A nudge in the right direction: The efficacy of visual nudges for encouraging healthier dietary behaviours

By

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Summary

The contemporary food landscape heavily promotes the consumption of unhealthy, ultra-processed foods and beverages. Sugary drinks, being the second largest contributor to this landscape and the primary source of excess sugar consumption in Australia, particularly among young adults, warrants specific focus. The overconsumption of such unhealthy products can lead to a range of physical and mental health issues such as cardiovascular disease, cancer, anxiety, and depression. As such, effective strategies are needed for promoting healthier diets.

Traditional methods for encouraging healthier diets, like sugar taxes or health campaigns, have shown limited success in achieving long-lasting, widespread change. This could, in part, be due to their failure to acknowledge the importance of consumer autonomy and the automatic nature of dietary behaviours and decisions. In contrast, nudging is an implicit approach that recognises and leverages automatic decision-making processes while preserving autonomy. Nudges guide people towards desired (e.g., healthier) behaviours by making them more prominent or the simplest/default option. Given the highly visual nature of our food and beverage environment, visual nudges offer potential for influencing consumption behaviours.

This thesis investigates the effectiveness of implicit nudging interventions in promoting healthier choices, with a particular focus on visual nudges and beverage choices. It comprises four empirical studies and a systematic review and meta-analysis.

Studies 1 and 2 (Chapter 2) examined subtle beverage primes for nudging drink choices from a food and beverage environment akin to a vending machine. While extremely subtle primes had no influence (Study 1), clearer but still subtle primes nudged drink choices (Study 2). However, the primes did not affect the healthiness of choices, suggesting that a more obvious approach is needed to promote healthier choices.

Studies 3 and 4 (Chapter 3), assessed a more overt approach to nudging drink choices, where the primes were the primary focus of a vending machine advertising poster. The healthy (water) prime successfully encouraged water choices in a beverage-only vending machine (Study 3) but had less impact when food options were added (Study 4).

Findings from Studies 1-4 indicated potential variations in the effectiveness of different nudges in different contexts. To provide an overview of the literature, Chapter 4 presented a systematic review and meta-analysis (Study 5) examining the effectiveness of various food- and body-related visual nudges for influencing food and beverage choices and identified potential mechanisms and moderators of nudge success. Results supported the efficacy of visual nudges for influencing food and beverage choices but demonstrated the need for further research to elucidate why, when, and for whom specific nudges are most effective.

Overall, the present thesis demonstrates the potential of visual nudging interventions for promoting healthier dietary behaviours, with important implications for public health interventions aimed at improving population health. However, findings underscored the importance of tailoring nudging strategies for specific settings, and the need for further research to better enable this process. Insights from the present thesis provide valuable knowledge for policymakers, educational institutions, and food vendors interested in fostering healthier eating habits, especially when combined with future research elucidating underlying mechanisms and moderators.

Declaration

I certify that this thesis:

1. does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university
2. and the research within will not be submitted for any 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.

Enola Kay

Signed: Date: 06/04/2024

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List of Manuscripts and Publications from this Thesis

Kay, E., Kemps, E., Prichard, I., & Tiggemann, M. (2023). Instagram-based priming to nudge drink choices: Subtlety is not the answer. *Appetite*, 180, 106337. https://doi.org/10.1016/j.appet.2022.106337

Kay, E., Kemps, E., Prichard, I., & Tiggemann, M. (2024). Effectiveness of visual nudges for encouraging healthier beverage choices from vending machines. *Health Promotion Journal of Australia.* https://doi.org/10.1002/hpja.856

Kay, E., Kemps, E., & Prichard, I., (2024). A systematic review and meta-analysis of visual cues and primes for nudging consumption-related behaviours. [manuscript under preparation]

CHAPTER 1: GENERAL INTRODUCTION

Chapter overview

The overarching aim of this thesis is to advance our understanding of methods for encouraging healthier food and beverage consumption behaviours through subtle changes to the food environment, by way of nudging. This introductory chapter seeks to provide an overview of the current food environment and how it drives choice and consumption behaviours, as well as outlining relevant theories of decision-making and nudging. Nudging research, with a particular focus on visual cueing and priming interventions, is summarised. Finally, the chapter presents the primary aims of the thesis and an outline of the subsequent chapters.

The food environment

Consumption behaviours are determined by the complex interplay between various features of our food environment. Turner et al. (2018) proposed a conceptual framework of the food environment that explains purchasing and consumption behaviours as being influenced by a combination of personal and external factors. Outside of industry-level factors such as the production, storage, transformation, and transportation of food products, it is the interactions between our personal and external food domains that are said to predict the foods and beverages we purchase and consume.

The personal domain largely relates to an individuals' ability to access and afford products, the perceived ease of use and convenience of products, and personal desires for foods and beverages (Turner et al., 2018). Personal factors also include individual characteristics, such as knowledge, attitudes, beliefs, and values. Demographic characteristics such as age and gender, health status, culture, social networks, habits and routines, taste preferences, and food-related skills (e.g., cooking skills) are also important features of the personal domain. These personal factors can influence food and beverage consumption

behaviours in many ways. For example, whether an individual believes they need to consume healthier foods and beverages, knows which options are healthier, and/or can afford the healthier products, can all influence choices (Alsubhi et al., 2022; Dhuria et al., 2021). These personal factors then interact with features of the external domain.

The external food domain refers to the broader physical and social contexts in which food and beverage choices are made (Turner et al., 2018). This includes the availability of foods nearby, market-set pricing, vendor and product properties (e.g., vendor types, product quality, processing levels, and packaging), and marketing and regulation properties (e.g., advertising, branding, and food-related policies). Each of these elements of the external food domain can influence each other and interact with features of the personal domain to determine consumer behaviours.

In current Western external food environments, people are surrounded by a wealth of physical food spaces, making food and beverage products overwhelmingly available to consumers (Needham et al., 2020). For example, there are a wide range of vendors providing food, beverage, and meal options through places such as restaurants, cafés, and grocery stores, as well as canteens and vending machines which bring foods and drinks into schools and workplaces. The combination of these vendor types results in near constant access to an extensive array of food and beverage options. Access is also being enhanced through the increasing digitisation of the food environment, which has led to the rise of online food ordering applications offering options from an increasingly wide variety of vendors (Sushant, 2023).

Food and beverage marketing is another influential aspect of the external food environment. Marketing and promotional efforts include product branding and packaging, advertising and sponsorships, and other visual and promotional aspects designed to increase consumer desires to purchase certain products or engage with specific vendors (Turner et al.,

2018). Companies try to make their products and packaging as visually appealing as possible to increase the visibility and recognisability of their brands, and this is largely done through advertising (Connor, 2006; Rodríguez et al., 2023). Advertising can take many forms and appear in a multitude of print and digital environments, such as television commercials, social media, and magazines, as well as on billboards, public transport, and sportsgrounds. It also occurs through sponsorships and less conspicuous techniques such as product placement. Influential figures such as celebrities and athletes are also commonly used in order to develop positive attitudes towards products and companies, thereby increasing desire for and, consequently, purchasing of these products (D'Ambrogio et al., 2023; Min et al., 2019; von Felbert & Breuer, 2021). Notably, in the current food environment, unhealthy foods and beverages are much more heavily advertised than healthier options. For example, a review conducted by the World Health Organisation (2022) noted that up to 90% of advertising in the appetitive domain was for unhealthy foods, particularly fast-foods and sugar-sweetened beverages. This heavy advertising of unhealthy products can encourage the consumption of such items over healthier options.

The final element of the external environment refers to the laws and policies governing the food environment that can influence food and beverage choices (Turner et al., 2018). For example, policies around food labelling could require greater detail to be included on nutrition panels, or adding advisory labels to products, enabling consumers to make more informed choices (Temple, 2020). Alternatively, marketing regulations such as banning fast-food commercials during children's television programs could be introduced (Alfraidi et al., 2023), or a tax placed on certain types of foods and/or beverages (e.g., a sugar tax; Liu et al., 2021).

The interplay between the aforementioned personal and external food domains determines purchasing and consumption behaviours (Turner et al., 2018). For example,

someone with a personal factor of strong health beliefs and an external domain with access to healthier food and beverage options may make different choices than someone who lacks access to healthy options. The current food environment, however, is heavily dominated by unhealthy foods and beverages, tending to drive consumption of these products over healthier options.

The current food environment

The contemporary food landscape is characterised by an abundance of food and beverage options, including an overrepresentation of energy dense, high calorie, low-nutrient (unhealthy) products (Hirsch et al., 2023; Schultz et al., 2021). Unhealthy foods and beverages are widely available in a variety of settings including supermarkets, convenience stores, fast-food restaurants, vending machines, and more. This results in near constant access to an extensive array of, primarily unhealthy, food options. These unhealthy products are often marketed and sold in ways that make them more easily accessible, convenient, and appealing to consumers (Ettridge et al., 2023; WHO, 2022). Additionally, unhealthy food and beverage products are often cheaper and more widely promoted than healthier options, making them more appealing to people with limited budgets and/or time (Darmon & Drewnowski, 2015). Healthier options, such as fresh fruits and vegetables, on the other hand, are much harder to access and are usually more expensive, making healthier foods financially unviable for many people. The cost of food products is partially determined by their availability, and unhealthy products, which are heavily processed, have longer shelf-lives and are less seasonal (Gupta et al., 2019; Harrison et al., 2010). Therefore, they are typically more readily accessible and less expensive than their healthier counterparts. In addition, the convenience of pre-packaged and pre-prepared unhealthy foods contrasts with the time and effort required to obtain healthier options, contributing to the relative inaccessibility of

healthier items. As a result, unhealthy foods dominate the current food landscape in terms of affordability, accessibility, and convenience.

Our food environments are also becoming increasingly digitised, further exacerbating exposure and access to, as well as the convenience of, unhealthy foods (Granheim et al., 2022; WHO, 2021). We now have constant access to unhealthy foods through the addition of online food ordering applications such as UberEats and JustEats that provide an ever-increasing variety of foods and vendors in the digital domain (Curry, 2022). The rise of such online food ordering applications also means consumers now have the luxury and convenience of being able to order from the comfort of their own homes and receive food deliveries at a desired time. The added ease of these processes has greatly enhanced the accessibility and convenience of purchasing foods, beverages, and meals, which are predominantly unhealthy (Duthie et al., 2023; Keeble et al., 2022).

The digital realm has also exacerbated exposure to food and beverage marketing, with social media now a major site for such advertising (WHO, 2022). Young adults are particularly susceptible to social media marketing, due in part to their greater exposure to digital media (Auxier & Anderson, 2021; Social Media Perth, 2022), and their still developing eating habits and food preferences (Kelly et al., 2015; Winpenny et al., 2018). Social media marketing also uses social media influencers alongside the more traditional use of celebrities and athletes, to specifically target and appeal to this younger demographic, thereby increasing desire, and therefore purchasing, of their products among these younger audiences (Balaban & Racz, 2020; Croes, Bartels, 2021; Mayrhofer et al., 2020).

Implications of the current food environment

This perpetual exposure to tempting and highly palatable unhealthy foods and beverages in our current food environment, paired with the increasing availability of these ultra-processed products, is decreasing diet quality. For example, a review of ultra-processed

food consumption across multiple countries reported such products to account for up to 56.1% of total energy intake (Elizabeth et al., 2020). In Australia, ultra-processed foods have been reported to account for 38.9% of total energy intake among adults (18 years and over; Machado et al., 2020). Further, sugary drinks, which account for the largest proportion of added sugar intake in Australian diets, are consumed at an average rate of 2.9 cups per day (3.2 cups for diet drinks), with 6.4% of adults consuming sugary drinks daily (AIHW, 2023). Among young adults (18-24 years), who are the core consumers of sugary drinks, this proportion increases to 8.5%. Most Australians are also not consuming enough healthy foods. For example, 93.8% of Australian adults (18+) and 93.1% of young adults (18-24 years) are not meeting recommended fruit and vegetable servings per day (AIHW, 2023). With such high consumption of unhealthy, ultra-processed products, and limited consumption of healthier options, it is clear that many Australians have relatively poor diets.

Poor diets are in turn linked to a wide range of health implications. For example, unhealthy eating habits have been linked to a range of physical conditions and noncommunicable diseases such as type II diabetes, cardiovascular diseases, and some cancers (AIHW, 2021). Further, poor diet has been linked to mental health implications such as depression, anxiety, and decreased life satisfaction (Jacka et al., 2017; Solomou et al., 2022). Dietary risks were estimated to be responsible for 7.94 million deaths globally in 2019, among over 25-year-olds (Qiao et al., 2021). In Australia, overweight and obesity, and dietary risks are the second and third leading contributors to disease burden, respectively (AIHW, 2021). With diet quality decreasing and lifestyle-related diseases increasing it is important that we better understand the interaction between the food environment and consumption behaviours to determine how best to create healthier food environments and encourage healthier dietary behaviours.

Previous attempts to encourage healthier consumption behaviours

With the link between poor diets and health implications widely accepted, many efforts have been made to encourage healthier consumption behaviours. Existing approaches have tended to be quite explicit in nature and primarily fit into two broad categories: (1) restriction based, or (2) awareness/education based. Restriction-based strategies aim to limit access to unhealthy products, while awareness and education-based approaches seek to enhance knowledge regarding the importance and benefits of making healthier dietary choices (Roberto & Gorski, 2015). However, neither approach has resulted in significant long-term changes in health-related behaviours and rates of lifestyle-related diseases continue to increase (ABS, 2020-2021; Afshin et al., 2019).

Restrictive approaches, such as taxing products high in sugar or fat, assume that decreasing the accessibility of unhealthy products and/or increasing the effort involved in obtaining these products by making them more expensive will shift consumer behaviour towards healthier options (Vinelli, 2009). However, increasing prices through taxes, or restricting access, does not make healthier products more accessible or affordable, especially when such options are significantly less available, accessible, and affordable in the first place (Hagmann et al., 2018). Without simultaneously lowering the cost of healthier products and making them more available and accessible to everyone, such restrictive approaches struggle to produce significant, wide-spread behaviour changes. Furthermore, these restrictive methods tend not to be well received by consumers who report preferring and supporting less intrusive methods (Bos et al., 2018; Diepeveen et al., 2013). Restrictive approaches can cause feelings of diminished autonomy, resulting in consumers actively seeking out unhealthy products to reassert their freedom of choice (Laurin et al., 2012).

Unlike restrictive approaches which attempt to remove unhealthy options for consumers, softer, education-based approaches place the responsibility and burden on

consumers (Mozaffarian et al., 2018). Approaches based around education and awareness, such as public health and mass media campaigns tend to be better received by the public but remain relatively ineffective (Baghurst & McMichael, 2010; Gill & Boyland, 2012; Piekara et al., 2022; Thakur & Mathur, 2021; Walls et al., 2009). For example, education-based approaches have been found to successfully create awareness and effectively inform consumers about their choices and the importance of making healthier choices, but this knowledge is rarely translated into behaviour change (Bucher et al., 2016).

Educational approaches assume that people are reflective about their health- and diet-related decisions, and that awareness can decrease the desirability of unhealthy options while increasing the desirability of healthier options (Bucher et al., 2016; Hofmann et al., 2008; Houlihan, 2018). However, these approaches rely on individuals making effortful changes and exercising high levels of motivation and restraint, rather than choosing the easiest, cheapest, most convenient, and/or most desirable options (Bucher et al., 2016; Turner et al., 2018). It is becoming increasingly clear that individuals often struggle to make well-informed health-related decisions (Arno & Thomas, 2016; Bucher et al., 2016). In the moment, people seem to ignore long-term consequences, and instead make choices based more on impulses, habits, convenience, and immediate gratification (Bucher et al., 2016).

Thus, while both restrictive and education-based approaches address some important aspects of the food environment, they are not doing so adequately. The range of existing mainstream approaches to encourage healthier diets are clearly insufficient to address the growing problem of poor diets and associated health implications. There are several psychological theories of decision making that may explain the relative ineffectiveness of these traditional approaches for encouraging healthier diets.

Decision making theories

Several decision-making theories indicate that consumption behaviours may be more automatic than traditional behaviour change methods allow for. For example, Food-Cue Reactivity Theory (Jansen, 1998) essentially states that exposure to foods results in automatic physiological and psychological responses to seeing those foods. This then results in increased cravings or desire for those specific foods, or increased hunger, thus leading to consumption. While the theory notes that individuals vary in their sensitivity to food-related cues, it maintains that this process is still largely automatic overall. Given the heavy prevalence of unhealthy foods in our food environments, this Food-Cue Reactivity Theory may be one way of explaining why education-based approaches fail to encourage healthier diets despite increasing knowledge.

Another decision-making theory, Goal Conflict Theory (Stroebe et al., 2013), posits food choices as being made within the context of an individuals' goals. While this indicates that encouraging healthier goals through education-based approaches may be effective, it is the conflict between these healthy long-term goals and the more immediate goals that determines behaviours. When it comes to food-related decision, it is often the shorter-term goals such as enjoying the tasty, unhealthy food or drink in that moment, that outweighs any potential long-term health goals that may exist (Sullivan & Huettel, 2021).

Relatedly, Dual Processing Theory (Evans, 2008; Houlihan, 2018) indicates that food choices are generally made based more in the context of short-term reward than long-term gains, and that decision making around foods is generally quite automatic. The theory posits that there are two main processing systems that we utilise when making decisions (the controlled and automatic processing systems). The controlled system involves a deliberate process requiring extensive effort (Hofmann et al., 2008; Houlihan, 2018). Using this system, careful consideration is given to all available data and knowledge to understand both short-

and long-term implications of each possible action. Existing education-based approaches rely on this controlled system for encouraging healthier consumption behaviours as it is a reflective system that takes goals, values, and intentions into consideration. Ideally this is the system we should be using when making health- and diet-related decisions in order to ensure population health, but in reality, many people are not (Hofmann et al., 2009; Houlihan, 2018; van't Reit et al., 2011).

When it comes to health- and diet-related decisions we tend to fall back on the second much faster system within Dual Processing Theory, the automatic processing system (Hofmann et al., 2009). This system requires very little cognitive effort. It is instinctual, impulsive, and habitual, based on heuristics, attitudes, and immediate consequences, as well as both physical and social environmental factors. Physical cues can include advertisements encouraging us to buy a certain product, or the presence of food reminding us we are hungry, while social cues can result in us adjusting our behaviours to match that of others, to conform to social norms and expectations (de Ridder, 2014; Houlihan, 2018; Prinsen et al., 2013). According to Dual Processing Theory, the less motivated we are and the fewer cognitive resources we have available, the more likely we are to engage in more reflexive, automatic processing to determine our consumption behaviours (Hofmann et al., 2009). As such, research is increasingly moving towards more implicit methods for encouraging healthier consumption behaviours. For example, methods like nudging, which acknowledge the automatic nature of decision making, are gaining increasing interest (Thaler & Sunstein, 2008; Sunstein, 2014; Bucher et al., 2016).

Each of these theories offers a potential explanation for the struggle to continually make consumption-related decisions that benefit our long-term health, despite knowing how and why to make such healthy choices (Bucher et al., 2016; Marteau et al., 2011). Each of these theories, and especially Dual Processing Theory, also indicate the potential benefit of

approaches such as nudging that acknowledge and capitalise on the automatic nature of decision making. Nudging approaches may be more effective and/or complement traditional approaches to changing consumption behaviours as they address the roles of both deliberate and intuitive processes in shaping food choices.

Nudging consumption behaviours

Nudges are behaviour change intervention tools that address several pitfalls of previous approaches since they acknowledge and capitalise on the automatic nature of decision making, maintain consumer autonomy, and receive greater support from consumers (Thaler & Sunstein, 2008; de Ridder et al., 2022; Evers et al., 2018). Nudges are generally implicit in that they gently guide behaviour through subtle suggestions, rather than imposing choices, and thus maintaining freedom of choice. As such, nudging typically involves subtle methods, such as rearranging environments, to gently guide certain behaviours by making those desired behaviours the easiest and/or default choice, without telling consumers what to do, forbidding access to the undesired alternatives, or changing economic incentives (Thaler & Sunstein, 2008). Some nudges may be more implicit than others, however. For example, rearranging the placement of products to make the desired choice the most noticeable and/or easiest item to select would be a more covert approach to nudging, while front-of-pack or point-of-sale warning labels can be used to nudge choices in a more overt way, whilst still making a small change to the environment to gently guide behaviour, and maintaining freedom of choice.

The effectiveness of both highly implicit and more overt nudging approaches on behaviour change has already been demonstrated across a range of domains, such as smoking, alcohol consumption, exercise, financial planning, and driving (e.g., Cai, 2019; Liu et al., 2022; Marteau et al., 2011; Nurchis et al., 2023). Research demonstrating the effectiveness of nudging in the consumption domain is growing (e.g., Arno & Thomas, 2016;

Broers et al., 2017; Buckland et al., 2018, Cadario & Chandon, 2019; Gynell et al., 2022). Examples of nudges in the consumption domain include placement, labelling, and visual cueing or priming interventions. Nudges that involve altering the placement of foods include strategies to make the healthier items more prominent, such as placing healthier items at eye-level in a supermarket or changing the order of foods presented in menus or food ordering apps in a relatively covert way (Arno & Thomas, 2016; Broers et al., 2017; Gynell et al., 2022). Alternatively, including calorie, nutritional, or traffic light labels can highlight healthier choices more overtly, and the use of visual cues and primes such as food or diet-related images can be used covertly or overtly to highlight healthier choices, depending on how they are presented (Buckland et al., 2018; Cadario & Chandon, 2019). Of all of these nudging types, visual cues and primes would be particularly well suited to combatting, or at least reducing, the impact of the highly visual external food environment (Vermeir & Roose, 2020). They involve the use of visual environmental stimuli to encourage certain behaviours, and while the two terms are often used interchangeably in the literature, they represent distinct approaches to influencing behaviour.

Visual cues refer to environmental stimuli that are presented during a target behaviour, such as when individuals are making a food choice or consuming foods (Lindsey et al., 2020). These stimuli are designed to make the desired behaviour more likely, such as encouraging the selection of a healthier food option, or reducing consumption of unhealthy foods, by increasing salience or guiding attention. For instance, highlighting healthier foods in a cafeteria or buffet setting using stickers or arrows (a more overt nudging approach) can increase the selection and consumption of such foods (Bauer et al., 2021). Similarly, serving foods on a smaller plate or bowl (a more covert nudging approach) can decrease consumption by creating the illusion of having consumed a larger portion (Petit et al., 2018).

Visual primes, on the other hand, are presented prior to the target behaviour, such as before individuals make a food choice (Lindsey et al., 2020). They are intended to activate specific mental representations or concepts (e.g., health goals, diet goals, social norms) that can subsequently prompt certain behaviours, such as healthier choices. For example, research has shown that exposing people to images of healthier foods, or images of thin or athletic bodies that are associated with health- and/or diet related thoughts or goals can ultimately lead to healthier choices (e.g., Brunner & Siegrist, 2012; Ohtomo, 2017; Sharps et al., 2020; Stämpfli & Brunner, 2016; Stöckli et al., 2016; Tonkin et al., 2019). These cueing/priming nudges could be relatively implicit if subtly presented in the background and/or in a way not explicitly linked to the outcome behaviour (e.g., choice or consumption), for example, via a screensaver or poster in the background of the choice/consumption environment (e.g., Brunner & Siegrist, 2012; Stämpfli & Brunner, 2016). Alternatively, they could be more overt by being explicitly paired with the outcome behaviour, for example, such as by giving out a healthy recipe card while a person is grocery shopping (Papies et al., 2014), or linking to explicitly branded items (e.g., Smarandescu & Shimp, 2015).

Notably, the same stimuli can oftentimes also be used as either a cue or a prime, depending on how they are presented. For instance, images presented on the cover of a menu can be used to prime healthier food choices, while the same image presented inside the menu (presented alongside the food choices) can serve as a visual cue (Tonkin et al., 2019). Similarly, cooking shows that focus on healthy foods can cue concurrent consumption (e.g., snacking while viewing; Anschutz et al., 2008; Bourn et al., 2015), or prime subsequent (i.e., post-viewing) consumption behaviours (Folkvord et al., 2020; Naderer et al., 2018; Ngqangashe et al., 2018).

Broadly, both visual cueing and priming as nudging techniques are thought to encourage healthier consumption-related behaviours by making healthier products more

appealing and/or salient (cueing), or by activating mental representations of depicted foods or activating health- and diet-related goals (priming; Lindsey et al., 2020). However, we still have a long way to go before we have a clear understanding of the mechanisms underlying the effectiveness of these visual nudging techniques. Evidence demonstrating the effectiveness of these nudges in food related consumption environments is promising and the field is expanding. A recent systematic review of 23 studies found that implicit nudging interventions, including visual cues and primes, like images of healthier foods, can be effective for encouraging healthier food choices, but also indicated further research is needed (Gynell et al., 2022). Furthermore, research exploring the effectiveness of visual cues and primes is still lacking. In addition, relative to food consumption behaviours, our understanding of the effect of cues and primes on beverage consumption remains limited.

Research specifically investigating ways to encourage healthier beverage consumption-related behaviours is important considering the overconsumption of sugar-sweetened beverages, especially among young adults (AIHW, 2023). These sugary drinks are one of the largest sources of free sugar intake and have been linked to a wide range of health conditions, including anxiety, depression, dental caries, heart disease, high blood pressure, and cancer (Freije et al., 2021; Liu et al., 2022; Pietrantoni & Mayrovitz, 2022; Valenzuela et al., 2021). There are also potential differences in the effects of nudges on drink consumption behaviours as people often consider the calorie/energy content of drinks differently to that of foods (DiMeglio & Mattes, 2000; Malik et al., 2022), and beverages lack the satiety effect that foods do (Malik et al., 2010).

Thesis aims and overview

The overarching aim of the present thesis is to evaluate the efficacy of visual cues and primes as implicit nudging techniques for encouraging healthier food and beverage consumption behaviours. Individual studies then have their own specific sub-aims.

Chapter 2 presents the results of Studies 1 and 2 which investigate the impact of subtle beverage primes, incorporated into Instagram images, for influencing drink choices from a food and beverage display. Instagram provides a good setting for using visual cues and primes because of its visual nature, its wide reach, particularly among young adults, and its customisable, targeted content (Instagram, 2016; Moshin, 2019; Pokrop, 2023; Social Media Perth, 2022). Visual cues and primes can easily be incorporated into various post formats and can reach an expansive and targeted audience to encourage healthier consumption-related behaviours. Study 1 involves subtly incorporating water, soft drink, or no beverage images into the background of non-food or -beverage related Instagram images. In Study 2, the beverage primes are made less subtle.

Studies 3 and 4 (Chapter 3) use a much less subtle approach to priming. Water, soft drink, general health, and no beverage images are introduced as potential advertising posters for vending machines, and the influence of these images on beverage (Studies 3 and 4) and food (Study 4 only) choices from a vending machine environment are examined. Vending machines provide an important context for encouraging healthier consumption behaviours as they offer primarily unhealthy high sugar, calorie rich products, such as sugary drinks and chocolate bars, and provide constant access to these unhealthy products in a variety of locations, including schools, universities, and workplaces (Hua & Ickovics, 2016; Rosi et al., 2017).

Chapter 4 then presents a systematic review and meta-analysis which addresses multiple aims in relation to visual cues and primes used to nudge food and/or beverage consumption behaviours. First, the review compares a range of visual nudging techniques (e.g., images or media associated with foods, weight and/or diet, social pressure, or different colours) to determine if certain visual nudging methods may be more effective than others. The review then summarises underlying mechanisms and moderators that have been

proposed or measured for their impact on the effectiveness of the visual cueing and priming techniques.

Finally, Chapter 5 presents a general discussion synthesising the results from all studies and discusses practical implications, strengths, limitations, and potential future research directions. Other than Chapters 1 and 5, all chapters in the present thesis are formatted as manuscripts for publication. As a result, Chapters 2-4 include a small amount of repetition, particularly in their introduction sections. Chapter 2 has been published as an article in the journal *Appetite*, Chapter 3 has been accepted for publication with the *Health Promotion Journal of Australia*, and Chapter 4 is currently in preparation for submission.

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CHAPTER 2: STUDIES 1 AND 2

Instagram-based priming to nudge drink choices: Subtlety is not the answer

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Abstract

Instagram-based priming (e.g., subtly incorporating healthy drinks into the background of Instagram images) could potentially nudge healthier consumption behaviours. Given the negative health consequences associated with sugar-sweetened-beverage consumption, two experiments tested the effect of three sets of Instagram-based primes for nudging drink choices from a visual food and drinks display. Participants (18-25 years) were randomly assigned to view a series of Instagram advertising images (for technology, travel, or homeware products) that included a glass containing water (water prime) or cola (soft drink prime), or no drink (control). They then selected an item from the visual display containing snack foods and drinks. In Experiment 1 (n = 493) beverages were subtly incorporated into the priming images; in Experiment 2 (n = 471) beverages were made more prominent. Priming condition did not predict choice in Experiment 1 but did so in Experiment 2, where participants in the soft drink prime condition were significantly more likely to select a drink versus a food, compared to those in the water prime and control conditions. The water prime did not predict choice in either study. A greater percentage of participants noticed the beverage primes in Experiment 2 than in Experiment 1. Overall, it appears that when clearly visible, soft drinks incorporated into Instagram-style images can nudge drink choices. However, a less subtle approach may be needed to effectively encourage healthier drink choices.

Keywords: nudging, pictorial priming, Instagram, drink choices, food choices

Introduction

Image-based social media sites, like Instagram, have become overwhelmingly popular, with over nine million Australians on Instagram, and over three billion people currently using social networking sites worldwide (Moshin, 2019; Pokrop, 2019). Young adults, in particular, are avid users of such online media with nearly two thirds of Instagram users aged 18-29 years (Social Media Perth, 2022). With people spending several hours each day on social media (Social Media Perth, 2022; Vassallo et al., 2018), companies have started using these platforms for marketing, and social media has become a major site for food and beverage advertising (WHO, 2016; Digital Silk, 2022). Studies in the marketing and consumer behaviour domain demonstrate positive associations between advertising and consumption of the advertised products, particularly unhealthy items as most marketing in the appetitive domain focusses on unhealthy foods and drinks (WHO, 2022). For example, sugar-sweetened beverages are advertised most often, followed by chocolate and confectionary products (WHO, 2022). These sugary beverages and sweet snacks contribute greatly to the excess sugar, salt, and fat in many people's diets (WHO, 2021). An unhealthy diet is linked to a myriad of negative physical (e.g., cardiovascular disease, stroke, and cancer) and mental health (e.g., depression, anxiety, and decreased life satisfaction) implications (Habibov et al., 2019; Williams et al., 2015; Wyatt et al., 2006). The World Health Organisation considers poor diet to be a leading global health risk, and as such, it is important to find ways to encourage healthier diets (WHO, 2020).

Traditionally, attempts to encourage healthier consumption behaviours have involved quite explicit techniques, such as public health campaigns and sugar taxes (Marteau et al., 2011). However, these have had minimal effect and tend to be met with resistance from consumers who feel they are being manipulated, and their freedom restricted (Bos et al., 2018; Diepeveen et al., 2013; Evers et al., 2018; Hofmann et al., 2009; Laurin et al., 2012).

As such, there has been an increasing move towards more implicit approaches, like nudging, that maintain consumer autonomy.

Nudging, a term coined by Thaler and Sunstein (2008), refers to a range of subtle and unobtrusive tools to gently guide behaviour (Bucher et al., 2016; Sunstein, 2014). Importantly, nudges are designed to work relatively unconsciously and aim to make the desired option (e.g., healthier items) the easiest and/or default choice. For example, placing healthy foods at checkout counters or rearranging supermarket shelves to make healthier foods more prominent have been found to increase healthy food purchases in some studies (e.g., Foster et al., 2014; Sigurdsson et al., 2014; van Gestel et al., 2018). The unhealthy options remain available, but the healthier options are more obvious and easier to access, therefore being more likely to be chosen.

Pictorial priming is an example of a nudging technique well suited to an online social media environment like Instagram. Pictorial priming involves showing something that prepares or encourages individuals to engage in a certain behaviour (Barbosa et al., 2020). For example, highlighting healthy foods in a cooking program can prime people to select a healthier food in a subsequent food choice task (Folkvord et al., 2020). Similarly, placing an image of a certain food (e.g., grapes) on the bottom of a plate can prime the selection and consumption of the depicted food (Sharps et al., 2020). In the online context, greater selective exposure to Instagram images promoting healthier foods led to a greater number of participants choosing a gift card for a healthy food outlet (Whole Foods or Hello Fresh), whereas participants who were exposed to unhealthy food images were more likely to choose a gift card for an unhealthy food outlet (McDonald's or Ben & Jerry's; Wilson et al., 2019).

Little research, however, has examined the effectiveness of pictorial primes for nudging drink choices. The WHO (2015) recommends reducing free sugar intake to less than 10% of total energy intake and sugar-sweetened beverages are a primary source of excess

sugar consumption globally (WHO, 2015), accounting for 50% of excess sugar intake in Australia (Lei et al., 2016). Thus, effective strategies for reducing sugar-sweetened beverage consumption are urgently needed, especially considering their widespread consumption (ABS, 2020; Miller et al., 2020; Popkin & Hawkes, 2016). In addition, while people tend to compensate for increased calories from snack foods by reducing subsequent consumption, the same does not occur following drink intake (French et al., 2013). Sugar-sweetened beverages are high in calories, yet these excess calories do not result in the same increased feelings of satiety as after consuming food (Malik et al., 2010). This means that people do not then compensate for the excess calories consumed via beverages, resulting in much higher overall energy consumption.

Research in the marketing domain, particularly product placement techniques, suggests that subtle pictorial priming nudges could potentially encourage healthier beverage consumption behaviours (Guo et al., 2019; Sharma & Bumb, 2022; Villegas-Navas et al., 2020). However, marketing is centred around increasing brand visibility to increase preferences for and/or consumption of a specific company's products or services over its competitors, with the overarching aim of increasing revenue for that company (Guo et al., 2019; Turner et al., 2018). It is unclear if a less specific and subtler nudging approach (i.e., using non-branded items) would still be effective for nudging choices. Thus, the present research aimed to determine if subtle beverage primes can nudge healthier drink choices more generally, rather than steering consumers towards a particular product. The drink primes in the present research involved no branding of any kind and were subtly incorporated into the background of images advertising other unrelated products. Instagram was chosen as the priming environment due to its high volume of consumer generated food and drink images (Holmberg et al., 2016; Ventura et al., 2021). If incorporating general beverage primes into the background of non-food or -beverage related Instagram marketing can nudge

subsequent drink choices, the method holds potential promise. For example, if a university wanted to encourage healthier drink choices on campus (e.g., from vending machines), they could incorporate water glasses into the background of their social media marketing materials.

Overall, the present research aimed to investigate whether subtly incorporating images of non-branded beverages into the background of Instagram images could influence subsequent choices from a food and drink display akin to a vending machine. More specifically, two experiments investigated the effectiveness of two active priming conditions where glasses containing water (water prime), or a cola-coloured beverage (soft drink prime) were incorporated into Instagram-style advertising images. In Experiment 1, the beverage primes were subtly incorporated into the Instagram-style images, whereas in Experiment 2 they were made a little more prominent. In both experiments, we expected the two active primes (water and soft drink) to nudge drink (versus food) choices from the display, and for the water primes to nudge healthier beverage choices than the soft drink primes.

Experiment 1

Experiment 1 sought to assess the effectiveness of three types of pictorial primes (water prime, soft drink prime, control) integrated into Instagram-style advertising images for nudging choices from a visual display containing a mix of healthy and unhealthy snacks and drinks. It was predicted that the active primes would nudge beverage choices, the water prime would nudge healthier beverage choices and potentially healthier food choices, and the soft drink prime would nudge less healthy beverage choices and potentially less healthy food choices, relative to the control.

Method

Participants. Participants were 493 young adults (aged 17-25 years) recruited from the Flinders University student population ($N = 90$) and the wider Australian population via

the online survey platform Prolific ($N = 403$). The sample consisted of 343 women, 140 men, and 10 other/prefer not to say. Participants were reimbursed with course credits or a small honorarium.

Design. The experiment used a between-subjects experimental design with participants randomly allocated to one of three conditions (water prime, soft drink prime, control) by the online survey platform, Qualtrics. The dependent variable was food/beverage choice (healthy food, unhealthy food, healthy beverage, unhealthy beverage) from a virtual vending-machine-style visual display.

Procedure. As a cover story, participants were recruited for an online consumer behaviour project containing two separate studies: the first investigating consumer interactions with Instagram-style advertising, and the second exploring consumer choices from a vending machine-style display. After providing consent, participants were randomised to one of the three conditions. Participants then provided some demographics and background information before starting the first study.

In the first study, participants were told they were participating in a study relating to Instagram-style advertising and that we were interested in their feedback on a series of proposed advertising images to give us an indication of how well the images would be received by Instagram users. Participants were then presented with one of the three sets of Instagram images, depending on their allocated condition (water prime, soft drink prime, control), and indicated their agreement with several associated statements for each image.

In the second study, participants were told they were participating in a study relating to a proposed new vending machine display setup and that we were interested in the types of items consumers would select from such a display. Participants were then presented with the display from which they selected one item before providing a brief rationale for their choice.

Finally, participants completed some follow-up measures, including measures of

habitual consumption and liking, measures of height and weight for the calculation of body mass index (BMI; kg/m^2), and a manipulation check. The study protocol (also for Experiment 2) was approved by the Flinders University Research Ethics Committee (Project code: 8376).

Materials.

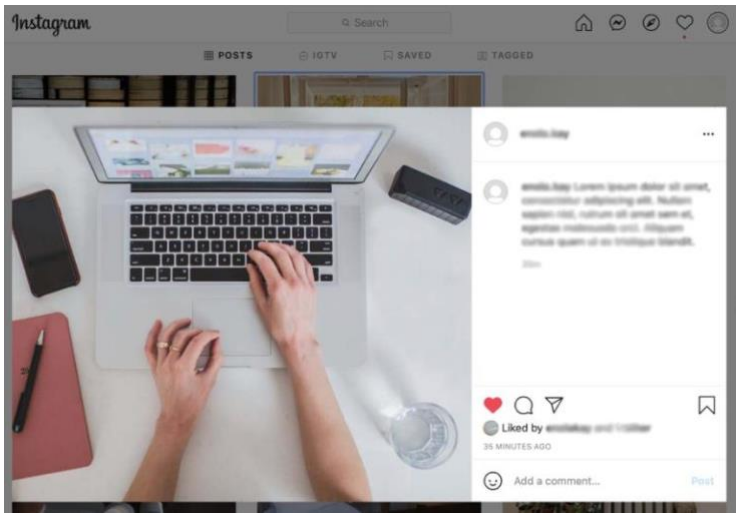
Primes. All participants were asked to provide feedback on a series of 15 Instagram-style images. These were presented as advertising for a range of technology, travel, and homeware companies (e.g., an image of a laptop and phone on a desk). Participants were told that we were interested in how well these kinds of marketing images would be received by Instagram users. Images were presented on the Instagram desktop background with the post caption and likes blurred (see Figure 1 for example images).

The images were identical across all conditions, except for the inclusion of a beverage glass in the background of 11 of the 15 images in the two active priming conditions. Participants in the control condition saw the same series of 15 images, but with no beverages present. Drink glasses were added into priming images (or removed for control images) using Photoshop, and the colour of the beverages was manipulated to depict water in the water prime condition and cola in the soft drink prime condition (since cola is a prototypical soft drink). Care was taken to ensure the beverage glasses were subtly and unobtrusively incorporated into the images, such that the glass was a small component of the image, rather than the main focal point. The remaining four images were filler images and did not contain a beverage; these filler images were intermixed with the active priming images.

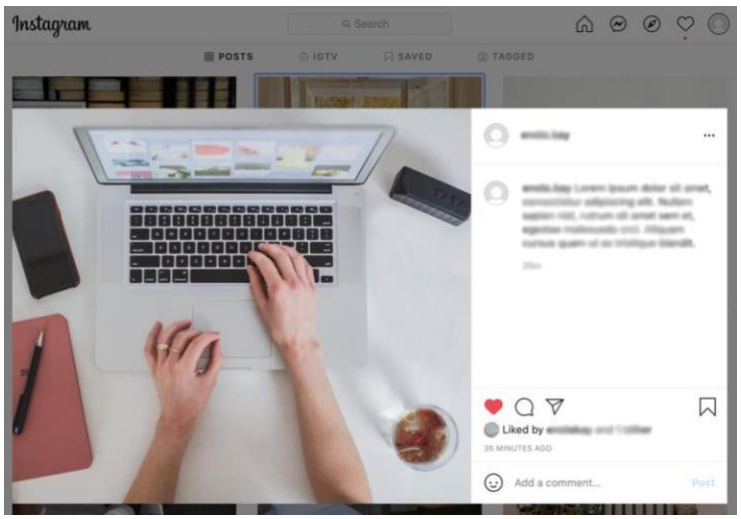
In accordance with the cover story concerning marketing companies seeking feedback on proposed Instagram-based advertising images, and to ensure that participants attended to the images, participants were asked to rate their agreement with a series of four statements about each image. The first two statements addressed how appealing participants found the

Figure 1
Experiment 1: Example priming images

Water Prime



Soft Drink Prime



Control

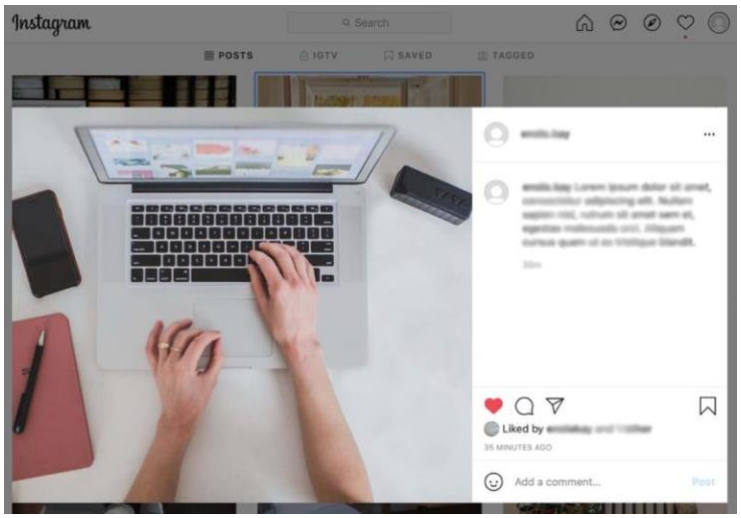


image and whether they liked the layout of the image. The third statement asked participants to indicate whether they felt the image accurately advertised the indicated company type (i.e., tech/gadget, travel, holiday homes, homewares, or plant nurseries). In the final statement, participants indicated whether they felt the image would encourage them to interact with the products/company on Instagram.

