or level) adj4 (SSB* or soda* or soft drink* or cola or lemonade or sprite or coke or fanta or sugar sweetened or sugar-sweetened or beverag* or sweetened* or carbonated or fizzy)).ti,ab,id. 5. "Beverages (Nonalcoholic)"/ 6. exp choice behavior/ or exp decision making/ or exp cognitive processes/ or Consumer Behavior/ or exp Consumer Attitudes/ or exp Intention/ or Drinking Behaviour/ 7. 5 and 6
Determinants	8. (attitud* or belief* or intent* or habit* or norm* or self* or self-* or self-efficac* or self-regulat* or perception* or perceive or self-affirmation* or inhibit* or motivat* or predictor* or behav* or personal or pattern* or determinant* or cue* or determinant* or cognit* or influence* or social or socio* or socio-cognitive).ti,ab,id. 9. exp self-perception/ or self-regulation/ or exp Attitudes/ or Health Belief Model/ or exp Intention/ or Habits/ or exp Motivation/ or exp Social influences/ or exp Cognitive Processes/ 10. 8 or 9 11. 3 and (4 or 7) and 10

MEDLINE	
Sample	1. (child* or adolescen* or teenage* or young people or young person* or young adult* or youth* or youngster* or teen* or pediatric or paediatric or student* or school* or universit* or college*).ti,ab,id. 2. Child/ or Child Behavior/ or Adolescent Behavior/ or Adolescent/ or Young Adult/ 3. 1 or 2
Consumption or Purchasing Behaviour Related Words	4. ((consumption or consume* or intake* or drink* or preference* or habit* or decision* or choice* or decide* or inclin* or like* or choose* or select* or pick* or purchas* or buy* or sale* or vend* or sell* or frequenc* or amount or level) adj4 (SSB* or soda* or soft drink* or cola or lemonade or sprite or coke or fanta or sugar sweetened or sugar-sweetened or beverag* or sweetened* or carbonated or fizzy)).ti,ab,id. 5. Sugar-Sweetened Beverages/ or Carbonated Beverages/ or Artificially Sweetened Beverages/ 6. exp Decision Making/ or exp Cognition/ or Executive Function/ or Intention/ or exp Perception/ or exp Thinking/ or Volition/ or Drinking/ 7. 5 and 6
Determinants	8. (attitud* or belief* or intent* or habit* or norm* or self* or self-* or self-efficac* or self-regulat* or perception* or perceive or self-affirmation* or inhibit* or motivat* or predictor* or behav* or personal or pattern* or determinant* or cue* or determinant* or cognit* or influence* or social or socio* or socio-cognitive).ti,ab,id. 9. exp Attitude/ or exp Behavior/ or exp Motivation/ or exp “Psychology, Social”/ or Intention/ or Habits/ or Self Efficacy/ or exp Self-Control/ or exp Perception/ 10. 8 or 9 11. 3 and (4 or 7) and 10

ProQuest	
Sample	1. MAINSUBJECT.EXACT("Children & youth") OR MAINSUBJECT.EXACT("Young adults") 2. TI,AB,IF(child* OR adolescen* OR teenage* OR young people OR young person* OR young adult* OR youth* OR youngster* OR teen* OR pediatric OR paediatric OR student* OR school* OR universit* OR college*)) 3. la.exact("English") 4. (1 OR 2) and 3
Consumption or Purchasing Behaviour Related Words	5. MAINSUBJECT.EXACT("Nonalcoholic beverages") OR MAINSUBJECT.EXACT("Soft drinks") 6. TI,AB,IF(consumption OR consume* OR intake* OR drink* OR preference* OR habit* OR decision* OR choice* OR decide* OR inclin* OR like* OR choose* OR select* OR pick* OR purchas* OR buy* OR sale* OR vend* OR sell* OR frequenc* OR amount OR level NEAR/4 SSB* OR soda* OR soft drink* OR cola OR lemonade OR sprite OR coke OR fanta OR sugar sweetened OR sugar-sweetened OR beverag* OR sweetened* OR carbonated OR fizzy) 7. la.exact("English") 8. (5 or 6) and 7
Determinants	9. (MAINSUBJECT.EXACT("Habits") OR MAINSUBJECT.EXACT("Self regulation") OR MAINSUBJECT.EXACT("Motivation") OR MAINSUBJECT.EXACT("Attitudes") OR MAINSUBJECT.EXACT("Perceptions") OR MAINSUBJECT.EXACT("Consumer attitudes") OR MAINSUBJECT.EXACT("Social perception") OR MAINSUBJECT.EXACT("Behavior") OR MAINSUBJECT.EXACT("Cognitive psychology") OR MAINSUBJECT.EXACT("Addictive behaviors") OR MAINSUBJECT.EXACT("Norms") OR MAINSUBJECT.EXACT("Human influences") OR MAINSUBJECT.EXACT("Influence") 10. TI,AB,IF(attitud* OR belief* OR intent* OR habit* OR norm* OR self* OR self-efficac* OR self-regulat* OR perception* OR perceive OR self-affirmation* OR inhibit* OR motivat* OR predictor* OR behav* OR personal OR pattern* OR determinant* OR cue* OR determinant* OR cognit* OR influence* OR social OR socio* OR socio-cognitive) 11. la.exact("English")

	12. (9 or 10) and 11 13. 4 and 8 and 12

Scopus	
Sample	1. TITLE-ABS-KEY (child* or adolescen* or teenage* or young people or young person* or young adult* or youth* or youngster* or teen* or pediatric or paediatric or student* or school* or universit* or college*)
Consumption or Purchasing Behaviour Related Words	2. TITLE-ABS-KEY (consumption or consume* or intake* or drink* or preference* or habit* or decision* or choice* or decide* or inclin* or like* or choose* or select* or pick* or purchas* or buy* or sale* or vend* or sell* or frequenc* or amount or level W/4 SSB* or soda* or soft drink* or cola or lemonade or sprite or coke or fanta or sugar sweetened or sugar-sweetened or beverag* or sweetened* or carbonated or fizzy)
Determinants	3. TITLE-ABS-KEY (attitud* or belief* or intent* or habit* or norm* or self* or self-* or self-efficac* or self-regulat* or perception* or perceive or self-affirmation* or inhibit* or motivat* or predictor* or behav* or personal or pattern* or determinant* or cue* or determinant* or cognit* or influence* or social or socio* or socio-cognitive) 4. 1 and 2 and 3

PubMed	
Sample	1. (("children"[All Fields]) OR ("adolescent"[All Fields]) OR ("young adult"[All Fields]))
Consumption or Purchasing Behaviour Related Words	2. (("soft drink"[All Fields]) OR ("beverage"[All Fields]) OR ("sugar sweetened"[All Fields]) OR ("soda"[All Fields]) OR ("ssb"[All Fields]) OR ("carbonated"[All Fields]) OR ("fizzy"[All Fields])) 3. (("consumption"[All Fields]) OR ("intake"[All Fields]) OR ("drinking"[All Fields]) OR ("purchase"[All Fields])) 4. 2 and 3
Determinants	5. (("attitude"[All Fields]) OR ("belief"[All Fields]) OR ("intent"[All Fields]) OR ("habit"[All Fields]) OR ("norm"[All Fields]) OR ("self efficacy"[All Fields]) OR ("self regulation"[All Fields]) OR ("perception"[All Fields]) OR ("self affirmation"[All Fields]) OR ("inhibit"[All Fields]) OR ("motivation"[All Fields]) OR ("behaviour"[All Fields]) OR ("cognition"[All Fields])) 6. 1 and 4 and 5

Supplementary Materials

Table S1

Study quality analysis based on the Mixed Methods Appraisal Tool.

Author	Year	Criteria from the Mixed Methods Appraisal Tool																								
		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4	5.5
Beaulieu et al.	2020																1	1	1	1	1					
Chin A Paw et al.	2008						1	0	1	0	1															
de Bruijn and van den Putte	2009																1	1	1	1	1					
de Bruijn et al.	2007																1	1	1	0	1					
Deliens et al.	2015																1	1	1	0	1					
Figueroa et al.	2019																1	1	1	1	1					
Gan et al.	2019																1	1	1	0	1					
Geers et al.	2017																1	1	1	1	1					
Gesualdo and Yanovitzky	2019																1	1	1	1	1					
Ickes and Sharma	2012																1	1	1	0	1					
Jones and Robinson	2017											1	1	0	1	1										
Lally et al.	2011																0	0	1	0	1					
Riebl et al.	2016																1	1	1	1	1					
Robinson et al.	2016																1	1	1	0	1					
Smith et al.	2008											0	1	1	1	1										
Tak et al.	2011																0	0	1	1	1					
te Velde et al.	2014																0	0	1	0	1					
van der Horst et al.	2007																1	1	1	1	1					
Van der Horst et al.	2008																0	0	1	0	1					
Wouters et al.	2010																1	1	1	0	1					
Xu et al.	2017																1	1	1	1	1					
Zhang et al.	2019																1	1	1	1	1					

CHAPTER 3: VENDING MACHINE BACKGROUNDS: NUDGING HEALTHIER BEVERAGE CHOICES

Abstract

Soft drink overconsumption is a growing public health concern. The present research investigated whether priming nudges could decrease soft drink choices from a vending machine. We compared the effect of six vending machine wraps (Mount Franklin logo, Coca-Cola logo, picture of water, picture of soft drink, blue, red) on beverage choice against a black (control) computerised vending machine display. In two studies, young adult participants (17 – 25 years) were recruited from Flinders University (Study 1, *n* = 142, Study 2, *n* = 232). Participants were randomly allocated to choose a beverage from one of the wrap conditions. They also indicated how much they liked the beverages in the vending machine and how often they consumed them (Study 1), or rated the taste, healthiness, energy and refreshing value of each beverage (Study 2). We predicted that wraps referencing water would produce healthier choices and those referencing soft drink would result in unhealthier choices. Contrary to these predictions, the type of vending machine wrap did not significantly influence beverage choice in Study 1. However, viewing the black vending machine wrap resulted in significantly more caffeine-based choices in Study 2. Other significant predictors of beverage choice were how much participants liked the beverage and how often they consumed it (Study 1), as well as their perceptions of the healthiness, refreshing value, and taste of the beverage (Study 2). The finding that the black vending machine produced more caffeine-based beverage choices demonstrates, in principle, that colour-based priming nudges could influence beverage choices.

Keywords: Nudging; vending machine; beverage choice; soft drink; caffeine

Introduction

Worldwide, the overconsumption of soft drinks (beverages that contain carbonated water and are high in sugar) is an increasing public health concern (Tahmassebi & BaniHani, 2020). The core consumers of soft drinks are young adults and adolescents (Australian Bureau of Statistics, 2018). Due to their high sugar content, the overconsumption of soft drinks can lead to health problems, such as diabetes, tooth decay, and obesity (Basu et al., 2013; Çetinkaya & Romaniuk, 2020). In an attempt to mitigate this public health concern, the World Health Organization (WHO, 2015) made a strong recommendation that people limit their daily intake of free (added) sugar to 10% of their total energy intake, equating to roughly 50 grams or 12 tsp of sugar.

Current strategies to reduce soft drink consumption include taxation, restricting access, and using front-of-package labels. Taxing soft drink has become increasingly common around the world, with evidence supporting its effectiveness in reducing soft drink consumption (Teng et al., 2019). However, soft drink taxation has been shown to shift purchasing behaviour to other high sugar items (Nakhimovsky et al., 2016). In addition, although restricting access to soft drinks in schools can successfully reduce soft drink consumption, it does so only within the school environment, with consumption often shifting outside of school (Micha et al., 2018). Front-of-package labels have also been shown to effectively reduce soft drink purchases in lab based studies, with some countries now mandating nutritional warning labels on soft drinks (Temple, 2020). However, there is limited research to support the effectiveness of these warning labels in real world applications (Temple, 2020).