Manipulation check. As the primes were quite subtle, at the end of the study participants were asked whether they had noticed any beverages in the Instagram images and to indicate the percentage of images that contained a beverage, on a 100mm VAS ranging from 0-100%. Participants were also asked to specify the kind of beverage they noticed in the images.

Snack food and beverage display. As depicted in Figure 2, the display contained a combination of snack foods (50%) and beverages (50%). The display was modelled on a vending machine as these provide a common and familiar setting for the purchase of snacks and drinks that are arranged in a highly visual manner (Grech et al., 2017). The top half of the display contained a mix of 11 healthy and 11 unhealthy foods, and the lower half contained 11 healthy and 11 unhealthy drinks (see Figure S1 in the Supplementary Materials for an overview of item classifications). Each row contained a combination of healthy and unhealthy products. The items included in the display were chosen from a piloted list of 46 snack foods and 66 beverages identified as being either healthy or unhealthy according to Australian classifications, using the Victorian Government Healthy Eating Advisory Service's Food Checker (Nutrition Australia & Victoria State Government, 2016).

These items were then piloted by 20 volunteers (85% female) aged 19-25 years who were shown an image of each item and asked to indicate how healthy they thought each product was and how likely they would be to choose each item, both using eight-point scales ranging from 'extremely unhealthy / unlikely to purchase' to 'extremely healthy / likely to

Figure 2
Vending machine style display

purchase'. Based on the data from the pilot study, any items rated as being highly unlikely to be purchased were excluded, and the 11 food items rated as most healthy and 11 rated as least healthy were chosen for inclusion in the display, along with the 11 most and 11 least healthy rated beverages.

Choice task. Participants were asked to imagine they were "standing in front of a vending machine, intending to make a selection (irrespective of price)". They were then presented with the display from which they selected one item. Participants were free to choose any item from the machine; they were not instructed to specifically select a beverage in an effort to keep their choice behaviours as naturalistic and genuine as possible. After making their selection, participants provided a brief rationale for their choice to determine the most common reasons for choices, as well as probing for any suspicion about the nature of the study.

Demographics and background information. Participants were asked to report their age and gender, as well as how long since they last ate or drank anything. They also indicated their current thirst and hunger levels on 100mm visual analogue scales, ranging from 'not at all thirsty/hungry' to 'extremely thirsty/hungry'. Participants were also asked to report how regularly they use Instagram on a 7-point scale ranging from 'never' to 'multiple times a day'.

Habitual consumption and liking. To account for potential differences in usual consumption behaviours, participants were asked to indicate how regularly they consume each product included in the display on a seven-point scale ranging from 'never' to 'multiple times a day'. In addition, participants indicated how much they liked each item (if they had tried the item before), using a 100mm visual analogue scale ranging from 'not at all' to 'very much'. Mean consumption and liking scores were then calculated for each outcome category.

Analysis strategy. A chi-square analysis tested differences between conditions (water

prime, soft drink prime, control) in beverage recall from the priming task. Three separate binary logistic regressions were then performed to determine the influence of priming condition on beverage versus food choices, healthy versus unhealthy beverage choices, and healthy versus unhealthy food choices, respectively. Physiological state (hunger and/or thirst), habitual consumption, and liking were controlled for in all analyses; other demographic characteristics (e.g., gender, age, BMI, hunger, thirst) were not associated with vending machine choice (*p*s > .201) and thus were not included in the final models.

Results

Sample characteristics. The average age of participants was 21.0 years (*SD* = 2.31). The mean BMI of the sample was 24.05 kg/m^2 (*SD* = 5.61). Participants were, on average, not very hungry (*M* = 34.72, *SD* = 29.12) and moderately thirsty (*M* = 46.37, *SD* = 25.30). Most participants (54.2%) reported using Instagram multiple times a day. There were no significant differences between conditions on any of these variables (*F*s < 1.66, *p*s > .192).

Overall, unhealthy foods were the most frequently chosen (38.9%), followed by unhealthy beverages (29.0%), then healthy beverages (19.9%), with healthy foods chosen least often (12.2%). The most popular individual items were double espresso iced coffee (unhealthy beverage; 7.3%), Kit Kat (unhealthy food; 6.7%), salt and vinegar potato chips (unhealthy food; 5.1%), and Coca-Cola classic (unhealthy beverage 5.1%).

Manipulation check. A chi-square analysis revealed a significant difference between conditions in the proportion of participants recalling seeing beverages in the Instagram priming images $\chi^2(4) = 164.45$, $p < .001$. Beverages were noticed by a greater proportion of participants in the soft drink prime condition (78.5%) compared to the water prime condition (57.1%). However, a greater proportion of participants in the water prime condition identified the drinks as water (72.0% of those who noticed the beverages), compared to the soft drink prime condition where less than half (41.4%) of participants who noticed the beverages

identified them as some kind of soft drink or cola-coloured drink. In the control prime condition, most participants (83.0%), correctly reported not seeing beverages.

Effect of condition on food/beverage choice. As can be seen in Table 1, overall choices fell relatively evenly between beverages (48.9%) and foods (51.1%). A first binary logistic regression explored the potential effect of condition on choice of a drink over a food item. Hunger, thirst, and mean consumption and liking scores for foods and beverages were included in the regression to account for individual differences and to determine whether condition had an effect over and above these factors.

Table 1.
Experiment 1: Descriptive statistics for vending machine choice by condition

	Water Prime *n* = 164	Soft Drink Prime *n* = 164	Control Prime *n* = 165
(a) Beverage			
Unhealthy	48 (29.3%)	45 (27.4%)	50 (30.3%)
Healthy	33 (20.1%)	29 (17.7%)	36 (21.8%)
(b) Food			
Unhealthy	59 (36.0%)	70 (42.7%)	63 (38.2%)
Healthy	24 (14.6%)	20 (12.2%)	16 (9.7%)

The overall regression model was significant, $\chi^2(8) = 65.58$, $p < .001$. However, condition was not a significant predictor of choice. The choice of a beverage was instead predicted by regular consumption of the beverages included in the display, B = 0.77, *SE* = 0.20, Wald's $\chi^2(1) = 15.19$, $p < .001$. The choice of a food item was predicted by hunger ratings, B = -0.01, *SE* = 0.00, Wald's $\chi^2(1) = 3.94$, $p = .047$, regular consumption of the food, B = -0.73, *SE* = 0.20, Wald's $\chi^2(1) = 13.07$, $p < .001$, and food liking ratings, B = -0.03, *SE* = 0.01, Wald's $\chi^2(1) = 10.79$, $p = .001$. See Table S1 in the Supplementary Materials for an overview of all parameter estimates.

The next set of analyses tested the effect of condition on particular choice within a category. Separate logistic regressions were conducted to examine the impact of condition on the healthiness of choice (healthy, unhealthy), among those who chose a beverage and those who chose a food item.

Beverages. Unhealthy beverages (59.3%) were chosen more frequently than healthy beverages (40.7%) overall, and in each condition. Healthy beverages were equally popular in all conditions (control prime: 41.9%; water prime: 40.7%; soft drink prime: 39.2%). For beverages, the regression model was significant overall, $\chi^2(7) = 73.19$, $p < .001$, but condition was not a significant predictor of choice. Choice of a healthy beverage was instead predicted by thirst ratings, B = -0.01, *SE* = 0.01, Wald's $\chi^2(1) = 4.42$, $p = .035$, and regular consumption of healthy beverages, B = -0.85, *SE* = 0.29, Wald's $\chi^2(1) = 8.41$, $p = .004$. Choice of an unhealthy beverage was predicted by regular consumption, B = 0.68, *SE* = 0.26, Wald's $\chi^2(1) = 7.12$, $p = .008$, and liking ratings, B = 0.04, *SE* = 0.01, Wald's $\chi^2(1) = 12.09$, $p < .001$. See Table S2 in the Supplementary Materials for an overview of all parameter estimates.

Foods. Unhealthy foods (76.2%) were more frequently chosen than healthy foods (23.8%) overall, and in each condition. Healthy foods were chosen most frequently in the water prime condition (28.9%), followed by the control condition (22.2%) and were least likely to be chosen in the soft drink prime condition (20.3%). The regression model was significant overall, $\chi^2(7) = 45.99$, $p < .001$, but condition did not significantly predict choice. Healthy food choice was predicted by regular consumption (B = -0.92, *SE* = 0.28, Wald's $\chi^2(1) = 10.53$, $p = .001$) and liking (B = -0.04, *SE* = 0.02, Wald's $\chi^2(1) = 6.90$, $p = .009$) of healthy foods. Choice of an unhealthy food was predicted by liking ratings for unhealthy foods, B = 0.03, *SE* = 0.01, Wald's $\chi^2(1) = 4.05$, $p = .044$. See Table S3 in the Supplementary Materials for an overview of all parameter estimates.

Discussion

Priming condition did not predict food or beverage choice. Choice was instead predicted by hunger, thirst, habitual consumption, and liking. Not surprisingly, participants were more likely to select an item from a category they liked and regularly consumed. However, one notable feature of the experiment was that less than half of the participants in the water prime condition noticed the water glasses in the priming images, and while more participants in the soft drink prime condition recalled seeing beverages, less than half identified the beverages as soft drinks. Although priming can occur unconsciously (Harris et al., 2009), it is possible that the drinks were too subtle to be noticed or identified sufficiently to influence drink choices. Perhaps slightly more prominent primes might be better able to nudge choices.

Experiment 2

Experiment 2 sought to further assess the effectiveness of beverage primes incorporated into Instagram-style advertising images at nudging choices from a vending machine style display. As the beverage primes in Experiment 1 were often missed or misidentified, these were made more prominent by making them clearer and less subtle. Under these circumstances, it was again predicted that the active primes would nudge drink choices, the water prime would nudge healthier drink (and potentially healthier food) choices, and the soft drink prime would nudge less healthy drink (and potentially less healthy food) choices, relative to control.

Method

Participants. Participants were 471 young adults (aged 18-25 years), recruited from the wider Australian population via the online survey platform Prolific. The sample consisted of 309 women, 146 men, and 16 other/prefer not to say. Participants were reimbursed with a small honorarium.

Design. The design was the same as in Experiment 1.

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

Materials. Materials were the same as in Experiment 1, apart from the priming task. Specifically, to simplify the task the number of advertising images was reduced to eight (with six active primes and two filler images) and all images advertised technology products. The active priming images in the two priming conditions contained either a glass (as in Experiment 1) or an image of a beverage (e.g., as a screensaver on a laptop; see Figure 3 for example images). In an effort to shift attention closer to the beverage in the priming images without explicitly pointing it out, an additional question was asked. For example, if the glass was next to a pile of books, the question asked, "how many books are stacked on the table?". As in Experiment 1, participants in all conditions viewed the same series of images, in the same order, with the only difference being the presence (or absence) of a beverage (either water or cola-coloured beverage, depending on condition). The manipulation check, beverage and snack food display, choice task, background questions, and habitual consumption and liking measures were the same as those in Experiment 1.

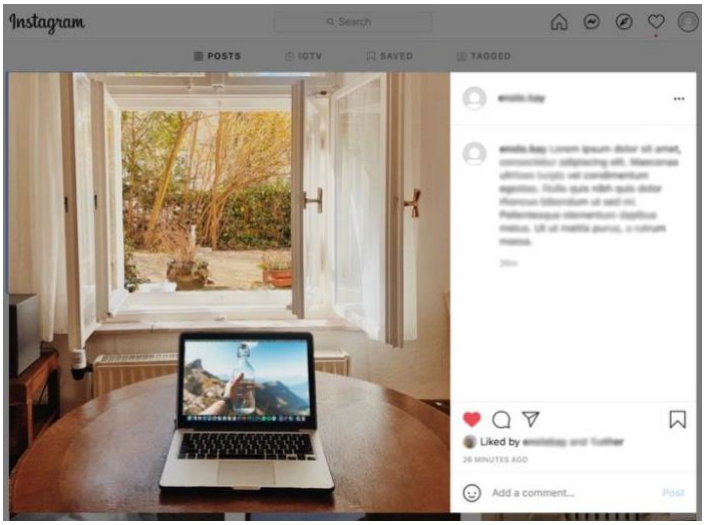
Analysis strategy. The analysis strategy was the same as in Experiment 1.

Results

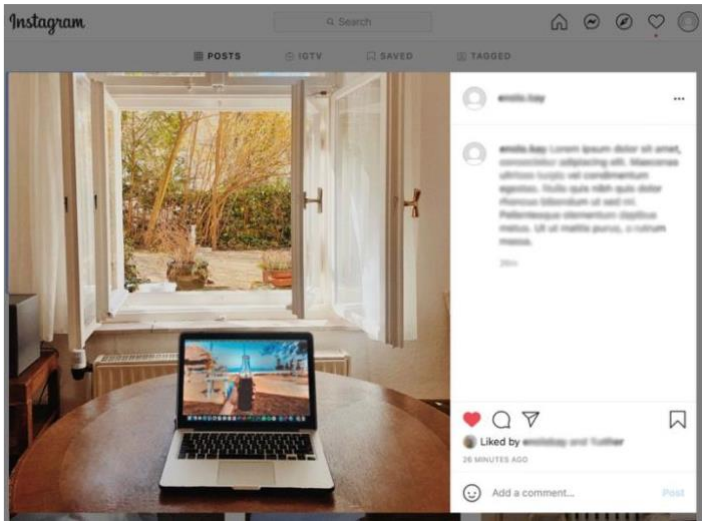
Sample characteristics. The average age of participants was 21.38 years (SD = 2.22). The mean BMI of the sample was 24.42 kg/m^2 (SD = 6.41). On average, participants reported relatively low levels of hunger (M = 33.81, SD = 28.21), and moderate thirst (M = 46.79, SD = 25.89). Most participants (48.8%) reported using Instagram multiple times a day. BMI differed significantly between conditions, $F(2) = 3.59$, $p = .028$, and as such was controlled for in all analyses. Participants in the soft drink prime condition had the highest

Figure 3
Experiment 2: Example priming images

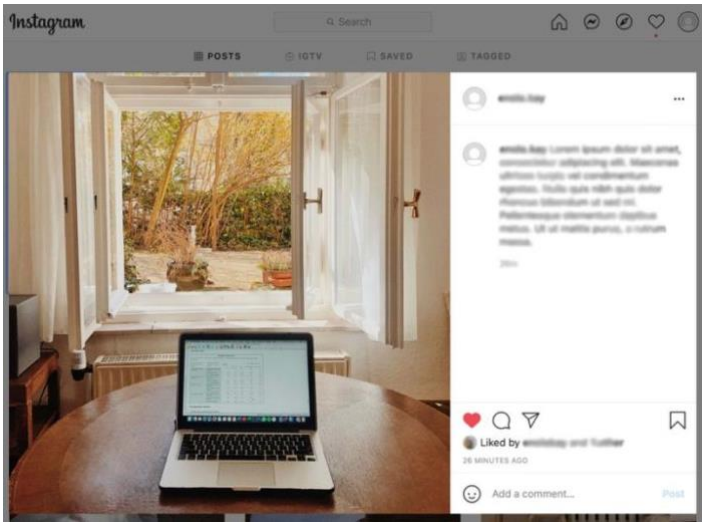
Water Prime



Soft Drink Prime



Control



BMI (M = 25.23, SD = 6.04), followed by those in the water prime condition (M = 24.71, SD = 7.73), with participants in the control condition having the lowest BMI (M = 23.36, SD = 5.12). There were no significant differences between conditions for any other variables (Fs < 2.62, ps > .074).

Overall, unhealthy foods were the most frequently chosen (34.2 %), followed by healthy beverages (28.7%), unhealthy beverages (27.6%), and finally, healthy foods (9.6%). The most popular individual items were plain water (healthy beverage; 12.7%), flavoured water (healthy beverage; 8.5%), double espresso iced coffee (unhealthy beverage; 7.9%), and Kit Kat (unhealthy food; 6.2%).

Manipulation check. A chi-square analysis revealed a significant difference between conditions in the percentage of participants noticing beverages in the Instagram priming images, $\chi^2(4) = 241.91$, $p < .001$. Beverages were noticed by a greater percentage of participants in the soft drink prime condition (89.8%) compared to the water prime condition (69.2%). Of those who noticed the beverages, 91.4% of those in the water prime condition correctly identified the drinks as water, compared to 78.7% correctly identifying soft drinks in the soft drink prime condition. In the control condition, where beverages were not present, 90.0% correctly recalled seeing no beverages.

Effect of condition on food/beverage choice. As can be seen in Table 2, beverages (56.3%) were a slightly more popular choice than foods (43.7%). Beverages were most frequently chosen in the soft drink prime condition (65.6%), followed by the water prime condition (53.2%). Participants in the control condition were equally likely to select a beverage or food (50.0%). A binary logistic regression examined the potential effect of condition on choice of a drink or food item, controlling for hunger, thirst, habitual consumption and liking of the food and drink items, and BMI.

Table 2
Experiment 2: Descriptive statistics for vending machine choice by condition

	Water Prime *n* = 154	Soft Drink Prime *n* = 157	Control Prime *n* = 160
(a) Beverage			
Unhealthy	37 (24.0%)	56 (35.7%)	37 (23.1%)
Healthy	45 (29.2%)	47 (29.9%)	43 (26.9%)
(b) Food			
Unhealthy	55 (35.7%)	45 (28.7%)	61 (38.1%)
Healthy	17 (11.0%)	9 (5.7%)	19 (11.9%)

The regression model was significant overall, $\chi^2(9) = 39.79$, $p < .001$, and condition significantly predicted choice, $\chi^2(2) = 8.31$, $p = .016$. Participants in the water prime condition were more likely to choose a beverage over a food item compared to those in the control condition, but not significantly so. Participants in the soft drink prime condition, however, were significantly more likely to select a drink over a food item from the display, compared to those in both the water prime, B = 0.56, *SE* = 0.25, Wald's $\chi^2(1) = 5.28$, $p = .022$, and control conditions, B = 0.66, *SE* = 0.24, Wald's $\chi^2(1) = 7.28$, $p = .007$. Beverage choice was also predicted by thirst, B = 0.01, *SE* = 0.00, Wald's $\chi^2(1) = 5.29$, $p = .021$, and regular consumption of the beverages included in the display, B = 0.71, *SE* = 0.21, Wald's $\chi^2(1) = 11.28$, $p < .001$. Food choice was predicted by hunger, B = -0.01, *SE* = 0.00, Wald's $\chi^2(1) = 6.24$, $p = .012$. See Table S4 in the Supplementary Materials for an overview of all parameter estimates.

Two separate logistic regressions tested the effect of condition on the healthiness of choices within categories. The first regression addressed those who chose a beverage, and the second regression addressed those who chose a food item.

Beverages. Choices fell relatively evenly between healthy (50.9%) and unhealthy

(49.1%) beverages. Healthy beverages were chosen more frequently than unhealthy beverages in the water prime (54.9%) and control conditions (53.8%). Unhealthy beverages were chosen more frequently than healthy beverages in the soft drink prime condition (54.4%). The regression model was significant overall, $\chi^2(8) = 81.68$, $p < .001$. However, condition was not a significant predictor of the healthiness of the choice. Choice of a healthy beverage was instead predicted by regular consumption of healthy drinks, B = -0.70, *SE* = 0.31, Wald's $\chi^2(1) = 5.04$, $p = .025$. Choice of an unhealthy beverage was predicted by regular consumption, B = 0.89, *SE* = 0.23, Wald's $\chi^2(1) = 14.71$, $p < .001$, and liking ratings for unhealthy drinks, B = 0.03, *SE* = 0.01, Wald's $\chi^2(1) = 11.43$, $p < .001$. See Table S5 in the Supplementary Materials for an overview of all parameter estimates.

Foods. Unhealthy foods (78.2%) were more frequently chosen than healthy foods (21.8%) overall, and in each condition. Participants in the control prime condition were the most likely to select a healthy food (23.8%), closely followed by those in the water prime condition (23.6%). Participants in the soft drink prime condition were the least likely to select a healthy food (16.7%). The regression model was significant overall, $\chi^2(8) = 43.27$, $p < .001$. However, condition was not a significant predictor of the healthiness of the choice. Choice of a healthy food was instead predicted by regular consumption, B = -0.71, *SE* = 0.34, Wald's $\chi^2(1) = 4.37$, $p = .037$, and liking ratings for healthy foods, B = -0.70, *SE* = 0.19, Wald's $\chi^2(1) = 13.65$, $p < .001$. Choice of an unhealthy food was predicted by liking ratings for unhealthy foods, B = 0.03, *SE* = 0.02, Wald's $\chi^2(1) = 4.03$, $p = .045$. See Table S6 in the Supplementary Materials for an overview of all parameter estimates.

Discussion

Priming condition predicted whether participants chose a beverage or food, but it did not predict the healthiness of choices. Participants in the soft drink prime condition were more likely to select a beverage over a food compared to those in both the control and water

prime conditions. The percentage of participants who correctly recalled and identified the beverages included in the Instagram priming images was considerably higher than in Experiment 1, indicating that we had successfully increased the visibility of the primes in this experiment. Participants in the soft drink prime condition were the most likely to recall seeing the beverage glasses in the priming images. Overall, it seems that increasing the visibility of beverage primes incorporated into Instagram images may be an effective tool for nudging drink choices (irrespective of healthiness) from a vending machine style display.

General Discussion

The present experiments investigated whether subtly incorporating beverages into Instagram images could nudge choices from a vending machine-style visual display. In both experiments, glasses of water (water prime) or cola (soft drink prime), or no beverages (control) were incorporated into a series of Instagram-style advertising images. Experiment 1 involved very subtle beverage primes, while in Experiment 2 the beverages were made more obvious, although still not a major focus of the advertisement. The soft drink prime was an effective means of nudging drink choices over food choices, but only when the primes were clearly visible (i.e., in Experiment 2). In both experiments, choice was also predicted by hunger and thirst, as well as habitual consumption and how much participants liked the food and drink items.

In Experiment 1, the beverage primes had little effect on participants' choices. However, few participants in the active priming conditions recalled seeing the water or soft drinks (depending on condition) in the Instagram advertising images. In particular, less than a third of participants (32.5%) were able to correctly identify the soft drink prime. The beverage primes were made more obvious in Experiment 2, with the result that more of the participants noticed them. Specifically, over 60% of participants now noticed the water glasses, and over 70% noticed the soft drink glasses.

Under the conditions of Experiment 2, participants in the water prime condition were more likely to select a drink than a food, compared to those in the control condition, but not significantly so. Participants in the soft drink prime condition, where the beverage primes were noticed most often, were significantly more likely to select a drink than a food, compared to participants in both the control and water prime conditions. While, as predicted, healthy drinks were most popular in the water prime condition and least popular in the soft drink prime condition, condition did not significantly predict the healthiness of drink choices. These findings indicate that subtle beverage primes incorporated into Instagram images, as used in the current experiments, have limited impact on the healthiness of drink choices from a vending machine setting. In addition, condition did not predict the healthiness of food choices, indicating that beverage primes may not generalise to food choices.

Existing research in the appetitive domain, focussing on foods, indicates that Instagram-style images can effectively nudge healthier choices and consumption behaviours. Instagram-style images of healthy or unhealthy foods have successfully nudged the healthiness of food-related choices (gift cards representing healthy or unhealthy food intake intentions; Wilson et al., 2019) and the consumption of healthy and unhealthy foods (Coates et al., 2019). However, in the above studies the foods were the primary focal point in the images (e.g., a close-up of a bowl of cereal on a table; Wilson et al., 2019) rather than being subtly incorporated into the background as in the two experiments here. Moreover, by using Instagram Influencers, the Coates et al. study also drew on social norms and modelling to influence choices, rather than simply priming (Qutteina et al., 2019). These results indicate that more obvious priming, and a product placement style approach in an Instagram platform, can influence choices. Thus, to be effective, we may need images featuring (non-branded) drinks; for example, a university advertising their campus vending machines could use a non-branded water bottle as the feature image of their advertisement. However, such an obvious

approach moves away from nudging, which involves subtle and unobtrusive tools to gently guide behaviours (Sunstein, 2014).

Some research in the nudging domain does indicate that very subtle priming images can influence food-related behaviour. For example, Brunner and Siegrist (2012) used a laptop screensaver, which was only peripherally visible to participants, to influence chocolate consumption in a taste test task. When the screensaver depicted extremely thin human-like Giacometti sculptures, participants ate less chocolate than when a neutral artwork was displayed. However, there were several important differences between the present study and Brunner and Siegrist's experiment. While they presented their priming image during the taste test, we presented ours before the food/beverage choice task. Perhaps our subtle primes might have been more effective had they been presented alongside the choice task. Nevertheless, some studies have found subtle priming to be effective for nudging consumption or choice, even when presented temporally before items for consumption or choice (e.g., Papies & Hamstra 2010; Tonkin et al., 2019). In addition, whereas we used item-specific primes, Brunner and Siegrist used a general-health prime, which works by activating health- or diet-related goals. Nudging the healthiness of choices could be reliant on activating these goals. While some studies have successfully used item specific primes to nudge healthier behaviours (e.g., Sharps et al., 2020), these have focussed on increasing the amount served and/or consumed, rather than on the choice of a healthy or unhealthy item. Brunner and Siegrist likewise measured consumption in a taste test task. Perhaps nudging people towards healthier choices is different from and harder to accomplish than reducing the amount of food that is consumed. We know that people inherently gravitate towards high sugar/fat items because they are more rewarding (e.g., van Meer et al., 2016). People might still choose an unhealthy item but consume less of it when presented with a healthy prime. Lastly, Brunner and Siegrist focussed purely on foods, while we included both drinks and foods. Perhaps

nudging drink choices is different from nudging food choices.

Food and drink choices are clearly habitual in nature, with participants in both experiments more likely to choose something they regularly consume and like. While vending machine choice was not associated with most demographic characteristics in the present experiments, habitual consumption and liking were, potentially indicating that the visual nudges may be less effective for regular consumers and that nudging healthier drink and food choices may be made difficult by the need to override the habitual nature of dietary choices. However, the observed nudge effects in the present experiment appeared when controlling for habitual consumption and liking, demonstrating promising potential for this kind of approach to nudge choices. In addition, unhealthy foods and drinks are much more available and frequently advertised than healthier alternatives, which consequently are less familiar (Hallum et al., 2020; WHO, 2022). Unhealthy foods and drinks also tend to come in brightly coloured packaging incorporating the role of visual appeal, and being higher in fats, salts, and sugars, are generally considered tastier and more flavoursome than healthier items (Raghunathan et al., 2006).

As with all research, there are several limitations in the present experiments. First, it is possible that the link between the beverage primes and the choice task in our two experiments was lost as a function of the way our tasks were presented. In both experiments here, the priming task was presented as entirely separate from the choice task. Participants were told that they were participating in two separate, unrelated studies. While this was a methodological strength, it may have weakened the inherent link between the item specific primes and the choice task. Future research could attempt to link the image task more closely (yet still unobtrusively) to the choice task. Second, in Experiment 2, a few of the images incorporated the water or soft drink primes into scenes which may have triggered beverage-specific associations. For example, one image in the water prime condition included a

mountain scene which in and of itself may be associated with water, while one image in the soft drink prime condition included a tropical scene which in turn may be closely related to soft drink consumption. Thus, it may not purely be the beverage glasses that may influence choices. Third, due to the online nature of our experiments, we used self-report measures. Some research (e.g., Robinson et al., 2022) indicates potential underreporting of height and weight, particularly among those who are more overweight. However, although there was a significant difference in BMI between conditions in Experiment 2, this was controlled for in the analyses and was not related to beverage/food choice. Finally, our experiments did not include a tangible outcome (e.g., can of drink). Instead, participants made a hypothetical choice which may reduce the external validity of our findings. While hypothetical choices do demonstrate behavioural intentions, which are indicative of behaviour change (Grummon & Hall, 2020; Kang et al., 2011), there can still be an intention-behaviour gap. While we were unable to provide participants with their chosen item from the vending machine due to using a large, nationally representative sample, future research would benefit from including a real-stakes outcome. For example, future research might ask participants to select an item as thanks for taking part in the study, with the knowledge that they will then be sent the product.

In conclusion, the results of the current two studies show that incorporating drink primes into the background of Instagram-style images can be an effective means of nudging the choice of a drink over food from a visual display. In the context of previous research, however, nudging healthier drink choices appears to be more challenging than nudging healthier food consumption behaviours. Finding an effective means of encouraging healthier drink choices is important considering the adverse health consequences associated with consumption of sugary beverages.

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Supplementary materials

Instagram-based priming to nudge drink choices: Subtlety is not the answer

Figure S1: Vending machine item classification

Table S1: Experiment 1: Overview of results for beverage versus food choices

Table S2: Experiment 1: Overview of results for healthy versus unhealthy beverage choices

Table S3: Experiment 1: Overview of results for healthy versus unhealthy food choices

Table S4: Experiment 2: Overview of results for beverage versus food choices

Table S5: Experiment 2: Overview of results for healthy versus unhealthy beverage choices

Table S6: Experiment 2: Overview of results for healthy versus unhealthy food choices

Figure S1
Vending machine item classification

Note: Green = Healthy; Red = Unhealthy

Table S1
Experiment 1: Overview of results for beverage versus food choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	-0.08	0.24	0.10	.751	0.93
versus Soft Drink Prime	0.23	0.24	0.91	.339	0.80
Soft Drink Prime					
versus Control Prime	-0.31	0.24	1.66	.197	0.74
Physiological State					
Thirst	0.01	0.00	3.63	.057	1.01
Hunger	-0.01	0.00	3.94	.047*	0.99
Habitual Consumption					
Beverage Consumption	0.77	0.20	15.19	<.001*	2.16
Food Consumption	-0.73	0.20	13.07	<.001*	0.48
Liking					
Beverage Liking	0.01	0.01	3.25	.071	1.01
Food Liking	-0.03	0.01	10.79	.001*	0.97

Note: * $p < .05$

Table S2
Experiment 1: Overview of results for healthy versus unhealthy beverage choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	0.19	0.34	0.24	.623	1.20
versus Soft Drink Prime	-0.00	0.39	0.00	.993	1.00
Soft Drink Prime					
versus Control Prime	0.19	0.38	0.24	.621	1.21
Physiological State					
Thirst	-0.01	0.01	4.42	.035*	0.99
Habitual Consumption					
Healthy Beverages	-0.85	0.29	8.41	.004*	0.43
Unhealthy Beverages	0.68	0.26	7.15	.008*	1.98
Liking					
Healthy Beverages	-0.00	0.01	0.12	.733	1.00
Unhealthy Beverages	0.04	0.01	12.09	.001*	1.04

Note: * $p < .05$

Table S3
Experiment 1: Overview of results for healthy versus unhealthy food choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	-0.47	0.41	1.31	.253	0.62
versus Soft Drink Prime	-0.31	0.40	0.64	.426	0.73
Soft Drink Prime					
versus Control Prime	-0.16	0.41	0.14	.705	0.86
Physiological State					
Hunger	0.00	0.01	0.03	.856	1.00
Habitual Consumption					
Healthy Foods	-0.92	2.83	10.53	.001*	0.40
Unhealthy Foods	0.42	0.26	2.51	.113	1.52
Liking					
Healthy Foods	-0.04	0.02	6.90	.009*	0.96
Unhealthy Foods	0.03	0.01	4.05	.044*	1.03

Note: * $p < .05$

Table S4
Experiment 2: Overview of results for beverage versus food choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	0.09	0.24	0.16	.689	1.10
versus Soft Drink Prime	-0.56	0.25	5.28	.022*	0.57
Soft Drink Prime					
versus Control Prime	0.66	0.24	7.28	.007*	1.93
Physiological State					
Thirst	0.01	0.00	5.29	.021*	1.01
Hunger	-0.01	0.00	6.24	.012*	0.99
Habitual Consumption					
Beverage Consumption	0.71	0.21	11.28	.001*	2.03
Food Consumption	-0.32	0.19	2.88	.090	0.72
Liking					
Beverage Liking	-0.00	0.01	0.08	.778	.998
Food Liking	-0.01	0.01	1.62	.203	0.99
BMI	0.02	0.02	0.91	.340	1.02

Note: * $p < .05$

Table S5
Experiment 2: Overview of results for healthy versus unhealthy beverage choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	-0.23	0.28	0.37	.542	0.80
versus Soft Drink Prime	-0.51	0.36	2.02	.156	0.60
Soft Drink Prime					
versus Control Prime	0.28	0.36	0.61	.435	1.32
Physiological State					
Thirst	0.00	0.01	0.05	.826	1.00
Habitual Consumption					
Healthy Beverages	-0.70	0.31	5.04	.025*	0.50
Unhealthy Beverages	0.89	0.23	14.71	<.001*	2.44
Liking					
Healthy Beverages	-0.02	0.01	1.75	.185	0.99
Unhealthy Beverages	0.04	0.01	11.43	.001*	1.04
BMI	-0.01	0.02	0.23	.632	0.99

Note: * $p < .05$

Table S6
Experiment 2: Overview of results for healthy versus unhealthy food choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Prime					
versus Control Prime	0.37	0.46	0.66	.416	1.45
versus Soft Drink Prime	-0.18	0.53	0.12	.734	0.84
Soft Drink Prime					
versus Control Prime	0.55	0.49	1.24	.266	1.73
Physiological State					
Hunger	0.00	0.01	0.01	0.92	1.00
Habitual Consumption					
Healthy Foods	-0.71	0.34	4.37	.037*	0.49
Unhealthy Foods	0.47	0.34	1.94	.163	1.60
Liking					
Healthy Foods	-0.07	0.02	13.65	<.001*	0.93
Unhealthy Foods	0.03	0.02	4.03	.045*	1.03
BMI	-0.01	0.02	0.05	.817	0.99

Note: * $p < .05$

CHAPTER 3: STUDIES 3 AND 4

Effectiveness of visual nudges for encouraging healthier beverage choices from vending machines

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Preamble

The findings of the experimental studies reported in Chapter 2 (Studies 1 and 2) revealed that subtle beverage priming may not be the most effective means of nudging drink choices from a vending machine-style food and beverage environment. In Study 1, a glass of water or soft drink was incorporated very subtly into the background of a series of Instagram images used as priming nudges. Neither priming nudge, however, influenced choices relative to a neutral control, but few participants were able to recall and/or identify the depicted drinks in either condition. While still a background component of the Instagram images, the beverage primes were made clearer and a little less subtle in Study 2. Findings indicated that the soft drink prime nudged the selection of a drink over a food. However, the water prime, which was less noticed than the soft drink prime, still did not influence choices. Again, neither prime predicted the healthiness of drink or food choices, leading to the conclusion that perhaps a more obvious approach may be needed. As outlined in the general discussion of Chapter 2, research demonstrating the effectiveness of item-specific nudges, like those used in Chapter 2, used obvious approaches where the priming nudge was presented as the central focus of the image, rather than being subtly incorporated. In comparison, studies demonstrating the effectiveness of subtle nudges used body-related images.

Building on the results of Studies 1 and 2 and existing nudging literature outlined in the general discussion of Chapter 2, Studies 3 and 4, presented in Chapter 3, assessed the effectiveness of a much more obvious approach to priming, with the drink primes being a central focus of a vending machine advertising poster. They also incorporated a body-related, general-health prime (an image of a runner), in comparison to the drink primes and a control prime, to build upon the existing research demonstrating the effectiveness of such visual nudging approaches for foods. Further, considering the results of Studies 1 and 2 and the literature outlined in the general discussion of Chapter 2, it was also thought that the

effectiveness of beverage primes may be context specific, given the success of similar nudges in food-specific environments. Thus, the effectiveness of the primes used in Chapter 3 were tested in a beverage only (Study 3) and a combined food and beverage vending machine environment (Study 4).

Abstract

Research suggests visual nudging techniques can subtly encourage healthier consumption. Two experiments explored the effect of four visual nudges on drink choices from a vending machine display. Participants (17-25 years) were randomly assigned to view vending machine advertising posters containing pictorial nudges of water, soft drink, general health (runner), or a text-only control. Participants then selected an item from a vending machine display containing drinks only (Experiment 1; $n = 164$), or both drinks and snack foods (Experiment 2, $n = 684$). In both experiments, nudging condition predicted choice. Specifically, the water image nudged healthier beverage choices in both experiments. However, there was no effect on food choice in Experiment 2. Furthermore, in both experiments, liking and habitual consumption of chosen items were also significant predictors of choice, but condition predicted beverage choice over and above these. Findings have the potential to inform strategies for encouraging healthier beverage choices from vending machine environments.

Keywords: nudging, vending machines, beverage choice, food choice

Introduction

Poor diet, especially one high in fat and sugar, is considered a major contributor to a wide range of noncommunicable diseases, including heart disease, type 2 diabetes, and cancer, which are some of the leading causes of death in Western societies (WHO, 2021). As such, the World Health Organisation has stressed the need to limit intake of free sugars and salt, as well as saturated and trans-fats (WHO, 2021). Soft drinks are one of the major sources of excess sugar in people's diets, particularly among young adults, and pre-packaged snack foods are a leading source of excess fat and salt (ABS, 2022; French et al., 2013; Miller et al., 2020; WHO, 2021). Conversely, plain water has been linked to positive health outcomes for a range of physical and mental health conditions including obesity, coronary diseases, and depression (Chan et al. 2002; Fresán et al., 2016; Haghighatdoost et al., 2018; Muckelbauer et al., 2013; Stookey et al. 2008).

Many traditional approaches to encouraging healthier consumption behaviours have had limited success (Marteau et al., 2011). Education, public health, and mass media campaigns, for example, often fail to account for the automatic nature of decision making. Consumers tend to rely more on attitudes, impulses, and habits to make fast-paced decisions in the moment, rather than carefully considering their choices (Bucher et al., 2016; Houlihan, 2018). Consumers also often report feeling manipulated by more restrictive approaches, like sugar taxes, producing a backlash effect whereby they actively seek out less healthy products to reassert their autonomy (Diepeveen et al., 2013; Evers et al., 2018; Laurin et al., 2012). Consequently, there has been a move toward more implicit approaches, like nudging, to encourage healthier consumption behaviours.

Nudging is an umbrella term for an array of techniques, grounded in behavioural economics, that acknowledge the automatic nature of decision making (Bucher et al., 2016; Sunstein, 2014). They are designed to operate relatively outside of consciousness, thus

requiring very little cognitive engagement. Nudging techniques involve subtly rearranging environments so the desired (in this case, healthier) choice becomes the default and easy option (de Ridder, 2014; Thaler & Sunstein, 2008). Another key component of nudging is maintaining freedom of choice (Sunstein, 2014). The undesired (less healthy) option remains available, thereby maintaining autonomy, and thus less likely to result in backlash effects (de Ridder, 2014; Thaler & Sunstein, 2008). Nudges also tend to garner support from consumers as being less invasive and more trustworthy (Evers et al., 2018; Junghans et al., 2015).

The effectiveness of nudging for improving a range of behaviours, such as tobacco use, exercise, and financial planning, has already been demonstrated (e.g., Marteau et al., 2011). In the appetitive domain, a handful of systematic reviews and meta-analyses have demonstrated that nudging is also effective for encouraging healthier food consumption behaviours (e.g., Arno & Thomas, 2016; Cadario & Chandon, 2019; Vecchio & Cavallo, 2019). Most of these studies involved techniques such as labelling (e.g., calorie or nutritional labelling), positioning/placement (e.g., manipulating visibility or convenience of choice), or manipulating portion size (either perceived or actual size). However, less research has investigated subtler visual nudges, such as pictorial cues and primes.

Pictorial cues and primes are images that are in some way related to the desired behaviour and are designed to shift attention and preferences by activating mental concepts (Papies et al., 2013). In the food domain, for example, placing an image of grapes on the bottom of a child's plate has been found to increase the portion of grapes selected and consumed by children (6-11 years) serving themselves (Sharps et al., 2020). Similarly, Papies and Hamstra (2010) found that the presentation of a poster advertising a healthy recipe reduced consumption of sample meatballs in a butcher's shop. A different type of pictorial nudge involves the use of a more general health-related image to activate dieting concepts, motivating consumers to make healthier choices (Forwood et al., 2015). For example, several

studies decreased food consumption in a taste test task using unobtrusive screensavers depicting thin, human-like Giacometti sculptures (e.g., Brunner & Siegrist, 2012; Stämpfli & Brunner, 2016; Stämpfli et al., 2017).

Most existing research in the appetitive domain has focused on nudging food consumption behaviours. Research exploring the effectiveness of similar nudges for beverage consumption behaviours is limited. However, one study found subliminally priming participants with smiling faces (compared to frowning faces) led to increased serving and consumption of drinks (Winkielman et al., 2005). Considering the regularity of sugar-sweetened beverage consumption, and the associated negative health implications, beverage-related nudging research is important. Sugar-sweetened beverages such as soft drinks account for 50% of free sugar intake in Australia and contribute significantly to overall energy consumption (Lei et al., 2016), with nearly 64% of Australians reporting consuming soft drinks (Miller et al., 2020).

Vending machines provide a context that might be particularly suited to pictorial nudges as they offer a highly visual form of display. Vending machines provide constant access to a range of less healthy beverage and food options high in excess sugar, fat, and salt, which should be limited according to WHO guidelines (Hua & Ickovics, 2016; Rosi et al., 2017; WHO, 2021). An analysis of vending machine items available across a large Australian university campus found that 49% of beverages and 95% of foods were unhealthy (Grech et al., 2017). One field study has found that an incidental poster placed next to a vending machine influenced food choices (Stöckli et al., 2016), with posters of nature or physical activity scenes resulting in healthier snack choices than hedonic (fun-fair) or no posters. A recent pair of online studies added visual cues to the vending machines themselves by manipulating vending machines wraps to display water or soft drink brand logos, images of water or soft drink, the colour blue or red, versus the colour black (Calabro et al. 2023).

These studies found no effect of vending machine wrap on drink choices other than a slight increase in caffeine drinks in the black (control) condition in one of the studies. To date, however, no research has examined the effectiveness of pictorial primes (presented prior) for encouraging healthier drink choices in a vending machine environment.