The aforementioned approaches tend to focus on large and policy driven changes. Other less common strategies focus on altering the environment or the presentation of soft drinks. These closely align with the principle of ‘nudging’ and are less obvious to consumers than removing the option to choose soft drinks or increasing the financial cost for those who choose them. Nudging is a behaviour change strategy that attempts to alter people’s behaviour in a predictable way without removing any options or changing economic incentives (Hummel & Maedche, 2019). Nudging has shown some success in bringing about behaviour change across a range of domains such as road safety, energy use and healthy food choices (Hansen & Jespersen, 2013; Hummel & Maedche, 2019).

One clear benefit of nudging is that it can encourage a sense of autonomy and thus is less likely to result in reactance; engaging in the desired behaviour (e.g., healthy eating) involves little or no effort. In addition, unlike other behaviour change strategies, nudging does not require any form of self-regulation or self-control which can otherwise lead to a state of fatigue known as ego-depletion (Moller et al., 2006). Furthermore, nudging does not make use of reward or punishment to encourage the desired behaviour. According to Deci and Flaste (1995), pursuing a behaviour for something other than reward or punishment leads to the behaviour being performed more, with increased enjoyment while doing so. Moreover, recent research has made a link between self-support approaches (such as nudging) and better psychological outcomes (Behzadnia & FatahModares, 2022).

There are many different types of nudges (for a review see Wilson et al., 2016). One particular type and the focus of the present study is a priming nudge. Priming nudges are subconscious cues that can be physical, verbal, or sensory,

which are designed to subtly guide a particular choice. They differ from other types of nudges because they do not change the default option, provide an incentive, enforce commitment, or establish norms. Instead, examples of priming nudges include changing the location of food items on a menu (Gynell et al., 2022), changing the shelf positions of food and beverages in shops and supermarkets, and using colour to promote certain food consumption behaviours (Wilson et al., 2016).

To date, several studies have shown that priming nudges can successfully promote the consumption of healthier beverages. Two of these reported an effect of the colour of plates and cups on the amount participants consumed from them (Akyol et al., 2018; Genschow et al., 2012). A third found that the presence of snack and beverage brand logos in schools was associated with an increased consumption of unhealthy foods (e.g., chocolate, and salty snacks), but not beverages (e.g., soft drink) (Minaker et al., 2011). Brown and Tammineni (2009) examined a range of factors designed to increase the number of healthy beverage purchases from vending machines in primary schools. These included reducing the availability of soft drinks and reducing the price of healthy beverages, as well as changing the vending machine wraps (the surround of the drink display) to reflect physical activity, feature school logos, or feature one of the healthier beverage choices through branding. Brown and Tammineni (2009) found that soft drink purchases decreased and healthy beverage purchases increased. However, as the study did not isolate the effect of the vending machine wrap (primes) from changes made to availability and pricing, it remains unclear which factor(s) were responsible for the healthier beverage choices.

The aim of the present research was to investigate specifically the effect of vending machine wraps on beverage choice. Vending machines are readily available across many different environments, such as shopping centres, factories, office

buildings, airports, and schools (Statistic Brain Research Institute, 2017), thereby providing easy access to on-the-go snacks and drinks. People often purchase soft drinks from vending machines (Grand View Research, 2019), and may be unknowingly influenced by features incorporated into the wrap of the vending machine. Yet research into the effects of priming nudges on selections from vending machines is limited. A more general review of factors that influence vending machine choices (Hua & Ickovics, 2016) identified only one study that focused on priming nudges, namely that of Brown and Tammineni (2009) mentioned above.

In the present research, in two studies (one laboratory, one online) we manipulated the wrap on a computerised vending machine display to feature priming nudges (beverage brand logo, picture of a beverage in a glass, or the colour of a brand of beverage). In each study, participants were randomly allocated to one of seven vending machine wrap conditions and asked to choose a beverage from the vending machine without considering price. Based on the previous research (Akyol et al., 2018; Brown & Tammineni, 2009; Genschow et al., 2012), we hypothesised that brand logos, pictured beverages, or associated brand colour wraps could influence beverage choices. Specifically, we predicted that participants would be more likely to choose water (a healthy option) from vending machine wraps that featured the Mount Franklin (a popular brand of water in Australia) logo, a picture of water in a glass, or were coloured blue (a visual representation of water/Mt. Franklin brand) (Hypothesis 1). We also predicted that participants would be more likely to choose a soft drink (an unhealthy option) from vending machine wraps that featured the Coca-Cola logo, a picture of soft drink (Coca-Cola) in a glass, or were coloured red (a visual representation of soft drink/Coca-Cola brand), relative to a black coloured (control) vending machine (Hypothesis 2). In addition, we measured how

much participants liked the various beverages in the vending machine and how often they consumed them (Study 1), and how healthy, tasty, refreshing and energising they perceived the beverages to be (Study 2).

Study 1 Method

Participants

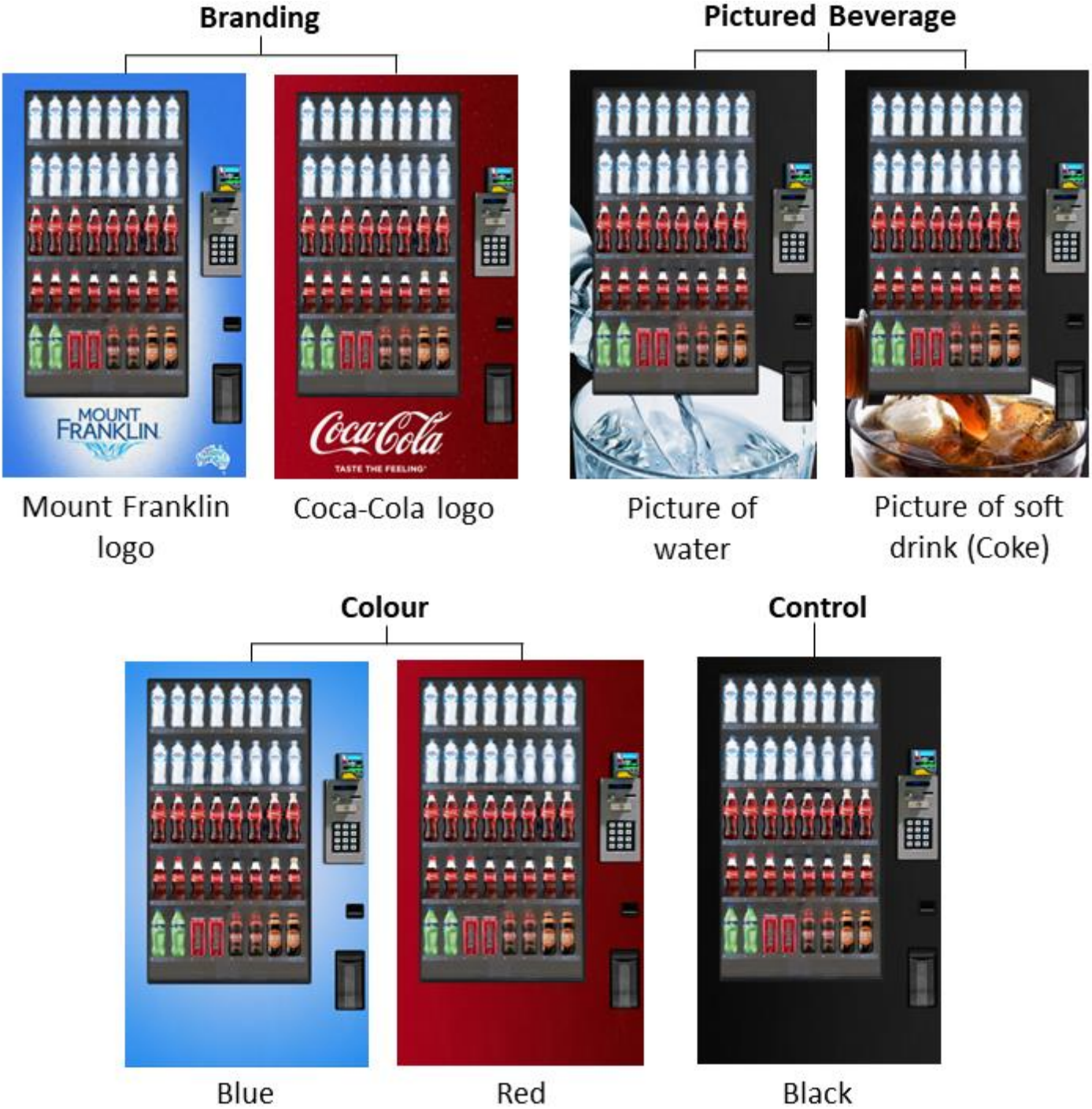
Participants were 142 undergraduate students at Flinders University who took part for course credit or a $5 reimbursement. The sample size was based on an a priori power calculation to detect a moderate sized effect with an alpha level of .05 and 80% power (Cohen, 1992). Participants were recruited via a university research participation system for a study investigating the psychology of drink choices from vending machines. Participation was limited to young adults (17 – 25 years) to capture the core consumers of soft drinks. The sample consisted of 118 women and 24 men with a mean age of 19.77 years (*SD* = 1.92). The mean BMI of the sample was 24.27 kg/m^2 (*SD* = 6.20).

Design

The experiment used a between-subjects design. Participants were randomly allocated to one of seven experimental conditions by the random allocation feature in the survey creation software Qualtrics. The seven vending machines wraps were Mount Franklin logo, Coca-Cola logo, picture of water, picture of soft drink, blue, red, or black. The dependent variable was the type of beverage chosen (water, soft drink, caffeine-based).

Materials

Figure 1
The seven vending machine conditions.



Vending Machine Wrap Displays. Seven vending machine wraps were created: Mount Franklin logo, Coca-Cola logo, picture of water, picture of soft drink, blue, red, or black. As shown in Figure 1, the two branding wraps featured a Mount Franklin or Coca-Cola logo and their respective slogan on a coloured background that was blue for Mount Franklin and red for Coca-Cola. The pictured beverage wraps featured a picture of water or soft drink (Coca-Cola) in a glass on a black background. The colour wraps were either blue or red. The control was black, i.e., the colour of a vending machine without a wrap.

Each vending machine image was displayed in portrait orientation on a touchscreen computer. This allowed for a realistic representation and a larger overall image size. The beverage arrangement was identical across all vending machine conditions and was based on observations of typical vending machines in Australia. These commonly feature two rows of water, two rows of soft drink and one row of beverages that are high in caffeine. Thus, the beverage selection included water (Mount Franklin), soft drinks (Coca-Cola, Vanilla Coca-Cola and Sprite), as well as a well-known energy drink (Mother), and coffee beverages (Barista Bros Iced Coffee and Barista Bros Double Espresso). Because of its high caffeine content, the energy drink was categorised along with the two coffee beverages as a ‘caffeine-based’ beverage.