Thus, the overall aim of the present research was to examine the effect of visual nudges on beverage selections from vending machine environments. Experiment 1 focussed on nudging choices from a vending machine display containing drinks only, while Experiment 2 sought to extend findings to a vending machine display containing both drinks and snack foods. There were three active nudging conditions: water (image of a glass of water), soft drink (image of a cola-coloured drink), and general health (image of a runner), presented as part of an advertising poster. The water and general health images were expected to nudge healthier drink choices, while the soft drink image was expected to nudge less healthy drink choices.

Experiment 1

Experiment 1 sought to assess the effectiveness of four images (water, soft drink, general health, control) for nudging choices from a beverage vending machine. It was predicted that, relative to the control condition, the water image and general health image would nudge healthier choices and the soft drink image would nudge less healthy choices.

Method

Participants. Participants were 164 undergraduate students (aged 17-25 years) recruited from Flinders University. The sample consisted of 135 women, 27 men, and 2 who identified as ‘other’. Participants were reimbursed with course credits or a small honorarium.

Design. The experiment used a between-subjects experimental design with participants randomly allocated to one of the four nudging conditions: water, soft drink, general health, or control. The dependent variable was beverage choice.

Materials.

Nudges. Participants were presented with one of four nudging images (according to allocated condition) on a vertical laboratory touch screen computer. The water image depicted water being poured into a glass, the soft drink image depicted a cola-coloured beverage being poured into a glass, the general health image depicted a person running along a beach at sunrise, and the control image was a simple coloured circle (see Figure 1). Glasses were chosen for the two beverage nudges to avoid the shape of a bottle (even with label removed) indicating a specific brand. The runner image was chosen to activate health- or diet-related concepts and motivations as it depicts a common exercise intrinsically associated with a healthy lifestyle. In line with the cover story of the image being a proposed advertising poster to be placed around the university campus, each image contained the text: "Drink. Refresh. Replenish. Flinders University Beverage Vending Machines. Quenching your thirst since 2002.".

To ensure attention and support the cover story, participants were asked to rate their level of agreement with four statements about the advertising poster on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The first three statements addressed the design and layout of the image (e.g., "I like the colour scheme of this image"). The final statement asked participants to indicate whether they thought the image would "encourage [them] to use a Flinders University beverage vending machine."

Beverage choice task. Participants were asked to imagine they were standing in front of a vending machine, intending to choose a drink. They were then presented with the beverage vending machine display on the computer. The items in the machine were arranged identically to a beverage vending machine present on the University campus. As depicted in Figure 2, the machine consisted of five rows of eight beverages with a total of 33 beverage options across the 40 spaces. The top row contained canned soft drinks; the second row four

Figure 1
Experiment 1 nudging images

Water

Soft Drink

General Health

Control

bottles of plain water, one bottle of plain sparkling water, two flavoured aloe vera drinks and a can of coconut water; the middle row contained various flavours of sparkling water, iced tea, and sports drinks; the fourth row contained energy drinks; and the bottom row contained bottled soft drinks as well as two flavoured milk drinks. Beverages were classified into three categories: water (including all forms of water: plain, sparkling, coconut), soft drinks (including soft drinks and energy drinks) and 'other' (including all other beverages, such as iced tea, sports drinks, aloe vera drinks, and flavoured milk). Participants were asked to select a beverage by physically touching the product on the screen. To determine the most common reasons for item selection and to probe for suspicion of the study aims, participants were asked to provide a brief rationale for their choice.

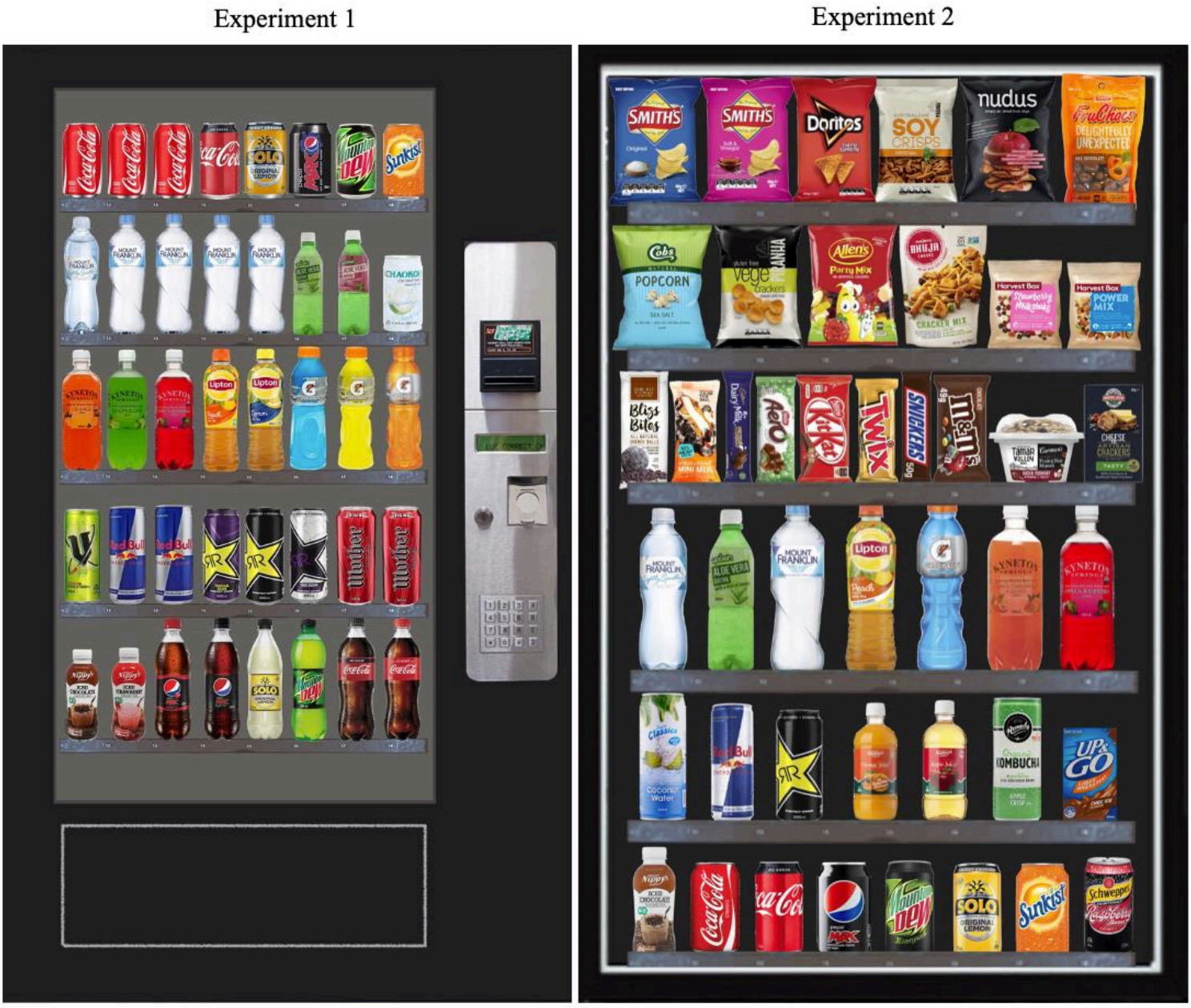
Background. Participants were asked to report their age and gender, and how long since they last drank anything. They also rated their current thirst on a 100mm visual analogue scale ranging from 'not at all thirsty' to 'extremely thirsty'.

Habitual consumption and liking. To account for the potential influence of individual differences in usual beverage consumption, participants were asked to indicate how often they consume each product included in the vending machine display on a seven-point scale ranging from 1 (multiple times a day) to 7 (never). In addition, for each item they had tried before, participants were also asked to indicate how much they liked it on a 100mm visual analogue scale ranging from 'not at all' to 'very much'. Mean scores for consumption and liking ratings were calculated for each outcome category (water, soft drink, other).

Procedure. Participants were recruited for a study exploring the psychology of choices from vending machines. They attended the Applied Cognition Laboratory at Flinders University where up to three participants were tested at a time, in separate cubicles, in a session of approximately 15 minutes. Participants provided written informed consent and completed the background questionnaire before starting the two tasks. In the first task,

Figure 2

Vending machine displays for Experiment 1 (left) and Experiment 2 (right)



participants were provided with the cover story and presented with one of the nudging images (according to allocated condition) as a proposed vending machine advertising poster before answering the associated questions. Participants then completed the beverage choice task. Finally, participants completed the habitual consumption and liking items and had measures of their height and weight taken by the researcher, from which body mass index (BMI; kg/m^2) was calculated. The study protocol (also for Experiment 2) was approved by the

Flinders University Social and Behavioural Research Ethics Committee (Project number: 8376).

Results

Sample characteristics. The average age of participants was 19.98 years (*SD* = 1.94). The mean BMI of the sample was 23.68 kg/m^2 (*SD* = 5.30). Participants were on average moderately thirsty with a mean rating of 56.21 (*SD* = 23.29). There were no significant differences between conditions on any of these variables (*F*s < 1.15, *p*s > .330).

Overall, beverage choices fell relatively evenly across the three categories, with 34.8% of participants choosing a water, 23.2% choosing a soft drink, and 42.1% choosing 'other'. The most popular items were iced tea (other; 23.2%), plain water (water; 17.7%), coca cola (soft drink; 11.6%), flavoured sparkling mineral water (water; 9.8%) and flavoured milk (other; 9.1%). The two most common reasons for choosing a water were that participants were avoiding soft drinks and/or other sugary beverages (40.4%), and that they were thirsty/wanted something refreshing (36.8%). In contrast, the two most common reasons for choosing a soft drink or 'other' drink were that it was their usual or favourite choice (soft drink 44.7%; other 31.9%), and flavour/taste (soft drink 44.2%; other 40.6%).

Effect of condition on beverage choice. As can be seen in Table 1(a), for participants in the water nudge condition, water was the most popular choice (48.8%), while for all other conditions, beverages from the 'other' category were the most popular. Additionally, participants in all active nudging conditions (water, soft drink, general health) were more likely to select a water compared to the control condition.

Table 1
Descriptive statistics for vending machine choice by condition

Choice category	Water	Soft Drink	General Health	Control
(a) Experiment 1	*n* = 41	*n* = 41	*n* = 41	*n* = 41
Water	20 (48.8%)	15 (36.6%)	15 (36.6%)	7 (17.1%)
Soft Drink	8 (19.5%)	9 (22.0%)	8 (19.5%)	13 (31.7%)
Other	13 (31.7%)	17 (41.5%)	18 (43.9%)	21 (51.2%)
(b) Experiment 2				
(i) Beverage	*n* = 169	*n* = 170	*n* = 174	*n* = 171
Less Healthy	27 (16.0%)	32 (18.8%)	36 (20.7%)	27 (15.7%)
Healthier	64 (37.9%)	50 (29.4%)	36 (20.7%)	61 (35.7%)
(ii) Food				
Less Healthy	49 (29.0%)	57 (33.5%)	62 (35.6%)	49 (28.7%)
Healthier	29 (17.2%)	31 (18.2%)	40 (23.0%)	34 (19.9%)

To formally investigate the effect of nudging condition on beverage choice category, a multinomial logistic regression was conducted. To account for the potential influence of individual differences in usual consumption and liking of beverages, and to determine if condition had an effect over and above these factors, mean consumption and liking scores for each beverage choice category were also included in the model; demographic characteristics (e.g., gender, age, BMI, thirst, tiredness, time since last drink) were not associated with vending machine choice and thus not included in the final model (*p*s > .127). The final model was significantly different from the intercept only model, $\chi^2(18) = 85.73$, $p < .001$. As can be seen in Table 2 (a), while consumption and liking ratings did predict choice, condition was also a significant unique predictor, $\chi^2(6) = 12.86$, $p = .045$.

Table 2
Regression results predicting vending machine choice

Effect	Chi-Square	Sig.
(a) Experiment 1		
Condition	12.86	.045*
Usual Consumption		
Water	11.22	.004*
Soft Drink	5.08	.079
Other	9.00	.011*
Liking		
Water	0.65	.724
Soft Drink	11.24	.004*
Other	8.37	.015*
(b) Experiment 2		
(i) Beverage		
Condition	11.05	.011*
Usual Consumption		
Less Healthy	19.95	<.001*
Healthier	0.02	0.897
Liking		
Less Healthy	7.73	.005*
Healthier	2.05	0.152
(ii) Food		
Condition	0.62	0.891
Usual Consumption		
Less Healthy	11.73	<.001*
Healthier	9.30	.002*
Liking		
Less Healthy	15.28	<.001*
Healthier	7.59	.006*

Note: $*p < .05$

Parameter estimates show that participants in the water nudge condition were significantly more likely than participants in the control condition to select an item from the water category over both the other, $b = 1.84$, $p = .005$, $OR = 6.30$, 95%CI: 1.73, 22.91, and soft drink categories, $b = 2.14$, $p = .007$, $OR = 8.47$, 95%CI: 1.79, 40.06. Similarly, participants in the water condition were more likely than participants in the general health condition to select from the water category than from the other category, $b = 1.27$, $p = .035$, $OR = 3.55$, 95%CI: 1.10, 11.47. Furthermore, participants in the soft drink condition were significantly more likely than participants in the control condition to select an item from the water category over an item from the soft drink category, $b = 1.80$, $p = .027$, $OR = 6.08$, 95%CI: 1.23, 30.01. See Table S1 of the Supplementary Materials for an overview of the parameter estimates.

Discussion

Overall, participants in the three active nudging conditions (water, soft drink, general health) were more likely to select a water beverage than participants in the control condition. When controlling for habitual consumption and liking, the water nudge was a significant predictor of water choice, with participants in this condition significantly more likely to select from the water category, compared to participants in both the general health and control conditions. Although participants in the general health prime condition were more likely to select a water compared to the control condition, this was not significant. In addition, contrary to prediction, participants in the soft drink image condition were not more likely to select a soft drink.

Not surprisingly, irrespective of condition, beverage choice was predicted by consumption and liking ratings. Higher mean consumption ratings and/or greater liking of items included in the category predicted choice from that category. However, the water image significantly predicted choice of a water over and above usual consumption and liking.

Experiment 2

As many vending machines include foods as well as beverages (Grech et al., 2017), Experiment 2 sought to examine the effectiveness of nudging images in a combined food and beverage vending machine environment. The images were the same as those used in Experiment 1. Based on the results of Experiment 1, the water image was expected to nudge healthier beverage choices, and potentially also healthier food choices, relative to control. While the water image was the most effective in Experiment 1, the general health image also nudged healthier beverage choices relative to the control, and thus we expected to see the same here. The study was conducted online, reducing potential demand effects and social desirability bias, as well as providing greater anonymity and a larger, more diverse sample.

Method

Participants. Participants were 684 young adults (aged 17-25 years) recruited from the Flinders University student population ($N = 248$) and the wider Australian population via the online survey platform Prolific ($N = 436$). The sample consisted of 413 women, 259 men, and 12 who identified as other/prefer not to say. Participants were reimbursed with course credits or a small honorarium.

Design. The design was the same as in Experiment 1.

Materials.

Nudges. Nudging images were the same as those used in Experiment 1, but the text on the images was changed to "Refresh. Replenish. Snack and Beverage Vending Machines," to reflect the inclusion of foods in the vending machine and to remove the association with Flinders University, as participants were also drawn from the wider Australian population. Similarly, the cover story was adapted to remove the association with university campuses; participants were simply told that the image was of a proposed poster for advertising vending machines.

Vending machine choice task. As in Experiment 1, participants were asked to imagine they were standing in front of a vending machine before being presented with a vending machine display. However, as shown in Figure 2, there were fewer beverage options because the top three shelves of the machine contained foods. Both the food and beverage options selected for the machine consisted of half 'healthy' and half 'less healthy' options. While products generally included in vending machines are typically high in fat, salt and/or sugar i.e., less healthy (e.g., chips, lollies, soft drinks; Grech et al., 2017), some vending machine companies are starting to offer healthier options. 'Healthy' items were selected from those listed as healthy by vending machine companies (AusBox Vending; https://www.ausboxgroup.com.au/healthy-vending-machines) and included foods such as crackers and fruit/nut mixes, and drinks such as water, kombucha and fruit juices. Accordingly, choices were categorised as being a healthy food, less healthy food, healthy beverage, or less healthy beverage.

Background. The background questionnaire was the same as in Experiment 1 with the addition of two eating-related questions. Participants were asked to indicate how long since they last ate, as well as providing a rating of their current hunger level.

Habitual consumption and liking. These were the same as in Experiment 1, with ratings averaged across each vending machine category (healthy food, less healthy food, healthy beverage, less healthy beverage).

Procedure. The procedure was similar to Experiment 1, except that Experiment 2 was conducted entirely online using the Qualtrics survey platform. After providing written informed consent, Qualtrics randomly assigned participants to one of the four nudging conditions before they were presented with the first task. In this task, participants rated their agreement with a series of statements related to their randomly allocated advertising poster. Participants were then taken to the second task where they were presented with the vending

machine display and asked to select one item (either a food or a beverage) before being asked to provide a brief rationale for their choice. Participants self-reported their height and weight for the calculation of BMI. To ensure data quality and detect bots, timing and page usage data were collected.

Results

Sample characteristics. Three responses were identified as spam (identical responses within a 24-hour period) by the online survey platform Qualtrics and were removed from the dataset. All other participants were included in the analyses. The average age of participants was 20.83 years (SD = 2.43). The mean BMI of the sample was 23.96 kg/m^2 (SD = 5.40). Participants, on average, had low to moderate levels of hunger (M = 36.28, SD = 27.78) and thirst (M = 44.59, SD = 26.03). There were no significant differences between conditions on any of these variables (Fs < 1.81, ps > .143).

The most popular individual items were iced tea (healthy, 9.9%), Doritos (less healthy, 5.8%), Kit Kat (less healthy, 5.6%), water (healthy, 4.8%), and soy crisps (healthy, 4.7%). The most common reasons provided by participants for choosing a healthy food were that they were considering the healthiness of their choice (37.3%) and taste/flavour (29.1%). The most common reasons for selecting a less healthy food were that it was their usual/favourite choice (40.1%) and because of taste/flavour (30.9%). The most common reasons for selecting a beverage (both healthy and less healthy) were that it was their usual/favourite item (healthy 31.2% less healthy 43.4%), and that it was the item they most felt like or wanted in that moment (healthy 26.5%, less healthy 19.7%).

Effect of condition on vending machine choice. Overall, choices fell relatively evenly between beverages (48.7%) and foods (51.3%). An initial binary logistic regression showed that condition was not a significant predictor of selecting a beverage versus a food, $\chi^2(3) = 5.88$, $p = .118$. Thus, tests of the effect of nudge condition (water, soft drink, general

health, control) on choice were conducted separately for beverages and foods. As in Experiment 1, mean consumption and liking scores were included in each binary logistic regression to account for individual differences and to determine whether condition had an effect over and above usual consumption and liking.

Beverage choices. Table 1 (b, i) shows that healthier beverages were most popular in the water nudge condition (37.9% of total choices; 70.3% of beverage choices) and least popular in the general health nudge condition (20.7% of total choice, 50.0% of beverage choices). The regression model was significant overall, $\chi^2(7) = 51.85$, $p < .001$. As can be seen in Table 2 (a, i), condition significantly predicted beverage choice over and above consumption and liking, $\chi^2(3) = 11.05$, $p = .011$. Participants in the water condition were more likely to select a healthy beverage compared to all other conditions; however, only the comparison with the general health condition was statistically significant, B = -1.06, *SE* = 0.36, Wald's χ^2 (1) = 8.70, $p = .003$. Participants in the soft drink condition were less likely to select a healthy beverage compared to both the water and control conditions, but not significantly so. Participants in the general health condition were the least likely to select a healthy beverage and were significantly less likely to do so compared to participants in the water, B = 1.06, *SE* = 0.36, Wald's χ^2 (1) = 8.70, $p = .003$, and control conditions, B = 0.96, *SE* = 0.36, Wald's χ^2 (1) = 7.02, $p = .008$. See Table S2 in the Supplementary Materials for an overview of all comparisons.

Food choices. Table 1 (b, ii) shows that less healthy foods were more popular than healthy foods across all conditions. The regression model was significant overall, $\chi^2(7) = 52.78$, $p < .001$. However, Table 2 (b, ii) shows that condition did not significantly predict choice of healthy or less healthy foods ($p = .891$) over and above usual consumption and liking ratings, which were significant predictors.

Discussion

Condition significantly predicted choice of a healthy or less healthy beverage when controlling for habitual consumption and liking. The water nudge predicted healthier beverage choices, but only significantly so compared to the general health condition. Contrary to predictions, there was no effect of the soft drink image, and the general health image did not lead to healthier beverage choices, performing worse than the control. Condition did not significantly predict whether participants chose a healthy or less healthy food.

Not surprisingly, choice was again predicted by liking and consumption ratings for both beverages and foods. Participants were more likely to select an item from a category that they liked and/or regularly consumed. As in Experiment 1, the water nudge predicted beverage choice over and above liking and usual consumption.

General Discussion

The present experiments investigated the effectiveness of pictorial nudges (water, soft drink, and general health) for nudging beverage choices from common vending machine environments. Experiment 1 focussed on nudging choices from a beverage-specific vending machine display, while Experiment 2 used a combined beverage and snack food vending machine display. Overall, the water nudge was found to be an effective means of encouraging healthier beverage choices above overall liking and usual consumption, particularly in a beverage-specific choice set. The soft drink and general health nudges had little effect.

In Experiment 1 (beverage only environment), when controlling for habitual consumption and liking, the water nudge resulted in significantly more choices from the water category (such as plain, sparkling, flavoured sparkling, or coconut water) compared to the control condition, indicating that the water image successfully nudged participants toward water. In Experiment 2, when foods were added to the vending machine environment,

participants in the water nudge condition were still the most likely to select a water, but only significantly so compared to those in the general health condition. These findings indicate that in a beverage only environment, a water image may be an effective means of encouraging water choices, and subsequent consumption, but it may be less effective when foods are included in the environment.

Although there were differences in results across the two studies for the soft drink and general health conditions, overall, these two nudges had little influence on vending machine choices. While the soft drink image nudged water choices in Experiment 1, it did not affect choices in Experiment 2. The general health image did not significantly nudge healthier choices in Experiment 1, and performed worse than the control in Experiment 2. In both studies, the water image was found to be significantly more effective than the general health image. This may be due to the water image being more specific and closely related to the choice behaviour than the general health image. Specifically, an image of a glass of water is directly linked to the act of selecting a drink from a vending machine, in a way that an image of a runner is not. Consequently, different forms of processing are involved. Item specific nudging largely works unconsciously and autonomically (Harris et al., 2009), while a general health nudge relies on consumers (consciously or unconsciously) linking the image to health goals and then linking these goals to beverage selection (Forwood et al., 2015). The latter is a longer and more complex process that will not work for individuals who fail to make the relevant connections (Aarts & Dijksterhuis, 2003). In support, several studies have found general health nudges to be less effective for unrestrained eaters (i.e., people not concerned about dieting) than they are for restrained eaters (e.g., Papies & Hamstra, 2010; Stämpfli et al., 2017). Alternatively, the ineffectiveness of the general health nudge may be related to the image itself. Depicting a runner, the general health image was intended to evoke thoughts related to a healthy lifestyle. However, it may have inadvertently triggered compensatory

behaviours whereby participants essentially felt they could treat themselves in response to having exercised, despite not actually having exercised (Albarracin et al., 2009), in this case, resulting in unhealthy vending machine choices.

The soft drink prime had little effect on choices overall, similar to previous research finding unhealthy nudges ineffective. For example, Folkvord et al. (2020) found that a cooking video involving healthy foods increased healthy food choice in a subsequent task, while a similar video involving unhealthy foods did not increase unhealthy food choice. Perhaps it is more difficult to increase motivation for, and selection of, unhealthy products like sugary soft drinks because they are already inherently very rewarding (Olszewski et al., 2019). However, the soft drink nudge did have some (albeit unexpected) effect in Experiment 1, where participants chose more water beverages. The soft drink image may have counterintuitively activated health goals, essentially reminding participants to avoid the depicted unhealthy drinks, and nudging them instead towards healthier drink options (Fishbach et al., 2010).

Habitual consumption and liking were significantly associated with vending machine choice, indicating that nudging may be less effective among regular consumers. However, habitual consumption and liking were controlled for in analyses and the observed nudge effects occurred over and above habitual consumption and liking, indicating that nudges have the potential to influence choices even among regular consumers. Further research is needed, however, to identify nudging approaches that will be effective for general consumers, rather than specific subgroups, if we are to encourage healthier consumption behaviours, more generally, or alternatively to determine the most effective nudges for specific target groups (e.g., among those most at risk of developing diet-related health conditions).

Overall, based on the present experiments, it appears that beverage specific pictorial nudges, in this case depicting water, have the potential to be a beneficial means of subtly

encouraging healthier beverage choices from a beverage-specific environment. The WHO guidelines stress the need to reduce excess sugar consumption, of which soft drinks and other sweetened beverages are a primary source (WHO, 2021). Thus, finding ways to encourage healthier beverage choices is important, especially for water with its links to a range of physical and mental health benefits (Haghighatdoost et al., 2018; Muckelbauer et al., 2013). While the effectiveness of a water image for encouraging healthier choices in a beverage environment has been demonstrated here, the result requires replication in field contexts. If replicated, the finding has important practical implications. In particular, pictorial nudges might provide a simple low-cost means of encouraging healthier beverage choices (Sunstein, 2014). A simple water image, like used in the present experiments, could easily be incorporated into vending machine environments, for example by placing the image next to vending machines on university campuses. Pictorial nudges are also likely to receive greater support from consumers, compared to the more heavy-handed restriction-based approaches (Evers et al., 2018; Junghans et al., 2015).

Although the present research was focussed on vending machines, this kind of display arrangement for drinks is very common. For example, self-service fridges typically arrange beverages similarly to vending machines and are common in places like cafes, service stations and supermarkets. Supermarkets also present their drinks organised by category and brand on their open shelves. Thus, findings from the current research have the potential to be extended to these similar beverage-related environments.

As with all research, the present studies have some limitations. First, the sample used in Experiment 1 was limited to Flinders University students, although Experiment 2 used an Australia-wide young adult sample. While young adults are the core consumers of soft drinks (French et al., 2013), future research might address nudging influence on beverage choices made by children or adolescents and older consumers. Second, in Experiment 2 participants

were asked to select only one item from the vending machine display (i.e., a food or a beverage). This resulted in only about half (48.7%) selecting a beverage. Future designs might specifically ask participants to select a beverage from the display or ask them to select one drink and one food item. Third, some aspects of the nudging images themselves may have inadvertently affected choices. To create images that were plausible as vending machine advertisements, we included text on each image indicating that they were refreshing and replenishing. This text may have inadvertently activated reward pathways which may in turn have influenced choices (Papies et al., 2022). In addition, the colour of the control image (orange) could be considered to be similar to that of a soft drink, thereby acting as a soft drink cue in and of itself. However, recent research investigating the effect of colour on drink choices from vending machines found that neither soft drink (red) or water (blue) coloured vending machines influenced choices (Calabro et al., 2023). Lastly, we acknowledge the hypothetical nature of the experimental choices. Although hypothetical choices are indicative of behavioural outcomes (Grummon & Hall, 2020), future research would benefit from including a real-stakes outcome.

In conclusion, the present experiments demonstrate support for the effectiveness of a water-related pictorial nudge for encouraging healthier beverage choices from a beverage vending machine environment. The findings have the potential to inform strategies designed to nudge healthier beverage choices and thereby reduce excess sugar consumption, an important contemporary public health issue.

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Supplementary materials

Effectiveness of visual nudges for encouraging healthier beverage choices from vending machines

Table S1: Experiment 1: Overview of parameter estimates

Table S2: Experiment 2: Overview of results for healthy versus unhealthy beverage choices

Table S1
Experiment 1: Overview of parameter estimates

	b	*p*	OR	95% CI
Condition				
Water Nudge				
versus Control Nudge				
Water over Soft Drink	2.14	.007*	8.47	1.79, 40.06
Water over Other	1.84	.005*	6.30	1.73, 22.91
Soft Drink over Other	-0.30	.658	0.74	0.20, 2.76
versus Soft Drink				
Water over Soft Drink	0.33	.656	1.39	0.32, 6.01
Water over Other	0.69	.217	2.00	0.67, 6.00
Soft Drink over Other	0.36	.626	1.43	0.34, 6.08
versus General Health Nudge				
Water over Soft Drink	0.92	.227	2.52	0.56, 11.22
Water over Other	1.27	.035*	3.55	1.10, 11.47
Soft Drink over Other	0.34	.629	1.41	0.35, 5.67
Soft Drink Nudge				
versus Control Nudge				
Water over Soft Drink	1.80	.027*	6.08	1.23, 30.01
Water over Other	1.15	.084	3.15	0.86, 11.59
Soft Drink over Other	-0.66	.341	0.52	0.14, 2.00
versus General Health Nudge				
Water over Soft Drink	0.59	.450	1.80	0.39, 8.35
Water over Other	0.57	.341	1.77	0.55, 5.78
Soft Drink over Other	-0.02	.982	0.98	0.24, 4.10
General Health Nudge				
versus Control Nudge				
Water over Soft Drink	1.22	.137	3.37	0.68, 16.72
Water over Other	0.58	.388	1.78	0.48, 6.56
Soft Drink over Other	-0.64	.343	0.53	0.14, 1.98
Habitual Consumption				
Water Consumption				
Water over Soft Drink	1.43	.012*	4.19	1.37, 12.75

Water over Other	1.27	.005*	3.56	1.48, 8.54
Soft Drink over Other	-0.16	.772	0.85	0.28, 2.55
Soft Drink Consumption				
Water over Soft Drink	-1.54	.052	0.21	0.05, 1.01
Water over Other	-0.94	.987	0.91	0.22, 3.81
Soft Drink over Other	1.45	.050*	4.26	1.00, 18.17
Other Consumption				
Water over Soft Drink	-0.41	.655	0.67	0.11, 3.99
Water over Other	-1.86	.009*	0.16	0.04, 0.63
Soft Drink over Other	-1.45	.065	0.23	0.05, 1.10
Liking				
Water Liking				
Water over Soft Drink	0.00	.840	1.00	0.97, 1.04
Water over Other	0.01	.442	1.01	0.99, 1.04
Soft Drink over Other	0.01	.645	1.01	0.98, 1.04
Soft Drink Liking				
Water over Soft Drink	-0.06	.002*	0.95	0.91, 0.98
Water over Other	-0.01	.348	0.99	0.96, 1.01
Soft Drink over Other	0.04	.010*	1.05	1.01, 1.08
Other Liking				
Water over Soft Drink	0.03	.182	1.03	0.99, 1.06
Water over Other	-0.02	.111	0.98	0.95, 1.01
Soft Drink over Other	-0.05	.007*	0.95	0.92, 0.99

Note: *$p < .05$

Table S2

Experiment 2: Overview of results for healthy versus unhealthy beverage choices

	b	SE	Wald's χ^2	Sig	Exp(B)
Condition					
Water Nudge					
versus Control Nudge	-0.10	0.35	0.08	.784	0.91
versus Soft Drink Nudge	-0.61	0.35	3.13	.077	0.54
versus General Health Nudge	-1.06	0.36	8.70	.003*	0.35
Soft Drink Nudge					
versus Control Nudge	0.52	0.35	2.16	.141	1.68
versus General Health Nudge	-0.44	0.35	1.60	.206	0.64
General Health Nudge					
versus Control Nudge	0.96	0.36	7.02	.008*	2.61
Habitual Consumption					
Healthy Drink Consumption	0.55	0.23	5.97	.015*	1.74
Unhealthy Drink Consumption	-0.67	0.20	11.42	<.001*	0.51
Liking					
Healthy Drink Liking	-0.02	0.01	3.76	.052	0.98
Unhealthy Drink Liking	0.02	0.01	4.19	.041*	1.02

Note: *$p < .05$

CHAPTER 4: STUDY 5

A systematic review and meta-analysis of visual cues and primes for nudging consumption-related behaviours

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Statement of co-authorship: Enola Kay, Eva Kemps, and Ivanka Prichard designed the review and wrote the protocol. Enola Kay conducted searches, screening, and data extraction, under the supervision of Eva Kemps. Enola Kay wrote the first draft of the manuscript. All authors edited subsequent drafts of the manuscript and have approved the final manuscript.

Preamble

The findings of the experimental studies reported in Chapter 3 demonstrated the effectiveness of an obvious beverage priming approach for nudging drink choices from a vending machine environment. Specifically, a water prime presented as the central focus of a vending machine advertising poster nudged healthy (water) choices over less healthy (soft drink) choices in both studies. This effect was stronger in a beverage-only choice environment (Study 3) compared to a combined food and beverage environment (Study 4), indicating that beverage-specific primes may be less effective when foods are also present. The soft drink and general health primes were found to have little effect.

The combined results of Studies 1-4 (Chapters 2 and 3) indicate potential differences in nudge effectiveness in specific contexts and/or for different individuals. For example, it appears that characteristics of participants (e.g., presence of a relevant health goal), nudges (e.g., obvious versus subtle, item-specific versus general health-related), and environments or outcomes (e.g., beverage only versus food and beverage choice environment, or measuring choice versus intake) may determine or moderate the effectiveness of visual nudges on consumption-related behaviours.

Study 5, presented in the present chapter, sought to provide a comprehensive systematic review and meta-analysis of the current literature on the efficacy of various implicit food- and-body-related visual nudges for influencing food and/or beverage consumption-related behaviours. Study 5 also sought to identify potential mechanisms and moderators of nudge success to inform future discourse on the creation of effective, targeted visual nudging interventions for shaping consumption-related behaviours.

Abstract

Healthy diets are crucial for maintaining overall wellbeing and reducing risk of health complications. Visual cues and primes are becoming popular implicit nudging techniques for promoting healthier consumption habits. The present review and meta-analysis aimed to evaluate the effectiveness of these cues and primes for nudging consumption-related behaviours. Six electronic databases were comprehensively searched for experimental studies on the use of non-marketing-based visual cues/primes on food/beverage consumption. Sixty-three studies from 50 articles were included, resulting in 182 comparisons categorised into seven groups for separate analyses: (1) healthy food- and (2) body-related nudges, and (3) unhealthy food- and (4) body-related nudges, versus neutral controls; (5) mixed-health food- and (6) body-related comparisons; and (7) nudges not inherently health-related. Overall, nudges effectively influenced consumption-related behaviours. Healthy and unhealthy food- and body-nudges encouraged healthier behaviours relative to neutral controls, and for healthier body-nudges, relative to unhealthy nudges. Non-health-related nudges influenced behaviours in the expected direction, relative to comparison/control conditions. Nudge effectiveness, especially for unhealthy food-nudges, was moderated by participant age and weight, nudge timing (prime/cue) outcome measure (intake/choice), and whether the outcome was real or hypothetical. A range of participant, nudge, and outcome-related mechanisms proposed to underlie nudge effectiveness were also identified. Findings supported the efficacy of visual cues and primes for eliciting changes in consumption-related behaviours, indicating they may be effective for encouraging healthier consumption, when the right nudges are used. Results also indicated different forms of nudges may be more appropriate in different circumstances (e.g., for different types of participants or food-related outcomes). Further research is needed to thoroughly comprehend the mechanisms underlying these nudges and their effectiveness.

Introduction

In today's food environment, unhealthy foods are overwhelmingly prevalent through omnipresent advertising, as well as being readily available and easy to access across diverse settings, including eateries and stores, schools, and workplaces, and increasingly, online (Swinburn et al., 2011). The constant exposure to these, tempting, unhealthy foods, both visually and physically in our environments, significantly contributes to the widespread consumption of such unhealthy items, resulting in poor dietary habits (Temple, 2023; WHO, 2022). Poor diets, characterised by excessive consumption of heavily processed foods high in sugar, fat, and salt, have consistently been linked to a range of health issues (Afshin et al., 2019). For example, poor diet is associated with non-communicable diseases like type II diabetes and cardiovascular disorders, and mental health implications such as anxiety and depression (WHO, 2020). Conversely, healthier diets rich in fruits and vegetables have been associated with greater overall wellbeing and reduced prevalence of diet-related health concerns (Holder, 2019; Tucker 2020).

The prevalence of poor diets is alarmingly high and still increasing. An analysis of global food consumption-behaviours in 2017 found consumption of healthy foods to be below optimal levels, while consumption of unhealthy foods well exceeded recommended levels (Afshin et al., 2019). In Australia only 6.1% of adults reported meeting daily fruit and vegetable consumption recommendations in 2021-22, while 6.4% reported consuming sugary drinks each day (ABS, 2020-2021). Given the high prevalence of poor diets and the associated health implications, it is imperative to find effective methods for encouraging healthier eating habits. Many efforts have been made over the years to do just this, but rates of poor diets remain high. Many of the more traditional approaches for encouraging healthier dietary behaviours involve explicit education or restriction-based techniques such as mass media campaigns or taxes (Marteau et al., 2011). These explicit methods do show some

promise. For example, education-based approaches like school programs and mass media campaigns can increase knowledge around the importance of healthier diets and the implications of poor diets (Dudley et al., 2015). In addition, the implementation of sugar taxes has been found to reduce sales of sugary drinks (e.g., Andreyeva et al., 2022). However, increased knowledge does not always translate into behaviour change (Baghurst & McMichael, 2010; Thakur & Mathur, 2021; Walls et al., 2009). In addition, restrictive approaches like taxes tend to receive backlash and resistance from consumers as they are seen to limit autonomy (Diepeveen et al., 2013; Laurin et al., 2012). As such, other approaches to promote healthier eating behaviours are needed.

The explicit interventions mentioned may not be sufficient alone, but may be complemented by other, more implicit approaches, such as nudging. Nudges are subtle and unobtrusive tools and techniques that gently steer individuals toward certain choices or discourage undesirable behaviours while allowing consumers to retain their freedom of choice (Bucher et al., 2016; Sunstein, 2014; Thaler & Sunstein, 2008). They vary in their degree of implicitness, but a nudge to promote healthier choices might, for instance, involve placing an image of healthy foods on the cover of a menu, making the healthier items more prominent and/or appealing than unhealthy items (e.g., Tonkin et al., 2019). This approach does not restrict access to unhealthy items but rather makes healthier options the simpler and/or more appealing choice.

In addition, given that food and beverage companies tend to prioritise profits to maintain a competitive position in the market, they may be unlikely to voluntarily shift toward promoting healthier foods given the success of their current methods. Thus, an alternative approach like visual cueing or priming, which is not necessarily dependent on the cooperation of these companies, could prove effective. By incorporating visual nudges into environments where food choices are made or integrating healthy foods and/or healthy bodies

into media representations, the prevalence and appeal of healthier options could be enhanced, thus potentially contributing to healthier diets.

A recent meta-analysis has shown that nudging interventions are particularly effective in the food domain (Mertens et al., 2022). As such, nudging appears to be a promising avenue for encouraging healthier consumption-related behaviours. However, while some evidence supports the effectiveness of visual cues and primes as nudging techniques, findings have been mixed. In addition, investigating proposed and tested mechanisms underlying the effectiveness of these nudges could help determine under which circumstances or for whom these nudges are most effective. This knowledge could be instrumental in developing visual nudging techniques that successfully promote healthier consumption behaviours. Thus, overall, the aim of this review was twofold. First, to conduct a meta-analysis to determine the effectiveness of implicit food- and body-related visual nudges in influencing both healthy and unhealthy consumption-related behaviours. Second, to investigate proposed and tested mechanisms thought to underlie the effectiveness of visual cues and primes for nudging such consumption-related behaviours.

Method

The review process is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and was registered with Open Science Framework (OSF registration number: osf.io/sw346).

Search strategy

In consultation with an academic librarian, and after reviewing related systematic reviews and meta-analyses, search strategies were developed for six electronic databases: CINAHL, Medline, PsycArticles, PsycInfo, PubMed, and Scopus. The search strategies were built around key terms relating to the nudging techniques of visual cues and primes, as well as the choice and intake of foods and beverages (see Supplementary Material A for full

search strategy). The initial search was conducted on 9th June 2020, with a follow-up search conducted on 19th March 2023 to identify papers published after the initial search. Search results were limited to peer-reviewed, published articles in the English language containing an original empirical study with a human sample.

Inclusion criteria

To be eligible for inclusion, studies needed to meet the following criteria: (1) include an implicit, non-marketing-based, food- or body-related visual cue or prime (e.g., an image or poster), (2) measure and report at least one behavioural outcome relating to food and/or non-alcoholic beverage consumption-related behaviours (e.g., choice or intake), (3) be an experimental or intervention study, or have a pre/post design, and (4) be a full-text article published in the English language in a peer-reviewed journal. No limits were placed on the publication date.

Marketing-based nudge approaches were excluded to keep the focus on more implicit visual nudging techniques. Interventions were considered marketing-based if they were actively trying to 'sell' a specific product or brand. Further, studies were only included if they reported results of isolated nudge effects. For example, if a study assessed multiple interventions but reported the results of the relevant visual nudge(s) separately then it was included. However, studies were excluded if multiple interventions were implemented at once and/or the relevant nudges also incorporated elements of other nudging approaches (e.g., exposing participants to the smell of foods alongside a relevant pictorial food-specific nudge, or incorporating norm-based messages such as 'popular choice' into the nudge).

Selection of studies

Covidence, an online systematic review management platform, was used to screen all retrieved papers. Screening of titles and abstracts was conducted by two independent reviewers before full-text screening commenced. Any conflicts were discussed until a

consensus was reached. Additional studies were then located through forward and backward searching of citations, and these additional papers were also reviewed at the title and abstract level by two independent reviewers, followed by full-text screening of eligible papers. See Figure 1 for the PRISMA flow diagram.