Beverage Choice Task. Participants were asked to imagine that they were standing in front of a vending machine and to choose a beverage that they would like to drink straight away, without consideration of price. Participants made their selection by touching their beverage of choice on the screen and were then asked

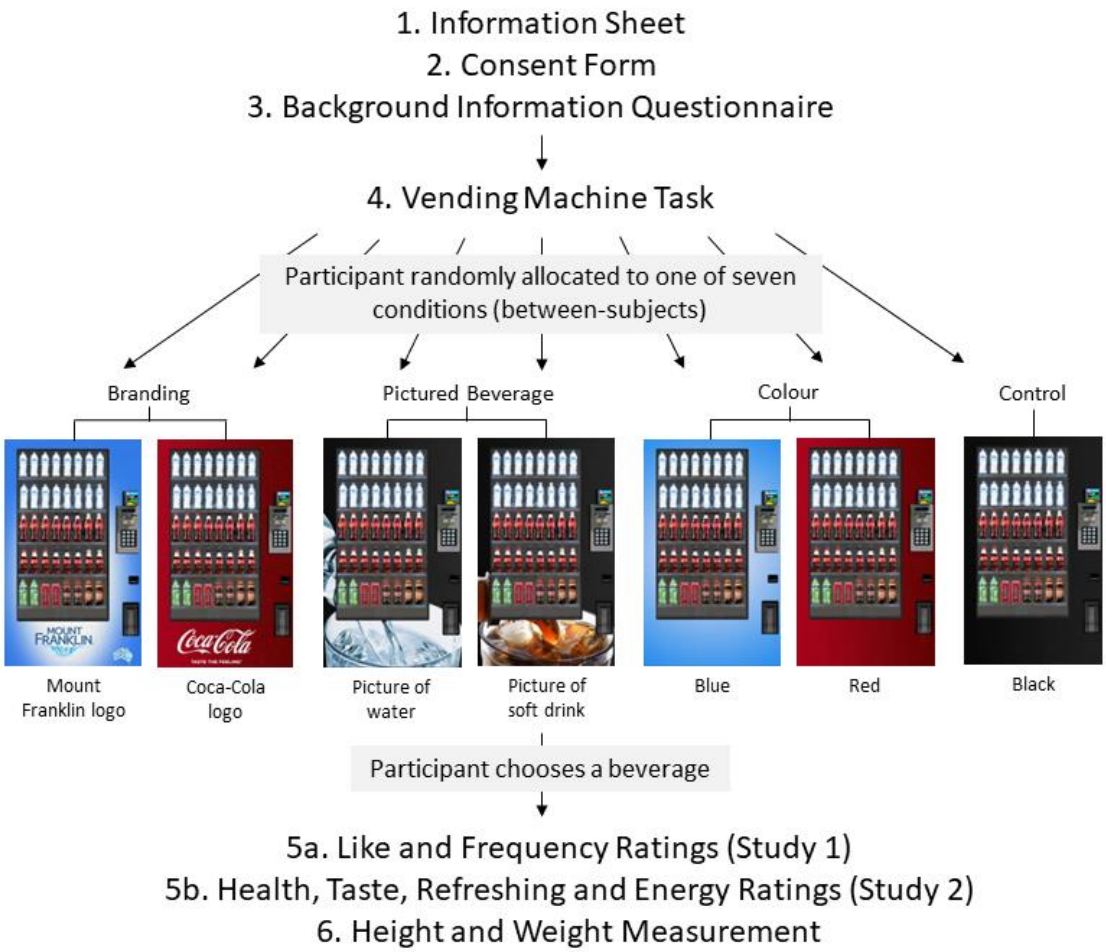
why they chose that particular beverage. Such choice tasks in the food domain have shown high test-retest reliability (Foerde et al., 2018).

Participants were then asked to rate how often they typically consume each of the beverages in the vending machine display (rated on a 7-point Likert scale ranging from ‘never’ to ‘daily’). They were also asked to rate how much they like each of the beverages (rated on a 100mm visual analogue scale ranging from ‘not at all’ to ‘very much’). Such ratings in the food consumption domain have demonstrated a high test-retest reliability (Foerde et al., 2018).

Demographic Information. Participants reported their age and gender, and the last time they drank anything (estimated to the nearest 15 minutes). They also rated how thirsty they were on a 100mm visual analogue scale ranging from ‘not at all thirsty’ to ‘extremely thirsty’.

Figure 2

A flow chart of the procedure used in Studies 1 and 2.



Procedure

The study received ethics approval from the Flinders University Social and Behavioural Research Ethics Committee (approval number 8391) and was run in accordance with the National Statement on Ethical Conduct in Human Research (2007). It was conducted in the Food Research Laboratory at Flinders University. Figure 1 provides a flow-chart overview of the procedure. Participants were seated in front of a touchscreen computer. After providing informed consent, participants provided demographic information. They then completed the beverage choice task

and post-choice questions. Finally, the participant's height was measured by the researcher, and the participant weighed themselves and entered their weight in kg into the survey. These measurements were used to calculate body mass index (BMI; kg/m^2). All questionnaires were administered via Qualtrics and participants completed the study in 10-15 minutes.

Data Analysis

To test the effect of condition (Mount Franklin logo, Coca-Cola logo, picture of water, picture of soft drink, blue, red, or black) on beverage choice (water, soft drink, caffeine-based), a multiple logistic regression was conducted using the IBM Statistical package for Social Sciences (SPSS, version 26) software, with significance levels set at $p < 0.05$. This analysis was the most suitable due to the categorical nature of the independent and dependent variables. In addition, this type of analysis allowed us to control for potential confounds such as thirst and gender. All comparisons were conducted using the control (black) vending machine as the comparison condition, and water as the comparison beverage choice.

Results

Table 1

Percentage (and number) of beverage type chosen in each condition for Study 1.

Condition	Water	Soft Drink	Caffeine-based
Mt. Franklin logo	47.6% (10)	47.6% (10)	4.8% (1)
Coca-Cola logo	47.6% (10)	38.1% (8)	14.3% (3)
Picture of Water	47.6% (10)	33.3% (7)	19.0% (4)
Picture of Soft Drink	57.1% (12)	28.6% (6)	14.3% (3)
Blue	50.0% (10)	15.0% (3)	35.0% (7)
Red	35.0% (7)	55.0% (11)	10.0% (2)
Black	30.0% (6)	50.0% (10)	20.0% (4)

Beverage Choice

Overall participants mostly chose water (45.1%), followed by soft drinks (38.2%) and caffeine-based beverages (16.7%). Table 1 provides a breakdown of beverage choices per condition. The most commonly reported reason for choosing a particular beverage was because it was liked (10.4%), or because it was considered refreshing (9.7%), energising (8.3%), tasty (7.6%), or healthy (6.3%).

Table 2

Study 1 multinomial logistic regression results to predict beverage choices (water, soft drink, caffeine-based).

Effect	Model Fitting Criteria (-2 Log Likelihood of Reduced Model)	Chi-Square	*df*	Sig.
Condition	170.610	11.853	12	.458
Gender	160.839	2.082	2	.353
Thirst Rating	158.858	.102	2	.950
Liking Ratings				
Water	168.105	9.348	2	.009**
Soft Drink	168.722	9.965	2	.007**
Caffeine-based	163.910	5.153	2	.076
Frequency of Consumption				
Water	161.087	2.330	2	.312
Soft Drink	167.636	8.880	2	.012*
Caffeine-based	171.418	12.661	2	.002**

Notes: The reference category is water. *$p < .05$, **$p < .01$

Effect of Vending Machine Condition on Beverage Choice

A multinomial regression was conducted to test the effect of multiple factors (vending machine wrap condition, gender, thirst, beverage liking, frequency of consumption) on beverage choice (water, soft drink, caffeine-based). The overall model explained a significant 69.4% of the variance, X^2 (28, N = 142) = 131.059, p < .001, and did not violate the Pearson (X^2 (252, N = 142) = 220.795, p = .922) or Deviance (X^2 (252, N = 142) = 158.757, p = 1.000) tests for goodness of fit.

The analysis showed that condition was not a significant predictor of beverage choice (see Table 2). Not surprisingly, how much water and soft drink were liked, and how often soft drink and caffeine-based beverages were typically consumed were significant predictors of beverage choice. More specifically, the parameter estimates show that participants who chose soft drink reported liking soft drink significantly more, b = 0.50, p = .004, OR = 1.052 (95% CI: 1.016, 1.088), and water significantly less, b = -0.36, p = .007, OR = .964 (95% CI: .939, .990), than those who chose water. The parameter estimates further show that how often a caffeine-based beverage was consumed significantly predicted a caffeine-based choice over a water choice, b = 2.502, p = .016, OR = 12.211 (95% CI: 1.588, 93.905).

Discussion

Study 1 investigated whether priming nudges incorporated into vending machine wraps could influence beverage choice behaviour. In contrast to Hypothesis 1, vending machine wraps that featured priming nudges related to healthy beverages (Mount Franklin logo, picture of water in a glass, or a blue coloured wrap) did not result in more healthy beverage choices. Likewise, in contrast to Hypothesis 2, priming nudges related to unhealthy beverages (Coca-Cola logo, picture of Coca-

Cola in a glass, or a red coloured wrap) did not result in more unhealthy beverage choices. Instead, participants chose beverages that they liked and regularly consumed. The most common reasons for beverage choice were related to the refreshing, energising, taste, and health aspects of the beverage. We therefore examined these factors directly as potential drivers of beverage choice in Study 2. In contrast to the lab-based set-up of Study 1, Study 2 was conducted online to mitigate against any social desirability bias in beverage choices from the presence of the experimenter in the room.

Study 2 Method

Participants

Participants were 232 undergraduate students at Flinders University who took part for course credit or a $5 reimbursement. The sample size was again based on an a priori power calculation to detect a moderate sized effect with an alpha level of .05 and 80% power (Cohen, 1992). Participants were again recruited from the online research participation system for a study investigating the psychology of drink choices from vending machines. The sample was again limited to young adults (17 – 25 years) and consisted of 186 women and 46 men with a mean age of 19.39 years (*SD* = 2.08). Mean BMI of the sample was 24.85 kg/m^2 (*SD* = 6.00).

Design, Materials, Procedure, and Data Analysis

Study 2 was conducted fully online during COVID-19 restrictions. This carried the advantages of greater anonymity and reduced possible social desirability and demand effects. Design, materials, procedure, and data analysis were the same as in Study 1, except that the liking and frequency ratings were replaced by ratings of how healthy, tasty, refreshing and energising each beverage featured in the vending

machine was perceived to be, based on the most common reported reasons for choosing a beverage in Study 1. These were measured using 100mm visual analogue scales ranging from ‘not at all’ to ‘very much’.

Results

Table 3

Percentage (and number) of beverage type chosen in each condition for Study 2.

Condition	Water	Soft Drink	Caffeine-based
Mt. Franklin logo	34.4% (11)	53.1% (17)	12.5% (4)
Coca-Cola logo	45.5% (15)	36.4% (12)	18.2% (6)
Picture of Water	44.1% (15)	41.2% (14)	14.7% (5)
Picture of Soft Drink	28.6% (10)	51.4% (18)	20.0% (7)
Blue	50.0% (17)	35.3% (12)	14.7% (5)
Red	51.5% (17)	42.4% (14)	6.1% (2)
Black	35.3% (12)	38.2% (14)	26.5% (5)

Beverage Choice

Participants mostly chose soft drinks (42.6%), closely followed by water (41.3%), with fewer choosing caffeine-based beverages (16.2%). Table 3 provides a breakdown of beverage choices per condition. The most commonly reported reason for choosing a beverage was that it was liked (12.3%), followed by it being energising (8.5%), healthy (8.0%), thirst quenching (8.0%), and refreshing (7.2%).

Table 4

Study 2 multinomial logistic regression results to predict beverage choices (water, soft drink, caffeine-based).