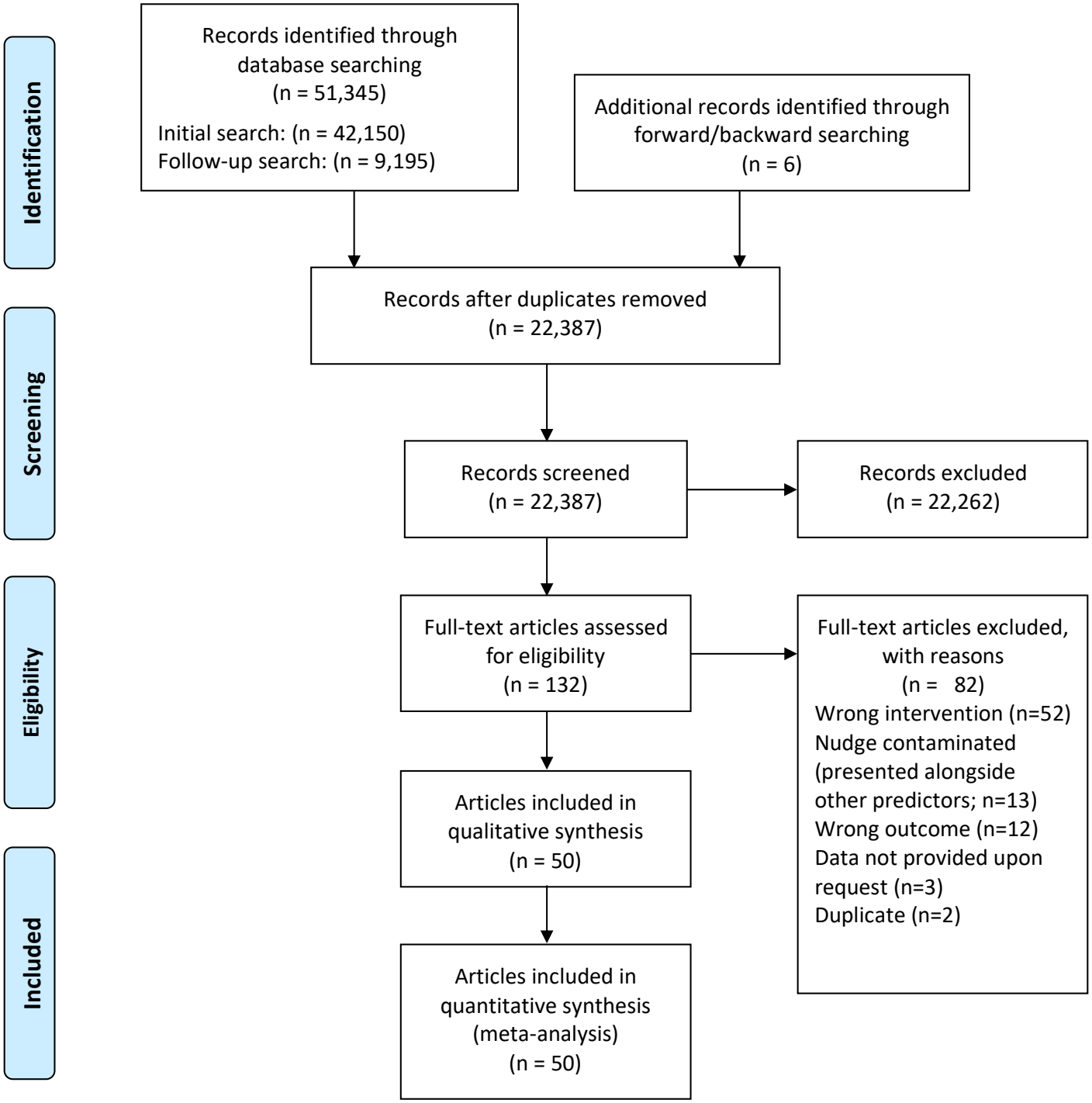
Data extraction and allocation of comparisons to categories

Data extraction was conducted by the first author, using a standardized form developed for this review. Extracted information included sample characteristics, study design and methodology, the nature of the visual cue and/or prime(s), primary outcomes (food and/or beverage choice/intake behaviours), proposed and/or tested underlying mechanisms or moderators (if any), key consumption-related findings, and effect sizes.

Cohen's *d* and Hedges' *g* (and 95% confidence intervals) were calculated for condition comparisons to be used in the meta-analyses. Condition comparisons were grouped into seven categories for separate analyses. Note that we refer to comparisons, not studies, as a single study could include multiple comparisons suited to different categories, or multiple comparisons that fit within one category.

Categories 1 and 2 included comparisons between a "healthy" (designed to encourage healthier consumption-related behaviours) food- and body-related nudges, respectively, and a neutral control condition. A nudge was considered "healthy" if it was inherently associated with encouraging the consumption of healthier foods, reducing general consumption, or reducing consumption of unhealthy foods. Examples of the kinds of nudges in Category 1 included images of healthy foods, like fruits and/or vegetables, and in Category 2, images of body types associated with health (e.g., slim bodies). We acknowledge that despite health generally being conflated with thinness, being thin does not necessarily equate to being healthy (Reiheld, 2021) however, for the purposes of this review they were considered as healthy nudges. Further, note that for body-related nudges (Category 2) in particular, the

Figure 1
PRISMA flowchart



nudges classified as healthy (i.e., slim bodies) for the purpose of analysis were not always considered healthy nudges within their respective individual studies (i.e., they may not nudge someone towards a healthier choice). For example, a few studies tested the idea that slim bodies would act as unhealthy nudges (i.e., promoting increased consumption of unhealthy foods or general consumption) rather than the more common idea that they act as healthy nudges. We coded all as healthy, however, to facilitate direct comparisons of all slim body-related nudges rather than categorising them separately based on opposing theories, which would not allow us to truly determine whether thin body nudges increase healthy or unhealthy consumption-related behaviours.

Categories 3 and 4 included comparisons between "unhealthy" nudges (encouraging less healthy consumption-related behaviours) food- and body-related nudges, respectively, and a neutral control condition. A nudge was considered “unhealthy” if it was inherently associated with and/or encouraged the consumption of less healthy foods, encouraged increased consumption in general, or was inherently associated with stereotypically unhealthy behaviours. Examples of the kinds of nudges in Category 3 included images of high energy-dense foods like sweets or fast foods, and in Category 4, images of overweight/obese bodies. Again, we acknowledge that increasing intake of energy dense foods is not always unhealthy and that despite the stereotypes and stigma around overweight bodies, being overweight does not necessarily equate to being unhealthy (Puhl, 2022; Reiheld, 2021; Tischner & Malson, 2011). In addition, similar to the slim body nudges in Category 2, overweight body-related nudges were not considered unhealthy nudges across all studies. A few studies classified overweight or obese body-related nudges to be likely to encourage healthier consumption-related behaviours (reactance effect), but all overweight body-related nudges were classified as unhealthy nudges for the purpose of analyses, to facilitate direction comparisons.

Categories 5 and 6 included mixed-health food- or beverage-related nudge

comparisons, respectively. These categories included, for example, comparisons between healthy and unhealthy nudges (e.g., fruits and vegetables versus junk foods [Category 5], or thin versus overweight bodies [Category 6]), comparisons between healthy and mid-range (e.g., normal-weight bodies) nudges, and comparisons between mid-range and unhealthy nudges.

Category 7 included nudges that were not inherently related to health or food consumption. For example, images of nature are thought to encourage healthier consumption-related behaviours but are not inherently related to consumption. Other nudges in this category included images of hedonic environments (e.g., fun-fair), colours (e.g., red), perceived portion sizes (e.g., using the delboeuf illusion), or perceived social pressure (e.g., images of influential figures).

For the purpose of this review and for ease of interpretation, the outcomes of consumption-related behaviours were classified as healthy or unhealthy as identified in the specific study. If such classifications were not made, nutrient rich foods such as fruits and vegetables were coded as healthy while energy dense foods high in salt, fat, and/or sugar (e.g., chocolate) were coded as unhealthy.

Quality assessment

Two independent reviewers assessed the quality of included studies using the Mixed Methods Assessment Tool (MMAT; Hong et al., 2018). Each included study was assessed according to the checklist criteria for the relevant study type. Studies were rated from 1 (low quality) to 5 stars (high quality) based on the percentage of quality criteria met.

Statistical analyses

The online Campbell Collaboration tool (https://campbellcollaboration.org/research-resources/effect-size-calculator.html) was used to calculate Cohen's *d* and 95% confidence intervals for each comparison. Cohens' *d* values were then transformed into Hedges' *g*

values. Effect sizes were calculated such that a positive effect size indicated an effect in the expected direction. For example, in Categories 1 and 2 (healthy versus control nudges), a positive effect size indicated that healthier consumption-related behaviours were higher in the healthy food- or body-related nudge condition compared to the control condition, while in Categories 2 and 3 (unhealthy versus control nudges), a positive effect indicated that unhealthy consumption-related behaviours were higher in the unhealthy nudge condition compared to the control condition.

To account for non-independence of effect sizes when multiple effects were reported from a single sample, multi-level meta-analyses were conducted, and adjustments to reduce false positive rates (similar to the Knapp-Hartung method) were made, in line with the approach outlined by Harrer et al. (2021). Analyses were conducted in R, a free software environment for statistical analyses (R Core Team, 2021), using the metafor package (Viechtbauer, 2010) to run the multi-level models and produce forest plots. Moderator analyses investigated the influence of study characteristics (participant source, setting), participant characteristics (age, gender, weight status, restraint status), condition type (nudge type, timing, medium, and interaction), and consumption-related outcome characteristics (outcome measure, type, healthiness, taste, and tangibility [i.e., whether the outcome was real or hypothetical]) on the relationship between condition and consumption-related outcomes. For ease of interpretation, only significant interactions are reported.

Heterogeneity was assessed using Q and I^2 statistics. A significant Q statistic indicates that variability is unlikely due to chance (Laird et al., 2017). An I^2 statistic of 0 indicates no variation, ≤ 30 indicates mild variation, and ≥ 50 indicates notable variation between study estimates due to heterogeneity (Higgins & Thompson, 2002).

Egger's regression intercept (Egger et al., 1997) was used to test for evidence of publication bias. As, to the best of our knowledge, there is no function in R for running an

Egger's test for multilevel meta-analyses sample variance was included as a moderator to extend the test to our models, following advice from Viechtbauer (2015). Similar approaches were used by Habeck and Schutz (2015) and de Valle et al. (2021). A significant regression intercept indicates that publication bias may be present.

Results

Study characteristics

Data were extracted from 63 studies, drawn from 50 articles, resulting in a total of 182 comparisons included in the meta-analyses. See Supplementary Material B for information about study characteristics results on a study-by-study basis. Study samples were largely drawn from universities (k = 30; 47.6%) and schools (k = 14; 22.2%) and were based in 15 countries with the United States (k = 14; 22.2%) being most highly represented. Most studies were conducted in laboratory and/or controlled environments (k = 43; 68.3%) with few studies conducted in field settings (k = 13; 20.6%) or online (k = 6; 9.5%). Studies primarily recruited adult samples (k = 46; 73.0%), and the overall average mean for participant age was 21.42 years. Most studies used mixed-gender samples (k = 39; 61.9%), but females were largely represented overall, comprising an average of 68.2% of participants, and 19 studies included female only samples. Most of the included studies involved body-related visual nudges (e.g., slim, average-sized, or overweight bodies; k = 26; 41.3%), or food-related nudges (e.g., images of healthy or unhealthy foods; k = 20; 31.8%).

Quality assessment

Of the 63 included studies, the most common quality ratings were 5 (n = 17) and 4 (n = 17) stars according to the Mixed Method Appraisal Tool (MMAT) criteria. See Table C1 in Supplementary Material C for the quality rating of each included study. The remaining studies scored either 3 stars (n = 15) or 2 stars (n = 14). Of the studies scoring 2 stars, indicating low quality, most failed to blind outcome assessors to the intervention provided

and provided insufficient detail to determine whether randomisation had been appropriately performed and whether groups were comparable at baseline.

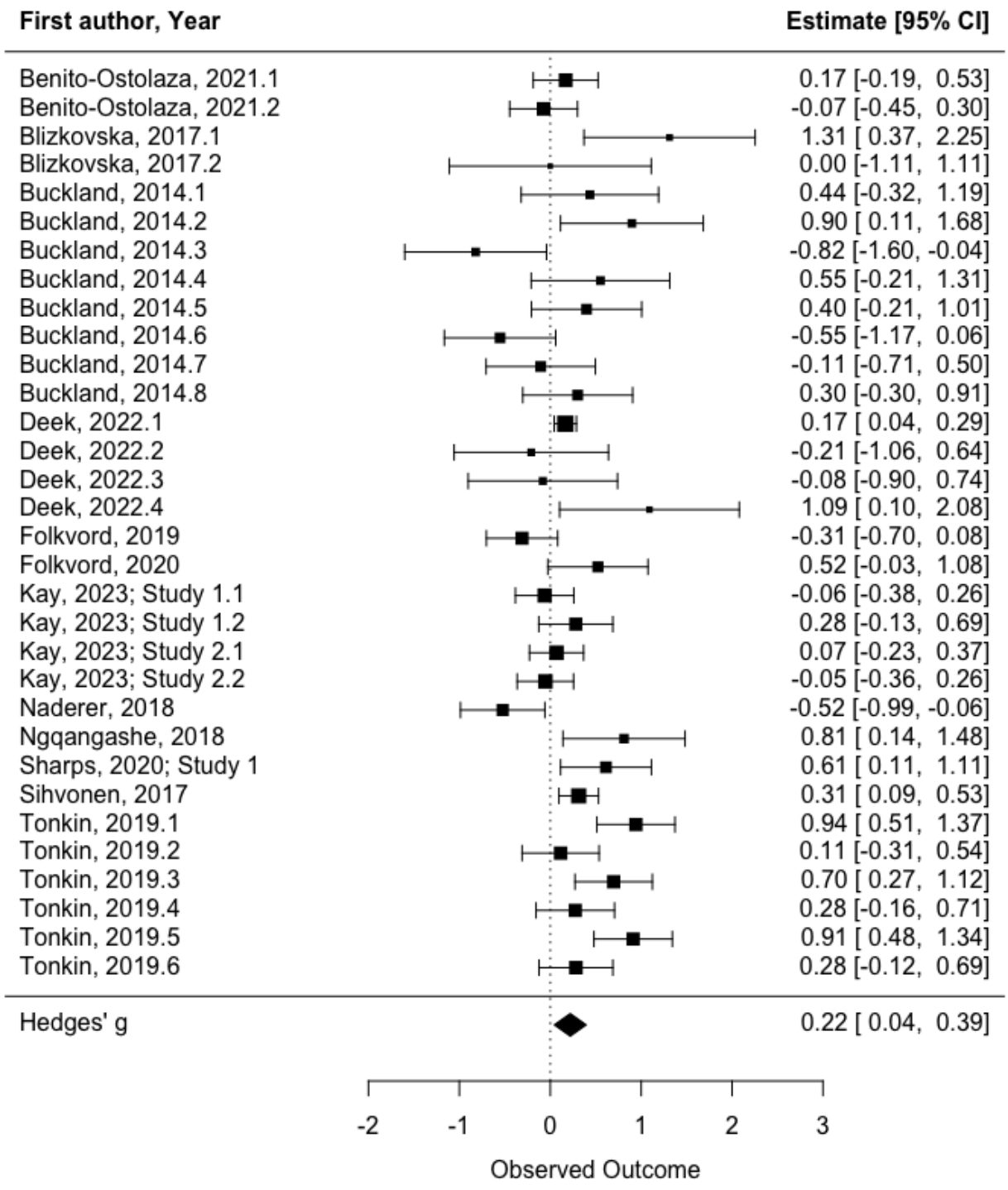
Meta-analyses

Of the 182 included comparisons, Category 1 (healthy food-specific nudges versus neutral controls) included 32 comparisons (17.6%) and Category 2 (healthy body-specific nudges versus neutral controls) included 30 comparisons (16.5%). Category 3 (unhealthy food-specific nudges versus neutral controls) included 28 comparisons (15.4%) and Category 4 (unhealthy body-specific nudges versus neutral controls) included 8 comparisons (4.4%). Category 5 (mixed-health food-specific nudge comparisons) included 25 comparisons and Category 6 (mixed-health body-related nudge comparisons) included 19 comparisons. Finally, Category 7 (nudges not inherently health-related) comprised 39 comparisons (21.4%). Forest plots for each meta-analysis are presented in Figures 2-8.

Healthy versus Control Nudges

Category 1: Healthy food-related nudges versus neutral controls. Category 1, involving comparisons between healthy food- (or beverage) specific nudges and neutral controls, included 32 comparisons drawn from 13 studies. No outlier effects were identified through viewing the forest plot (Figure 2), scanning the Hedges' *g* values, and comparing confidence intervals. The pooled effect size indicated a small significant positive impact of healthy food-specific nudges on consumption-related behaviours relative to neutral control conditions, Hedges' $g = 0.22$, 95% CI = 0.05, 0.40, $p = .016$. In other words, the healthy food-specific nudges encouraged healthier consumption-related behaviours (increased intake/choice of healthier foods, decreased intake/choice of unhealthy foods, or decreased general intake). Heterogeneity was moderate-high ($Q = 88.12$, $p < .001$, $I^2 = 71.94$) and was attributed to both within-study ($I^2 = 56.54$) and between-study ($I^2 = 15.40$) variance.

Figure 2
Category 1 Forest Plot



The effectiveness of healthy food-related nudges was moderated by the timing of nudge presentation, $F_{(1,30)} = 6.13$, $p = .019$. Priming (nudge presented prior to outcome; $n = 27$) significantly increased healthy consumption-related behaviours ($g = 0.28$), while cueing (nudge presented during outcome; $n = 5$) significantly decreased healthy consumption-related behaviours ($g = -0.14$). No other moderators were significant.

Category 2: Healthy Body-Related Nudges versus Neutral Controls. Category 2, involving comparisons between healthy body-related nudges and neutral controls, included 30 comparisons drawn from 18 studies. One outlier effect was identified (see Supplementary Material D for a summary of results with outliers retained). The outlier originated from Qui and Cui's (2018) Study 2, comparing a thin image with perceived high socioeconomic status to a neutral control image. Healthy body-related nudges had a significant moderate positive effect on consumption-related behaviours (i.e., increased healthier behaviours) relative to neutral controls, Hedges' $g = 0.32$, 95% CI = 0.16, 0.47, $p < .001$ (see Figure 3). Heterogeneity was moderate-high ($Q = 72.58$, $p < .001$, $I^2 = 63.41$) and was attributed to both within-study ($I^2 = 22.39$) and between-study ($I^2 = 41.02$) variance. No significant moderators emerged.

Unhealthy versus Control Nudges

Category 3: Unhealthy food-related nudges versus neutral controls. Category 3, involving comparisons between inherently unhealthy food-specific nudges and neutral controls, included 28 comparisons derived from 13 studies. No outliers were identified. While some studies had larger or smaller effect sizes, their confidence intervals overlapped with effect sizes from other comparisons, thus all comparisons were included in the analysis. The pooled effect size indicated that unhealthy food-specific nudges had a small positive impact on unhealthy consumption behaviours (i.e., increased general intake or intake of unhealthy foods, or decreased intake of healthy foods) relative to control conditions, Hedges'

g = 0.28, 95% CI = 0.04, 0.51, p = .024 (see Figure 4). Heterogeneity was high (Q = 91.58, p < .001, I^2 = 76.71) and was attributed to within-study variance (I^2 = 76.71; between-study I^2 = 0.00).

Figure 3
Category 2 Forest Plot

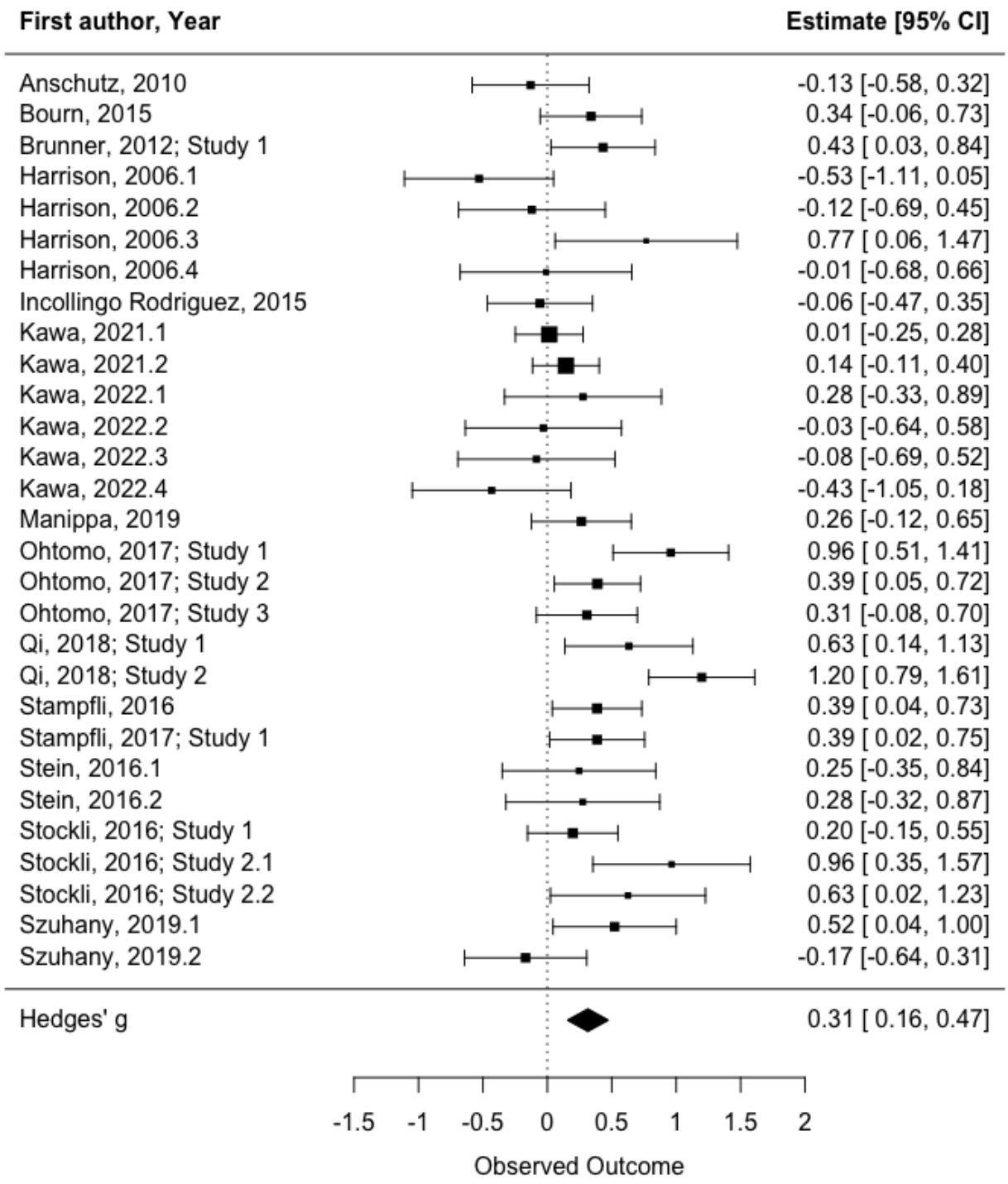
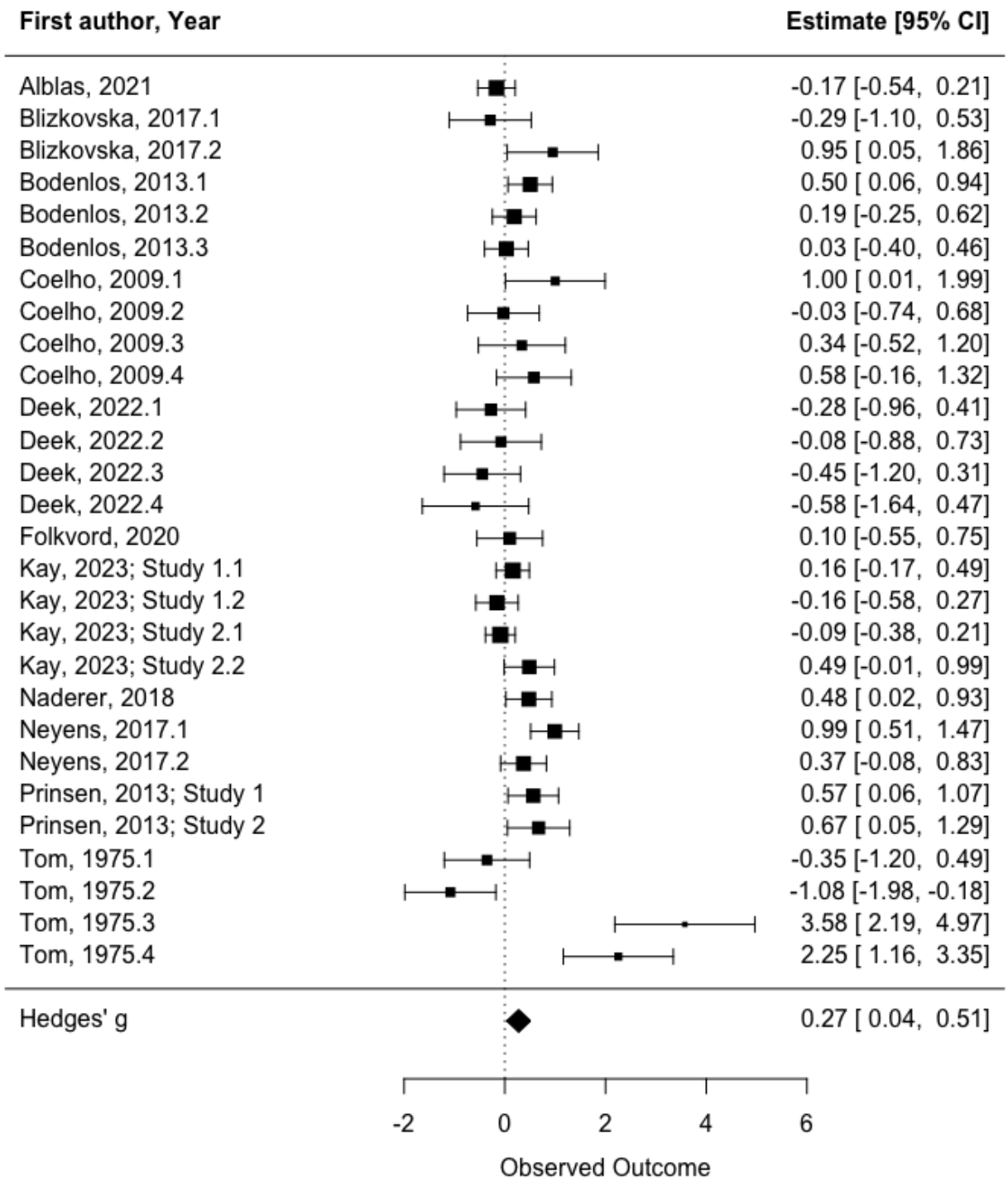


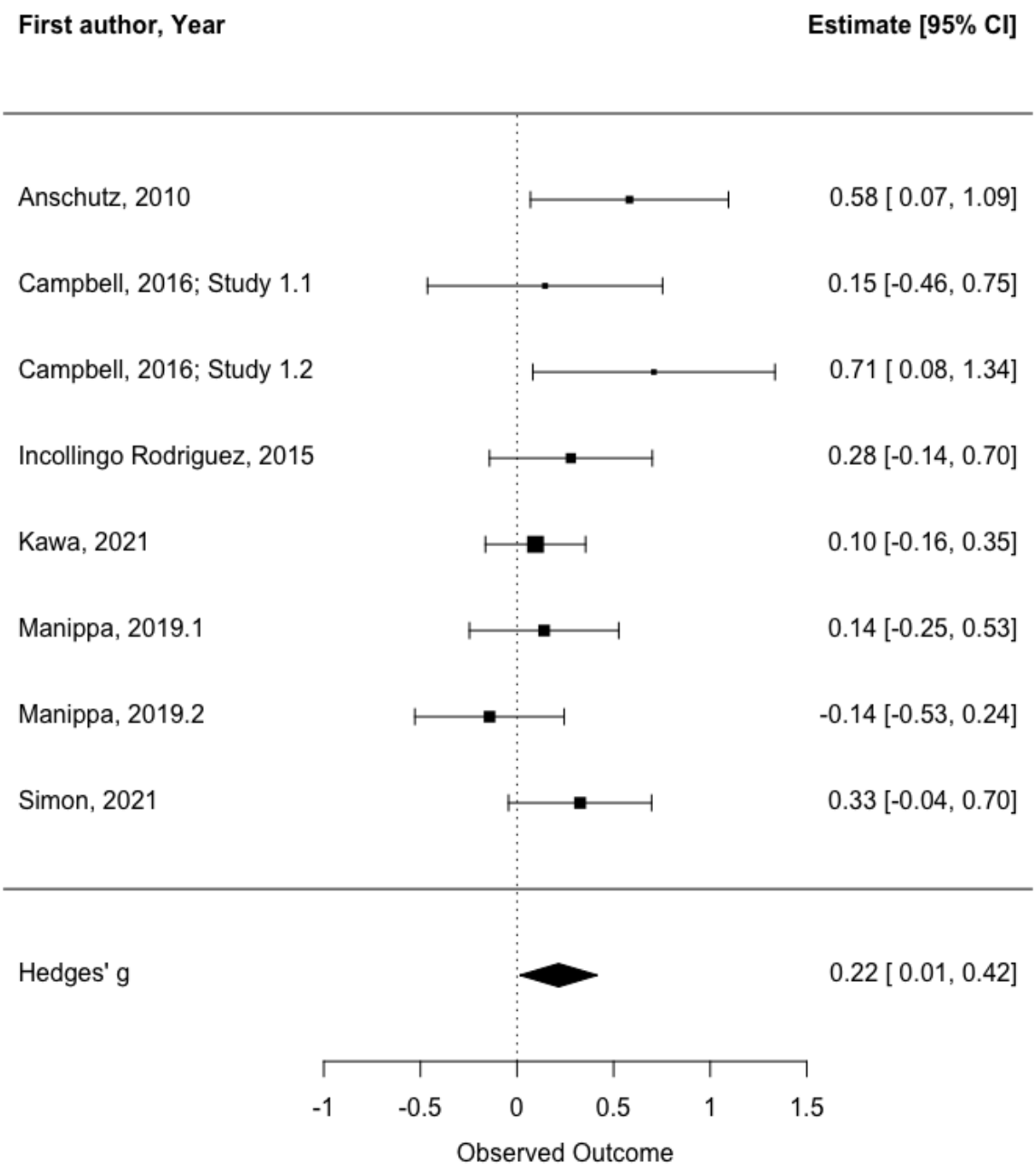
Figure 4
Category 3 Forest Plot



Participant weight moderated the effectiveness of unhealthy food-related nudges, $F_{(2,25)} = 18.92$, $p < .001$, significantly increasing unhealthy food consumption-related behaviours in mixed-weight ($n = 28$; $g = 0.26$, $p = .012$) and overweight ($n = 2$; $g = 2.85$, $p < .001$) samples but significantly decreasing unhealthy consumption-related behaviours in normal weight samples ($n = 3$; $g = -0.39$, $p = .025$). The type of outcome measured (intake, choice) also moderated nudge effectiveness, $F_{(1,26)} = 5.31$, $p = .029$, significantly increasing unhealthy food intake ($n = 15$; $g = 0.50$, $p = .001$), but not choice ($n = 13$; g = 0.02, $p = .880$). Lastly the tangibility of outcomes moderated nudge influence, $F_{(1,26)} = 6.80$, $p = .015$, with significant increases in unhealthy food consumption-related behaviours in studies with tangible outcomes ($n = 19$; $g = 0.46$, $p = .001$), but significantly decreasing unhealthy consumption-related behaviours in studies with hypothetical outcomes ($n = 9$; $g = -0.08$, $p = .015$).

Category 4: Unhealthy body-related nudges versus neutral controls. Category 4, including comparisons between unhealthy body-related nudges and neutral controls, included nine comparisons from six studies. One outlier was identified through scanning the forest plot and confidence intervals (see Supplementary Material D for results with outlier retained). The outlier was from Simon and Hurst's (2021) study, comparing an average-weight body poster to a neutral control. The pooled effect size indicated that unhealthy body-related nudges significantly increased unhealthy consumption-related behaviours relative to neutral controls, Hedges' $g = 0.22$, 95% CI = 0.02, 0.42, $p = .039$ (see Figure 5). Heterogeneity was low and not significant ($Q = 9.00$, $p = .253$, $I^2 = 18.96$). No significant moderators emerged.

Figure 5
Category 4 Forest Plot

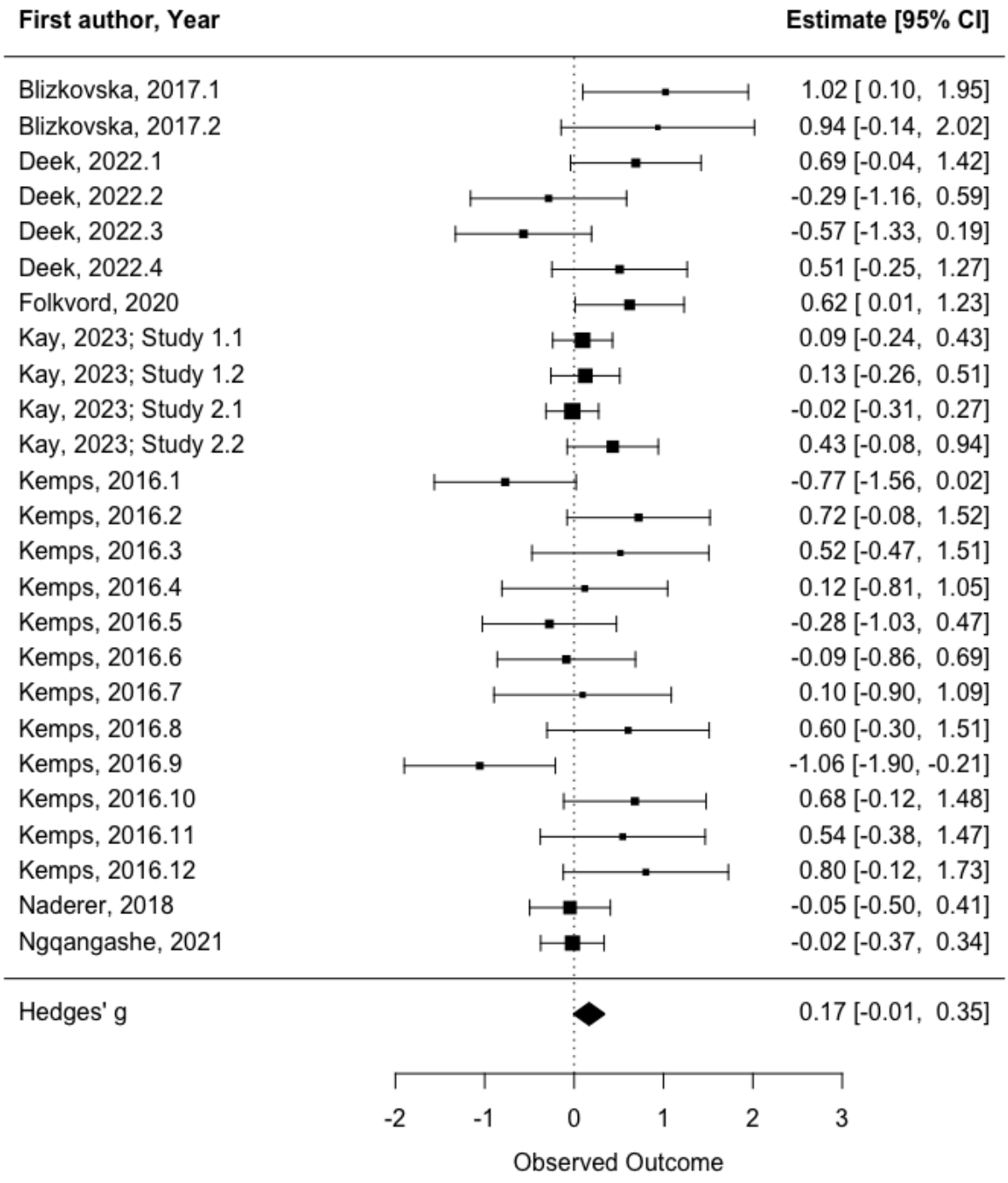


Mixed-Health Comparisons

Category 5: Mixed food-related nudge comparisons. Category 5, involving mixed-health food-related nudge comparisons (e.g., healthy versus unhealthy food-related nudges), included 25 comparisons from eight studies. Healthier food-related nudges did not significantly influence consumption-related behaviours, relative to less healthy food-related

nudges, Hedges' g = 0.17, 95% CI = -0.01, 0.35, p = .063 (Figure 6). Heterogeneity was moderate-high (Q = 41.5, p = .015, I^2 = 40.80) and was attributed to within-study variance (I^2 = 40.80; between-study I^2 = 0.00).

Figure 6
Category 5 Forest Plot



Category 6: Mixed body-related nudge comparisons. Category 6, involving mixed-health body-related nudge comparisons (e.g., thin versus overweight, thin versus average-sized, or average-sized versus overweight body nudges) contained 19 comparisons from 12 studies. One outlier was identified (Supplementary Fig D2) from Simon and Hurst's (2021) study comparing a body-positive television show featuring average-sized versus overweight individuals (see Supplementary Material D for results with outlier retained). Healthier body-related nudges significantly encouraged healthier consumption-related behaviours relative to less healthy body-related nudges, Hedges' $g = 0.19$, 95% CI = 0.01, 0.37, $p = .039$ (see Figure 7). Heterogeneity was moderate-high ($Q = 51.02$, $p < .001$, $I^2 = 70.60$) and was attributed to within-study variance ($I^2 = 70.60$; between-study $I^2 = 0.00$).

Participant age emerged as a significant moderator of body-related mixed-health comparisons, $F_{(1,16)} = 5.35$, $p = .034$, with healthier consumption-related behaviours increasing among child ($n = 8$; $g = 0.42$, $p = .034$), but not adult ($n = 11$; $g = 0.05$, $p = .627$) samples.

Category 7: Not Inherently Health-Related Nudges

Category 7, involving nudges not inherently related to health, included 39 comparisons from 18 studies. Comparisons comprised 13 colour nudges, 9 perceived portion size nudges, 5 social pressure nudges, and 9 other nudges. Two outliers were identified (Supplementary Fig D3) from Rolls et al.'s (2007) Study 1, comparing small versus medium and medium versus large containers (see Supplementary Material D for results with outliers retained). The model was significant, Hedges' $g = 0.20$, 95% CI = 0.07, 0.33, $p = .003$ (see Figure 8), indicating nudges significantly affected consumption-related behaviours, in the expected direction (Figure 5). Heterogeneity was high ($Q = 120.57$, $p < .001$, $I^2 = 74.56$) and was attributed to both within-study ($I^2 = 65.00$) and between-study ($I^2 = 9.56$) variance. No significant moderators were found.