Effect	Model Fitting Criteria (-2 Log Likelihood of Reduced Model)	Chi-Square	*df*	Sig.
Condition	353.846	21.312	12	.046*
Gender	342.416	9.882	2	.007**
Thirst Rating	333.843	1.308	2	.520
Health Ratings				
Water	345.759	13.225	2	.001**
Soft Drink	338.127	5.592	2	.061
Caffeine-based	333.074	.539	2	.764
Refreshing Ratings				
Water	334.464	1.930	2	.381
Soft Drink	343.929	11.394	2	.003**
Caffeine-based	346.616	14.082	2	.001**
Taste Ratings				
Water	344.123	11.589	2	.003**
Soft Drink	352.618	20.084	2	.000***
Caffeine-based	359.324	26.790	2	.000***
Energy Ratings				
Water	336.354	3.819	2	.148
Soft Drink	333.268	.734	2	.693
Caffeine-based	335.919	3.385	2	.184

The reference category is water. *$p < .05$, **$p < .01$, ***$p < .001$

Effect of Vending Machine Condition on Beverage Choice

A multinomial regression was conducted to test the effect of multiple factors (vending machine wrap condition, gender, thirst, and the ratings of how healthy, refreshing, tasty and energising each beverage was) on beverage choice (water, soft drink, caffeine-based). The overall model explained a significant 52.4% of the variance, X^2 (40, N = 232) = 141.355, p < .001, and did not violate the Pearson (X^2 (422, N = 232) = 426.068, p = .436) or Deviance (X^2 (422, N = 232) = 332.534, p = 1.000) tests for goodness of fit.

Overall, condition was a significant predictor (p = .046) of beverage choice (see Table 4). Specifically, the parameter estimates show that participants made significantly more caffeine-based choices than water choices in the black condition, compared to the water, b = -1.908, p = .044, OR = .148 (95% CI: .023, .952), red, b = -3.672, p = .001, OR = .025 (95% CI: .003, .229), or blue, b = -2.639, p = .007, OR = .071 (95% CI: .010, .486) conditions. Gender was also a significant predictor of beverage choice (p = .007), with the parameter estimates showing that men were more likely to choose caffeine-based beverages, b = 1.883, p = .003, OR = 6.574 (95% CI: 1.888, 22.890) than women. In addition, how tasty (water, soft drink, caffeine-based), refreshing (soft drink, caffeine-based), and healthy (water) beverages were significantly predicted beverage choice; energy ratings were not a significant predictor.

Discussion

In line with the findings of Study 1, the results of Study 2 did not support the hypotheses. Specifically, vending machine wraps that featured priming nudges related to healthy beverages (Mount Franklin logo, picture of water in a glass, or a

blue coloured wrap) did not result in more healthy beverage choices, and priming nudges related to unhealthy beverages (Coca-Cola logo, picture of Coca-Cola in a glass, or a red coloured wrap) did not result in more unhealthy beverage choices. However, the black coloured (control) vending machine did influence beverage choice, with relatively more people choosing caffeine-based beverages in this condition. We speculate that the black colour of the vending machine may have influenced caffeine-related thoughts (due to caffeine being associated with the colour black) and therefore potentially resulted in more caffeine-based choices. In addition, men were more likely to choose caffeine-based beverages than women. Participants also chose beverages they considered to be tasty, refreshing, and healthy.

General Discussion

The present studies aimed to examine whether priming nudges featured on a vending machine wrap could influence beverage choice behaviour. The findings from Study 1 showed that vending machine wraps had no significant effect on beverage choices, while Study 2 found a significant effect for the black vending machine (control) condition only. Specifically, participants who viewed the black vending machine chose relatively more caffeine-based beverages than water. Not surprisingly, beverage choices were also driven by how much a beverage was liked, how often it was consumed (Study 1), and perceptions of its taste, refreshing qualities and healthiness (Study 2).

We had predicted that participants would be more likely to choose water (a healthy option) from vending machine wraps that featured the Mount Franklin (a popular brand of water in Australia) logo, a picture of water in a glass, or were coloured blue (a visual representation of water/Mt. Franklin brand) compared to a black coloured (control) vending machine (Hypothesis 1). Conversely, we had

predicted that participants would be more likely to choose a soft drink (an unhealthy option) from vending machine wraps that featured the Coca-Cola logo, a picture of soft drink (Coca-Cola) in a glass, or were coloured red (a visual representation of soft drink/Coca-Cola brand), relative to a black coloured (control) vending machine (Hypothesis 2). The results of neither study supported these hypotheses. Thus the present findings are inconsistent with those of Brown and Tammineni (2009). In contrast to the present studies which isolated the effect of changes in vending machine wrap, Brown and Tammineni (2009) reported on the effect of these nudges in combination with changes in beverage availability and pricing. Our findings suggest that the effects on beverage choice observed by Brown and Tammineni (2009) were most likely due to the changes in the pricing and availability of beverages rather than their vending machine wraps. Future research should test each of the above factors independently. The present findings are, however, consistent with those of Minaker et al. (2011) who found no association between the presence of beverage logos and beverage consumption in schools (although there was an association between the presence of snack logos and unhealthy food consumption). In a similar vein, Stöckli et al. (2016) showed that the presentation of a poster depicting a health-evoking nature scene, physical activity or skinny Giacometti sculptures on a vending machine resulted in healthier snack food choices. Together these findings suggest that priming nudges on vending machines may be more effective for food choices than beverage choices.

The finding that the black vending machine resulted in more caffeine choices in Study 2 supports in a general way the previously reported colour effects by Genschow et al. (2012) and Akyol et al. (2018). Although we had predicted that the blue and red prime wraps would influence beverage choice positively and negatively,

respectively, we found instead that the black vending machine increased caffeine-based choices. It seems likely that the black colour of the vending machine may have primed or cued caffeine because it is readily associated with the colour of coffee. Future research could usefully examine whether other colours could similarly influence beverage choices from vending machines; for example, a green vending machine (a colour associated with healthiness) might encourage healthier beverage choices.

Interestingly, the effect of the black vending machine on caffeine-based choices was only observed in Study 2. One difference between the two studies is that participants could complete Study 1 only during working hours (9am – 5pm), whereas they could complete Study 2 at any time of the day. Participants who completed Study 2 at night may have had a greater desire for caffeine-based beverages due to a need for energy at that time. There was indeed a large proportion of caffeine choices (>50%) after 10pm. As a result, participants may have been more susceptible to the black vending machine condition priming caffeine related thoughts.

Not surprisingly, participants' beverage choices in Study 1 were largely based on how much they liked the beverages and how often they consumed them. These two factors suggest that beverage choices are mostly habitual, as has been shown previously for sugar sweetened beverage consumption (Dono et al., 2021; Zhen et al., 2011). In Study 2, participants' perceptions of how healthy, tasty, and refreshing the beverages were contributed to their choices, which fits with previous research that has linked unhealthy beverage consumption behaviour to perceptions of the taste of beverage (Block et al., 2013; Dono et al., 2020). Looking at the patterns of perceptions in more detail, not surprisingly water choices were the only beverage

choice associated with healthiness. In contrast, soft drinks and caffeine-based beverage choices were primarily associated with how refreshing and tasty they are. This difference likely reflects the focus of marketing strategies that promote soft drinks and caffeine-based beverages as tasty and refreshing. It is therefore possible that bottled water could be made a more attractive choice if its refreshing nature was more strongly empathized. More generally, attempts to shift individuals towards healthier beverages might usefully target and increase people's perceptions of how tasty, refreshing, and healthy beverages are.

At a practical level, the priming nudges incorporated into the vending machine wraps in the present studies may not have been sufficiently strong to override existing habitual consumption behaviours. However, the finding that a black vending machine produced more caffeine-based beverage choices demonstrates, in principle, that colour-based priming nudges might be a useful tool. In the present case, if one wanted to reduce the choices of caffeine-based beverages, one could avoid the colour black on vending machines, a suggestion that could be tested in a field study. If effective, this type of priming nudge may then extend to other environments such as restaurant menus, supermarkets shelves, and drink fridges in cafes. Any such change (e.g., changing the colour of a display) would be easily implementable, and does not depend on government regulation or policy change. Future research might specifically examine other colours in more powerful designs. In addition, although the focus of the present studies was on soft drink choices, it should be noted that the caffeine-based beverages in the vending machine displays also contained a high amount of sugar (in addition to caffeine), similar to that of soft drink (more than 40 grams of sugar per serve). Therefore, these caffeine-based beverages share the same negative health consequences as soft drinks, in addition

to the potential cardiovascular risks associated with overconsumption of caffeine (Poole et al., 2017).

The present research carries a number of limitations. First, the samples consisted of predominantly female students of mostly normal weight. Future research should investigate whether the current findings generalise to other demographic groups. Second, the limited range of beverages offered in the vending machine displays may have restricted participant choice but was modelled on actual vending machines. In addition, some brands of beverage were exclusive to the Australian market. Third, participants in the present studies did not receive or have opportunity to consume their chosen drink. Nevertheless, hypothetical choices have been shown to activate similar brain systems as real choices (Kang et al., 2011), and thus are a valid predictor of actual choices. Fourth, the main effects from the multinomial logistic regression models in the present studies should be interpreted with caution as these analyses featured multiple comparisons, and thus some of the significant findings could be explained by chance variation. Finally, the present studies were conducted in the lab or online, and therefore may not best represent what would happen in naturalistic environments. Future research should seek to test the effects of vending machine wraps on actual machines in the field.

In conclusion, the present studies offer little evidence that vending machine wraps can shift beverage choices. However, they might do under certain circumstances. Specifically, the black vending machine wrap resulted in more caffeine-based choices than water and thus should be avoided. This is a promising start for priming nudges as a pathway towards promoting healthier beverage consumption behaviour.

Statements and Declarations

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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CHAPTER 4: EFFECTS OF TRAFFIC LIGHT LABELLING AND INCREASED HEALTHY RANGE ON BEVERAGE CHOICES FROM VENDING MACHINES

Abstract

The overconsumption of soft drinks is a growing public health concern, leading several countries to implement strategies to reduce such consumption through taxation, restricting access, or plain packaging. These strategies rely heavily on government regulation and policy change. The present studies examined whether alternative strategies such as a traffic light system or increased healthy range might prove effective. Two studies (*n* = 558, 420) tested whether the provision of traffic light labels (green, amber and red) and an increased range of healthy beverages (from 20% to 50% green options), individually and in combination, could increase healthy beverage choices from a digital vending machine display. Participants were instructed to choose one drink from the display. Featuring traffic light labels on a vending machine did not result in a significant increase in healthy beverage choices (Studies 1 & 2), whereas increasing the healthy range did (Study 2). The combination of traffic light labels and an increased healthy range (Study 2) resulted in the largest significant increase in healthy beverage choices and was the only condition where the percentage of healthy (green) choices exceeded that of unhealthy (red) choices. It was suggested that the provision of traffic light labels supplied the necessary nutritional information, and the increased healthy range offered greater opportunity to act in accordance with that information. In so doing, the present findings offer a promising pathway for reducing soft drink consumption

Keywords: soft drink; beverage choice; vending machine; traffic light system; healthy range; nudging

Introduction

The consumption of soft drinks (carbonated beverages that are high in sugar, not including sugar-free varieties) is increasing worldwide, leading to an increased prevalence of health problems related to overconsumption (Tahmassebi & BaniHani, 2019), including diabetes, tooth decay, and obesity (Basu et al., 2013; Çetinkaya & Romaniuk, 2020). Concerningly, one of the largest age groups that consume soft drinks are adolescents and young adults (Han & Powell, 2013), who are particularly sensitive to developing lifelong habits that can negatively impact long-term health. In response to this growing health concern, the World Health Organization (WHO, 2015) made a strong recommendation that people limit their daily intake of free (added) sugar to 10% of their total energy intake, equating to roughly 50 grams or 12 tsp of sugar. With soft drinks being one of the main sources of sugar in many people's diet (Australian Bureau of Statistics, 2020), this growing health concern has highlighted the importance of reducing soft drink consumption.