Figure 7
Category 6 Forest Plot

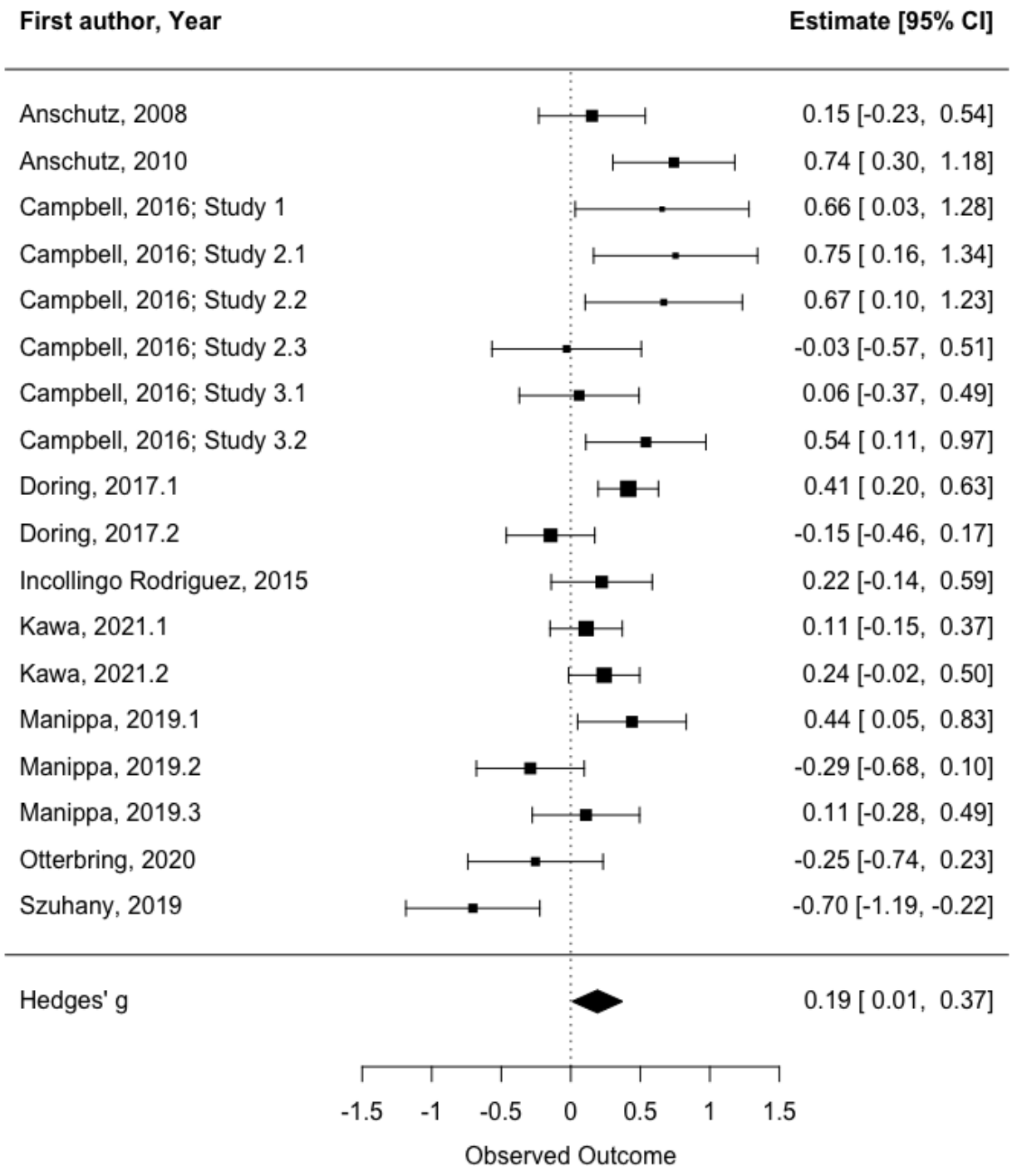
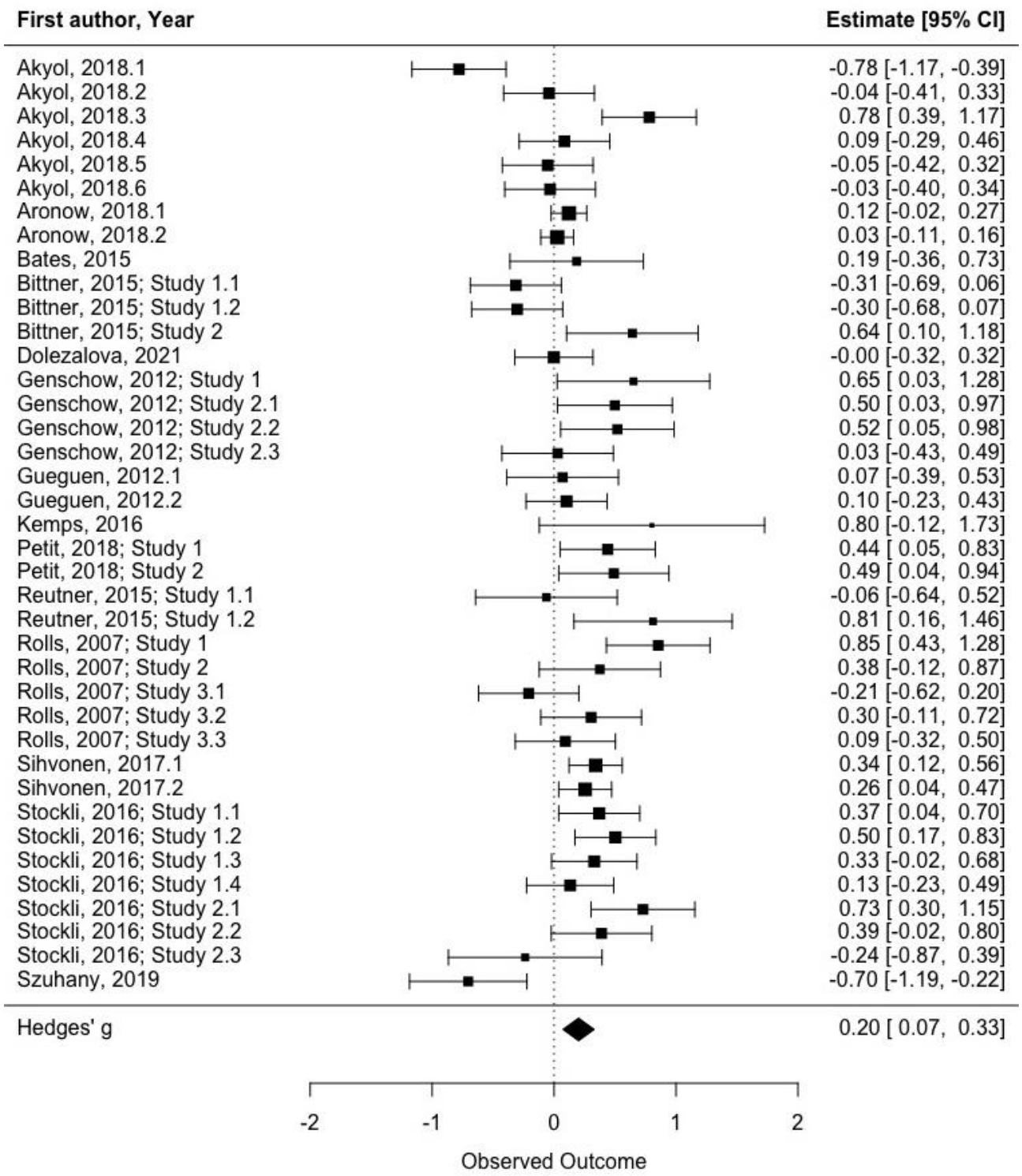


Figure 8
Category 7 Forest Plot



Publication bias

The funnel plots for all categories are available in Fig E1 through E7 in Supplementary Material E. Egger's regression tests were significant for Categories 2 ($p < .001$) and 3 ($p = .008$), indicating potential bias in these categories, but was not significant in Category 1 or in Categories 4-7 (*p*s < .207). In the Category 2 model excluding outliers, however, the Egger's regression test was no longer significant ($p = .814$).

Narrative review of tested and proposed determinants of nudge success

Determinants of nudge success include underlying mechanisms, moderators, and mediators. Many of the tested mechanisms and moderators only appeared in a few studies, resulting in insufficient numbers for testing statistically. Thus, these are investigated narratively here, rather than in the meta-analyses, to provide a more comprehensive overview of all tested and proposed variables thought to influence or explain the effectiveness of visual nudges for impacting consumption-related behaviours. As this section includes both tested and proposed mechanisms and moderators there is a small degree of repetition from the meta-analysis section where sufficient studies allowed for statistical comparisons. See Table 1 for an overview of articles testing or proposing each mechanism/moderator.

Mechanisms and moderators were recorded as being proposed (to explain or underlie nudge effects; P), supported (tested and found to significantly predict or moderate nudge effectiveness; S), or not supported (tested and found to not significantly predict or moderate nudge effectiveness; NS). For the purposes of this review, a study was considered to have proposed a mechanism/moderator if authors provided a clear explanation for why it was expected to account for, or have influenced, their findings but were not included if the variable was listed without any justification for their potential impact on results. Similarly, tested mechanisms/moderators were not included if the variable was only tested for main effects without being tested or discussed in relation to nudge(s) and outcome(s).

Table 1

Tested and proposed underlying mechanisms and moderators

Mechanism	Proposed	Tested; supported	Tested; not supported
Mechanisms underlying the effectiveness of nudges (n = 22)			
Dependent on participant characteristics			
Age	Kawa et al., 2022	Kawa et al., 2021 Neyens & Smits, 2017	Anschutz & Engels, 2010 Campbell et al., 2016 – Study 3 Rolls et al., 2007
Gender		Bates & Shanks, 2015 Benito-Ostolaza et al., 2021 Harrison et al., 2006	Brunner & Siegrist, 2012 – Study 1 Folkvord & Laguna-Camacho, 2019 Kawa et al., 2022 Reutner et al., 2015 – Study 1 Rolls et al., 2007 Sharps et al., 2020 – Study 1
Weight / BMI		Döring & Wansink, 2017 Naderer et al., 2018 Tom & Rucker, 1975	Benito-Ostolaza et al., 2021 Folkvord & Laguna-Camacho, 2019 Incollingo Rodriguez et al., 2015 Neyens & Smits, 2017 Rolls et al., 2007 Stein et al., 2016 Szuhany & Otto, 2020
Hunger			Doleszalova et al., 2021 Folkvord & Laguna-Camacho, 2019 Genschow et al., 2012 – Study 2
Eating habits	Folkvord & Laguna-Camacho, 2019 Kay et al., 2023	Ohtomo, 2017 – Study 1 and Study 2	Ohtomo, 2017 – Study 3
Unhealthy willingness		Ohtomo, 2017 – Study 3	
Eating restraint / dieting status / weight related concerns		Anschutz et al., 2008 Blížkovská, 2017 Bourn et a., 2015 Coelho et al., 2009 Deek et al., 2022 Kemps et al., 2016 Ohtomo, 2017 – Study 3 Stämpfli et al., 2017 Tonkin et al., 2019	Ohtomo, 2017 – Study 1 and Study 2 Rolls et al., 2007 Stein et al., 2016
Perceived self-regulatory success (PSRS)			Alblas et al., 2021
Compensatory eating tendency			Stein et al., 2016
(Un)successful (un)restrained eaters (restraint * PSRS)			Alblas et al., 2021
Dieting / weight loss success			Alblas et al., 2021
Disinhibition		Buckland et al., 2014	Rolls et al., 2007
Discrepancy status		Harrison et al., 2006	
Exercise		Stein et al., 2016	
Pre-test mood			Anschutz et al., 2008
Impulsivity			Alblas et al., 2021
Trait self-control			Alblas et al., 2021
Perfectionism	Anschutz et al., 2008		
Self-esteem	Anschutz et al., 2008		
Pre-existing (non-food related) values		Sihvonen & Luomala, 2017	
Reliant on pre-activation / presence / use of…			
Pre-activation of health goal			Bittner & Kulesz, 2015 – Study 1 Prinsen et al., 2013 – Study 3
Pre-activation of health knowledge		Campbell et al., 2016 – Study 3	
Nutrition knowledge		Naderer et al., 2018	
Active general eating goal / motivation (not diet related)	Stämpfli & Brunner, 2016		
Use of self-control (during outcome measurement)			Alblas et al., 2021 Stein et al., 2016
Depend on associative links	Stöckli et al., 2016		
Dependent on nudge characteristics			
Nudge familiarity			Alblas et al., 2021 Anschutz & Engels, 2010
Nudge novelty	Kawa et al., 2021		
Nudge type (healthy,		Blížkovská, 2017	

unhealthy)			
Nudge framing		Benito-Ostolaza et al., 2021	
Nudge-goal congruence	Blížkovská, 2017		
Attainability	Anschutz et al., 2008		
Nudge gender		Döring & Wansink, 2017	
Colour contrast	Doelszalova et al., 2021	Akyol et al., 2018	
Dependent on engagement with / perceptions of the nudge			
Nudge salience	Alblas et al., 2021 Kay et al., 2023 Manippa et al., 2019		
Attention / concentration	Buckland et al., 2014	Coelho et al., 2009	Alblas et al., 2021 Stämpfli & Brunner, 2016
Unconscious processing	Blížkovská, 2017 Brunner & Siegrist, 2012 Buckland et al., 2014 Genschow et al., 2012 Guguen et al., 2012	Kawa et al., 2021 Stämpfli & Brunner, 2016	
Nudge being engaging / entertaining / task being enjoyable	Neyens & Smits, 2017		Alblas et al., 2021 Anschutz & Engels, 2010 Folkvord & Laguna-Camacho, 2019
Appeal of nudged item(s)	Sharps et al., 2020		Alblas et al., 2021
Timing of nudge	Kay et al., 2023	Tonkin et al., 2019	
Dependent on (food-related) outcome characteristics			
Measurement of immediate versus prolonged/delayed consumption-related behaviours		Akyol et al., 2018 Deek et al., 2022	Alblas et al., 2021 Ohtomo, 2017 – Study 2
Specificity (effects nudged item/s only) versus generalisability (also affects other items)		Akyol et al., 2018 Bittner & Kulesz, 2015 – Study 1 Bodenlos & Wormuth, 2013 Guéguen et al., 2012 Kay et al., 2023 – Study 2	Alblas et al., 2021 Deek et al., 2022 Kay et al., 2023 – Study 1 Kemps et al., 2016
Type of outcome: Health (healthy, unhealthy) Taste (sweet, savoury) Category (meal/snack, food/drink) Flavours	Akyol et al., 2018 (health) Folkvord & Laguna-Camacho, 2019 (health) Manippa et al., 2019 (health)	Bodenlos & Wormuth, 2013 (health, taste) Deek et al., 2022 (health, category) Döring & Wanskink, 2017 (taste) Genschow et al., 2012 – Study 1 (flavours) Kawa et al., 2021 (taste) Reutner et al., 2015 – Study 1 (health)	Bourn et al., 2015 (health, taste) Buckland et al., 2014 (health, taste) Kawa et al., 2022 (health) Kemps et al., 2016 (health) Stämpfli et al., 2017 – Study 1 (health) Tonkin et al., 2019 (taste, category)
Type of outcome measure (intake versus choice)	Kay et al., 2023 Kemps et al., 2023		
Order of presentation (healthy or unhealthy first) / primacy effects / item placement		Deek et al., 2022	
Perceived tastiness of outcome foods			Alblas et al., 2021
Cravings	Buckland et al., 2014		
Familiarity of outcome items	Kay et al., 2023		
Appeal of outcome items	Kay et al., 2023		
Liking of outcome foods		Stämpfli & Brunner, 2016	
Attention / engagement during outcome task / consumption	Rolls et al., 2007		
Mechanisms explaining the effect of nudges			
...by activating or changing certain processes (n = 27)			
Social norms / normative standards / stereotypes	Anschutz & Engels, 2010 Campbell et al., 2016 – Studies 1 and 2 Döring & Wansink, 2017 Incollingo Rodriguez et al., 2015 Prinsen et al. 2013 Sharps et al., 2020		
Reminder of pre-existing diet / weight-related goals	Blížkovská, 2017 Brunner & Siegrist, 2012 Coelho et al., 2009 Kay et al., 2023 Kemps et al., 2016 Manippa et al., 2019 Ohtomo, 2017 Reutner et al., 2015 Stämpfli et al., 2017		Buckland et al., 2014

	Stein et al., 2016 Tonkin et al., 2019		
Prompting weight / diet-related thoughts	Bourn et al., 2015		
Activate unconscious processes	Blížkovská, 2017 Bodenlos & Wormuth, 2013		
Activates avoidance motivation	Genschow et al., 2012		
Prompting mental simulations		Petit et al., 2018 – Study 2	Petit et al., 2018 – Study 1
Prompting SES comparisons	Qi & Cui, 2018 – Study 1	Qi & Cui, 2018 – Study 2	
Changing perceived portion size	Rolls et al., 2007		
Activating compensatory eating response	Szuhany & Otto, 2020		
Inspirational (e.g., body size)	Anschutz & Engels, 2010		
Permission to eat / reactance (opposite to expected effect)	Bourn et al., 2015 Kawa et al., 2022 Kemps et al., 2016		
...by changing certain characteristics (n = 21)			
Hunger / satiety / appetite / desire to eat	Naderer et al., 2018 Petit et al., 2018 Szuhany & Otto, 2020		Akyol et al., 2018 Alblas et al., 2021 Bodenlos & Wormuth, 2013 Buckland et al., 2014
Prospective food consumption (how much think can consume)			Akyol et al., 2018
Desire for foods / attitudes towards foods			Akyol et al., 2018 Bodenlos & Wormuth, 2013 Ngqangashe et al., 2018
Consumption experience	Genschow et al., 2012 Reutner et al., 2015 – Study 1		
Cravings		Kemps et al., 2023	Ngqangashe et al., 2018
Perceived self-regulatory success (PSRS) in dieting		Bittner & Kulesz, 2015 – Study 2	
Shifting attention / focus (dwell times, number of fixations, fixation duration)	Tonkin et al., 2019	Manippa et al., 2019 (dwell times) Otterbring et al., 2020	Manippa et al., 2019
Mood / Affect			Coelho et al., 2009
Changes general health / nutrition attitudes			Ngqangashe et al., 2018
Intentions to eat / prepare foods		Ngqangashe & De Backer, 2021	
Intuitive eating	Simon & Hurst, 2021		
Theories	***(suggest as explanation)***	***(support)***	***(challenge)***
Goal-conflict theory	Buckland et al., 2014 Deek et al., 2022 Kemps et al., 2016	Tonkin et al., 2019	Blížkovská, 2017
Food cue-reactivity theory		Coelho et al., 2009 Folkvord et al., 2020 Neyens & Smits, 2017 Ngqangashe & De Backer, 2021	
Theory of planned behaviour		Ngqangashe & De Backer, 2021	
Theory of reason action		Ngqangashe & De Backer, 2021	
Dual motivation model		Ohtomo, 2017 – Study 3	
Social comparison theory		Qi & Cui, 2018	
Social Cognitive Theory		Folkvord et al., 2020	
Automatic goal pursuit		Brunner & Siegrist, 2012	
Forbidden fruit effect – Commodity theory		Naderer et al., 2018	
Socialisation theory		Neyens & Smits, 2017	
Self-discrepancy theory / activation		Harrison et al., 2006	Harrison et al., 2006
Counteractive control theory			Coelho et al., 2009
Gaze bias theory			Manippa et al., 2019
Stimulus-organism-response (SOR) model	Guéguen et al., 2012		
Spreading Activation theory	Guéguen et al., 2012		

Moderators of nudge success

Thirty-eight articles reported on at least one variable thought to predict nudge effectiveness. These were broadly grouped into participant, nudge, and outcome characteristics.

Participant characteristics. The participant characteristics examined and/or tested for their predictive qualities (across 38 articles) encompassed various factors primarily grouped across physical participant characteristics and eating- or body-related factors. Physical participant characteristics included age (P=1; S=2; NS=3), gender (S=3; NS=6), and weight or BMI (S=3; NS=7). Eating- and body-related factors included hunger levels (NS=3), eating habits (P=2, S=1, NS=1), willingness to eat unhealthy foods (S=1), dieting and/or restraint status (S=9, NS=3), perceived self-regulatory success in dieting (NS=1), compensatory eating tendency (NS=1), success in dieting, restraint, and/or weight loss (NS=1), disinhibition (S=1; NS=1), body-related discrepancy status (S=1), and recent exercise (S=1).

Other individual characteristics considered for their role in nudge effectiveness were pre-test mood (NS=1), impulsivity (NS=1), self-control (NS=1), perfectionism (P=1), self-esteem (P=1), and values (e.g., responsibility or status; S=1). The pre-activation, presence, or use of other participant-related characteristics were noted across a few articles. Namely, nudge success was thought to be reliant on pre-existing nutrition knowledge (S=1), the pre-activation of health goals (NS=2) or health knowledge (S=1), the presence of non-diet related general eating goals or motivations (P=1), the use of self-control during outcome measurement (NS=2), or being dependent on associative links (P=1)

Nudge characteristics. The nudge characteristics examined and/or tested for their predictive qualities (across 21 articles) were broadly grouped into characteristics of the nudge itself, and engagement with or perceptions of the nudge. Nudge effectiveness was thought to

be dependent on whether it was a healthy or unhealthy nudge (S=1), the framing of the nudge (e.g., positive towards healthy foods or negative towards unhealthy foods; S=1), the nudge being familiar (NS=2), or conversely being novel (P=1), and there being congruence between the nudge and individual goals (P=1). Also, specifically for body-related nudges, the attainability of the depicted body (P=1) and the gender of the nudge (S=1) were noted, as was colour contrast (P=1, S=1) for colour nudges.

Outside of nudge characteristics, other nudge-related aspects were noted as potentially underlying the effectiveness of nudges, particularly relating to engagement with and/or perceptions of the nudges. Engagement-related mechanisms included how engaging, entertaining, or enjoyable the nudge and/or nudging task were (P=1; NS=3), the salience of the nudge (P=3), the level of attention or concentration applied to the nudge or nudging task (P=1, S=1, NS=2), or the nudging being unconsciously processed (P=5, S=2). Perception-related mechanisms included the appeal of nudged items for food-related nudges (P=1, NS=1), and the timing of nudge presentation (before or during food-related outcome measures; loosely translating into cueing or priming; P=1, S=1).

Outcome characteristics. The food-related outcome characteristics considered for their predictive qualities across 22 articles were broadly grouped into task- and product-related mechanisms. Task related mechanisms included the timing of outcome measurement, with two articles reporting visual nudges worked only on immediate consumption-related behaviours, while two articles reported their nudges also affected prolonged or delayed behaviours). Specificity of effects was also noted, with five articles finding nudges to only affect consumption-related behaviours for nudged items, or items within the nudged category, while four papers either found no effect for nudge or non-nudged foods, or that the effects generalised to other food categories or other non-depicted items.

Product-related mechanism included the type of outcome measured (intake or choice;

P=2). The healthiness of outcome items (P=3, S=3, NS=5), outcome taste (sweet or savoury; S=2; NS=3), outcome category (e.g., comparing meal, afters, and drink choices from a menu; S=1; NS=1), and flavour (P=1). Other consumption-related outcomes included perceived tastiness of outcome foods (NS=1), cravings for outcome foods (P=1), familiarity and/or appeal of outcome items (P=1), liking of outcome foods (S=1), and level of attention and/or engagement during consumption-related outcome task (P=1).

Mechanisms explaining nudge success

Twenty-six articles reported on at least one variable thought to explain how nudges influences consumption-related behaviours, such as through activating or changing certain processes. Six papers proposed that visual nudges work by activating social norms, normative standards, and/or stereotypes. Eleven papers proposed nudges act as a reminder of pre-existing diet and/or weight related goals, while one paper did not support this idea. Papers also proposed that nudges work by prompting weight and/or diet-related thoughts (P=1), activating unconscious processes (P=2), activating avoidance motivations for unhealthy foods (P=1), prompting mental simulations (S=1; NS=1); prompting socioeconomic status comparisons (P=1; S=1), changing perceived portion size (P=1); being inspirational (P=1), activating a compensatory eating response (P=1), or in the case of papers finding opposite to expected results (e.g., increased eating following a healthy nudge), permission to eat or reactance (P=3).

Eighteen articles suggested that nudges may work by changing participant eating-related characteristics, including by changing hunger, satiety, appetite, and/or desire to eat foods (P=3; NS=4), prospective food consumption (NS=1), desire for or attitudes towards the specific outcome foods (NS=3), consumption experiences (P=2), cravings (S=1, NS=1), intentions to eat and/or prepare foods (S=1), and intuitive eating (P=1). Alternatively, studies proposed that nudges work by changing perceived self-regulatory success in dieting (S=1), by

shifting attention or focus (P=1, S=2, NS=1), changing mood or affect (NS=1), or changing general health and/or nutrition attitudes (NS=1).

Theories explaining the effect of nudges

The use of theory overall was not common (16 articles), but within those that did use theory a wide range of theories were noted. The most commonly noted theories were Goal-Conflict Theory (P=3; S=1; NS=1) and Food Cue Reactivity Theory (S=4). One article each noted support for the Theory of Planned Behaviour, the Theory of Reasoned Action, the Dual Motivation Model, Social Comparison Theory, Social Cognitive Theory, the Theory of Automatic Goal Pursuit, Commodity Theory (the forbidden fruit effect), and Socialisation Theory. One article reported partial support for Self-Discrepancy Theory. Counteractive Control Theory and Gaze Bias Theory were challenged by one article each, and one article suggested that the Stimulus-Organism-Response Model and Spreading Activation Theory potentially explained their findings.

Discussion

The present review aimed to assess the effectiveness of visual cues and primes for nudging consumption-related behaviours. To this end, a series of meta-analyses were conducted to examine the influence of a range of visual cues and primes, across various settings, on the choice or intake of foods and/or beverages. Visual nudges, such as images or videos, designed to encourage healthier or less healthy consumption-related behaviours were assessed. These included nudges inherently related to health and/or diet (e.g., healthy or unhealthy foods, slim or overweight bodies), and nudges not inherently related to health or diet but still designed to nudge (un)healthy consumption-related behaviours (e.g., colour, perceived portion size, perceived social pressure).

Seven meta-analyses were conducted, comparing healthy food- (Category 1) and body-related (Category 2) and unhealthy food- (Category 3) and body-related (Category 4)

nudges to neutral controls, comparing healthy food- (Category 5) and body-related (Category 6) nudges to unhealthy nudges, and comparisons involving nudges not inherently related to health (Category 7). Overall, the included nudge comparisons suggest that visual cues and primes can be an effective means of nudging consumption-related behaviours, albeit with relatively small effects.

More specifically, healthy and unhealthy food- and body-related nudges had small to moderate effects on consumption-related behaviours relative to neutral control conditions (Categories 1-4). Healthier body-related (Category 6) but not food-related (Category 5) nudges had a small positive effect on consumption-related behaviours relative to less healthy nudges. Nudges not inherently related to health (Category 4) had a small to moderate effect on consumption-related behaviours in the expected direction (noting that this category involved nudges designed to increase healthy or unhealthy consumption-related behaviours). These results broadly align with existing meta-analyses demonstrating the effectiveness of various nudging interventions (e.g., Buckland et al, 2018; Broers et al., 2017; Cadario & Chandon, 2019; Mertens et al., 2022). Across most meta-analyses (excluding for Category 4), there was moderate-high heterogeneity in results, with variance being largely explained by within-study differences (especially in Categories 3, 5, and 6). The high variability in results across all categories suggest that the effectiveness of nudges may be context-dependent, thus highlighting the importance of understanding the underlying mechanisms and moderators that may influence the effectiveness of visual cues and primes. Exploring these factors was the secondary aim of this review, with the hopes of helping to identify the specific conditions or populations in which visual cues and nudges may be most effective.

Potential moderators were assessed as part of the seven meta-analyses. These included study design (participant source, study setting), participant (age, gender, weight status, restraint status), nudge (type, timing, medium, interaction), and outcome

characteristics (measure, type, healthiness, taste, and tangibility). Given there was not sufficient data for some potential moderators (e.g., restraint status), to provide a more comprehensive overview of the mechanisms and moderators that may underlie or explain the effectiveness of nudges, a narrative review of tested and proposed mechanisms and moderators across all included articles was also conducted. Meta-analysis results did not differ as a function of study characteristics, but meta-analysis results and the narrative review of mechanisms and moderators revealed differing effects of nudges according to participant, nudge, and outcome characteristics.

Participant age was found to be a significant moderator of comparisons between healthy and less healthy body-related nudges in Category 6 (mixed-health body-related nudge comparisons). Healthier body-related nudges resulted in small to moderate increases in healthier consumption-related behaviours among children but not adults. Further, the narrative review revealed mixed results with respect to a moderating effect of participant age, with two articles reporting significant moderating effects, while three articles reported non-significant effects. However, all of these studies compared younger children to older children, or younger adults to older adults. No articles directly compared the effect of visual nudges on children versus adults, although one article suggested that thin body-related nudges may have different effects among adult and adolescent samples due to different experiences with, and/or exposures to, thin body shapes in the media (Kawa et al., 2022). Alternatively, some research indicates that preferences for thin bodies declines with age (Han et al., 2021), which could potentially account for the lack of effect among adults. However, further comparisons of body-related nudges on child versus adult samples are warranted, as is research to gain further insight into age-specific perceptions around different body sizes.

Despite gender differences in consumption behaviours being commonly reported (e.g., ABS, 2017-18; Manippa et al., 2017; Rolls et al., 1991), participant gender did not

appear as a significant moderator in any of the conducted analyses. It is perhaps especially surprising that there were no gender differences in the influence of body-related nudges given that males and females tend to have different body ideals (e.g., thin versus muscular bodies; Calogero & Thompson, 2010; Grogan, 2021), and few of the studies included in this review used gender specific nudges that catered to these specific body ideals (Harrison et al., 2006; Kawa et al., 2021; Kawa et al., 2022). The narrative review also indicated unlikely moderating effects of gender, with six articles reporting no gender differences, while three reported differences.

Participant weight was commonly noted in articles as a potential moderator of the effect of visual nudges and our meta-analyses revealed that participant weight significantly moderated the effectiveness of unhealthy food-specific nudges in comparison to neutral controls (Category 3). More specifically, unhealthy food-specific nudges increased unhealthy consumption-related behaviours with a small-to-moderate effect in mixed-weight samples and a large effect in overweight samples. However, small-to-moderate decreases in unhealthy consumption-related behaviours were found in normal weight samples. Interestingly, participant weight did not moderate the effectiveness of unhealthy body-related nudges (Category 4), although notably, this group involved only eight comparisons, limiting our ability to determine effects. Further, it is worth noting that only 7.1% of the comparisons included in Category 3 were based on participants classified as overweight, thus the large effect of the unhealthy food-nudges on overweight participants must be interpreted cautiously. In the narrative review, studies directly comparing participant weight revealed little evidence to support the moderating effect of participant weight or BMI on consumption-related behaviours, with seven studies reporting no moderating effect.

While the meta-analyses revealed no significant moderating effects of dietary restraint on the relationship between nudges and consumption-related behaviours, few of the included

comparisons separately assessed restrained and unrestrained eaters, particularly among body-related nudge comparisons, limiting our ability to detect effects in our individual category analyses. Dietary restraint and similar factors such as dieting status or weight-related concerns, were however, the most frequently considered potential mechanisms in the narrative review section of this paper. Several of the included articles suggested that restrained and unrestrained eaters may respond differently to food-specific nudges. For example, Kemps et al. (2016) and Tonkin et al. (2019) found more pronounced effects of their food-specific priming nudges for restrained compared to unrestrained eaters. Differences between restrained and unrestrained eaters were also found in some articles using body-related nudges, but interestingly 'healthy' body-related nudges (e.g., thin bodies or weight-loss focused nudges) which are generally thought to encourage healthier consumption-related behaviours, increased consumption among restrained compared to unrestrained eaters in some studies (e.g., Anschutz et al., 2008; Bourn et al., 2015). Thus, it appears that the influence of dietary restraint on nudge effectiveness may be dependent on the type of nudge. More studies are needed in this space to establish whether this is a consistent effect.

Several nudge-related characteristics (type, medium, engagement, salience, and timing) were assessed in the meta-analyses. The effectiveness of healthy food-related nudges (Category 1) was moderated by the timing of nudge presentation. Healthy food-specific nudges significantly increased healthy consumption-related behaviours when the nudge was presented prior to the consumption-related outcome (i.e., when priming), but significantly decreased healthy consumption-related behaviours when the nudge was presented during the outcome (i.e., when cueing). Comparing results of the meta-analyses also indicate some potential differences according to nudge type (food-specific, body-related). For example, while results were similar between unhealthy food-specific (Category 3) and body-related

(Category 4) nudges relative to neutral controls (Hedges' g = 0.28 and 0.22, respectively), healthy body-related nudges (Category 2) had a slightly stronger effect (g = 0.32) than healthy food-specific nudges (Category 1; g = 0.22), and in mixed-health comparisons (i.e., comparing healthier nudges to less healthy nudges), healthier body-related (Category 6; g = 0.19) but not food-specific (Category 5; g = .017) nudges encouraged healthier consumption-related behaviours. Nudge characteristics were not commonly identified as tested or proposed mechanisms in the narrative review, although some articles suggested that nudge effectiveness may be dependent on the level of attention or processing of the nudge. However, studies that assessed these kinds of factors (e.g., Alblas et al., 2021; Kawa et al., 2021; Stämpfli & Brunner, 2016) indicated that nudges need not be actively attended, consciously processed, or be engaging to be effective. These findings support the concept of nudging being an implicit method of behaviour change (Bucher et al., 2016; Thaler & Sunstein, 2008).

Several outcome-related characteristics (measure, type, healthiness, taste, and tangibility) were assessed in the meta-analyses. Outcome measure (intake, choice) and tangibility (tangible, hypothetical) appeared as significant moderators of the effect of unhealthy food-specific nudges compared to neutral controls (Category 3). Unhealthy food-nudges resulted in a moderate increase in unhealthy intake behaviours, but did not significantly affect choice behaviours. However, it is possible that despite a lack of effect in choice behaviours, the subsequent intake of selected foods could be affected by nudges. For example, a consumer may continue to select an unhealthy item despite being exposed to a healthy nudge, but then subsequently consume less of the selected item. This process has not been captured in the current studies in this review, thus future research would benefit from measuring food choices and subsequent intake of chosen foods.

Outcome healthiness (healthy, unhealthy, mixed) did not emerge as a significant

moderator of the meta-analyses. The narrative review demonstrated that the few studies directly comparing nudge effects on healthy versus unhealthy outcome items, found effects for unhealthy but not healthy foods (Bodenlos & Wormuth, 2013; Döring & Wansink 2017; Reutner et al., 2015). However, more studies found no effect of food healthiness (with most finding no effect of their nudge, irrespective of healthiness; e.g., Bourn et al., 2015, Buckland et al., 2014; Kawa et al., 2022). Overall, the taste of foods (sweet, savoury, both) also did not moderate the influence of unhealthy nudges. However, it is possible that the interaction between health and taste or health and food category might be relevant to consider, with some studies looking at meal choices finding differences according to meal element. For example, Deek et al. (2022) found a significant influence of their food primes on choices of mains (savoury) but not drinks or desserts (sweet). Kawa et al. (2021) found a significant effect on choices for salad (healthy, savoury) but not fruit salad (healthy, sweet) or chocolate pudding (unhealthy, sweet), while Reutner et al. (2015) found the colour red acted as a stop cue, reducing intake of chocolate (unhealthy, sweet) but not grapes (healthy, sweet).

Several studies also directly tested the specificity of nudge effects (i.e., whether the nudge effect is specific to nudged items or items within the nudged food category, or if nudge effectiveness generalises to other similar products) with results mixed. For example, Akyol et al. (2018) nudged food choices, and found the effect did not generalise to beverages, while Kay et al. (2023) nudged drink choices, and found the effect did not generalise to foods (Study 2; no effect for drink or food choices when nudges were subtler in Study 1). Similarly, Guéguen et al. (2012) found nudges specific to main meals affected main meal choice, but the effect did not extend to dessert choice. Other studies, however, did not find specificity effects. Kemps et al. (2016), for example, found that an image of grapes decreased subsequent consumption irrespective of whether the outcome food was grapes (nudged) or cookies. Deek et al. (2022), on the other hand, found participants were not more likely to

select the items depicted in their meal-based nudges, compared to non-depicted items. In addition, Alblas et al. (2021) found that their nudge, depicting sweet cakes, did not affect the healthiness of choices, even when only considering choices within the nudged food category (sweet foods).

Finally, the meta-analysis also revealed that unhealthy food-specific nudges (Category 3) had a moderate positive effect on tangible unhealthy consumption-related behaviours, but a moderate negative effect on hypothetical unhealthy consumption-related behaviours. It is possible that healthier consumption-related behaviours occurred following unhealthy nudges in hypothetical settings due to the nudges triggering avoidance motivations, essentially acting as a reminder to reduce consumption of unhealthy products (Fishbach et al., 2010). This may also explain why the effect was found for food-specific nudges clearly depicting the unhealthy products to avoid (Category 3), but not for body-related nudges (Category 4) which are less directly linked to unhealthy foods (Forwood et al., 2015). Thus, it could be that in a hypothetical situation without the immediate consequences of consumption, unhealthy nudges trigger a more reflective process with greater health considerations, while in a scenario involving real consumption-related outcomes, behaviours may be more automatic. When faced with actually consuming foods in real-world settings, the more habitual (unhealthy) behaviour or the more inherent appeal of the depicted unhealthy products may have more impact, triggering increased choice or intake of such unhealthy products. This would mirror some research outside of the eating domain which indicates that consumers are more likely to make choices that align with behaviours they believe they should be exhibiting if that choice is to be implemented in the future rather than in the shorter term (Rogers & Bazerman, 2008). However, research in the food domain is needed to disentangle the processes underlying the effect of such unhealthy nudges in both hypothetical and real-world scenarios to determine any differences, as findings could have important implications for

future research in the nudging domain and for the practical implication of nudge interventions. In addition, while moderating effects of outcome tangibility were not found in the other meta-analyses conducted here, potentially indicating more robust effects the healthy nudges, Category 2 did include the largest proportion of hypothetical outcomes (38%) which may account for the effect being found in this group but not others. Thus, further research comparing hypothetical and real consumption-related outcomes is warranted across all nudge types.

Other mechanisms that could potentially influence the effectiveness of nudges were also mentioned but in only a few articles, limiting our ability to draw any real conclusions on their potential impact. Additionally, several variables were tested as outcomes rather than moderators such as post-nudge changes in hunger, body-related perceptions, and perceptions of outcome foods. These factors could help explain how nudges work but since they were not assessed as moderators, their impact on consumption-related outcomes remains unknown. Many of these factors, however, were not significantly influenced by condition and/or did not have a significant main effect on consumption-related behaviours, which may explain why they were not explored further as moderators. While nudges are widely considered to work through subconscious mechanisms (Bucher et al., 2016) and are often described as working by increasing salience or by activating health goals and/or social norms (Bauer & Reisch, 2019), testing of these mechanisms and moderators has been limited. There remains insufficient evidence to determine the specifics of these subconscious processes and factors that moderate these unconscious processes. Further investigation into potential mechanisms and moderators of nudge success are sorely needed, and the need for this research has already been noted across multiple nudging reviews (e.g., Bauer & Reisch, 2019; Buckland et al., 2018; Mertens et al., 2022).

It is important to acknowledge that despite efforts to find articles assessing underlying

mechanisms, there are also studies that solely focus on examining these mechanisms without relating them to consumption-related behaviours. For example, determining whether attention or focus on (un)healthy choices changed following nudging, without also measuring whether people also chose the item they focussed on (e.g., Spielvogel et al., 2018). Such articles were not included in the current review but may be helpful in understanding how and when particular types of visual nudges are effective.

Implicit visual nudges, such as the ones included in the present review have the potential to be effective and are an easy to implement means of nudging consumption-related behaviours. These nudges also have the potential to be easily incorporated into a range of eating environments, such as by including images of healthy foods on menus (Deek et al., 2022; Tonkin et al., 2019) or tableware (Sharps et al., 2020), incorporating more healthy foods into cooking shows (Folkvord et al., 2020; Ngqangashe et al., 2018), or placing images of slim bodies into the background of food environments (Brunner & Siegrist, 2012; Stöckli et al., 2016). However, further research is needed to confirm the suitability of nudges in real-world settings as most of the included studies were conducted in laboratory/controlled environments which are inherently susceptible to the potential of social desirability in responding and demand effects as participants may predict the intentions of researchers and try to act in a behaviour concordant with the perceived aim. This may be especially the case for more obvious (less implicit) nudging approaches such as prominent posters present in the laboratory environment (e.g., Benito-Ostolaza et al., 2021; Kwa et al., 2022) or when participants are asked to view and provide feedback on images (even when presented to participants as unrelated to eating/choice tasks; e.g., Campbell et al., 2016; Harrison et al., 2006; Kay et al., 2023). However, nudge presentation/engagement (i.e., whether the nudge was presented subtly/unobtrusively or was prominent in the environment and whether the nudge was actively engaged with or was unattended and/or subliminally presented) did not

emerge as significant moderators of nudge success in the conducted meta-analyses.

While the mechanisms by which visual nudges influence consumption-related behaviours are still unclear, they are thought to work relatively unconsciously to influence behaviours and thus could nicely complement more explicit public health approaches, such as education and mass media campaigns that require more conscious engagement to influence choices. Further, while educational campaigns and similar can help to increase knowledge and awareness around the importance of healthy diets, they tend to have limited impact on consumption behaviours (Bucher et al., 2016). Pairing such educational campaigns with subtle environmental nudges may result in greater benefits. The campaigns can help to create the health-related goals that the nudges may then work to activate, thus prompting healthier consumption-related behaviours. An educational campaign alone may struggle to override the more habitual nature of consumption-related behaviours in the moment (Bucher et al., 2016), and healthy nudges may struggle to encourage healthier behaviours without pre-existing health-related goals to activate. Pairing the two approaches may, however, create health goals (via educative approaches) as well as subsequently activating such goals in the consumption-related moment (via implicit nudges) to ultimately change behaviours.

Overall, the conducted meta-analyses and narrative review of mechanisms indicate that visual nudges can effectively influence consumption-related behaviours, but there is considerable variability in their effects. Further research is needed, however, to fully understand the effectiveness of visual cues and primes for nudging consumption-related behaviours. While the meta-analyses conducted for the current review revealed few significant moderators, factors related to participants, the nudges themselves, and characteristics of the consumption-related outcome still have the potential to explain or predict the effectiveness of nudges on consumption-related behaviours. If future research consistently supports the effectiveness of visual nudging techniques for influencing

consumption-related behaviours, such nudges should be considered by policymakers, food vendors, and other spaces where foods are commonly sold, such as in schools and workplaces, as potential means of encouraging healthier consumption behaviours. Further research to develop a greater understanding of the mechanisms and moderators of nudge success can also aid in the development of the most effective visual nudging strategies for targeting specific consumers and/or food spaces. Using visual nudges to encourage healthier eating behaviours, particularly targeted nudges, has the potential to create widespread positive changes to dietary behaviours and subsequently improve health-related outcomes.