Over recent years, several countries (e.g., US, UK, Chile and NZ) have implemented strategies to reduce soft drink consumption, including taxing soft drinks (Tiffin et al., 2015), restricting access to soft drinks (Fernandes, 2008; Terry-McElrath et al., 2013) and providing nutritional warning labels (Taillie et al., 2020). Each of these strategies has had varying levels of success. For example, while the introduction of a soft drink tax has resulted in reduced soft drink purchases in various countries, it can also shift purchasing behaviour to other high sugar items (Nakhimovsky et al., 2016). In addition, while restricting access in schools can reduce soft drink consumption, it has been shown to result in increased soft drink consumption outside of school (Fernandes, 2008; Terry-McElrath et al., 2013). However, prominent warning labels on products high in sugar together with a tax

have reduced soft drink purchases in Chile (Taillie et al., 2020). Collectively, current strategies mostly involve government regulation and policy change.

An alternative strategy would be to implement a change within the immediate environment in which the choice is presented. An example is the introduction of a nutritional label at the point of sale rather than on the product itself. This carries the advantage that it still offers the choice of soft drink to those who choose to consume it and does not require manufacturers to change the labels of their products.

There are a variety of nutritional labelling systems in use around the world, such as the nutrient warning, health warning, nutritional score, and traffic light system. Of these, a recent review found the traffic light system to be one of the most popular and best performing at nudging consumers towards purchasing healthier food products (Song et al., 2021). This system offers an easy-to-understand visual cue using traffic light colours (red, amber, and green) to denote the nutritional value of food and beverages. These colours are universally understood concepts, with green denoting “go” or “good”, amber “slow down” or “limit” and red “stop” or “avoid”. A review of the traffic light system found that it had a significant influence in promoting healthy food choices from restaurants and cafeterias (Fernandes et al., 2016). Because of its success in these food environments, the traffic light system may also prove effective in other settings. One environment that is a common source of soft drinks is a vending machine. A vending machine typically offers many different varieties of food or beverages with no nutritional information at the point of purchase. Implementing the traffic light system for beverages within a vending machine could promote healthier choices much like it has in other consumption environments. To date, one study has investigated the effect of applying the traffic

light system to snack vending machines. Brown et al. (2014) placed green, amber, and red stickers on the shelving below snacks on five high use machines on a university campus, which resulted in a non-significant 50% increase in green product purchases. However, the vending machine only included snack foods.

It is also important to consider the proportion of the different beverage types that are offered, particularly in terms of the range of red, amber and green beverages. For instance, a person may want to choose a healthier beverage in response to the traffic light classification. However, if there are insufficient options or variants of their intended choice available, they may be less likely to choose to a healthier beverage (e.g., a sugar-free soft drink or flavoured sparkling water instead of a soft drink). While traffic lights are easier to apply to an existing vending machine, there may be a strong advantage to also increasing the proportion of healthy beverages available, to ensure that an appealing healthy alternative option is available. Research in the food domain has shown that increasing the range of healthy options is an effective means of increasing healthy food choices (Allan et al., 2021).

Thus, the aim of the present research was to test the impact of the traffic light system on a beverage vending machine. To this end, we tested the traffic light system in two studies. Study 1 featured a typical beverage vending machine representative of the range of drinks (proportion of healthy and unhealthy drinks) typically offered. Study 2 extended this by testing the traffic light system on a vending machine that was stocked with a greater proportion of healthy options following recent guidelines from the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a). Based on previous research

(Brown et al., 2014; Song et al., 2021), we predicted that the vending machine with the traffic light system would increase the percentage of healthy (green) choices in both studies.

Study 1 Method

Participants

Participants were 558 young adults (414 women and 143 men) with a mean age of 20.21 years (*SD* = 2.41). The sample size was based on an a priori power calculation to detect a moderate sized effect with an alpha level of .05 and 80% power (Cohen, 1992). The sample consisted of 317 undergraduate students at Flinders University who took part for course credit and 241 participants from Prolific who received a small monetary reimbursement. Participation was limited to young adults (17 – 25 years) to capture the core consumers of soft drinks. Mean BMI of the sample was 23.56 kg/m^2 (*SD* = 5.20).

Design

The experiment used a between-subjects design. Participants were randomly allocated to one of two vending machine display conditions: traffic light system or no traffic light system (control). The dependent variable was the classification of the beverage chosen (green, amber or red).

Materials

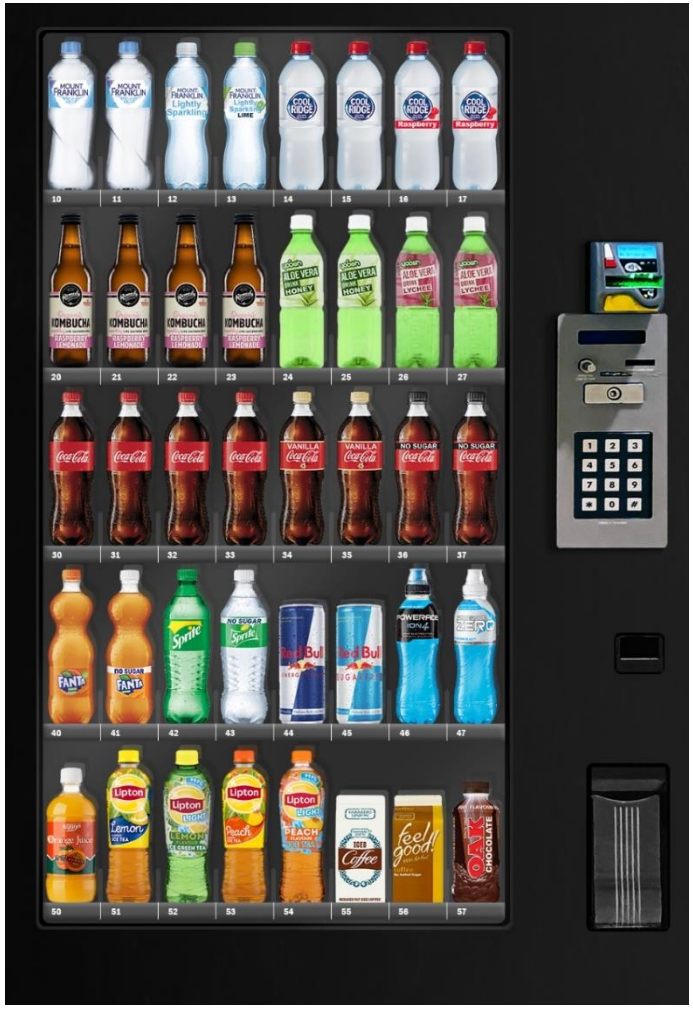
Vending Machine Displays. Two vending machine displays were created: traffic light system and control (no traffic light system). As shown in Figure 1, the traffic light system condition featured labelling under each beverage indicating whether it was classified as either green, amber or red based on nutritional value.

Text was also included in the colour classification labels to allow those who are colour blind to participate in the study. A legend in the top right-hand corner provided more information about the colour classifications, with green indicating ‘best choice’, amber ‘choose carefully’, and red ‘limit’. Drink colour classifications and the legend text for the colours were based on the Food Checker classification of the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a). This service enables beverages to be searched in an online database to find the colour classification according to set nutritional criteria. The criteria specify that green beverages are low in added sugar, energy or fat, red beverages are high in added sugar, energy or fat, and amber beverages are between the two (see Victorian Healthy Eating Advisory Service (2021b) for more information). The control vending machine had an identical drink layout and range but did not feature the traffic light system.

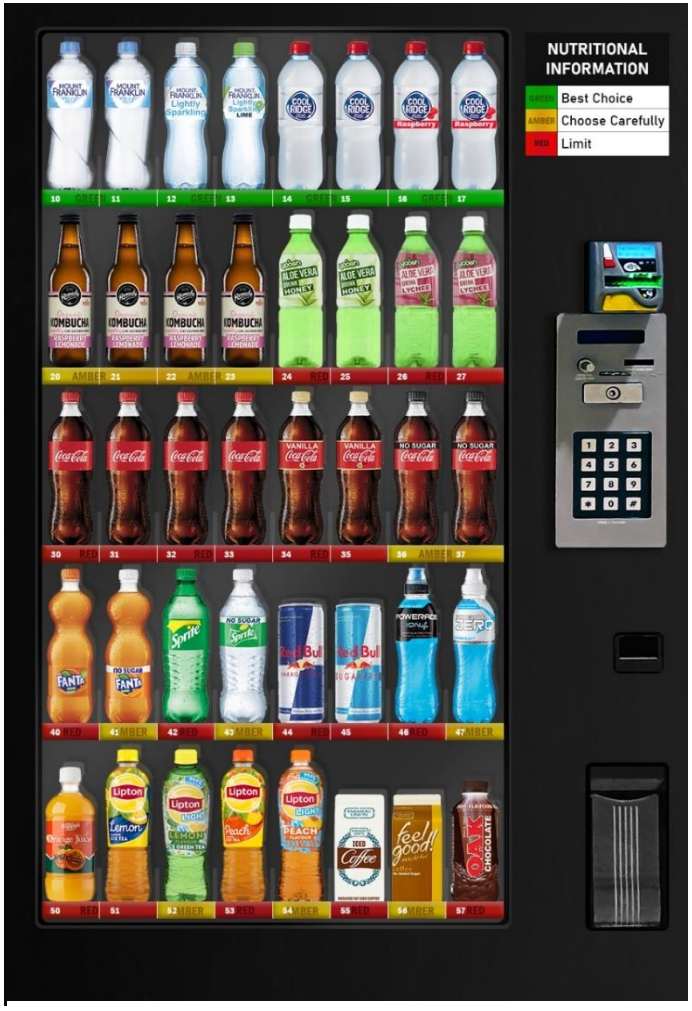
The selection and placement of the drinks in the vending machine were based on Flinders University vending machine sales data. This resulted in 8 spaces (20%) in the vending machine layout filled with green beverages, 12 spaces (30%) with amber beverages, and 20 spaces (50%) with red beverages. The selection of green beverages included popular Australian varieties of water (including lightly flavoured and sparkling waters). The amber beverages included kombucha, aloe vera drinks, and sugar free soft drinks. The red beverages included soft drinks and energy drinks. All serving sizes of beverages were kept as close as possible to a 500ml offering.

Figure 1

The two vending machine conditions featured in Study 1.



Control



Traffic Light System

Beverage Choice Task. Participants were asked to imagine that they were standing in front of a vending machine and to choose a beverage that they would like to drink straight away, without consideration of price or serving size. Participants made their selection by clicking on their beverage of choice. They were then asked to describe in a few words why they chose that particular beverage.

Demographic Information. Participants reported their age and gender, and the last time they drank anything (estimated to the nearest 15 min). They also rated how thirsty they were on a 100mm visual analogue scale ranging from ‘not at all thirsty’ to ‘extremely thirsty’.

Procedure

The study received ethics approval from the Social and Behavioural Research Ethics Committee (approval number 8391) and was run in accordance with the National Statement on Ethical Conduct in Human Research (2007). The study was conducted online using Qualtrics. After providing informed consent, participants provided demographic information. They then completed the beverage choice task and post-choice question. Most participants completed the study in 10-15 minutes.

Results

Beverage Choice

Overall participants mostly chose red beverages (57%), followed by green beverages (23%) and amber beverages (20%). The most commonly reported reason for choosing a particular beverage was because it was liked (18.8%), or because it was considered healthy (9.2%), a favourite (8.8%), refreshing (8.7%), or tasty (8.7%).