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Supplementary Materials

A systematic review and meta-analysis of visual cues and primes for nudging consumption-related behaviours

Supplementary Material A

Complete search strategies for each of the 5 databases

CINAHL

Visual nudge terms	1	T I (cue OR cue* OR prime OR primes OR primed OR priming OR image OR images OR poster OR posters OR nudge OR nudging OR nudges) OR AB (cue OR cue* OR prime OR primes OR primed OR priming OR image OR images OR poster OR posters OR nudge OR nudging OR nudges) OR SU (cue OR cue* OR prime OR primes OR primed OR priming OR image OR images OR poster OR posters OR nudge OR nudging OR nudges)
Consumption-related outcome terms	2	T I (food OR meal OR snack OR snacks OR snacking OR menu OR "vending machine" OR drink OR drinks OR beverage OR beverages OR soda OR "soft drink" OR "soft drinks" OR "carbonated drinks" OR "carbonated beverages" OR "sugar-sweetened beverages" OR ssb OR ssbs OR "artificially sweetened beverages" OR drinking OR fruit OR vegetable OR vegetables OR chocolate OR brand OR calori* OR energy OR diets OR calories OR nutrition) OR AB (food OR meal OR snack OR snacks OR snacking OR menu OR "vending machine" OR drink OR drinks OR beverage OR beverages OR soda OR "soft drink" OR "soft drinks" OR "carbonated drinks" OR "carbonated beverages" OR "sugar-sweetened beverages" OR ssb OR ssbs OR "artificially sweetened beverages" OR drinking OR fruit OR vegetable OR vegetables OR chocolate OR brand OR calori* OR energy OR diets OR calories OR nutrition) OR SU (food OR meal OR snack OR snacks OR snacking OR menu OR "vending machine" OR drink OR drinks OR beverage OR beverages OR soda OR "soft drink" OR "soft drinks" OR "carbonated drinks" OR "carbonated beverages" OR "sugar-sweetened beverages" OR ssb OR ssbs OR "artificially sweetened beverages" OR drinking OR fruit OR vegetable OR vegetables OR chocolate OR brand OR calori* OR energy OR diets OR calories OR nutrition)
	3	T I (consumption OR consume OR intake OR choice OR choices OR choosing OR selection OR select OR eat OR eating OR drink OR drinking OR preference OR preferences) OR AB (consumption OR consume OR intake OR choice OR choices OR choosing OR selection OR select OR eat OR eating OR drink OR drinking OR preference OR preferences) OR SU (consumption OR consume OR intake OR choice OR choices OR choosing OR selection OR select OR eat OR eating OR drink OR drinking OR preference OR preferences)
	4	S2 AND S3
	5	TI ("eating behavio#r" OR "health behavio#r" OR "choice behavio#r" OR "drinking behavio#r" OR "behavio#r change" OR "consumption behavio#r" OR "healthier behavio#r") OR AB ("eating behavio#r" OR "health behavio#r" OR "choice behavio#r" OR "drinking behavio#r" OR "behavio#r change" OR "consumption behavio#r" OR "healthier behavio#r") OR SU ("eating behavio#r" OR "health behavio#r" OR "choice behavio#r" OR "drinking behavio#r" OR "behavio#r change" OR "consumption behavio#r" OR "healthier behavio#r")
	6	S4 OR S5
Combining searches and adding limits	7	S1 AND S6
	8	S7 AND Limiters – English Language; Peer Reviewed; Human

Medline

Visual nudge terms	1	exp Cues/ or exp Priming/
	2	(cue or cue* or prime or primes or primed or priming or image or images or poster or posters or nudge or nudging or nudges).ti,ab,id.
	3	1or 2
Consumption-related outcome terms	4	exp Food/ or exp Food Intake/ or exp Food Preferences/ or exp Diets/ or exp Beverages/
	5	(food or meal or snack or snacks or snacking or menu or "vending machine" or drink or drinks or beverage or beverages or soda or "soft drink" or "soft drinks" or "carbonated drinks" or "carbonated beverages" or "sugar-sweetened beverages" or "artificially sweetened beverages" or SSB or SSBs or drinking or fruit or vegetable or vegetables or chocolate or brand or "calori* intake" or "energy intake" or "food intake" or "food preferences" or diets or calories or nutrition).ti,ab,id.
	6	4 or 5
	7	exp Eating Behavior/ or exp Health Behavior/ or exp Choice Behavior/ or exp Drinking Behavior/ or exp Decision Making/
	8	("eating behavio#r" or "behavio#r change" or "health behavio#r" or "drinking behavio#r" or "consumption behavio#rs" or "decision making" or consumption or consume or intake or choice or choices or choosing or selection or select or eat or eating or drink or drinking or preference or preferences).ti,ab,id.
	9	or/7-8
Combining searches and adding limits	10	3 and 6 and 9
	11	Limit 10 to (English language and humans)

PsycArticles

Visual nudge terms	1	exp Cues/ or exp Priming/
	2	(cue or cue* or prime or primes or primed or priming or image or images or poster or posters or nudge or nudging or nudges).ti,ab,id.
	3	1 OR 2
Consumption-related outcome terms	4	exp Food/ or exp Food Intake/ or exp Food Preferences/ or exp Diets/ or exp Calories/ or exp Nutrition/ or exp "Beverages (Nonalcoholic)"/
	5	(food or meal or snack or snacks or snacking or menu or "vending machine" or drink or drinks or beverage or beverages or soda or "soft drink" or "soft drinks" or "carbonated drinks" or "carbonated beverages" or "sugar-sweetened beverages" or "artificially sweetened beverages" or SSB or SSBs or drinking or fruit or vegetable or vegetables or chocolate or brand or "calori* intake" or "energy intake" or "food intake" or "food preferences" or diets or calories or nutrition).ti,ab,id.
	6	4 OR 5
	7	exp Eating Behavior/ or exp Health Behavior/ or exp Choice Behavior/ or exp Drinking Behavior/ or exp Decision Making/
	8	("eating behavio#r" or "behavio#r change" or "health behavio#r" or "drinking behavio#r" or "consumption behavio#rs" or "decision making" or consumption or consume or intake or choice or choices or choosing or selection or select or eat or eating or drink or drinking or preference or preferences).ti,ab,id.
	9	OR/7-8
Combining searches and adding limits	10	3 AND 6 AND 9
	11	limit 10 to (“0110 peer-reviewed journal” and english and human)

PubMed

Visual nudge terms	1	cues[MeSH Terms]
	2	cue[Title/Abstract] OR cues[Title/Abstract] OR cueing[Title/Abstract] OR cued[Title/Abstract] OR prime[Title/Abstract] OR primes[Title/Abstract] OR primed[Title/Abstract] OR priming[Title/Abstract] OR image[Title/Abstract] OR images[Title/Abstract] OR poster[Title/Abstract] OR posters[Title/Abstract] OR nudge[Title/Abstract] OR nudging[Title/Abstract] OR nudges[Title/Abstract]
	3	#1 OR #2
Consumption-related outcome terms	4	food OR "food intake" OR "food preferences" OR diets OR calories OR nutrition OR beverages[MeSH Terms]
	5	food[Title/Abstract] OR meal[Title/Abstract] OR snack[Title/Abstract] OR snacks[Title/Abstract] OR snacking[Title/Abstract] OR menu[Title/Abstract] OR "vending machine"[Title/Abstract] OR drink[Title/Abstract] OR drinks[Title/Abstract] OR beverage[Title/Abstract] OR beverages[Title/Abstract] OR soda[Title/Abstract] OR "soft drink"[Title/Abstract] OR "soft drinks"[Title/Abstract] OR "carbonated drinks"[Title/Abstract] OR "carbonated beverages"[Title/Abstract] OR "sugar-sweetened beverages"[Title/Abstract] OR "artificially sweetened beverages"[Title/Abstract] OR SSB[Title/Abstract] OR SSBs[Title/Abstract] OR drinking[Title/Abstract] OR fruit[Title/Abstract] OR vegetable[Title/Abstract] OR vegetables[Title/Abstract] OR chocolate[Title/Abstract] OR brand[Title/Abstract] OR "calorie intake"[Title/Abstract] OR "energy intake"[Title/Abstract] OR "food intake"[Title/Abstract] OR "food preferences"[Title/Abstract] OR diets[Title/Abstract] OR calories[Title/Abstract] OR nutrition[Title/Abstract]
	6	#4 OR #5
	7	"eating behavior" OR "health behavior" OR "choice behavior" OR "drinking behavior" OR "decision making"[MeSH Terms]
	8	"eating behavior"[Title/Abstract] OR "eating behaviour"[Title/Abstract] OR "behavior change"[Title/Abstract] OR "behaviour change"[Title/Abstract] OR "health behavior"[Title/Abstract] OR "health behaviour"[Title/Abstract] OR "drinking behavior"[Title/Abstract] OR "drinking behaviour"[Title/Abstract] OR "consumption behaviors"[Title/Abstract] OR "consumption behaviours"[Title/Abstract] OR "decision making"[Title/Abstract] OR consumption[Title/Abstract] OR consume[Title/Abstract] OR intake[Title/Abstract] OR choice[Title/Abstract] OR choices[Title/Abstract] OR choosing[Title/Abstract] OR selection[Title/Abstract] OR select[Title/Abstract] OR eat[Title/Abstract] OR eating[Title/Abstract] OR drink[Title/Abstract] OR drinking[Title/Abstract] OR preference[Title/Abstract] OR preferences[Title/Abstract]
	9	#7 OR #8
Combining searches and adding limits	10	#3 AND #6 AND #9
	11	#3 AND #6 AND #9 Filters: Humans, English

Scopus

Visual nudge terms	1	TITLE-ABS-KEY (cue OR cue* OR prime OR primes OR primed OR priming OR image OR images OR poster OR posters OR nudge OR nudging OR nudges)
Consumption-related outcome terms	2	TITLE-ABS-KEY (food OR meal OR snack OR snacks OR snacking OR menu OR "vending machine" OR drink OR drinks OR beverage OR beverages OR soda OR "soft drinks" OR "soft drinks" OR "carbonated drinks" OR "carbonated beverages" OR "sugar-sweetened beverages" OR ssb OR ssbs OR "artificially sweetened beverages" OR drinking OR fruit OR vegetable OR vegetables OR chocolate OR brand OR "calori* intake" OR "energy intake" OR "food intake" OR "food preferences" OR diets OR calories OR nutrition)
	3	TITLE-ABS-KEY (consumption OR consume OR intake OR choice OR choices OR choosing OR selection OR select OR eat OR eating OR drink OR drinking OR preference OR preferences)
	4	#2 AND #3
	5	TITLE-ABS-KEY ("eating behavio#r" OR "health behavio#r" OR "choice behavio#r" OR "drinking behavio#r" OR "behavio#r change" OR "consumption behavio#r" OR "healthier behavio#r")
	6	#4 OR #5
Combining searches and adding limits	7	#1 AND #6
	8	#7 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Human") OR LIMIT-TO (EXACTKEYWORD , "Humans")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j"))

Supplementary Material B

Characteristics of the included studies

Reference, Country	Study design	Participant characteristics	Nudge characteristics	Consumption-related outcome characteristics	Summary of consumption-related outcomes	Tested mechanisms and moderators	Effect size(s) and 95% Confidence Interval(s)	Quality
Akyol et al., 2018 Turkey	Design: crossover RCT Setting: laboratory / controlled environment. Randomisation: randomly allocated to condition on each test day	*N* = 54 females Source: university and community Age: adults (*M* = 22.22 years, SD = 0.14; range: 18-30). Weight: normal BMI (*M* = 21.29 kg/m^2, *SD* = 0.12) Restraint: non-dieting	Type: colour cue Medium: crockery (plate) Conditions: red, black, white Task: participants served themselves lunch on a coloured plate. Exposure: while serving and consuming food Engagement: actively interacted with nudge; unaware of nudge aspect; nudge aspect not central focus of task	Type: meal (food and beverage) intake (M kcal) Items (health): pasta in tomato-based sauce (healthy) and non-carbonated soft drinks Task: ad libitum buffet lunch meal (served and consumed; multiple trips permitted)	Plate colour significantly predicted food (but not beverage) intake. Red and black plates increased pasta intake relative to white plates (no difference in intake between red and black plates).	Immediate versus subsequent consumption: significant nudge effect on first but not subsequent buffet visits Specificity effects: nudge successfully nudged intake of food (nudge applied) but not drink (nudge not applied) Hunger / satiety / appetite / desire to eat / prospective food consumption / desire for foods: no change pre-post	<u>Food</u> Red versus White d = -0.79 95% CI =-1.18, -0.40 Red versus Black d = -0.04 95% CI =-0.42, 0.34 Black versus White d = 0.79 95% CI = 0.40, 1.18 <u>Drink</u> Red versus White d = 0.09 95% CI = -0.29, 0.46 Red versus Black d = -0.05 95% CI =-0.43, 0.32 Black versus White d = -0.03 95% CI =-0.41, 0.34	****
Alblas et al., 2021 Amsterdam	Design: single-factor between-subjects experimental design Setting: laboratory / controlled environment. Randomisation: randomly allocated to condition	*N* = 112 (80.4% female) Source: university Age: adults (*M* = 20.93 years, *SD* = 2.16, range: 18-29) Weight: mixed (*M* = 21.95 kg/m^2, *SD* = 3.36; range = 16.65-36.98) Restraint: mixed dieting status (mean restraint score = 13.66, *SD* = 3.14; range = 7-23)	Type: food prime Medium: video (television show) Conditions: cooking show; non-food show Task: viewed television show segment. Exposure: throughout video viewing Engagement: incidental interaction with nudge; unaware of nudge aspect; nudge aspect central focus of task	Type: hypothetical food choice (mean % unhealthy versus healthy calories) Items (health): healthy foods (range of fruits and vegetables); unhealthy foods (range of chocolates, cake, sweets, muffins, crisps, and fast-food items) Task: computerised choice task. Involving 20 target trials where chose between healthy and unhealthy foods (52 trials in total)	No main effect of condition on choices.	PSRS: no effect (Un)successful (un)restrained eaters (restraint * PSRS): no effect Dieting / weight loss success: no effect Impulsivity: no effect Trait self-control: no effect Nudge familiarity: no effect Attention / concentration: no effect Engaging / enjoyable nudge / nudging task: no effect Appeal of nudged items: no effect Immediate versus subsequent consumption: no effect Specificity effect: not effect Perceived tastiness of	d = -0.17 95% CI = -0.54, 0.21	***

						outcome: no effect Use of self-control during outcome measurement: no effect Hunger: no change pre-post		
Anschutz et al., 2008 Netherlands	Design: between-subjects experimental design Setting: naturalistic-style laboratory environment. Randomisation: not stated.	*N* = 104 females Source: university Age: adults (*M* = 20.8 years, *SD* = 3.6) Weight: normal weight (BMI ≤25; *M* = 21.3 kg/m^2, *SD* = 2.1) Restraint: mixed dieting status (48.1% restrained; mean restraint score: 2.5; SD = 0.9)	Type: body cue Medium: video (television show) Conditions: thin bodies (normal screen size); normal weight bodies (broad screen size) Task: passive viewing of video Exposure: throughout video viewing (30 min) Engagement: incidental interaction with nudge; unaware of nudge aspect; nudge aspect not central focus of task	Type: food intake (M kcal) Items: M&Ms (unhealthy) Task: free snacking while watching video	No main effect of condition of intake.	Restraint: unrestrained ate more in average weight (versus thin) condition while restrained ate more in the thin (versus average weight) condition. Pre-test mood: no effect	d = 0.15 95% CI = -0.23, 0.54	***
Anschutz & Engels, 2010 Netherlands	Design: between-subjects experimental design Setting: laboratory / controlled environment. Randomisation: randomly allocated to condition	*N* = 117 females Source: schools Age: children (*M* = 8.04 years, *SD* = 1.32; range: 6-10) Weight: mixed (*M* = 17.28 kg/m^2, *SD* = 2.7) Restraint: not measured / reported	Type: body prime Medium: game (toy) Conditions: thin doll, average-sized doll, Lego (control) Task: asked to dress the doll for a range of scenarios (control: asked to build a house) Exposure: while playing (10 min) Engagement: actively interacted with nudge; unaware of nudge aspect; nudge aspect not central to task	Type: food intake (grams) Items: chocolate-coated peanuts (unhealthy) Task: taste test task (8 min)	Significant main effect of condition. Consumption higher following exposure to the average-sized doll compared to the thin doll. No difference between average-size and control or between the thin doll and control condition.	Age: no effect Nudge familiarity: no effect Engaging / enjoyable nudge / nudging task: no effect	Thin doll versus Lego d = -0.13 95% CI = -0.59, 0.33 Av doll versus Lego d = 0.59 95% CI = 0.07, 1.11 Thin doll versus Av doll d = 0.75 95% CI = 0.31, 1.19	*****
Aronow et al., 2018 USA	Design: multi-year RCT Setting: field study (house providing treats on Halloween) Randomisation: randomly allocated to condition	*N* = 1,223 (47% female) Source: community (trick or treaters) Age: children (3+ years; *M* = 8.5) Weight: not measured / reported Restraint: not measured / reported	Type: social cue Medium: image (poster) Conditions: Michelle Obama (influential figure regularly associated with public health initiatives around healthy eating in children); comparison (comparison public figure or no poster)	Type: food choice (% healthy) Items: box of raisins (healthy) or small packaged chocolate (unhealthy) Task: treat choice	Children exposed to the experimental cue (poster of Michelle Obama's face) increased fruit (versus candy) choice compared to the control conditions	n/a	Obama versus Nothing d = 0.12 95% CI = -0.02, 0.27 Obama versus Comparison d = 0.03 95% CI = -0.11, 0.16	**

			Task: poster on wall of house during trick-or-treating at Halloween Exposure: while making food choice Engagement: incidental interaction with nudge, nudge obvious in environment; nudge aspect central					
Bates & Shanks, 2015 USA	Design: post-test randomised group design Setting: laboratory / controlled environment. Randomisation: randomly allocated to condition	*N* = 50 (68% female) Source: university Age: adults (mean range: 18-24 years) Weight: mixed weight (mean BMI: 23.87 kg/m^2, *SD* = 3.26) Restraint: not measured / reported	Type: other cue Medium: crockery (container) Conditions: container; no container (control) Task: take-out container provided at start of meal (or not if control) Exposure: throughout meal consumption Engagement: made aware of nudge, obviously presented in environment, nudge aspect central	Type: mean intake (kilocalories) Items: vegetable lasagne Task: ad libitum meal consumption	Participants in the experimental condition (container provided at start of meal) ate significantly less compared to the control.	Gender: intake higher among males in both conditions	d = 0.19 95% CI = -0.37, 0.74	**
Benito-Ostolaza et al., 2021 Spain	Design: RCT Setting: laboratory / controlled environment. Randomisation: randomly allocated to condition	*N* = 247 (45% female) Source: schools Age: children (range: 8-9 years) Weight: mixed weight (32% overweight / obese) Restraint: not measured / reported	Type: food prime Medium: image (poster) Conditions: positive healthy (happy emoji with health snack foods); negative unhealthy (sad emoji with unhealthy snack foods); nothing (control) Task: priming poster present on wall and on snack poxes (lids removed prior to choice) Exposure: while being weighed and measured (poster) and just prior to making food selection (snack box lids) Engagement: incidental interaction with nudge; nudge obvious in environment; nudge aspect central focus	Type: food choice (% healthy) Items: fruit box (healthy; fresh pieces of banana, kiwi, apple, grapes, and mandarin); sugary food box (unhealthy; pieces of vanilla cake, chocolate cake, and chocolate cookie) Task: choice between healthy or unhealthy mid-morning snack box	No main effect of condition on food choice.	Gender: positively framed nudge effective for girls but not boys. Weight / BMI: no effect	Pos healthy food versus Nothing d = 0.17 95% CI = -0.19, 0.53 Neg unhealthy food versus Nothing d = -0.07 95% CI = -0.45, 0.30	****

Bittner & Kulesz, 2015 (Study 1) Netherlands	Design: 2 (condition) x (health goal) between-subjects experimental design Setting: field Randomisation: randomly allocated to condition	*N* = 227 (55.5% female) Source: community (workplace) Age: adults (*M* = 27.4 years) Weight: not measured / reported Restraint: not measured / reported	Type: social cue Medium: image (on online shopping site) Conditions: eye cue (black and white image of two staring); no eye cue (control) Task: eye cue appeared at the top of an online shopping website where participants made food choices Exposure: during choice task Engagement: actively engaged but unaware of nudge and nudge not central to task	Type: hypothetical food choice (mean sum of healthy food choices) Items: high versus low in fat (e.g., fruit salad vs chocolate, or light versus regular products. Task: the participants were made several choices between healthy and unhealthy food pairs in an online supermarket setting (5 healthy vs unhealthy choices and 2 organic vs non-organic choices)	Participants made more healthy choices in the cue conditions versus the control conditions.	Specificity effects: nudge effect did not generalise to choices between organic and non-organic foods Pre-activation of health goals: main effect of health goal interaction but no interaction with condition (although strongest effect in condition combining nudge with health goal activation)	<u>Health goal: activated</u> Eye cue versus Nothing d = -0.32 95% CI = -0.69, 0.06 <u>Health goal: not activated</u> Eye cue versus Nothing d = -0.30 95% CI = -0.68, 0.07	***
Bittner & Kulesz, 2015 Study 2 Netherlands	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 54 (83.3% female Source: university Age: adults (*M* = 22.4 years) Weight: not reported Restraint: not measured / reported	Type: social cue Medium: image (on menu) Conditions: eye cue (as in Study 1), no eye cue (control) Task: eye cue appeared at the top of a physical menu card where participants made food choices Exposure: during choice task Engagement: actively engaged but unaware of nudge and nudge not central to task	Type: hypothetical food choice Items: high versus low in fat (e.g., French fries vs farmer salad, hamburger vs vegetarian sandwich, hotdog vs fried vegetables) Task: made three choices between food pairs on a menu	Participants made more healthy choices in the cue condition versus the control condition.	Perceived success in dieting – significant main effect of social presence cue; not tested in relation to food outcome BMI had no effect on food choice (included as covariate)	*d* = 0.65 95% CI = 0.10, 1.20	***
Blížkovská, 2017 Netherlands	Design: 3 (condition) x 2 (dietary restraint) between-subjects experimental design Setting: field (sports stadium) Randomisation: not stated	*N* = 92 (46.7% female) Source: community (sports stadium attendees) Age: adults (18+ years; *M* = 32.7 years; *SD* = 8.9) Weight: not measured / reported Restraint: mixed dieting status (43.5% dieters)	Type: food prime Medium: image (poster) Conditions: healthy food; unhealthy food; no prime Task: poster on each stadium entrance Exposure: while entering stadium Engagement: incidental interaction with nudge; obviously presented in environment; not central to behaviour/task	Type: healthy versus unhealthy food choice Items: range of healthy (e.g., banana, 'tostie') and unhealthy (e.g., cookie, fries) foods. Task: Purchased food(s) from stadium cafeteria	The healthy prime encouraged healthier choices relative to the control. The unhealthy prime did not predict choices.	Restraint: healthy prime effective for restrained not unrestrained; unhealthy prime effective for unrestrained but not restrained	<u>Restrained</u> Healthy food versus Nothing d = 1.34 95% CI = 0.38, 2.31 Unhealthy food versus Nothing d = -0.30 95% CI = -1.13, 0.54 Healthy food versus Unhealthy food d = 1.05 95% CI = 0.10, 1.99 <u>Unrestrained</u> Healthy food versus Nothing d = 0.00 95% CI = -1.11, 1.11 Unhealthy food versus Nothing	****

							d = 0.98 95% CI = 0.05, 1.90 Healthy food versus Unhealthy food d = 0.98 95% CI = -0.15, 2.10	
Bodenlos & Wormuth, 2013 USA	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 80 (72.5% female) Source: university Age: adults (*M* = 19.5 years; *SD* = 1.00; range: 19-22) Weight: mixed weight (*M* = 24.29 kg/m^2, *SD* = 0.46). Restraint: mixed (mean restraint score = 27.42; *SD* = 0.53)	Type: food prime Medium: video (television show) Conditions: cooking show (unhealthy); neutral (nature) show Task: passive television viewing Exposure: while watching show (10 min) Engagement: incidental interaction with nudge; unaware of nudge aspect; nudge central	Type: food intake (calories) Items: cheese curls, chocolate covered candies, carrots Task: taste test task (10 min)	No significant effect of condition on overall calorie consumption.	Specificity effects: significant effect for chocolate candies but not savoury foods; last foods shown in the video were sweet, unhealthy foods. Type of outcome: significant effect for sweet unhealthy foods but not savoury unhealthy or savour healthy Hunger / desire for foods: no change pre-post	<u>Choc candies</u> Food show versus Neutral d = 0.51 95% CI = 0.06, 0.96 <u>Carrots</u> Food show versus Neutral d = 0.19 95% CI = -0.25, 0.63 <u>Cheese curls</u> Food show versus Neutral d = 0.03 95% CI = -0.41, 0.47	*****
Bourn et al., 2015 Australia	Design: 2 (condition) x 2 (pre-post) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 99 females Source: university Age: adults (*M* = 19.35 years; *SD* = 2.11; range: 17-26) Weight: mixed weight (*M* = 23.51 kg/m^2; *SD* = 5.19; range: 15.57-44.63; 25.3% overweight/obese) Restraint: mixed (mean restraint score = 27.33; *SD* = 9.94)	Type: body cue Medium: video (television show) Conditions: reality weight loss show; neutral (home renovation) show Task: passive television viewing Engagement: actively attended; obvious; central	Type: food intake (calories) Items: chocolate candy, corn chips, mixed dried fruit Task: snacking while watching video	Few (20%) participants consumed food. No significant difference in overall food consumption between conditions.	Restraint: restrained eaters ate more in the nudge condition while unrestrained eaters ate more in the control condition Type of outcome: no effect of condition irrespective of outcome (healthy / unhealthy; sweet / savoury)	d = 0.34 95% CI = -0.06, 0.74	****
Brunner & Siegrist, 2012 (Study 1) Switzerland	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 95 (70% female) Source: community Age: adults (*M* = 35.4 years; range: 16-74) Weight: not measured / reported Restraint: not measured / reported	Type: body cue Medium: image (screensaver) Conditions: Giacometti artwork; neutral artwork Task: laptop screensaver in background of testing room (unobtrusively presented) Exposure: during testing Engagement: incidental; subtle; central	Type: food intake (piece count) Items: chocolate (unhealthy) Task: taste test task (5 min)	Participants consumed less chocolate in the experimental (Giacometti) condition compared to the control condition.	Gender: no effect	d = 0.44 95% CI = 0.03, 0.84	**

Buckland et al., 2014 UK	Design: 2 (condition) x 2 (diet status) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 67 females Source: mixed (university and community) Age: adults (*M* = 23.67 years; *SD* = 5.87; range: 18-55) Weight: mixed (normal to overweight; *M* = 23.48 kg/m^2; *SD* = 2.88; range: 18.5-40) Restraint: mixed (38.8% dieting to lose or maintain weight)	Type: food prime Medium: images Conditions: healthy foods (fruits and diet products); neutral (non-food) images Task: bogus response task; 9 healthy or control images subliminally presented 9 times (total of 45 trials) Exposure: target images shown for 23ms in each exposure Engagement: incidental; subtle; not central	Type: food intake (kcal) Items: high/low fat, sweet/savoury food Task: taste test (10 min)	Condition did not significant predict food intake.	Restraint and disinhibition: participants high in restraint and disinhibition consumed less after the diet versus control nudge Outcome type: no effect irrespective of outcome (healthy / unhealthy; sweet / savoury) Goal salience: no difference between conditions and no interaction with restraint Hunger: no pre-post change	***Dieters*** Healthy Savoury Healthy food versus Neutral d = 0.45 95% CI = -0.33, 1.23 Healthy Sweet Healthy food versus Neutral d = 0.93 95% CI = 0.12, 1.74 Unhealthy Savoury Healthy food versus Neutral d = -0.85 95% CI = -1.65, -0.04 Unhealthy Sweet Healthy food versus Neutral d = 0.57 95% CI = -0.22, 1.36 ***Non-Dieters*** Healthy Savoury Healthy food versus Neutral d = 0.41 95% CI = -0.21, 1.03 Healthy Sweet Healthy food versus Neutral d = -0.56 95% CI = -1.19, 0.06 Unhealthy Savoury Healthy food versus Neutral d = -0.11 95% CI = -0.72, 0.51 Unhealthy Sweet Healthy food versus Neutral d = 0.31 95% CI = -0.31, 0.92	*****

Campbell et al., 2016 (Study 1) USA	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 60 (42% female) Source: school Age: children (eighth graders; *M* = 12.9 years) Weight: not measured/reported Restraint: not measured/reported	Type: body prime Medium: image (cartoon character) Conditions: normal weight; overweight; neutral (mug) Task: survey about printer quality Exposure: while completing printer survey Engagement: active; obvious, not central	Type: food intake (piece count) Items: candies (unhealthy) Task: offered candy as a 'thank you'	Participants in the overweight condition took more candies than participants in the normal weight and control conditions. No difference between normal weight and control conditions.		Normal weight versus Neutral d = 0.15 95% CI = -0.47, 0.77 Overweight versus Neutral d = 0.72 95% CI = 0.08, 1.36 Normal weight versus Overweight d = 0.67 95% CI = 0.03, 1.31	**
Campbell et al., 2016 (Study 2) USA	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 74 (45% female) Source: school Age: children (sixth and seventh graders; *M* = 11.7 years) Weight: not measured/reported Restraint: not measured/reported	Type: body prime Medium: image (cartoon character) Conditions: normal weight; overweight; combined (normal and overweight) Task: survey about printer quality Exposure: while completing printer survey Engagement: active; obvious, not central	Type: food intake (piece count) Items: candies (unhealthy) Task: offered candy as a 'thank you'	Participants in the overweight and combined prime conditions took more candies than participants in the normal weight condition. No difference between overweight and combined conditions.		Normal weight versus Overweight d = 0.77 95% CI = 0.17, 1.37 Normal weight versus Combined OW NW d = 0.68 95% CI = 0.11, 1.25 Combined OW NW versus Overweight d = -0.03 95% CI = -0.58, 0.52	**
Campbell et al., 2016 (Study 3) USA	Design: 2 (prime) x 2 (health knowledge) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 167 (49% female) Source: school Age: children (*M* = 8.3 years; range: 6-10) Weight: not measured/reported Restraint: not measured/reported	Type: body prime Medium: image (cartoon character) Conditions: normal weight; overweight Task: brief exposure Exposure: 15 seconds Engagement: active; obvious, not central	Type: food intake (piece count) Items: cookies (unhealthy) Task: taste test (3 min)	No significant main effect on number of cookies eaten (as hypothesised).	Age: no effect Health knowledge (activated, not): manipulated Pre-activation of health knowledge: overweight prime increased consumption when health knowledge not activated but had no effect when health knowledge activated	<u>Health knowledge - activated</u> d = 0.06 95% CI = -0.37, 0.50 <u>Health knowledge - not activated</u> d = 0.55 95% CI = 0.11, 0.98	**
Coelho et al., 2009 Netherlands	Design: 3 (condition) x 2 (weight concern) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 69 females Source: university Age: adults (*M* = 21.2 years; *SD* = 3.6; range: 18-43) Weight: mixed (*M* = 22.58 kg/m^2; *SD*. = 0.42) Restraint: mixed (40.6% high weight-related concerns)	Type: food prime Medium: mixed – physical (food basket) and images (magazines) Conditions: attended unhealthy food cue, incidental unhealthy food cue, non-food cues (office supply basket, home and garden magazines) Task: Basket and three magazines on table while participants completed pre-questionnaires including a	Type: food intake (calories) Items: M&Ms, bite-sized KitKat pieces, sweet pepper flavoured potato chips, garlic flavoured coated. Peanuts Task: taste test (10 min)	No significant main effect of condition.	Weight concern: high weight concerned participants consumed more in the attended cue condition compared to the control condition and compared to low weight concerned participants Restraint: intake increased as restraint scores increases in the attended (but not incidental or control) condition	<u>Restrained</u> Active versus control d = 1.06 95% CI = 0.01, 2.11 Incidental versus control d = 0.35 95% CI = -0.55, 1.25 <u>Unrestrained</u> Active versus control d = -0.03 95% CI = -0.76, 0.70 Incidental versus control	*****

			perceptual experience writing task (neutral task for incidental and control conditions; about unhealthy foods for attended cue condition) Exposure: during writing task (7 min) Engagement: active / incidental; obvious, central				d = 0.60 95% CI = -0.17, 1.36	
Deek et al., 2022 Australia	Design: 3 (condition) x 2 (menu order) x 2 (dietary restraint) between-subjects experimental Setting: online Randomisation: randomly allocated to condition	*N* = 291 females Source: university Age: adults (*M* = 22.4 years; *SD* = 12.23; range: 17-68) Weight: mixed (*M* = 24.42 kg/m^2; *SD* = 5.79) Restraint: mixed (84% restrained)	Type: food prime Medium: image (cover image of online food ordering app) Conditions: healthy meal, unhealthy meal, neutral control Engagement: active; attended; central	Type: hypothetical meal choice (% healthy choices) Items: healthy (salad, sandwich) and unhealthy (pizza, burger) mains, healthy (water, juice) and unhealthy (milkshake, coke) drinks, and healthy (fruit salad, yoghurt) and unhealthy (brownies, cookies) desserts Task: meal ordering (chose one item from each category with either healthy or unhealthy foods appearing in the first space, according to randomised menu order condition)	No significant main effect of condition.	Restraint: restrained eater made more healthy choices than unrestrained eater in the healthy cue condition (when healthy item presented first) Immediate versus subsequent consumption: significant effect for mains (chosen first) but not drinks or desserts Specificity effect: no effect (no more likely to select item shown in nudge) Outcome type: significant condition x restraint interaction for mains but not drinks or desserts Order of presentation: significant effect of healthy cue (among restrained versus unrestrained eaters) when healthy item shown first but not when unhealthy food shown first	***Healthy first menu*** <u>Restrained</u> Healthy food versus Non-food d = 0.98 95% CI = 0.26, 1.70 Unhealthy food versus Non-food d = -0.28 95% CI = -0.98, 0.42 Healthy food versus Unhealthy food d = 0.70 95% CI = -0.04, 1.45 <u>Unrestrained</u> Healthy food versus Non-food d = -0.21 95% CI = -1.08, 0.65 Unhealthy food versus Non-food d = -0.08 95% CI = -0.89, 0.74 Healthy food versus Unhealthy food d = -0.29 95% CI = -1.18, 0.60 ***Unhealthy first menu*** <u>Restrained</u> Healthy food versus Non-food d = -0.08 95% CI = -0.92, 0.75 Unhealthy food versus Non-food d = -0.45 95% CI = -1.22, 0.32 Healthy food versus	*****

							Unhealthy food d = -0.58 95% CI = -1.35, 0.20 <u>Unrestrained</u> Healthy food versus Non-food d = 1.11 95% CI = 0.10, 2.12 Unhealthy food versus Non-food d = -0.59 95% CI = -1.67, 0.48 Healthy food versus Unhealthy food d = 0.52 95% CI = -0.25, 1.29	
Dolezalova et al., 2021 Czech Republic	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 148 males Source: mixed (university and community) Age: adults (*M* = 21.92 years; *SD* = 2.45; range: 18-32) Weight: not measured/reported Restraint: not measured/reported	Type: colour cue Medium: labels (on cups) Conditions: red; blue Task: cups with red or blue labels Exposure: during testing Engagement: active; obvious; not central	Type: drink intake (mg) Item: peach iced tea (diluted to three different levels) Task: taste test	No main effect of condition on drink intake.	Hunger: no effect	d = 0.00 95% CI = -0.32, 0.32	***
Döring & Wansink, 2017 USA, France, Spain	Design: between-subjects observational study Setting: field Randomisation: non-randomised	*N* = 497 (52.1% female) Source: restaurants Age: adults (*M* = 31.9 years; *SD* = 16.51) Weight: mixed (*M* = 23.68 kg/m^2; *SD* = 4.19; 56.5% high BMI) Restraint: not measured/reported	Type: body cue Medium: physical (confederate server) Conditions: low sever BMI; high server BMI Task: servers took meal orders in restaurants Exposure: while ordering food Engagement: incidental; obvious; not central	Type: food intake (number of items ordered) Items (categories): soup, salad, appetizer, main dish, dessert Task: meal ordering in restaurant	A grater average number of food items were ordered when server BMI was high (versus low; especially when diner BMI low).	BMI: condition effect strongest when diner BMI low (versus high) Outcome type: significant effect for desserts only	<u>Normal weight</u> d = 0.41 95% CI = 0.20, 0.63 <u>Overweight</u> d = -0.15 95% CI = -0.47, 0.17	*****
Folkvord & Laguna-Camacho, 2019 Mexico	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 100 (58% female) Source: School Age: Children (*M* = 8.8 years; *SD* = 1.6; range: 7-12) Weight: mixed (*M* = 19.0 kg/m^2; *SD* = 4.0) Restraint: not measured / reported	Type: food cue Medium: images (game) Conditions: vegetables; non-food Task: memory game Exposure: during game Engagement: active; attended; central	Type: food intake (grams) Items: cucumbers, carrots, peppers, cherry tomatoes Task: free snacking during tasting (including 5-min post cueing break)	No main effect of condition.	Gender: no effect Weight / BMI: no effect Hunger: no effect Engaging / enjoyable nudge / nudging task: no effect	Healthy food versus Non-food d = -0.31 95% CI = -0.71, 0.08	****

Folkvord et al., 2020 Netherlands	Design: one-factor experimental between-subjects design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition (at class level)	*N* = 125 (50% female) Source: School Age: Children (*M* = 11.2 years; *SD* = 0.69; range: 10-12) Weight: not measured / reported Restraint: not measured / reported	Type: Food prime Medium: Video (TV show) Conditions: healthy cooking show; unhealthy cooking show; neutral (non-food) show Task: viewed television show segment Exposure: while viewing show (10 min) Engagement: active; attended; central	Type: food choice (healthy versus unhealthy) Items: healthy (apple or cucumber) or unhealthy (crisps or mini pretzels) Task: children chose food reward on paper showing image of each option	Participants were more likely to select a healthy food in the healthy prime condition than in the unhealthy prime or control conditions. No significant difference in food choice between the unhealthy prime and control conditions.		Healthy food versus Non-food d = 0.53 95% CI = -0.03, 1.08 Unhealthy food versus Non-food d = 0.10 95% CI = -0.56, 0.76 Healthy food versus Unhealthy food d = 0.63 95% CI = 0.01, 1.24	***
Genschow et al., 2012 (Study 1) Switzerland	Design: between-subjects experimental design Setting: field Randomisation: randomly allocated to condition	*N* = 41 males Source: university Age: adults (*M* = 22.61 years; *SD* = 6.45) Weight: not measured / reported Restraint: not measured / reported	Type: Colour cue Medium: Labels (on cups) Conditions: red; blue Task: cups with blue or red labels Exposure: during testing Engagement: active; obvious; not central	Type: drink intake (ml) Items: three flavoured iced teas (white, lemon, green) Task: taste test	No significant main effect of condition.	Hunger: no effect Outcome type: significant effect for white and lemon but not green tea	d = 0.66 95% CI = 0.03, 1.30	**
Genschow et al., 20212 Study 2 Switzerland	Design: between-subjects experimental design Setting: field Randomisation: randomly allocated to condition	*N* = 109 (56.0% female) Source: university visitors Age: adults (*M* = 31.80 years, *SD* = 16.77); range: 13-75) Weight: not measured / reported Restraint: not measured / reported	Type: colour cue Medium: paper plate Conditions: red, blue, white Task: coloured plate (containing snacks) on table while completing unrelate questionnaires Exposure: during completion of unrelated questionnaires Engagement: incidental; obvious; not central	Type: food intake (piece count) Items: 10 pretzels Task: free snacking while completing unrelated questionnaires	Participants ate significantly fewer pretzels in the red condition compared to the blue and white conditions. No significant differences between blue and white conditions.	Hunger: no effect	Red versus White *d* = 0.50 95% CI = 0.03, 0.98 Red versus Blue *d* = 0.52 95% CI = 0.05, 0.99 Blue versus White *d* = 0.03 95% CI = -0.39, 0.53	**
Gueguen et al., 2012 France	Design: between-subjects experimental design Setting: field Randomisation: randomly allocated to condition	*N* = 342 (36.55% female) Source: community (lone diners in restaurant) Age: not measured / reported Weight: not measured / reported Restraint: not measured / reported	Type: 'Other' cue Medium: image (on menu) Conditions: seaside; countryside; neutral control Task: cue presented on top of menu card Exposure: while ordering food Engagement: active; subtle; not central	Type: food choice (healthy versus unhealthy) Items: salads, meat dishes, fish dishes, desserts Task: ordered meal in restaurant	The seaside prime significantly increased choice of fish dishes, relative to the control condition. The countryside prime did not significantly increase choice of meat dishes.	Specificity effects: nudges primed mains (linked to nudge) but not desserts (not linked to nudge); also, sea prime nudged fish choices (versus control) but country prime did not nudge meat (versus control)	Seaside versus Nothing d = 0.07 95% CI = -0.39, 0.53 Countryside versus Nothing d = 0.10 95% CI = -0.23, 0.44	****
Harrison et al., 2006 USA	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 159 (59.1% female) Source: university Age: adults (*M* = 19.62 years; *SD* = 1.12) Weight: mixed (*M* = 22.68 kg/m^2; *SD* = 4.4) Restraint: not measured /	Type: body prime Medium: images (slideshow) Conditions: thin female or male model; nothing Task: evaluation of rough magazine layouts Exposure: during evaluation	Type: food intake (piece count) Item: pretzels (healthy) Task: free snacking during follow-up questionnaires	No main effect of condition on pretzel intake.	Gender: among participants with high discrepancy status, the nudge decreased consumption for females but increased consumption for males) Discrepancy status: high (but	***High body discrepancy*** Female d = -0.54 95% CI = -1.13, 0.05 Male d = 0.79	***

		reported	task (30 slides shown for 30 seconds each) Engagement: active; attended; not central			not low) discrepancy females decreased eating in response to the nudge while males increased eating	95% CI = 0.06, 1.51 ***Low body discrepancy*** <u>Female</u> d = -0.12 95% CI = -0.70, 0.46 <u>Male</u> d = -0.01 95% CI = -0.69, 0.67	
Incollingo Rodriguez et al., 2015 USA	Design: between-subjects observational study Setting: field Randomisation: non-randomised	*N* = 262 (71.8% female) Source: community (obesity conference attendees) Age: adults (estimated age categories; most [34.7%] aged 40-49 years; range 20-69) Weight: mixed (21.8% underweight; 46.9% normal weight; 31.3% overweight / obese) Restraint: not measured / reported	Type: body cue Medium: images (slideshow) Conditions: thin; overweight; neutral control Task: image of person paired with slideshow of conference tips Exposure: viewed slideshow for at least 3 sec (prior to food choice) Engagement: incidental; unaware; not central	Type: food choice (healthy versus unhealthy) Items: M&Ms, apple slices (or none / both) Task: snack choice (bowl of each food presented next to laptop running slideshow)	Participants exposed to the overweight image were more likely to choose an unhealthy snack than those who viewed the thin image or no image.	Weight / BMI: no effect	Thin versus Nothing d = -0.06 95% CI = -0.47, 0.35 Overweight versus Nothing d = 0.28 95% CI = -0.14, 0.71 Thin versus Overweight d = 0.22 95% CI = -0.14, 0.59	*****
Kawa et al., 2021 Germany	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 904 (gender not measured; cohort estimate = 51.8% female for employees and 40.1% for students) Source: university Age: adults (not reported; range: approx. 17-68 years) Weight: mixed (*M*= 23.3 kg/m^2; *SD* =3.7) Restraint: mot measured / reported	Type: body cue Medium: image Conditions: Giacometti artwork, thin body shapes, thick body shapes, nothing Task: nudges displayed on left-hand corner of screen on every page of online experiment Exposure: throughout food choice measurement Engagement: incidental; obvious; not central	Type: hypothetical food choice (% healthy versus unhealthy choices made) Items: healthy (salad, fruit salad), unhealthy (pudding), or no food Task: ordering of food from virtual cafeteria setting (composed meal for self)	Salad ordering was higher (among staff, not students) in the Giacometti condition. The thin and thick nudges had no effect.	Awareness: greater awareness increased calories ordered from healthy foods in the cue versus control condition, while less awareness resulted in increased calories ordered from unhealthy foods Outcome type: significant effect (among staff) for salad (savour) but not fruit salad or chocolate pudding (sweet)	Thin versus Nothing d = 0.01 95% CI = -0.25, 0.28 Giacometti versus Nothing d = 0.14 95% CI = -0.11, 0.40 Thick versus Nothing d = 0.10 95% CI = -0.16, 0.36 Thin versus Thick d = 0.11 95% CI = -0.15, 0.37 Giacometti versus Thick d = 0.24 95% CI = -0.0, 0.50	*****
Kawa et al., 2022 Germany	Design: one-factorial quasi-experimental design Setting: laboratory / controlled environment Randomisation: not stated	*N* = 91 (50.6% female) Source: schools Age: children (*M* = 17.7 years; range: 7-20) Weight: mixed (*M* = 21.9 kg/m^2 [nudged]; *M* = 22.0 [control]) Restraint: 11% currently dieting	Type: body cue Medium: image (poster) Conditions: gender matched (male/female) thin body; nothing Task: poster on wall in front of participant Exposure: throughout testing Engagement: incidental; obvious; central	Type: food intake (grams) Items: blueberries (healthy) and chocolate (unhealthy) Task: taste test	No main effect of condition on food intake.	Gender: no significant effect but trend for nudge to have more effect for males than females on chocolate consumption and more effect for females than males for blueberry consumption. Outcome type: no effect irrespective of healthy versus unhealthy outcome	***Female*** <u>Blueberries</u> Thin versus Nothing d = 0.28 95% CI = -0.34, 0.90 <u>Chocolate</u> Thin versus Nothing d = -0.03 95% CI = -0.65, 0.59 ***Male***	****

							<u>Blueberries</u> Thin versus Nothing d = -0.09 95% CI = -0.71, 0.53 <u>Chocolate</u> Thin versus Nothing d = -0.44 95% CI = -1.07, 0.19	
Kay, et al. 2023 (Study 1) Australia	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 493 (69.6% female) Source: Mixed university / community (national) Age: adults (*M* = 21 years; *SD* = 2.3; range: 17-25) Weight: mixed (*M* = 24.05 kg/m^2; *SD* = 5.61) Restraint: not measured / reported	Type: drink prime Medium: images (Instagram) Conditions: water, soft drink, no beverage Task: provided feedback on a series of Instagram images (beverage primes subtly incorporated into background) Exposure: during Instagram feedback task Engagement: active; subtle; not central	Type: hypothetical drink choice (healthy versus unhealthy) Item: even mix of healthy foods (e.g., nuts, yoghurt), unhealthy foods (e.g., potato chips, chocolate bars), healthy drinks (e.g., water, flavoured water), and unhealthy drinks (e.g., soft drinks, energy drinks) Task: chose one item from a vending machine display	No main effect of condition on drink versus food choices nor on the healthiness of drink or food choices.	Specificity effect: no effect for the nudged or non-nudged categories	<u>Drink</u> Water versus Non-drink d = -0.06 95% CI = -0.38, 0.26 Soft drink versus Non-drink d = 0.16 95% CI = -0.17, 0.49 Water versus Soft drink d = 0.10 95% CI = -0.24, 0.43 <u>Food</u> Water versus Non-drink d = 0.28 95% CI = -0.13, 0.69 Soft drink versus Non-drink d = -0.16 95% CI = -0.58, 0.27 Water versus Soft drink d = 0.13 95% CI = -0.26, 0.51	*****
Kay et al., 2023 (Study 2) Australia	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 471 (65.6% female) Source: community (national) Age: adults (*M* = 21.38 years; *SD* = 2.22; range: 18-25) Weight: mixed (*M* = 24.42 kg/m^2; *SD* = 6.41)- Restraint: not measured / reported	Type: drink prime Medium: images (Instagram) Conditions: water, soft drink, no beverage Task: provided feedback on a series of Instagram images (beverage primes incorporated into background) Exposure: during Instagram feedback task Engagement: active; subtle; not central	Type: hypothetical drink choice (healthy versus unhealthy) Item: even mix of healthy foods (e.g., nuts, yoghurt), unhealthy foods (e.g., potato chips, chocolate bars), healthy drinks (e.g., water, flavoured water), and unhealthy drinks (e.g., soft drinks, energy drinks) Task: chose one item from a vending machine display	Participants in the soft drink prime condition (versus water prime and control) were more likely to select a drink versus food. No main effect of condition on the healthiness of drink or food choices.		<u>Drink</u> Water versus Non-drink d = 0.07 95% CI = -0.23, 0.37 Soft drink versus Non-drink d = -0.09 95% CI = -0.39, 0.21 Water versus Soft drink d = -0.02 95% CI = -0.32, 0.27 <u>Food</u>	*****

							Water versus Non-drink d = -0.05 95% CI = -0.36, 0.26 Soft drink versus Non-drink d = 0.49 95% CI = -0.01, 0.99 Water versus Soft drink d = 0.43 95% CI = -0.08, 0.94	
Kemps et al., 2016 Australia	Design: 3 (condition) x 2 (outcome food tasted) x 2 (restraint) experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 112 females Source: university Age: adults (*M* = 21.2 years; *SD* = 3.4; range: 17-31) Weight: mixed (*M* = 23.36 kg/m^2; *SD* = 5.24) Restraint: mixed (59.8% restrained)	Type: Food prime Medium: images Conditions: healthy food (grapes); unhealthy food (cookies); combined (grapes and cookies) Task: provided feedback on six food images Exposure: during feedback task (approx. 2-3 min) Engagement: active; attended; central	Type: food intake (grams) Items: grapes or cookies Task: taste test (of one food item; 10 min)	Significant effect of food cue for restrained but not unrestrained eaters. Restrained eaters consumed less (of either food) following exposure to the healthy (grape) cue compared to the unhealthy (cookies) and combined (grape and cookies) cues.	Restraint: restrained eaters ate less food following the healthy versus unhealthy and combined cues; no condition effect among unrestrained eaters Specificity effect: nudge reduced intake (among restrained eaters) regardless of whether provided food matched nudge food Outcome type: no effect Cravings: for restrained eaters, cravings and intake of cookies (but not grapes) decreased following grape cue; no effect in combined cue; cravings followed similar condition effect among unrestrained eaters but did not map onto intake	***Restrained*** Healthy food Healthy food versus combined d = -0.80 95% CI = -1.62, 0.02 Unhealthy food versus combined d = -0.29 95% CI = -1.06, 0.49 Healthy food versus Unhealthy food d = -1.09 95% CI = -1.97, -0.22 Unhealthy food Healthy food versus combined d = 0.75 95% CI = -0.08, 1.57 Unhealthy food versus combined d = -0.09 95% CI = -0.89, 0.71 Healthy food versus Unhealthy food d = 0.70 95% CI = -0.12, 1.53 ***Unrestrained*** Healthy food Healthy food versus combined d = 0.55 95% CI = -0.50, 1.60 Unhealthy food versus combined d = 0.10	***

							95% CI = -0.96, 1.16 Healthy food versus Unhealthy food d = 0.57 95% CI = -0.40, 1.54 Unhealthy food Healthy food versus combined d = 0.13 95% CI = -0.85, 1.11 Unhealthy food versus combined d = 0.63 95% CI = -0.32, 1.59 Healthy food versus Unhealthy food d = 0.84 95% CI = -0.13, 1.81	
Manippa et al., 2019 Italy	Design: crossover Setting: laboratory / controlled environment Randomisation: non-randomised	*N* = 50 females Source: Not clear Age: adults (*M* = 24.1 years; *SD* = 4.3) Weight: normal weight (*M* = 21.6 kg/m^2; *SD* = 2.5) Restraint: not measured / reported	Type: body prime Medium: images Conditions: male and female thin, normal weight, and overweight human shapes; non-human shapes (butterfly, 5-pointed star) Task: shape identification task (20 trials per condition; image order randomised) Exposure: maximum of 3sec exposure to each prime before making food choice Engagement: active; attended; central	Type: hypothetical food choices (% unhealthy versus healthy food choices) Items: sweet and savoury healthy and unhealthy foods Task: multiple selections between high and low calorie foods; 80 unique food pairs based on liking ratings from initial ranking task where indicated preferences for 160 foods; max of 3 seconds to make each food choice (each food pair directly followed exposure to a priming image)	No main effect of primes on choice.	Attention / focus shifting: no difference in number of fixations or fixation durations but significant difference between total dwell time on chosen high calorie foods and prolonged gaze on high versus low calorie foods in the overweight (versus thin and normal weight primes)	Thin versus Non-body d = 0.27 95% CI = -0.13, 0.66 Average weight versus Non-body d = 0.14 95% CI = -0.25, 0.53 Overweight versus Non-body d = -0.14 95% CI = -0.54, 0.25 Thin versus Average d = 0.45 95% CI = 0.05, 0.84 Average weight versus Overweight d = -0.30 95% CI = -0.69, 0.10 Thin versus Overweight d = 0.11 95% CI = -0.28, 0.50	****
Naderer et al., 2018 Austria	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 175 (51.4% female) Source: schools Age: children (*M* = 8.41 years, *SD* = 1.16; range: 6-11) Weight: mixed (*M* = 16.6 kg/m^2; *SD* = 2.51; 22.1% overweight/obese)	Type: food prime Medium: video (cartoons) Conditions: healthy food (mandarins), unhealthy food (fruit gums), no food Task: carefully watched cartoon with food placements integrated	Type: food choice (healthy versus unhealthy) Items: healthy (peeled mandarin) or unhealthy (piece of fruit gum) snack Task: reward choice	Stronger preference for unhealthy snacks in both the healthy and unhealthy cue conditions, compared to the control condition.	Weight: overweight and obese (versus normal weight) children more likely to eat fruit gum in fruit (but not candy) placement condition. Nutrition knowledge: higher preference for fruit cum in candy (versus control	Healthy food versus Non-food d = -0.53 95% CI = -1.00, -0.06 Unhealthy food versus Non-food d = 0.48 95% CI = 0.02, 0.94	****

		Restraint: not measured / reported	Exposure: food placement integrated seven times (approx. 50s each time) throughout cartoon (approx. 6.40-7.06 minutes) Engagement: active; attended, not central			condition) among children with lower knowledge (low, average, mildly high) but not among children with very high knowledge	Healthy food versus Unhealthy food d = -0.05 95% CI = -0.50, 0.41	
Neyens & Smits, 2017 Finland	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 111 (52% female) Source: school Age: children (*M* = 8.8 years; *SD* = 2.1; range: 6-11) Weight: mixed (*M* = 16.8 kg/m^2; *SD* = 1.9; 7.3% overweight) Restraint: not measured / reported	Type: food prime Medium: video (TV show) Conditions: cooking show with sugar portion-size norm; cooking show without sugar portion-size norm; non-food show Task: provided feedback on TV show Engagement: active; attended; central	Type: food intake (grams) Items: pancakes with brown sugar Task: eating of food as 'reward' for participating	Participants in the sugar portion prime condition consumed more pancakes than participants in the no sugar portion prime and control conditions. Participants in the sugar portion prime condition consumed more than participants in the no sugar portion prime condition. Participants in the two food prime conditions used more sugar than children in the control condition. No difference in sugar usage between the two prime conditions.	Age: class grade (no sig interaction but simple effects analyses showed a significant condition effect among the oldest but not youngest children). Weight / BMI: no effect	<u>Portion size cue - included</u> d = 1.00 95% CI = 0.52, 1.49 <u>Portion size cue - not included</u> d = 0.38 95% CI = -0.08, 0.83	***
Ngqangashe et al., 2018 Belgium	Design: experimental two group pre/post-test design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 85 (37.7% female) Source: schools Age: children (*M* = 10.98 years; *SD* = 0.71; range: 9-12) Weight: not measured / reported Restraint: not measured / reported	Type: food prime Medium: video (TV show) Conditions: healthy cooking show; non-food show Task: passive viewing of video Exposure: during television viewing (15 min) Engagement: active; attended; central	Type: food choice (healthy versus unhealthy) Items: mandarin (healthy) or cookie (unhealthy) Task: choice of reward	Participants in the healthy food prime condition were more likely to choose a fruit over a cookie than participants in the control condition.	Desire for foods / attitudes towards foods: no pre-post change Cravings: no moderating effect but cravings for unhealthy foods decreased in the healthy show (versus control) condition Shifting health/nutrition attitudes: no pre-post changes	d = 0.82 95% CI = 0.14, 1.50	***
Ngqangashe & De Backer, 2021 Belgium	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 126 (62% female) Source: schools Age: children (*M* = 13.9 years; *SD* = 1.2; range: 12-14) Weight: not measured / reported Restraint: not measured / reported	Type: food prime Medium: videos (social media) Conditions: health food videos; unhealthy food videos Task: passive viewing of short-form videos Exposure: while viewing videos (4min 7sec) Engagement: active; attended; central	Type: food choice (healthy versus unhealthy) Items: mandarin (healthy) or cookie (unhealthy) Task: choice of reward	No main effect of condition on food choice.	Shifting intentions to eat / prepare foods: intentions to eat sweet snacks mediated the odds of choosing a cookie over a fruit in the unhealthy food condition (intentions to eat fruits or vegetables and intentions to prepare sweet snacks not related to condition)	d = -0.02 95% CI = -0.38, 0.34	****

Ohtomo, 2017 (Study 1) Japan	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 84 females Source: university Age: adults (*M* = 20.74 years; *SD* = 0.66) Weight: not measured / reported Restraint: not reported	Type: Body prime Medium: Images Conditions: thin bodies; non-body-related (animals) Task: provided feedback on series of three images (order randomised) Exposure: while providing feedback Engagement: active; attended; central	Type: food intake (mean number of items taken) Items: packaged pieces of cake Task: reward (invited to take as many cake snacks as they wanted)	Participants took fewer snack in the experimental condition compared to the control.	Diet intention: no effect Eating habits: eating habits increased snacks taken in the control but not priming condition	d = 0.97 95% CI = 0.51, 1.42	****
Ohtomo, 2017 (Study 2) Japan	Design: longitudinal between-subjects experimental design Setting: Field Randomisation: randomly allocated to condition	*N* = 139 females Source: university Age: adults (*M* = 19.35 years; *SD* = 0.61) Weight: not measured / reported Restraint: not reported	Type: Body prime Medium: Image Conditions: thin body; non-body-related (animal) Task: provided feedback on image Exposure: while providing feedback Engagement: active; attended; central	Type: food intake (number of unhealthy snacks consumed) Items: unhealthy snacks (e.g., crisps, popcorn, Japanese high-calorie rice crackers) Task: unhealthy snack consumption for two weeks post nudging intervention	Participants in the priming condition consumed fewer unhealthy snacks than those in the control condition.	Diet intention: no effect Eating habits: significant effect in control but not priming condition	d = 0.39 95% CI = 0.05, 0.73	*****
Ohtomo, 2017 (Study 3) Japan	Design: longitudinal between-subjects experimental design Setting: Field Randomisation: randomly allocated to condition	*N* = 100 females Source: university Age: adults (*M* = 19.46 years; *SD* = 0.62) Weight: not measured / reported Restraint: not reported	Type: Body prime Medium: Image Conditions: thin body; non-body-related (animal) Task: provided feedback on image Exposure: while providing feedback Engagement: active; attended; central	Type: food intake (number of unhealthy snacks consumed) Items: unhealthy snacks (e.g., crisps, popcorn, Japanese high-calorie rice crackers) Task: unhealthy snack consumption for two weeks post nudging intervention	No main effect of condition on food intake.	Diet intention: decreased unhealthy snack consumption in the priming but not control condition Eating habits: no effect Unhealthy willingness: stronger effect in control versus priming condition and mediated the moderating process of habit on the control condition	d = 0.31 95% CI = -0.09, 0.70	*****
Otterbring et al., 2020 Denmark	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 96 females Source: university Age: adults Weight: not measured / reported Restraint: not measured / reported	Type: body prime Medium: video (scenario) Conditions: healthy-appearing person; unhealthy-appearing person Task: viewed video Exposure: while viewing video 15-20 seconds Engagement: active; attended; not central	Type: hypothetical food choice (healthy versus unhealthy) Item: 21 unique healthy and unhealthy cereal options (32 in total; proportion healthy versus unhealthy not stated) Task: exposed to a static image of a supermarket shelf with cereals and asked to choose one alternative they would consider buying	No main effect of condition on food choice.	Shifting attention / focus: the effect of the experimental condition on cereal choices was indirect (through visual attention); visual attention towards seemingly unhealthy cereals did not differ between conditions but participants in the unhealthy condition had significantly larger number of observations towards the seemingly healthy cereals compared to participants in the healthy condition	d = -0.26 95% CI = -0.75, 0.23	**

Petit et al., 2018 (Study 1) France	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 102 (45.1% female) Source: community Age: adults (*M* = 30.65 years; *SD* = 9.38) Weight: not measured / reported Restraint: not measured / reported	Type: perceived portion prime Medium: crockery (plate image) Conditions: small plate (large perceived portion); large plate (small perceived portion) Task: viewed depiction of pizza on plate Exposure: while viewing graphic Engagement: active; attended; central	Type: hypothetical food intake (% would eat) Item: frozen pizza Task: indicated the percentage of pizza they would like to eat in one go	Participants selected a smaller percentage of the pizza on the smaller versus larger plate.	Mental simulations: controlling for the portion size illusion, the self-reported number of mental simulations did not sig affect the percentage of pizza selected	d = 0.44 95% CI = 0.05, 0.84	***
Petit et al., 2018 (Study 2) France	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 76 (29% female) Source: university Age: adults (*M* = 21 years; *SD* = 3.04) Weight: not measured / reported Restraint: not measured / reported	Type: perceived portion prime Medium: crockery (bowl image) Conditions: small bowl (large perceived portion); large bowl (small perceived portion) Task: viewed depiction of cereal in bowl Exposure: while viewing graphic Engagement: active; attended; central	Type: food intake (grams) Item: cereal Task: served themselves cereal	Participants exposed to the smaller bowl image (larger perceived portion) served themselves less than participants exposed to the larger bowl image.	Mental simulations: in the larger portion illusion condition, serving did not differ according to mental simulations but for participants in the smaller portion illusion condition, serving increased for those with medium and high but not low levels of mental simulations	d = 0.50 95% CI = 0.04, 0.95	**
Prinsen et al., 2013 (Study 1) Netherlands	Design: independent groups one-factor design Setting: field Conditions counterbalanced according to time of day	*N* = 144 (gender not measured) Source: eatery (customers of a lunchroom in a local bakery) Age: not measured / reported Weight: not measured / reported Restraint: not measured / reported	Type: food cue Medium: physical (wrappers) Conditions: presence (20 wrappers in bowl besides chocolates) or absence (empty bowl) of empty wrappers. Task: wrappers (or no wrappers) in bowl next to chocolates on bakery countertop which customers pass by when they enter the lunchroom from the bakery Exposure: while at bakery counter Engagement: incidental; obvious; not central	Type: food intake (number of chocolates taken from the bowl; overall, not per participant) Item: chocolate (unhealthy) Task: free access to large transparent bowl with two hundred individually wrapped chocolates in lunchroom of bakery	More chocolates were taken when the wrappers were present versus when there were no wrappers.		d = 0.57 95% CI = 0.06, 1.07	****

Prinsen et al., 2013 (Study 2) Netherlands	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 65 (66.2% female) Source: university Age: adults (*M* = 21.58 years; *SD* = 3.08) Weight: mixed (*M* = 22.0 kg/m^2; *SD* = 3.23) Restraint: not measured / reported	Type: food cue Medium: physical (wrappers) Conditions: presence (10 wrappers) or absence (0 wrappers) of empty wrappers in separate bowl next to bowl of chocolates Task: unobtrusively presented with a bowl of 20 individually wrapped chocolates. Exposure: 10 minutes Engagement: incidental; obvious; not central	Type: food intake (consumed versus not) Item: chocolate Task: free snacking while 'relaxing' for 10 minutes prior to questionnaires	More chocolates were taken when the wrappers were present versus when there were no wrappers.		d = 0.68 95% CI = 0.05, 1.30	*****
Qi & Cui, 2018 (Study 1) China	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 64 females Source: university Age: adults (*M* = 20.78 years; *SD* = 1.46; range: 18-23) Weight: not reported Restraint: not measured / reported	Type: body cue Medium: images (social media) Conditions: thin, neutral Task: viewed 45 images including a thin female body (or product only images in control) before completing a questionnaire Exposure: 10 minutes Engagement: active, attended, not central	Type food intake (calories) Items: chocolate M&Ms and bite-sized cookies. Task: free snacking during cueing task	Participants ate more when exposed to the thin images (versus control).		d = 0.64 95% CI = 0.14, 1.14	*****
Qi & Cui, 2018 (Study 2) China	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 159 females Source: university Age: adults (*M* = 20.49 years; *SD* = 2.05; range: 19-26) Weight: mixed (*M* = 21.7 kg/m^2; *SD* =2.24; range: 18.92 – 24.67) Restraint: not measured / reported	Type: body cue Medium: images (social media) Conditions: thin + high SES (as in Study 1); thin + parallel-perceived SES; neutral (as in Study 1) Task: viewed 45 images including a thin female body (or product only images in control) before completing a questionnaire Exposure: 10 minutes Engagement: active; attended; not central	Type food intake (calories) Items: chocolate M&Ms and bite-sized cookies. Task: free snacking during cueing task	Participants ate more when exposed to the high-SES thin images (versus control). Participants ate less when exposed to the parallel- versus high-SES thin images. Consumption was similar between the parallel-SES and control conditions.		<u>Perceived SES: higher</u> d = -8.42 95% CI = -9.61, -7.22 <u>Perceived SES: equal</u> d = 1.21 95% CI = 0.79, 1.62	*****
Reutner et al., 2015 (Study 1) Switzerland	Design: 2 (condition) x 2 (outcome type) between-subjects experimental design. Setting: laboratory / controlled environment Randomisation: randomly	*N* = 82 (84.2% female) Source: university Age: adults (*M* = 21.93 years; *SD* = 5.35; range: 16-55) Weight: not measured / reported	Type: colour cue Medium: crockery (plate) Conditions: red or white plate Task: food presented on coloured plate while participants completed a neutral filler task	Type: food intake (piece count) Item: 10 squares of chocolate (unhealthy) or 10 grapes (healthy) Task: free snacking while completing neutral filler task	The red plate reduced consumption of chocolate but not grapes, compared to the white plate.	Gender: no effect Type of outcome: red reduced consumption chocolate but not grape consumption	<u>Grapes</u> d = -0.06 95% CI = -0.66, 0.53 <u>Chocolate</u> d = 0.83 95% CI = 0.17, 1.49	**

	allocated to condition	Restraint: not measured / reported	Exposure: during filler task (15 minutes) Engagement: incidental; unaware; not central					
Rolls et al., 2007 (Study 1) USA	Design: crossover Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 45 (48.9% female) Source: university Age: adults (*M* = 22.09 years; *SD* = 0.13; range: 20-45) Weight: mixed (normal / overweight [18 - 40 kg/m^2]; *M* = 22.9; *SD* = 0.14; 20% overweight) Restraint: non-dieting (*Mean restraint score* = 5.72, *SD* = 0.22)	Type: perceived portion cue Medium: crockery (plate) Conditions: small (17cm), medium (22cm), or large (26cm) white glass plate Task: attended lunch session once a week for 3 weeks; on each day were provided with an empty plate Exposure: while serving and consuming food Engagement: incidental; unaware; central	Type: food intake (grams) Item: macaroni & cheese Task: served and consumed food	No main effect of condition on intake.	Age: no interaction effect Gender: no effect (sig main effect – males consumed more than females) Weight / BMI: no effect Restraint: no effect Eating attitudes: no effect Tendency towards hunger: no effect Disinhibition: no effect	Small versus Medium d = -5.09 95% CI = -5.94, -4.24 Large versus Medium d = 5.96 95% CI = 4.99, 6.92 Small versus Large d = 0.87 95% CI = 0.44, 1.30	***
Rolls et al., 2007 (Study 2) USA	Design: crossover Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 30 (50% female) Source: university Age: adults (*M* =27.15 years; *SD* = 0.41; range: 20-45) Weight: mixed (normal / overweight [18 - 40 kg/m^2]; *M* = 23.8; *SD* = 0.20; 20% overweight) Restraint: non-dieting (*Mean restraint score* = 8.65, *SD* = 0.34)	Type: perceived portion cue Medium: crockery (plate) Conditions: small (22cm), or large (26cm) white glass plate Task: attended lunch session once a week for 2 weeks; on each day were provided with an empty plate Exposure: while consuming food Engagement: incidental; unaware; central	Type: food intake (grams) Item: macaroni & cheese Task: consumed pre-served food	No main effect of condition on intake.	Age: no interaction effect Gender: no effect (sig main effect: males consumed more than females) Weight / BMI: no effect Restraint: no effect Eating attitudes: no effect Tendency towards hunger: no effect Disinhibition: no effect	d = 0.39 95% CI = -0.12, 0.90	***
Rolls et al., 2007 (Study 3) USA	Design: crossover Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 44 (50% female) Source: university Age: adults (*M* = 22.65 years; *SD* = 011; range: 20-45) Weight: mixed (normal / overweight [18 - 40 kg/m^2]; *M* = 22.6; *SD* = 0.09; 14% overweight) Restraint: non-dieting (*Mean restraint score* = 6.5, *SD* = 0.15)	Type: perceived portion cue Medium: crockery (plate) Conditions: small (17cm), medium (22cm), or large (26cm) white glass plate Task: attended lunch session once a week for 3 weeks; on each day were provided with an empty plate Exposure: while serving and consuming food Engagement: incidental; unaware; central	Type: food intake (grams) Items: buffet comprising large quantities of five foods (chicken and noodles, macaroni and cheese, green bean casserole, broccoli salad, and sweet potato casserole) Task: served chosen foods onto plate from buffet; multiple trips permitted.	No main effect of condition on intake.	Age: no interaction effect Gender: no effect (sig main effect: males consumed more than females) Weight / BMI: no effect Restraint: no effect Eating attitudes: no effect Tendency towards hunger: no effect Disinhibition: no effect	Small versus Medium d = -0.21 95% CI = -0.63, 0.21 Large versus Medium d = 0.31 95% CI = -0.11,0.73 Small versus Large d = 0.09 95% CI = -0.32, 0.51	***

Sharps et al., 2020 (Study 1) UK	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 63 (60.3% female) Source: schools Age: children (*M* = 8.9 years; *SD* = 1.41; range: 6-11) Weight: Mixed (*z*BMI: *M* = 0.27, range = -3.25-2.97 [nudge]; *M* = 0.09, range = -2.61-1.75 [control]; 73% healthy weight) Restraint: not measured / reported	Type: food cue Medium: crockery (plate) Conditions: healthy food (grapes), nothing Task: image of grapes (or no image) on bottom of plate Exposure: while serving and consuming food Engagement: incidental; obvious; central	Type: food intake (grams) Item: grapes Task: filled plate from bowl of grapes; 7 min for consumption before completing unrelated game	Fruit consumption was higher in the cue condition compared to the control condition.	Gender: no effect	d = 0.62 95% CI = 0.11, 1.13	****
Sihvonen & Luomala, 2017 Finland	Design: between-subjects experimental design Setting: not clear Randomisation: non-randomised	*N* = 654 (66% female) Age: adults (*M* = 46.2 years; *SD* = 23.3) Weight: not measured / reported Restraint: not measured / reported	Type: food prime Medium: video Conditions: health, responsibility, status, nothing Task: evaluated video Exposure: while viewing video Engagement: active; attended, central	Type: hypothetical food choice (number of healthy items chosen) Items: 7 target categories – choice between 4 alternatives (linked to health, responsibility, status, or no symbolism) in each category (coffee, yoghurt, pork cold cuts, orange juice, gouda cheese, chicken fillet strips, and eggs); only included choice of healthy item in analyses Task: made grocery choices from 14 product categories (7 target)	Participants in primed conditions (health, responsibility, status) all selected a greater number of healthy options compared to participants in the control condition.	Pre-existing (non-food) values: participants chose more healthier foods in the prime versus control condition if high in achievement (health-prime), control (responsibility-prime), or universalism (status-prime) participants high in achievement value chose healthier foods in the health prime versus control condition	Healthy food versus Nothing d = 0.31 95% CI = 0.10, 0.53 Responsibility versus Nothing d = 0.34 95% CI = 0.12, 0.56 Status versus Nothing d = 0.26 95% CI = 0.04, 0.47	***
Simon & Hurst, 2021 UK	Design: between-subjects experimental design Setting: online Randomisation: randomly allocated to condition	*N* = 167 females Source: university Age: adults (estimated *M* = 27.74 years [category-based response]; range: 18-50+) Weight: mixed (*M* = 26.99 kg/m^2; *SD* = 8.0; range: 16.69 – 56.92) Restraint: not measured / reported	Type: body prime Medium: image (social media) Conditions: average-sized body, overweight body, neutral Task: viewed three body-positive images (no non-body, holiday posts in control) Exposure: at least 2 minutes Engagement: active; attended, central	Type: hypothetical meal choice (number of healthy items chosen) Items: 17-item menu containing mix of healthy and unhealthy drinks, mains, sides, and desserts Task: selected lunch from menu	No main effect of condition on total calories selected or percentage of nutritious choices.		Overweigh versus Non-body d = 0.33 95% CI = -0.04, 0.70 Average weight versus Non-body d = -1.32 95% CI = -1.73, -0.91 Average weight versus overweight d = -1.64 95% CI = -2.07, -1.21	****

Stämpfli & Brunner, 2016 Switzerland	Design: 2 (condition) x 2 (cognitive load) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: not stated	*N* = 128 (73.4% female) Source: community Age: adults (*M* = 46.35 years; *SD* = 14.2) Weight: not measured / reported Restraint: not measured / reported	Type: body prime Medium: image (screensaver) Conditions: thin (Giacometti), neutral (white) Task: image of three Giacometti sculptures as screensaver, moving in front of a black background (or static white image in control) Exposure: approx. 30 seconds while seating themselves Engagement: incidental, obvious, central	Type: food intake (grams) Items: 20 plain chips Task: taste test (5 min)	Participants in the Giacometti condition consumed significantly less than participants in the control condition.	Attention / concentration: nudge effect occurred independent of cognitive load Awareness: no effect Liking of outcome foods: nudge had effect when liking ratings relatively high but not when relatively low	d = 0.39 95% CI = 0.04, 0.74	**
Stämpfli et al., 2017 (Study 1) Switzerland	Design: 2 (condition) x 2 (outcome type) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: not stated	*N* = 114 (61.95% female) Source: Mixed: university and community (consumer panel) Age: adults (*M* = 31.72 years; *SD* = 14.11) Weight: not measured / reported Restraint: not reported	Type: body cue Medium: image (screensaver) Conditions: thin (Giacometti), neutral (blue screen) Task: screensaver projected (or not) onto screen in testing room Exposure: throughout testing Engagement: incidental; obvious; central	Type: food intake (grams) Items: 20 chocolates or 20 blueberries Task: taste test (5 min)	Participants in the Giacometti condition consumed significantly less than participants in the control condition.	Restraint: significant nudge effect for restrained but not unrestrained eaters Type of outcome: no effect of food healthiness	d = 0.39 95% CI = 0.02, 0.76	**
Stein et al., 2016 USA	Design: 2 (condition) x 2 (self-control) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 84 (65.5% female) Source: university Age: adults (*M* =18.6 years, *SD* = 1.0) Weight: (*M* = 23.03 kg/m^2; *SD* = 3.85; range: 16.22 – 36.51; 23.8% overweight) Restraint: mixed (*Mean restrain score* = 6.36, *SD* = 0.46)	Type: body prime Medium: image (poster) Conditions: healthy (three posters depicting runners / athletes), neutral artwork Task: three posters hung on wall Exposure: approx. 20sec while listening to script from researcher Engagement: active, attended, central	Type: food intake (kcal) Items: cookies, chocolate, and potato chips Task: taste test (5 min)	No main effect of condition of food intake.	BMI: no effect Restraint: no effect Exercise: high exercisers consumed less in prime versus control condition; no difference among low exercisers Compensatory eating tendency: no effect Self-control (during outcome measurement); no effect	<u>Self-control: fatigued</u> d = 0.25 95% CI = -0.36, 0.86 <u>Self-control: regular</u> d = 0.28 95% CI = -0.33, 0.89	****
Stöckli et al., 2016 (Study 1) Switzerland	Design: observational one factorial within-subjects design Setting: field (university campus) Randomisation: non-randomised	*N* = 528 (83.3% female) Source: university Age: adults (*M* = 29.6 years; *SD* = 9.77) Weight: not measured / reported Restraint: not measured / reported *Note: demographic data estimated from a small sub-sample*	Type: body cues Medium: image (poster) Conditions: nature, activity, fun-fair, no poster Task: three posters displayed alongside vending machine for one week (each condition applied for one week) Exposure: while making purchase from vending machine Engagement: incidental,	Type: food choice (total number of healthy versus unhealthy snack foods purchased from machine) Items: combination of approx. 15 different types of healthy (e.g., fruit, yoghurt, trail mix) and unhealthy (e.g., chocolate, chips, crackers) snack products (naturalistic vending machine items) Task: purchased product(s)	Healthy snacks were chosen more frequently in the nature condition compared to the fun-fair and control conditions. Healthy snacks were chosen marginally more frequently in the activity condition compared to the fun-fair condition. No difference in snack choices between the nature		Nature versus Nothing d = 0.37 95% CI = 0.04, 0.70 Nature versus Fun fair d = 0.50 95% CI = 0.17, 0.84 Exercise versus Nothing d = 0.20 95% CI = -0.15, 0.55 Exercise versus Fun fair	*****

			obvious, central	from vending machine (3 locations)	and activity conditions nor between the activity and control conditions.		d = 0.33 95% CI = -0.02, 0.68 Fun fair versus Nothing d = 0.13 95% CI = -0.23, 0.49	
Stöckli et al., 2016 (Study 2) Switzerland	Design: observational one factorial within-subjects design Setting: field (workplace) Randomisation: non-randomised	*N* = 252 (61.8% females) Source: community Age: adults (*M* = 42.53 years; *SD* = 10.34) Weight: not measured / reported Restraint: not measured / reported *Note: demographic data estimated from a small sub-sample*	Type: body cues Medium: image (poster) Conditions: Giacometti, activity, fun-fair, no poster Task: three posters displayed alongside vending machine for one week (each condition applied for one week) Exposure: while making purchase from vending machine Engagement: incidental, obvious, central	Type: food choice (total number of healthy versus unhealthy snack foods purchased from machine) Items: combination of healthy (range of natural snacks and drinks) and unhealthy (range of chocolate, chips, and soft drinks) snack products (naturalistic vending machine items) Task: purchased product(s) from vending machine	Healthy snacks were chosen more frequently in the Giacometti condition compared to the fun-fair and control conditions and marginally more frequently than in the activity condition. Healthy snacks were chosen more frequently in the activity condition compared to the control condition and marginally more frequently compared to the fun-fair condition.		Giacometti versus Nothing d = 0.97 95% CI = 0.36, 1.59 Giacometti versus Fun fair d = 0.73 95% CI = 0.30, 1.16 Exercise versus Nothing d = 0.63 95% CI = 0.02, 1.24 Exercise versus Fun fair d = 0.39 95% CI = -0.02, 0.81 Fun fair versus Nothing d = -0.24 95% CI = -0.87, 0.40	*****
Szuhany & Otto, 2020 USA	Design: between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 102 (56% females) Source: university Age: adults (*M* = 19.2 years; *SD* = 1.4; range: 18-25) Weight: mixed (*M* = 23.3 kg/m^2; *SD* = 3.5; range: 17-39; 26% overweight / obese) Restraint: not measured / reported	Type: body prime Medium: video (TV show) Conditions: overweight, normal weight, neutral Task: watched short video segment from popular television show depicting overweight or normal weight people vigorously exercising (or a no-exercise idol show containing participants of average and overweight status); recorded as many details of video as could remember post-viewing Exposure: while watching video (5 min) Engagement: active, attended, central	Type: food intake (calories) Items: chips, M&Ms, and cookies Task: taste test (7 min)	Participants in the normal weight condition consumed more than those in the overweight/obese condition (trend for greater consumption in control versus overweight/obese condition)	BMI: no effect	Exercise (OW) versus Non-body d = 0.53 95% CI = 0.04, 1.01 Exercise versus Non-body d = -0.17 95% CI = -0.65, 0.31 Exercise versus Exercise (OW) d = -0.71 95% CI = -1.20, -0.23	*****

Tom & Rucker, 1975 USA	Design: 2 (condition) x 2 (participant weight) x 2 (hunger) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: not stated	*N* = 80 (gender not reported) Source: university Age: adults (mean not reported) Weight: mixed (50% obese) Restraint: not measured / reported	Type: food prime Medium: image Conditions: food, neutral (scenery) Task: rated appeal of series of 35 slides Exposure: during rating task Engagement: active, attended, central	Type: food intake (piece count) Items: crackers (5 types) Task: taste test (15 min)	Significant main effect of condition on number of crackers eaten. Participants consumed more in the food prime versus control condition.	Weight: condition effect (increased cracker consumption) for obese but not normal weight participants	***Normal weight*** Full d = -0.37 95% CI = -1.25, 0.51 Hungry Food versus Non-food d = -1.13 95% CI = -2.07, -0.18 ***Obese*** Full Food versus Non-food d = 3.73 95% CI = 2.28, 5.18 Hungry Food versus Non-food d = 2.35 95% CI = 1.21, 3.49	**
Tonkin et al., 2019 Australia	Design: 3 (condition) x 2 (restraint) between-subjects experimental design Setting: laboratory / controlled environment Randomisation: randomly allocated to condition	*N* = 210 females Source: university Age: adults (*M* = 21.57 years; *SD* = 3.33; range: 18-32) Weight: mixed (*M* = 23.27 kg/m^2, *SD* = 4.93) Restraint: mixed (51.4% restrained)	Type: Food prime or cue Medium: Image (on menu) Conditions: healthy food (basket of fruits and vegetables); non-food control Task: nudge presented on cover (prime) or at top of menu (cue) Exposure: while viewing cover of menu (prime) or while selecting food (cue) Engagement: incidental; obvious; not central	Type: hypothetical food choice (% healthy versus unhealthy choices made) Items: 2 healthy and 2 unhealthy meal, afters, and beverage options (e.g., chicken salad or burger and chips, fruit salad or chocolate brownie, peppermint tea or chocolate shake) Task: selected one item from each of the three menu sections	Participants in the healthy prime condition made significantly more healthy choices than participants in the healthy cue and control conditions. No difference between the healthy cue and control conditions.	Restraint: condition effect more pronounced for restrained eaters (chose more healthy options than unrestrained eaters in the healthy prime condition but no difference in cue or control conditions) Type of outcome: no effect (significant condition effect for all food categories – meals, afters, beverages)	Savoury Prime versus Non-food d = 0.95 95% CI = 0.51, 1.38 Cue versus Non-food d = 0.11 95% CI = -0.31, 0.54 Sweet Prime versus Non-food d = 0.70 95% CI = 0.27, 1.13 Cue food versus Non-food d = 0.28 95% CI = -0.16, 0.71 Drink Prime versus Non-food d = 0.92 95% CI = 0.48, 1.35 Cue versus Non-food d = 0.28 95% CI = -0.13, 0.69	****

Supplementary Material C

Quality Assessment

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	4.5	5.1	5.2	5.3	5.4	5.5
Akyol et al.	2018						1	1	1	0	1														
Alblas et al.	2021						0	0	1	1	1														
Anschutz et al.	2008						0	0	1	1	1														
Anschutz & Engels	2010						1	1	1	1	1														
Aronow et al.	2018						1	0	1	0	0														
Bates et al.	2015						0	0	1	0	1														
Benito-Ostolaza et al.	2021						1	1	1	0	1														
Bittner & Kulesz (Study 1)	2015						0	0	1	1	1														
Bittner & Kulesz (Study 2)	2015						0	0	1	1	1														
Blížkovská	2017											1	1	0	1	1									
Bodenlos & Wormuth	2013						1	1	1	1	1														
Bourn et al.	2015						1	1	1	0	1														
Brunner & Siegrist (Study 1)	2012						0	0	1	0	1														
Buckland et al.	2014						1	1	1	1	1														
Campbell et al. (Study 1)	2016						0	0	1	0	1														
Campbell et al. (Study 2)	2016						0	0	1	0	1														
Campbell et al. (Study 3)	2016						0	0	1	0	1														
Coelho et al.	2009						1	1	1	1	1														
Deek et al.	2022						1	1	1	1	1														
Dolezalova et al.	2021						1	0	1	0	1														
Döring & Wansink	2017											1	1	1	1	1									
Folkvord & Laguna-Camacho	2019						1	1	1	0	1														
Folkvord et al.	2020						0	1	1	0	1														
Genschow et al. (Study 1)	2012						0	0	1	0	1														
Genschow et al. (Study 2)	2012						0	0	1	0	1														
Gueguen et al.	2012						1	0	1	1	1														
Harrison et al.	2006						0	0	1	1	1														
Incollingo Rodriguez et al.	2016											1	1	1	1	1									
Kawa et al.	2021						1	1	1	1	1														
Kawa et al.	2022						0	1	1	1	1														
Kay et al. (Study 1)	2023						1	1	1	1	1														

Kay et al. (Study2)	2023	1	1	1	1	1						
Kemps et al.	2016	1	0	1	0	1						
Manippa et al.	2019						1	1	1	0	1	
Naderer et al.	2018	0	1	1	1	1						
Neyens & Smits	2017	0	1	1	0	1						
Ngqangashe et al.	2018	0	1	1	0	1						
Ngqangashe & De Backer	2021	0	1	1	1	1						
Ohtomo (Study 1)	2017	1	1	1	0	1						
Ohtomo (Study 2)	2017	1	1	1	1	1						
Ohtomo (Study 3)	2017	1	1	1	1	1						
Otterbring et al.	2020	0	0	1	0	1						
Petit et al. (Study 1)	2018	0	0	1	1	1						
Petit et al. (Study 2)	2018	0	0	1	0	1						
Prinsen et al. (Study 1)	2013	1	0	1	1	1						
Prinsen et al. (Study 2)	2013	1	1	1	1	1						
Qi & Cui (Study 1)	2018	1	1	1	1	1						
Qi & Cui (Study 2)	2018	1	1	1	1	1						
Reutner et al. (Study 1)	2015	0	0	1	0	1						
Rolls et al. (Study 1)	2007	0	1	1	0	1						
Rolls et al. (Study 2)	2007	0	1	1	0	1						
Rolls et al. (Study 3)	2007	0	1	1	0	1						
Sharps et al. (Study 1)	2020	1	0	1	1	1						
Sihvonen & Luomala	2017						0	1	1	0	1	
Simon & Hurst	2021	1	0	1	1	1						
Stämpfli & Brunner	2016	0	0	1	0	1						
Stampfli et al. (Study 1)	2017	0	0	1	0	1						
Stein et al.	2018	1	1	1	0	1						
Stöckli et al. (Study 1)	2016						1	1	1	1	1	
Stöckli et al. (Study 2)	2016						1	1	1	1	1	
Szuhany & Otto	2019	1	1	1	1	1						
Tom & Rucker	1975	0	0	1	0	1						
Tonkin et al.	2019	1	1	1	0	1						

Supplementary Material D

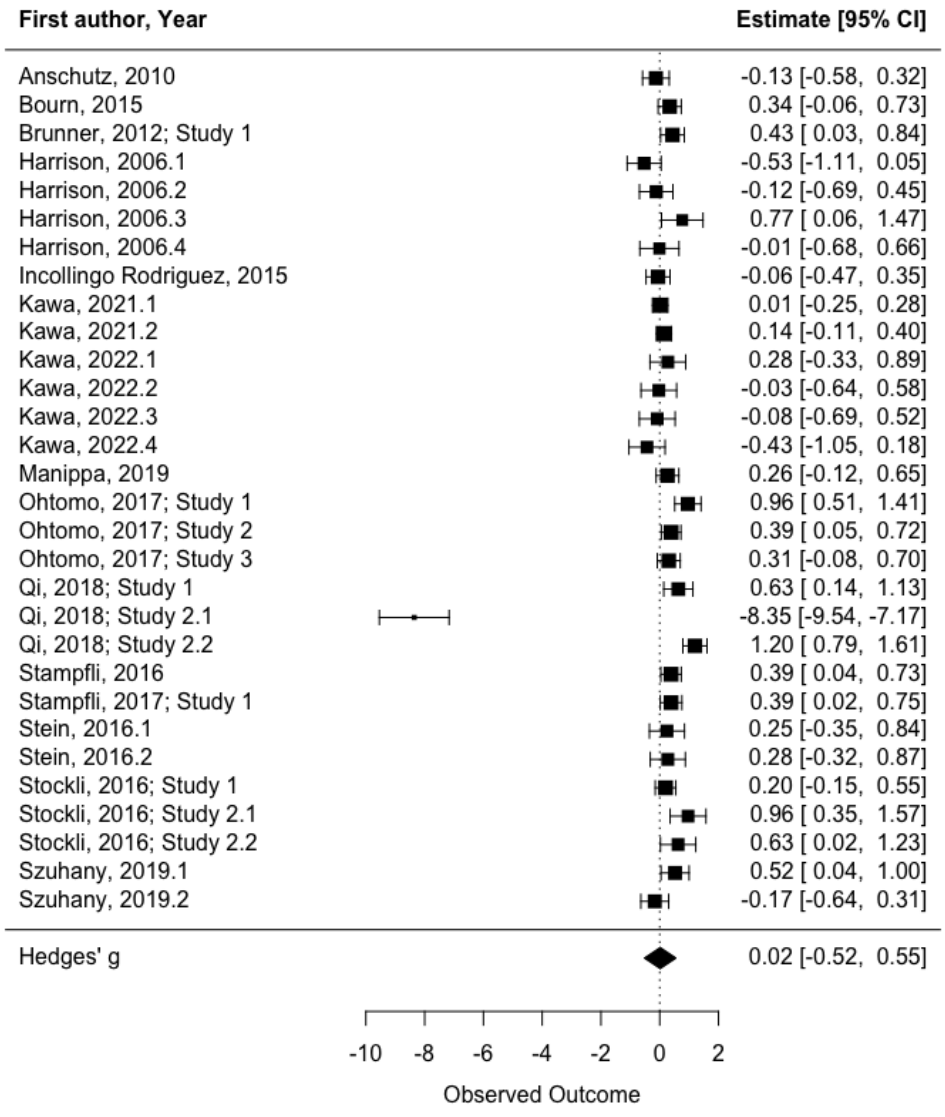
Results of models with outliers retained

Category 2. Healthy versus control body-related nudges

The pooled effect size indicated that, for the model with outliers retained, healthy body-related nudges do not significantly influence consumption-related behaviours, relative to neutral control conditions, Hedges' g = 0.02, 95% CI = -0.52, 0.56, p = .951 (See Fig D1 for Forest Plot). Heterogeneity was very high (Q = 274.64, p < .001, I^2 = 97.52) and was attributed to within-study variance (I^2 = 97.52; between-study I^2 = 0.00).