Table 1

Study 1 percentage of beverage colour classifications chosen in each condition.

Condition	Green	Amber	Red
Control	19.6%	20.4%	60.0%
Traffic light system	25.8%	20.5%	53.7%

Effect of Vending Machine Condition on Beverage Choice

From Table 1, it can be seen that there was a slight trend towards healthier beverage choices for the vending machine that featured the traffic light system, with green beverages chosen 6.1% more frequently and red beverages chosen 6.3% less frequently relative to the control machine. However, in both conditions most participants still chose unhealthy (red) beverages. A multinomial regression was conducted to test the main effect of traffic light system on beverage choice (green, amber, red). Individual differences in thirst were controlled. The overall model proved not significant, X^2 (8, N = 420) = 7.669, p = .104, indicating that the traffic light system was not a significant predictor of beverage choice.

Discussion

It was predicted that featuring the traffic light system on the vending machine would result in significantly more healthy beverage choices. Although there was a trend towards healthier (green) beverages and fewer unhealthy (red) beverages being chosen when featuring the traffic light system, the effect of the traffic light system was not significant. One possibility is that the traffic light system on its own is not strong enough to nudge participants to choose a healthier beverage.

Study 1 was modelled on a typical beverage vending machine. Recently, however, the Victorian Government has introduced some guidelines for the layout of vending machines (Victorian Healthy Eating Advisory Service, 2021a). These suggest having at least 50% green choices, and no more than 20% red choices. To test the additional impact of increasing the range of green options available, we designed Study 2 to feature vending machine displays with a healthier drink range, based on the guidelines (Victorian Healthy Eating Advisory Service, 2021a). These additional vending machine displays enabled us to independently test the main effects of the traffic light system and an increased healthy range, as well as the interaction between the two, on beverage choices.

Study 2 Method

Participants

Participants were 420 young adults (284 women and 136 men) with a mean age of 20.67 years (*SD* = 2.26). The sample size was again based on an a priori power calculation to detect a moderate sized effect with an alpha level of .05 and 80% power (Cohen, 1992). The sample consisted of 42 undergraduate students at Flinders University who took part for course credit and 378 participants from Prolific who received a small monetary reimbursement. Participation was again limited to young adults (17 – 25 years) to capture the core consumers of soft drinks. Mean BMI of the sample was 24.30 kg/m^2 (*SD* = 6.40).

Design

The experiment used a 2 (traffic light system: featured vs not featured) x 2 (increased healthy range: featured vs not featured) between-subjects design. The

outcome was the percentage of the colour classification of beverages chosen (green, amber, or red).

Figure 2

The four vending machine conditions featured in Study 2.

Control | **Traffic Light System** | **Increased Healthy** | **Traffic Light System**

X Increased Healthy Range

Materials

Vending Machine Displays. Four vending machine displays were created to test the main effects of the traffic light system (featured vs not featured) and increased healthy range (featured vs not featured), as well as the interaction of the traffic light system and increased healthy range, on the percentage of the colour classifications of beverages chosen. The traffic light system display was identical to the one used in Study 1. The increased healthy range display was created to closely match the guidelines of the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a) for the proportions of healthy and unhealthy products offered. This display featured 20 spaces (50%) filled with green beverages, 8 spaces (20%) with amber beverages, and 12 spaces (30%) with red beverages. Compared to the range featured on the other displays, this offered a 20% increase in the number of green choices, a 10% decrease in the number of amber choices and a 10% decrease in the number of red choices. To achieve these recommended percentages, the increased healthy range featured four additional green beverage choices (one additional water flavour, and three additional sparkling water options) and two fewer red beverage choices (soft drinks), removed based on their very low popularity in Study 1. Finally, a fourth display featured both the traffic light system and an increased healthy range.

Beverage Choice Task. The beverage choice task was the same as in Study 1.

Demographic Information. The demographic information questionnaire was identical to that of Study 1.

Procedure. The procedure was the same as in Study 1.

Results

Beverage Choice

As in Study 1, overall participants again mostly chose red beverages (53%), followed by amber beverages (25%) and green beverages (22%). The most commonly reported reason for choosing a particular beverage was because it was liked (18.1%), or because it was considered healthy (12.7%), a favourite (9.9%), tasty (8.7%) or refreshing (7.4%).

Table 2

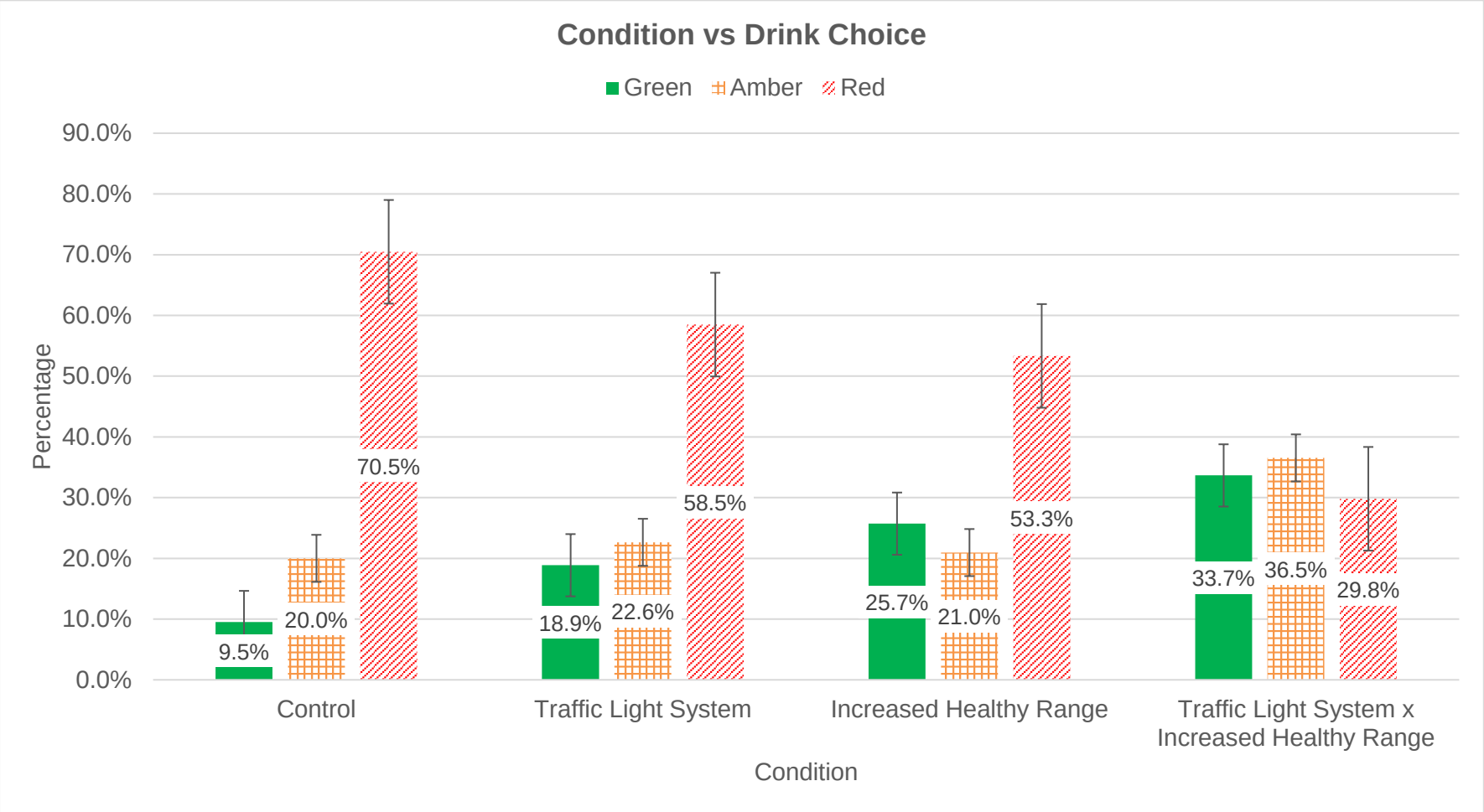
Study 2 likelihood ratio tests of the main effects and interaction entered in the multinomial regression.

Effect	*Model Fitting Criteria*	X^2	*p*
Thirst	613.424	8.246	.016*
Traffic Light System	609.604	4.426	.109
Increased Healthy Range	615.657	10.479	.005**
Traffic Light System X Increased Healthy Range	642.932	37.754	<.001**

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

Figure 3

Study 2 percentage of beverage colour classifications chosen in each condition.



Note: Error bars for the beverage colour choice percentages represent standard errors.

Effect of Vending Machine Condition on Beverage Choice

Figure 3 shows the beverage choices in each condition. It can be seen that red beverages were clearly the most frequently chosen in the first three conditions. In the combined traffic light and increased range condition, however, green and amber beverages were selected slightly more often than red beverages.

A multinomial regression was conducted to test the main effects of traffic light system and increased healthy range, together with their interaction, on beverage choice (green, amber, red) while controlling for thirst. The overall model was significant, X^2 (8, N = 420) = 49.898, $p < .001$, and did not violate the Pearson (X^2 (418, N = 420) = 463.778, p = .060) test for goodness of fit. As can be seen in Table 2, the main effect of the traffic light system (X^2 = 4.426, p = .109) was not significant, while the main effect of an increased healthy range was (X^2 = 10.479, p = .005). The interaction between the two was also significant (X^2 = 27.754, $p < .001$).

Discussion

Study 2 investigated the effect of the traffic light system on a vending machine offering a greater range of healthy options. As in Study 1, the traffic light system on its own produced a non-significant trend towards healthier beverage choices. However, increasing the range of green beverage options and correspondingly reducing the range of ‘red’ options in line with recent guidelines from the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a) did result in significantly more healthy beverage choices. In addition, the combination of an increased healthy range and the traffic light system resulted in the largest proportion of healthy beverage choices. In fact, it was the only condition where the percentage of healthy (green) choices (33.7%) exceeded that of unhealthy (red) choices (29.8%).

General Discussion

The present studies examined the effects of a traffic light system and an increased healthy range, individually and in combination on beverage choices from a vending machine. Featuring the traffic light system on the vending machine resulted in a non-significant trend towards more healthy beverage choices (Studies 1 and 2). However, increasing the range of healthy options did produce significantly more healthy beverage choices (Study 2). In addition, the combination of the traffic light system and an increased healthy range resulted in the largest proportion of healthy beverage choices.

The present studies reported a non-significant trend toward healthier beverage (green) choices when using the traffic light system. This parallels the result of Brown et al. (2014), although their reported (nonsignificant) increase (50%) was larger. These findings suggests that in settings where mostly unhealthy items are on offer, using traffic lights alone may not be enough to produce a substantial shift toward healthier choices. Traffic lights have been shown to be successful in increasing healthy choices in settings that typically offer a greater variety of healthy items (e.g., restaurants and cafeterias) (Fernandes et al., 2016), increasing the likelihood of an appealing alternative. Consequently, a stronger nudge than the traffic light system may be required to produce healthier beverage choices from a vending machine environment that typically features predominantly unhealthy beverages.

In Study 2, the effect of the increased range of healthy beverages was significant and was stronger than that of the traffic light system for increasing healthy beverage choices. The range of healthy beverages offered was based on the guidelines by the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a). The present findings show that following these guidelines for the stocking of beverage vending machines could potentially lead to an increase in the percentage of healthy beverage choices and a decrease in the percentage of unhealthy beverage

choices. One reason for the stronger effect compared to the traffic light system may simply be that the increased healthy range offered a greater number of appealing healthy options. It is also possible that stocking the vending machine with a majority of spaces (50%) featuring healthy beverages may have acted as a normative cue. This is line with previous research showing that increasing the ratio of healthy food offered in hospital settings was strongly associated with the healthiness of food choices (Allan et al., 2021). Similarly, research specifically on vending machines has found that increasing the ratio of healthy items resulted in a higher percentage of healthy item sales (Rosi et al., 2017).

Importantly, the interaction between featuring the traffic light system and an increased healthy range resulted in the largest increase in the percentage of healthy choices. It is possible that either alone addresses only one part of the process, whereas together they offer both easy to understand nutritional information though the traffic light system, together with sufficient opportunity to act on this information through the increased healthy range. It should be noted that the interaction resulted from an increase in both green and amber beverage choices, the latter possibly representing people who would have originally chosen an unhealthy (red) beverage changing their choice to a healthier option (amber), for example, choosing a sugar-free soft drink (amber) over a standard soft drink (red).

The present studies show the importance of both increasing the healthy range and including the traffic light system to maximise the percentage of healthy beverage choices from vending machines. While increasing the healthy range offered in the vending machine resulted in a significant increase in healthy choices, this effect was less than half of that obtained by combining it with the traffic light system. Indeed, the combined condition was the only condition where the percentage of healthy (green) choices exceeded that of unhealthy (red) choices. Such an increase in the percentage of healthy

beverage choices is a potentially significant step towards reducing negative health outcomes associated with the overconsumption of soft drink and other sugar-sweetened beverages. For example, on each occasion an individual chooses a sugar-free soft drink over a standard soft drink, they will consume approximately 12 teaspoons less of sugar, in turn making them more likely to meet the WHO recommendations for daily free sugar intake and avoid the health issues related to the overconsumption of soft drinks.

Although the effects of an increased healthy range in combination with traffic lights were demonstrated for vending machines, these colour coding and layout changes could also be implemented in other environments (such as drink fridges in cafes and schools) and may result in a similar increase in the percentage of healthy beverage choices. Future research could test these in other settings, especially in the field.

The present research carries a number of limitations. First, the samples consisted of participants of mostly normal weight, according to the World Health Organisation's BMI classifications (WHO, 2010). Future research should investigate whether the traffic light system has more of an effect on individuals with a higher weight. Second, participants in the present studies did not have the opportunity to drink their chosen beverage. Nevertheless, hypothetical choices have been shown to be a valid predictor of actual choices, as they activate similar brain systems (Kang et al., 2011).

In conclusion, the present studies offer evidence supporting the guidelines specified by the Victorian Healthy Eating Advisory Service (Victorian Healthy Eating Advisory Service, 2021a) for stocking and featuring traffic lights on vending machines. This seems a promising pathway for guiding people's choices away from soft drinks and other unhealthy drink options towards something healthier with less or no sugar, and thereby reducing sugar consumption.

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CHAPTER 5: GENERAL DISCUSSION

Chapter Overview

The overarching aim of the thesis was to determine the socio-cognitive determinants that are most associated with soft drink consumption (specifically varieties that contain sugar), and to examine the use of nudging to reduce soft drink consumption by targeting some of these determinants within the context of vending machines. Each chapter (and the studies therein) had its own separate aims. Study 1 (Chapter 2) was a comprehensive meta-analysis which aimed to determine the strongest correlating socio-cognitive determinants with sugar sweetened beverage consumption. Studies 2 and 3 (Chapter 3) aimed to investigate the effectiveness of using wrap-based nudges to increase healthy beverage choices from a vending machine display. Studies 4 and 5 (Chapter 4) aimed to investigate the effectiveness of featuring a traffic light system and increasing the range of healthy beverages offered, each on their own and in combination for increasing healthy beverage choices from a vending machine display. The current chapter will summarise the findings of the present thesis and discuss the theoretical and practical implications. Additionally, strengths, limitations and directions for future research will be addressed.

Summary of Findings

Within the overarching aim of the thesis, Study 1 (Chapter 2) first sought to determine the socio-cognitive determinants that are most associated with sugar sweetened beverage consumption. This was achieved by conducting a systematic literature review and meta-analysis designed to determine the strongest correlating socio-cognitive determinants with the amount and frequency of sugar sweetened beverage consumption. The findings from the meta-analysis showed that the amount of sugar sweetened beverage consumption was most strongly correlated with the habit (automaticity) of consumption, followed by the intention to consume sugar sweetened

beverages, and positive attitudes toward sugar sweetened beverages. The findings further showed that frequency of sugar sweetened beverage consumption was most strongly correlated with the habit (automaticity) of consumption, followed by injunctive norms (friends thinking they should not limit their consumption) and descriptive norms (the sugar sweetened beverage consumption behaviour of friends/parents). The review concluded that the strongest correlating socio-cognitive determinants of sugar sweetened beverage consumption that were easily modifiable mainly reflected components of the Theory of Planned Behaviour (attitudes, subjective norms, and perceived behavioural control), but also included components outside of the theory (e.g., habits). It was therefore suggested that interventions designed to reduce sugar sweetened beverage consumption should focus on multiple determinants, such as changing attitudes, norms, and habits, and increasing perceived behavioural control related to sugar sweetened beverages, as this may be the most effective approach for reducing unhealthy beverage consumption behaviour.

Studies 2 and 3 (Chapter 3) were designed to investigate the effect of wrap-based nudges on beverage choices from digital vending machines. The findings from Study 2 did not show any significant effect of the vending machine wraps on beverage choices. However, Study 3 did show a significant effect, with the black vending machine wrap leading to relatively more caffeine-based beverage choices in comparison to other conditions. Overall, the health focused wraps (i.e., advertising a healthy beverage brand, a pictured healthy beverage in a glass, or using the same colour as the healthy beverage brand) did not influence healthy beverage choices in either study. Additionally, Study 2 found that liking and frequency of consumption predicted beverage choice, while Study 3 found that perceptions of taste, refreshing quality and healthiness predicted choice. These two empirical studies concluded that vending machine wraps may nudge beverage choices in certain circumstances, but that it was necessary to examine more explicit forms

of nudging within vending machine environments, as the wrap-based nudges may have not been strong enough to change the underlying socio-cognitive determinants that drive beverage choice behaviour.

Studies 4 and 5 (Chapter 4) subsequently examined more explicit forms of vending machine nudges. Specifically, Study 4 examined whether including a traffic light system on a vending machine display could influence healthier beverage choices. Although this resulted in a slight trend towards healthier beverage choices, the effect was not statistically significant. Study 5 expanded the experimental design to examine whether increasing the range of healthy beverage options in conjunction with the traffic light system could produce a significant increase in healthy beverages choices. The findings of Study 5 showed that increasing the range of healthy options offered in the vending machine on its own resulted in significantly more healthy beverage choices. In addition, the combination of the traffic light system and an increased healthy range resulted in the largest increase of healthy beverage choices. These two studies concluded that either intervention alone does not have a strong influence on healthy beverage choices, whereas together they do. It was suggested that when the interventions are featured together, they offer easy to understand nutritional information through the traffic light system with sufficient opportunity to act on this information through the increased healthy range.

Theoretical Implications

Each of the studies in this thesis offer significant contributions to our understanding of the potential drivers of soft drink consumption, including environmental factors that can influence healthy beverage choices. Collectively they demonstrate that focussing on the components of the Theory of Planned Behaviour when designing nudging-based interventions could produce substantial shifts towards healthier choice behaviours.

The systematic review and meta-analysis (Study 1; Chapter 2) concluded that the most strongly correlated socio-cognitive determinants with sugar sweetened beverage consumption both in terms of amount and frequency were also major components of the Theory of Planned Behaviour (i.e., attitudes, subjective norms, and perceived behavioural control). The meta-analysis found attitude to be one of the strongest components of the Theory of Planned Behaviour that predicted sugar-sweetened beverage consumption. Previous research on the Theory of Planned Behaviour and sugar sweetened beverage consumption has also consistently found attitude to be the strongest driving component of this behaviour (Kassem & Lee, 2004; Kassem et al., 2003; Seyed Mortaza et al., 2019; Zoellner et al., 2012). In particular, the results from Study 1 suggest that attitudes towards sugar-sweetened beverage consumption may be the strongest correlating component of such consumption, because the other components of the theory (subjective norms, perceived behavioural control) are mostly affected by existing attitudes. For example, if someone holds negative attitudes about consuming sugar sweetened beverages, they are more likely to convince their friends not to consume such beverages (negative subjective norms) and have a stronger motivation to control their consumption (perceived behavioural control) than someone who holds positive attitudes.

From the results of Studies 2 and 3 (Chapter 3), it can be concluded that using subtle nudges, such as the advertising, branding, and colour of vending machine wraps, was mostly ineffective at influencing beverage choice behaviour. Specifically, changing the vending machine wrap was not an effective approach for reducing unhealthy choices, as the healthy focussed wraps (i.e., advertising a healthy beverage brand, a pictured healthy beverage in a glass, or using the same colour as the healthy beverage brand) did not result in an increase in healthy beverage choices. The black wrap was the only condition that significantly influenced beverage choices, but this was for caffeine-based choices rather than healthy ones. It is possible that the healthy wrap-based nudges were too

subtle, and not strong enough to influence choice. This may be because these nudges were not strong enough to influence the components of the Theory of Planned Behaviour that emerged from the meta-analysis (Study 1; Chapter 2) as some of the strongest correlates of consumption behaviour. In practice, the healthy focussed wraps would only have influenced subjective norms as they did not include any features that would have specifically influenced attitudes towards particular types of beverages or perceived behavioural control. The healthy focussed wraps may have influenced subjective norms in that the featured healthy beverage (branding or pictured healthy beverage in a glass) or reference to a healthy beverage (colour of the healthy beverage brand) was implied to be the beverage that was most often chosen by others, and hence why it was featured on the vending machine. However, this link is rather subtle and unlikely to override the strong effects of habit in this instance, and Studies 2 and 3 did not include direct measures of these constructs to confirm these links.

From Studies 4 and 5 (Chapter 4), it can be concluded that using less subtle nudges was more effective at changing beverage choices from a vending machine. Specifically, featuring both a traffic light system and increasing the range of healthy beverages offered was the most effective at increasing healthy beverage choices. It stands to reason that this approach was the most effective because it influenced all three components of the Theory of Planned Behaviour. In particular, featuring traffic lights on a vending machine may shift attitudes towards unhealthy beverages to become more negative as these beverages are signposted by a ‘red’ classification and include the message to ‘limit’ them. It has also been shown that attitudes towards sugar sweetened beverages are mostly tied to perceived healthiness (Bombak et al., 2021), and this system offers a clear indication of the healthiness of the beverages. The colour classification may also promote the concept of ‘good’ (e.g., beverages classified as green) and ‘bad’ (e.g., beverages classified as red) beverages and thus influence attitudes to those beverages

accordingly. This approach may have also indirectly influenced subjective norms about soft drink consumption, with the increased number of spaces occupied by healthy beverages suggesting that those beverages were the ones most likely to be chosen by others or to be perceived favourably by others, as they were classified as healthy (green). The traffic light system may also have influenced the perceived behavioural control of consumers, because it offers an easy-to-understand visual guide by way of colours and clear messaging to determine the best (or a better) beverage to choose based on healthiness. In addition, offering more opportunities to switch to a healthier option through the provision of an increased healthy range could also have increased perceived behavioural control as there are more options that are likely to appeal as a healthy alternative.

The findings of the present thesis also have some important theoretical implications for choice architecture (Thaler & Sunstein, 2009). Studies 2 and 3 showed that the use of visual nudges surrounding the beverages by way of vending machine wraps did not significantly influence beverage choices. This suggests that these more peripheral cues may not play a substantial role in consumers' decision-making process when choosing a beverage from a vending machine display. This could also be because participants associate vending machines with soft drinks, and thus healthier beverages are typically not considered in this context. Therefore, the subtle nudges used in Studies 2 and 3 may not have been sufficiently strong to change established choice behaviour from vending machines. In contrast, Studies 4 and 5 found that changes to the presentation (e.g., featuring a traffic light system) and partitioning (e.g., changes to the ratio and spaces occupied by healthy beverages) of the beverages within the vending machine display itself did significantly produce healthier beverages choices. In addition, these two changes proved most effective when featured together, suggesting that combining nudges produces a stronger effect. In so doing, the particular combination of nudges successfully

changed choice behaviour in a predictable way towards healthier beverages, while maintaining consumers' freedom of choice by not removing any options, and without changing any economic incentives.

Practical Implications

The present thesis offers evidence that featuring a traffic light system on a vending machine, together with increasing the range of healthy beverages offered in the machine is an effective strategy to both increase healthy beverage choices and decrease unhealthy choices. Featuring a traffic light system fits with the Victorian Healthy Eating Advisory Service's (2022) recommendation to include nutritional labelling on food and beverages that clearly classifies the food or beverage as green (best choice), amber (choose carefully) or red (limit). The Service further recommends that the explanation of the colour coding is displayed in a clearly visible location. Study 4 (Chapter 4) tested the effect of an intervention that matched these particular recommendations and found a small non-significant trend towards healthier beverage choices. This suggests that these particular recommendations may not work sufficiently when implemented in isolation and may benefit from including additional recommendations to change the ratio of healthy items offered.

The Victorian Healthy Eating Advisory Service (2022) recommends that healthy (green) choices should make up 50% of the available choices, amber choices can be offered but should not dominate the overall number of choices, and unhealthy (red) choices should not exceed 20% of the available choices. Study 5 (Chapter 4) increased the healthy range of beverages offered in accordance with these recommendations and found a small significant increase in the number of healthy beverage choices. However, this shift did not result in a greater proportion of healthy (green) choices than unhealthy (red) choices. Thus, although an increase to the healthy range does work by itself, this approach may benefit from the provision of nutritional information.

Featuring a traffic light system together with increasing the range of healthy beverages options appears to be an effective approach for improving beverage choices, as demonstrated by the results of Study 5 (Chapter 4). In particular, it shifted a majority of consumers away from unhealthy (red) beverages towards healthier beverages (amber and green), which contain less or no sugar. This means that consumers would be more likely to meet the recommendations from the WHO of no more than 50grams of added sugar per day (World Health Organization, 2015). In so doing, this approach could help to alleviate the health risks associated with the overconsumption of sugar, such as diabetes, tooth decay, cancer, and obesity (Bassett et al., 2020; Basu et al., 2013; Tahmassebi & BaniHani, 2019).

On the basis of the findings of the present thesis, and the recent recommendations from the Victorian Healthy Eating Advisory Service (2022), Flinders University has committed to piloting the two successful changes (featuring a traffic light system and increasing the range of beverages offered) to their vending machines on campus to promote healthier choices. While outside the scope of and timeframe for this thesis, this author has been involved in designing the implementation of this pilot, and will be involved in its evaluation. Of practical significance, findings from the present studies could also be implemented in other settings where beverages are sold, such as supermarkets, retail and fast-food outlets, and fridges in cafeterias. Implementing these changes in line with the recommendations from the Victorian Healthy Eating Advisory Service (2022) offers a promising pathway to enabling consumers to make healthier beverage choices. In addition, based on the findings of Study 3 (Chapter 3) that the wrap of a vending machine has the potential to play a small role in influencing beverage choices, it is recommended that these be designed so as to avoid a neutral colour (black).

Overall, the present thesis suggests that nudging interventions should be designed to consider the three components of the Theory of Planned Behaviour (attitudes, subjective norms, and perceived behaviour control) as well as certain components outside the theory (e.g., habits) to be maximally effective at changing the desired behaviour. In particular, the socio-cognitive determinants that are most associated with the target behaviour should be investigated and be the focus of nudging interventions. For example, interventions that promote more negative attitudes towards sugar sweetened beverages may be the most effective at reducing sugar sweetened beverage consumption. One avenue towards changing attitudes towards sugar sweetened beverages is through changing the health perceptions around consumption (Bombak et al., 2021). While nudging studies in the literature have typically reported significant shifts towards desired behaviours (Hummel & Maedche, 2019), the present thesis suggests that these nudges may be more effective if designed with a theoretical basis, such as the Theory of Planned Behaviour.

Strengths, Limitations, and Future Directions

The present thesis has several notable strengths. First, all the experimental studies utilised realistic representations of vending machines in both the lab (Study 2) and online environment (Studies 3, 4 and 5). These empirical studies featured high resolution images of vending machines that utilised custom coding to maximally scale to the participant's screen size, and displayed beverages with altered labels that were a larger size to ensure they were identifiable. As a result, very few participants (average of 3.7% across all studies) reported that they were unable to identify any of the beverages in the digital vending machine display. Second, the products and their location within the vending machines were based on observational data recorded from actual vending machines in the real world. This ensured that the vending machines offered a realistic depiction of how they appear in the real world. Third, the traffic light system and the increased range of

healthy options used in Studies 4 and 5 (Chapter 4) were based on recommendations from the Victorian Healthy Eating Advisory Service (2022). These could be practically implemented in real vending machines as per the current pilot at Flinders University. Finally, with the exception of Study 2, the experimental studies recruited a sample of participants which included non-university students through the online platform “Prolific”. This resulted in more diverse and more representative samples of participants.

Notwithstanding these strengths, the present thesis also has some limitations, which provide avenues for future research. Each of the specific study limitations have been reported in the relevant chapters. This section presents an overarching summary of some of the main limitations.

First, there were some limitations specifically related to the systematic literature review and meta-analysis reported in Study 1 (Chapter 2). There were relatively few studies on which to conduct the meta-analyses. This resulted in fewer determinants being able to be compared between the amount and frequency of sugar sweetened beverage consumption. Relatedly, many of the studies were based on the Theory of Planned Behaviour leading to an inherent bias towards measuring components of this theory (intentions, attitudes, subjective norms, and perceived behavioural control). However, the meta-analyses still offered an informative snapshot of the current research that has examined the socio-cognitive determinants of sugar sweetened beverage consumption. Another limitation was that the determinants of interest were often loosely defined in the included studies. Consequently, variables with varying definitions had to be grouped together under similar constructs in order to conduct the meta-analyses, and was done so with determinants that were clearly defined to ensure consistency.

Second, in all four experimental studies, the choice of beverage was a hypothetical one in that participants did not receive or have the opportunity to consume their chosen beverage. The later studies had intended to test the proposed interventions on an actual vending machine; however, the COVID-19 pandemic and its associated restrictions prevented this plan from going ahead. Instead, the instructions were worded to elicit as real a choice as possible by encouraging participants to choose a beverage they would actually want at that moment in time. However, future research is needed to confirm whether the observed results translate to real vending machines, as per the current pilot at Flinders University.

Third, Study 3 (Chapter 3) unexpectedly found that the black vending machine wrap promoted caffeine choices. It remains unknown if other colours, other than the ones featured in the other conditions (red and blue) could influence other types of beverage choices. Importantly, the analyses conducted for these studies included multiple comparisons, so the results should be interpreted with caution as the significant findings could be explained by chance variation. Future research could confirm the effect of the black vending machine wrap in the real world, and test whether other colours could influence other types of beverage choices. For example, a green vending machine might promote healthy choices (such as water) as it is colour that is commonly associated with healthiness and has been used on packaging to increase the perceived healthiness of food products (Spence & Van Doorn, 2022).

Fourth, some of the study samples included only a small number of men. This was due to there being more women than men available for participation from both recruitment sources (university students and Prolific). However, there is no reason to expect any differences between men and women in terms of their beverage choices, nor their susceptibility to environmental variables. The samples in the later studies (Studies 3, 4 and

5) did become more evenly distributed across genders, as the recruiting service (Prolific) introduced the option to equalise the number of female and male respondents. A potential avenue for future research is testing whether certain factors such as personality, or fatigue could make people more susceptible to the tested vending machine nudges.

Fifth, a limited range of beverages were offered in the vending machines across studies. This included some brands that were exclusive to the Australian market. However, as mentioned above, the stocking of the vending machines was representative of what a real vending machine would offer and was therefore realistic to Australian participants. In addition, most of the brands featured in the machine were well-known and available worldwide (e.g., Coke), and those brands that were exclusive to Australia (e.g., Mt. Franklin) have equivalent options in other countries. Future research could test whether the effects observed here generalise to other countries that offer a different range of beverages.

Sixth, while nudging has typically been thought of as encouraging autonomy, recent research on the ethics of nudging by Schmidt and Engelen (2020) has identified that some types of nudges such as financial (e.g., incentives or taxes) or proximity (e.g., increased versus or decreased accessibility) nudges, can still result in reactance from consumers and give rise to a reduced sense of autonomy. However, the nudges used in the present studies did allow participants to choose unhealthy beverages by not removing choice, or reducing their accessibility, but rather by offering nutritional advice to help them make a more educated choice of beverage. Therefore, we would argue that the nudges used in the present studies were unlikely to result in reactance or reduce autonomy. Future research could investigate public perceptions of the type of nudges used in the present thesis, and investigate if implementation of these would cause reactance.

Finally, in addition to the future research directions mentioned above, another avenue for further investigation would be to determine whether the effects of offering a greater range of healthy beverages and featuring the traffic light system continue to promote healthier (vending machine) choices beyond their initial introduction. For example, it is possible that these interventions have a stronger influence on beverage choices during their introductory period which then weakens over time. Or, alternatively, these interventions (the traffic light system and an increased healthy range) may have longer lasting effects and even translate to making healthier eating choices more generally.

Conclusion

In conclusion, the results of the present thesis suggest that nudge-based interventions with a clear theoretical focus may result in larger shifts towards desired health behaviours. In particular, the meta-analysis (Study 1; Chapter 2) showed that components of the Theory of Planned Behaviour, namely attitudes and perceived-behavioural control were amongst the strongest socio-cognitive determinants correlated with sugar sweetened beverage consumption. It is suggested that interventions that use nudging principles could be more effective when designed to target the three components of the Theory of Planned Behaviour. This was evident from the effectiveness of the more explicit nudges (traffic light system and increased healthy range) used in Studies 4 and 5 (Chapter 4), in contrast to the more subtle nudges (healthy vending machine wraps) used in Studies 2 and 3 (Chapter 3), which were not effective. Specifically, Study 5 which featured nudges in line with several components of the Theory of Planned Behaviour, reported the largest increase in healthy beverage choices, and the largest decrease in unhealthy beverage choices. Overall, the findings from Studies 2 and 3 (Chapter 3) suggest that nudges based on vending machine wraps may not be an effective approach for reducing soft consumption. In contrast, the findings from Studies 4 and 5 offer a promising pathway to combatting the health issues associated with excessive soft drink

consumption, and offer an easily implementable set of interventions that could help guide people's choices away from soft drinks towards something healthier with less or no sugar. Future research is now needed to test the effectiveness of the traffic light system and increased healthy range in actual vending machines as well as other beverage choice environments (e.g., supermarkets, cafés, and fast-food outlets), and also test the effects of these interventions over a longer period of time.

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