Fig D1

Category 2 forest plot with outliers retained

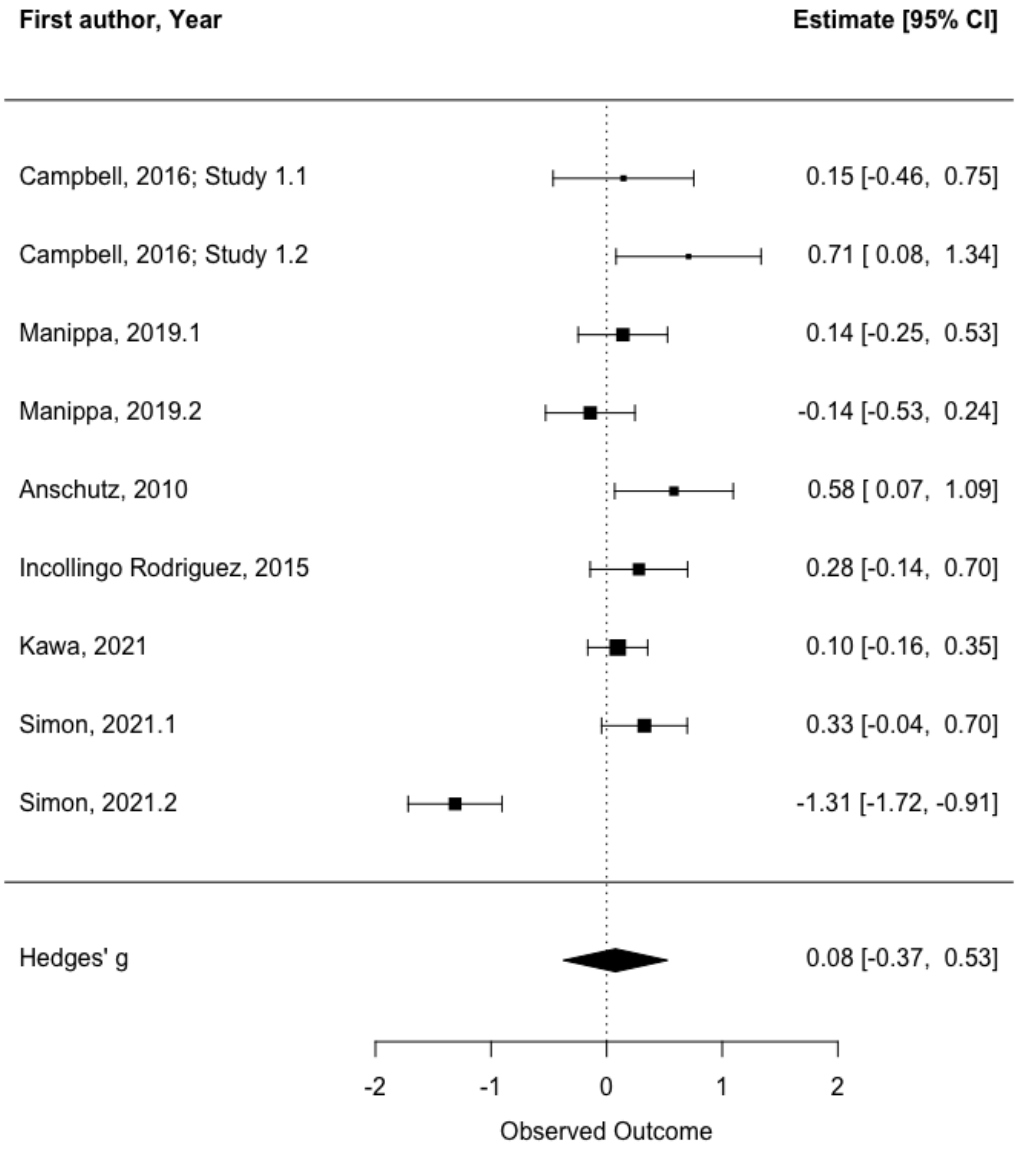


Category 4: Unhealthy body-related nudges versus neutral controls

The pooled effect size, for the model with outliers retained, indicated that unhealthy nudges do not significantly influence consumption-related behaviours relative to neutral controls, Hedges' $g = 0.08$, 95% CI = -0.37, 0.52, $p = .707$ (see Fig D2 for Forest Plot). Heterogeneity was moderate ($Q = 56.16$, $p < .001$, $I^2 = 87.06$) and was attributed to within-study variance ($I^2 = 87.06$; between-study $I^2 = 0.00$).

Fig D2

Category 4 forest plot with outlier retained

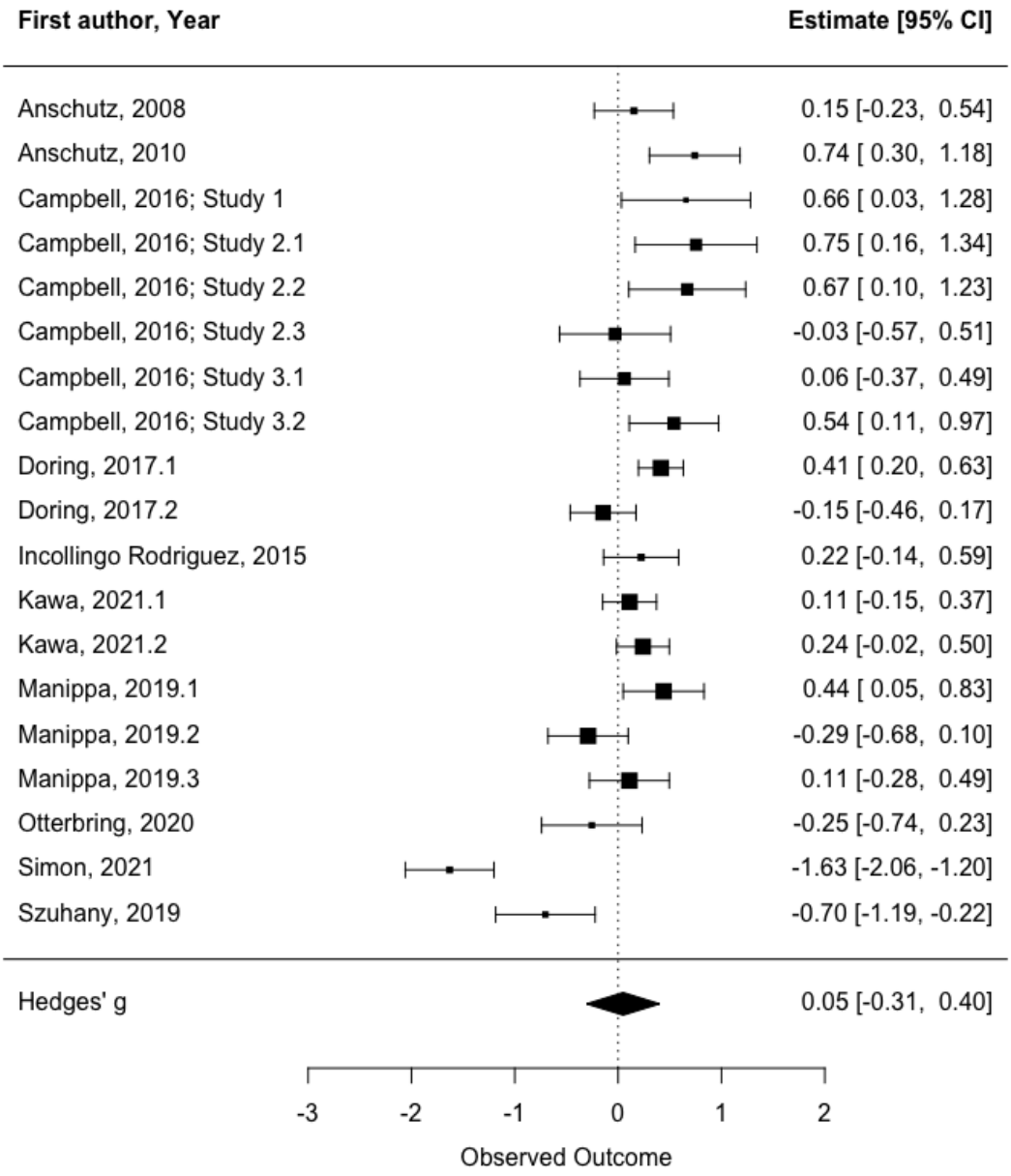


Category 6. Mixed-health body-related nudges

The pooled effect size, for the model with outliers retained, indicated that healthier body-related nudges do not significantly influence consumption-related behaviours, relative to less healthy nudges, Hedges' g = 0.05, 95% CI = -0.31, 0.40, p = .778 (See Fig D3 for Forest Plot). Heterogeneity was very high (Q = 117.85, p < .001, I^2 = 90.03) and was attributed to both within-study (I^2 = 27.1) and between-study (I^2 = 62.92) variance.

Fig D3

Category 6 forest plot with outliers retained

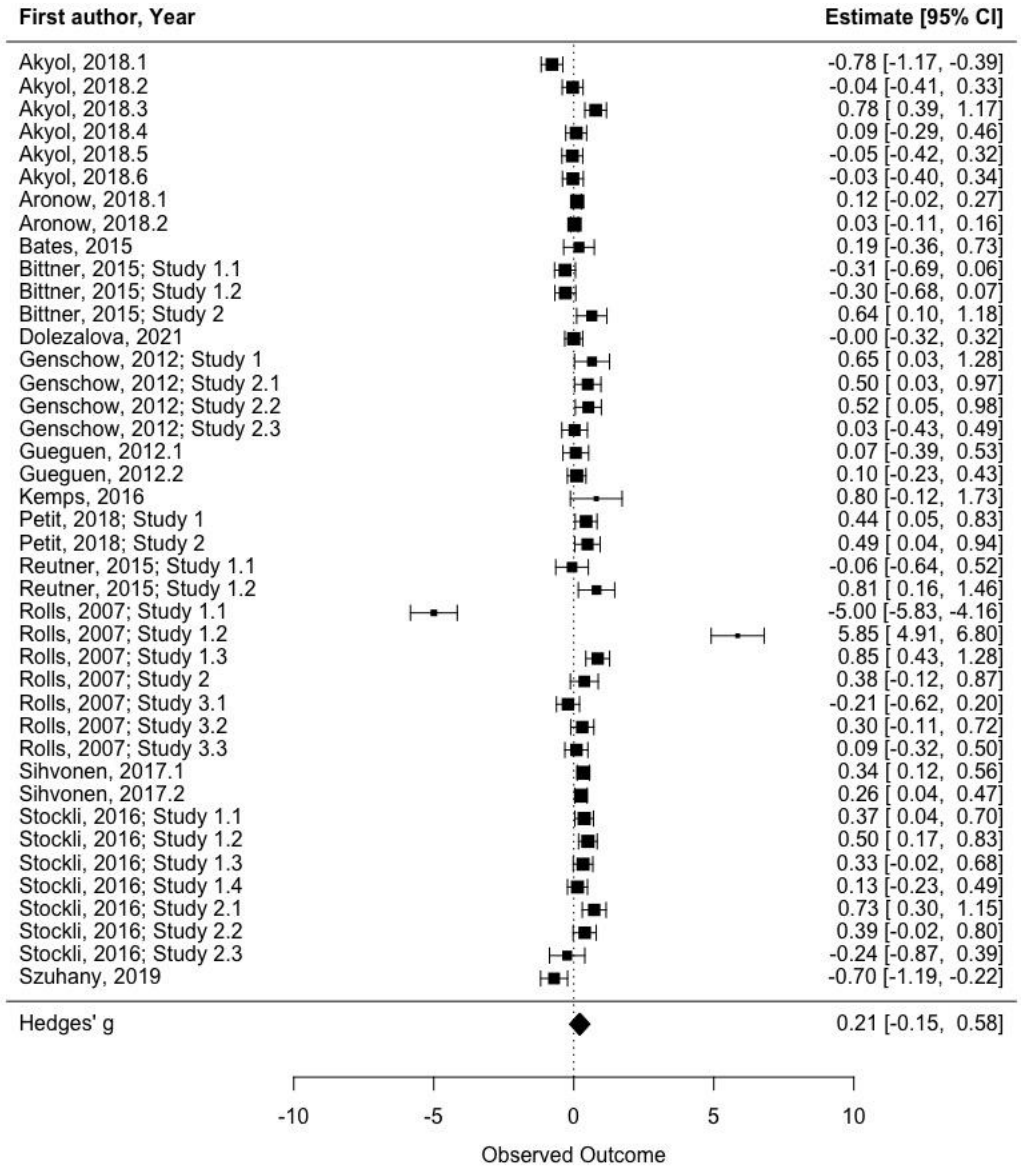


Category 7. Not inherently health-related nudges

The pooled effect size, for the model with outliers retained, indicated that nudges not inherently related to health do not significantly influence consumption-related behaviours, relative comparison conditions, Hedges' g = 0.21, 95% CI = 0.15, 0.58, p = .245 (See Fig D3 for Forest Plot). Heterogeneity was very high (Q = 405.94, p < .001, I^2 = 97.56) and was attributed to within-study variance (I^2 = 97.56; between-study I^2 = 0.00).

Fig D3

Category 7 forest plot with outliers retained



Supplementary Material E

Publication Bias Funnel Plots

Fig E1
Category 1 Funnel Plot (full model; outliers retained)

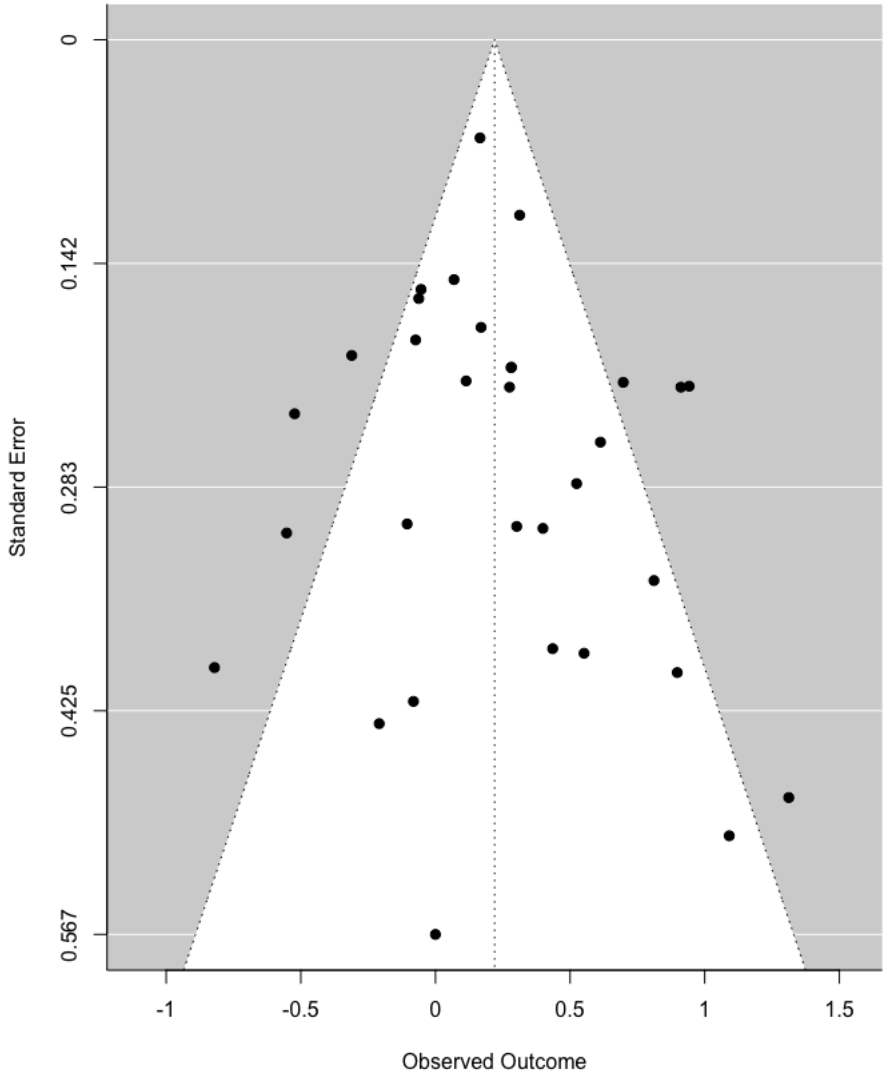


Fig E2
Category 2 Funnel Plot (full model; outliers retained)

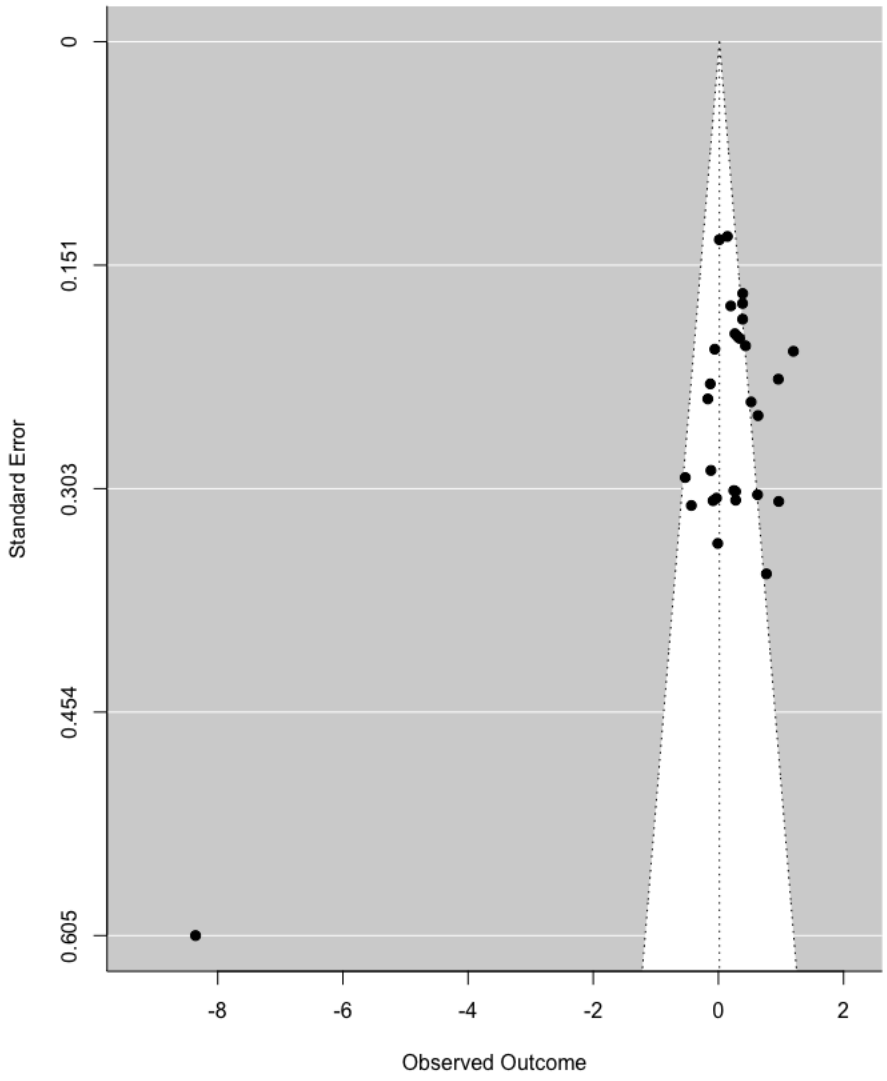


Fig E3
Category 3 Funnel Plot (full model; outliers retained)

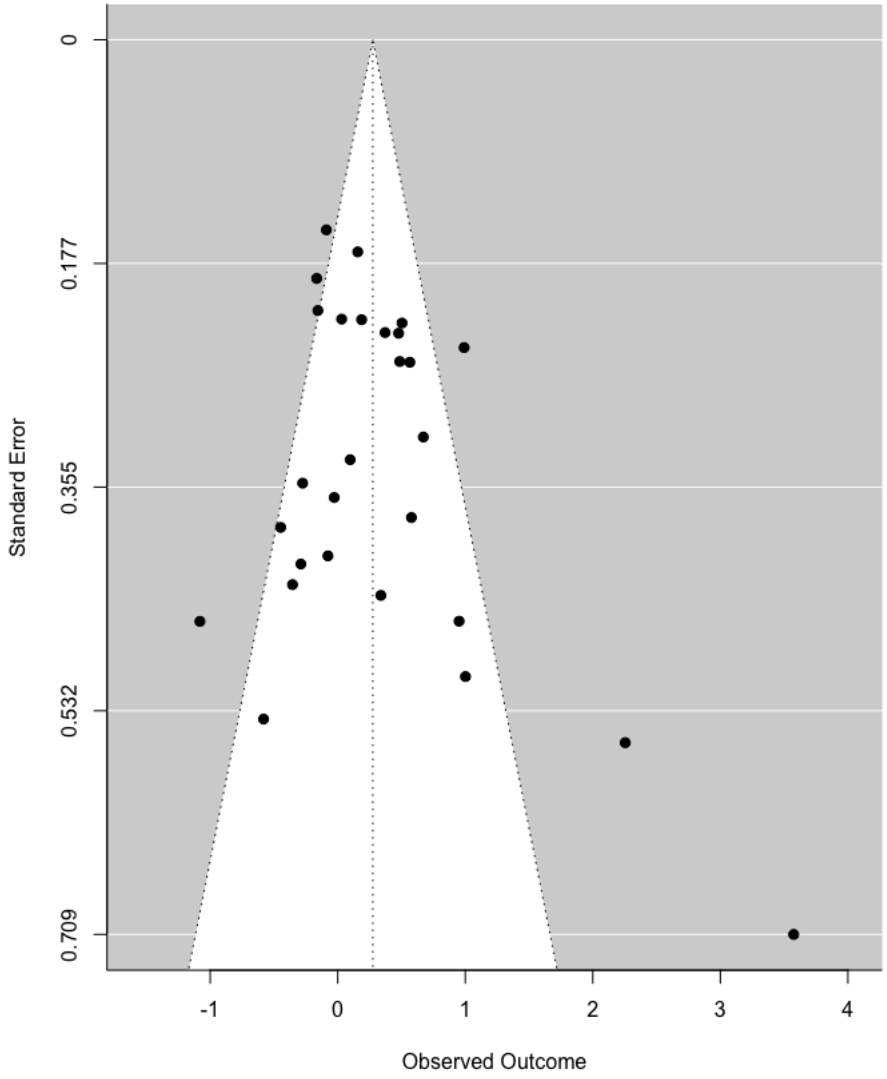


Fig E4
Category 4 Funnel Plot (full model; outliers retained)

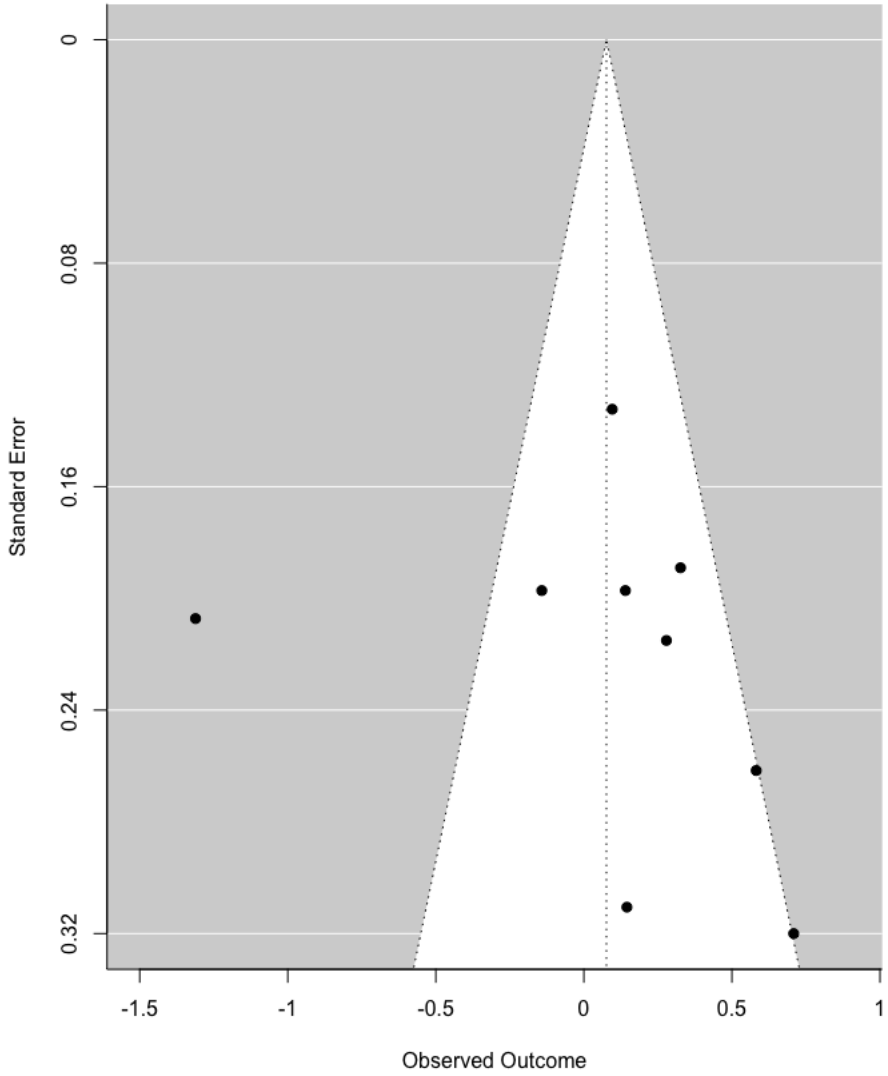


Fig E5
Category 5 Funnel Plot (full model; outliers retained)

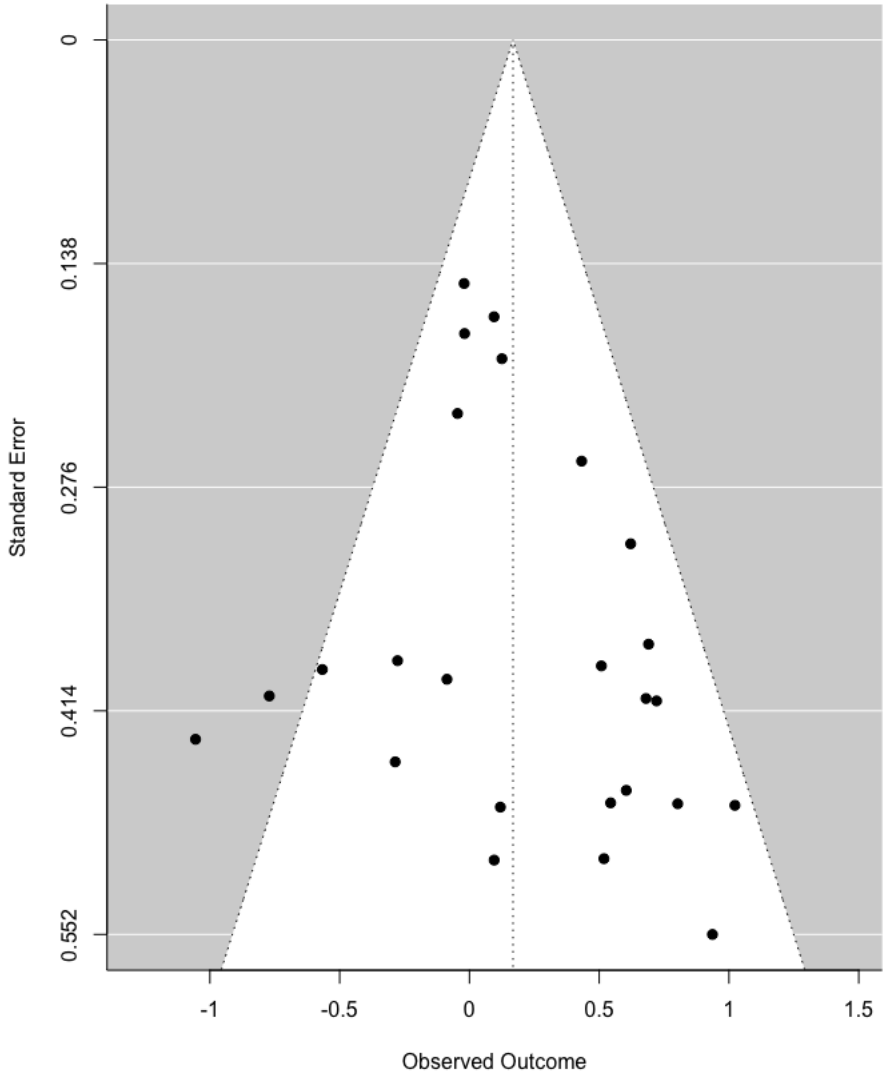


Fig E6
Category 6 Funnel Plot (full model; outliers retained)

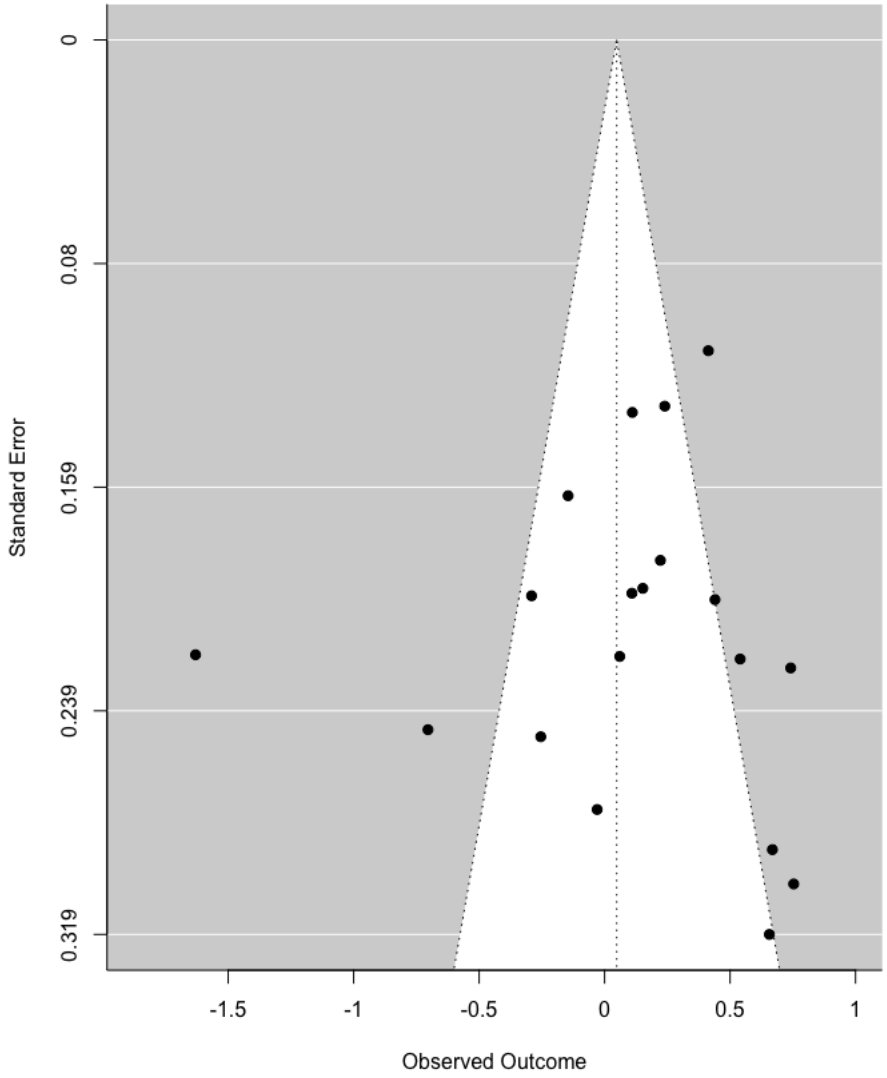
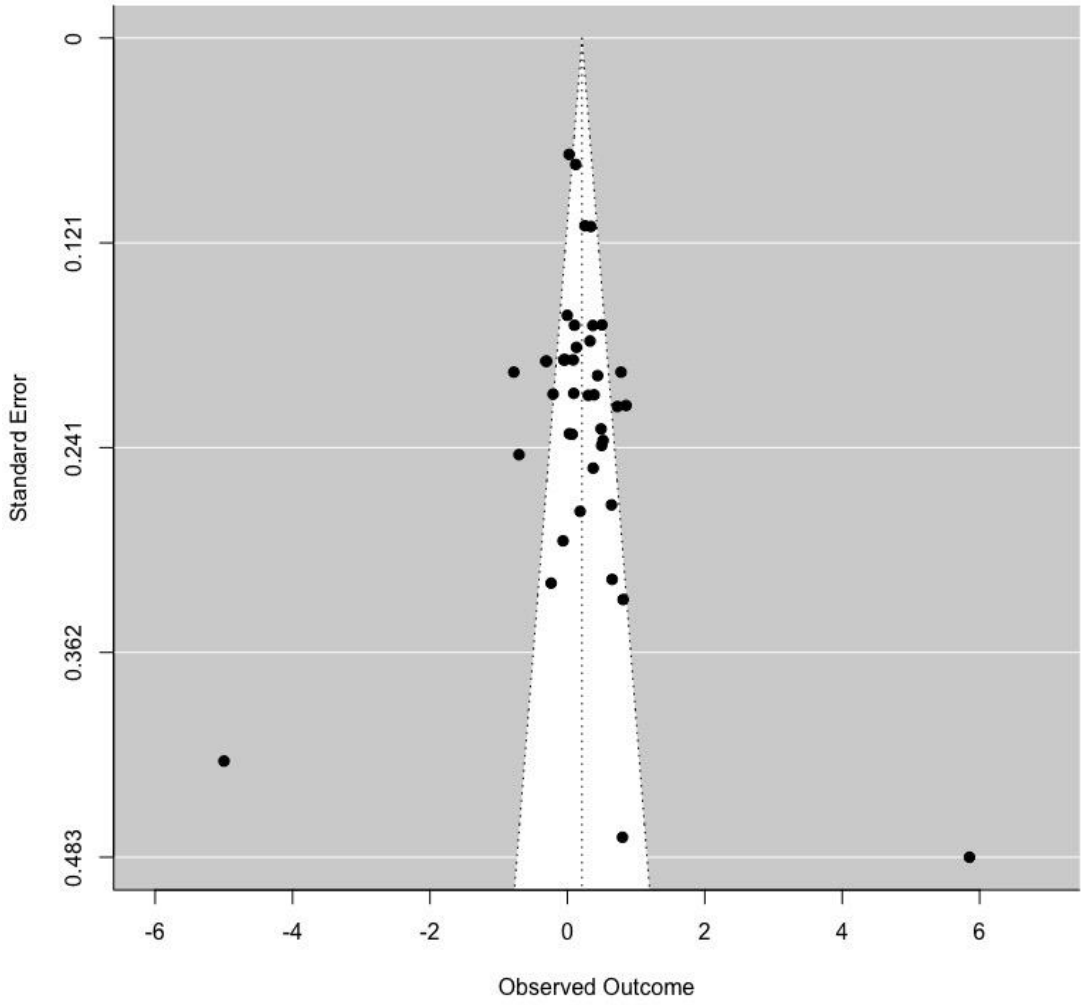


Fig E7
Category 7 Funnel Plot (full model; outliers retained)



CHAPTER 5: GENERAL THESIS DISCUSSION

Chapter overview

The overarching aim of the present thesis, as outlined in Chapter 1, was to advance our understanding on how subtle alterations to the food environment can promote healthier food and beverage choices through the use of nudging techniques. More specifically, the thesis aimed to evaluate the efficacy of visual cues and primes as implicit nudges for encouraging such behaviours.

Within this overall aim, each of the included chapters had their own specific sub-aims. First, Chapter 2 sought to assess the impact of subtle beverage primes, embedded into the background of Instagram images, for influencing drink choices from a visual food and beverage display (Studies 1 and 2). Chapter 3 (Studies 3 and 4) then sought to investigate the effectiveness of a less subtle approach to priming drink choices, by way of advertising posters for vending machines. Then, in an effort to develop a broader understanding of visual nudging, Chapter 4 comprised a systematic review and meta-analysis assessing a range of visual nudges for their influence on food and beverage consumption behaviours, and explored potential mechanisms underlying the effectiveness of such visual nudges.

The current chapter will summarise key findings from each of these chapters and outline theoretical and practical implications of the present thesis. In addition, the strengths and limitations of the body of work presented in this thesis will be discussed, as will recommendations for future research.

Summary of findings

Chapter 2, presenting the results of Studies 1 and 2, addressed the first sub-aim of the present thesis, investigating the efficacy of subtle beverage primes on drink choices. More specifically, the studies aimed to determine the effectiveness of healthy (glass of water) and unhealthy (glass of soft drink) beverage primes compared to when no beverages were present

(control). These primes were subtly incorporated into the background of Instagram images with the aim of influencing drink choices from a food and beverage environment, akin to a vending machine. The two active priming conditions (water, soft drink) were expected to nudge drink choices over food choices, relative to the no beverage control. Further, the water prime was expected to nudge healthier drink choices (and potentially also healthier food choices), while the soft drink prime was expected to nudge less healthy drink (and potentially less healthy food) choices.

In Study 1, the beverage primes were very subtly incorporated into the background of non-food/beverage-related Instagram images. Priming condition did not predict food or beverage choices. However, notably, few participants in the water prime condition reported noticing the water glasses in the Instagram images, and while more participants in the soft drink prime noticed the glasses, they struggled to identify the beverage as being a type of soft drink. Thus, it was proposed that perhaps the primes were too subtle to effectively nudge beverage choices from the food and beverage environment.

As a result, in Study 2, the primes were made less subtle, but still not a focal point of the Instagram images, and the drinks themselves were made clearer and easier to identify. The proportion of participants recalling and correctly identifying the beverages in the Instagram images was higher in Study 2 compared to Study 1, particularly for participants who viewed the soft drink prime. In addition, in Study 2, priming condition significantly predicted whether participants chose a beverage or food. More specifically, participants in the soft drink prime condition were more likely to select a beverage over a food compared to those in the water prime and control conditions. However, priming condition still did not significantly predict the healthiness of drink or food choices.

Overall, Chapter 2 demonstrated that very subtle beverage priming may not be an effective tool for nudging beverage choices (Study 1), but that increasing the visibility of

these primes may be more effective (Study 2). The primes still, however, had limited effects in Study 2. While both priming conditions (water, soft drink) increased drink choices over food choices, relative to the no drink control condition, this was only significant for the soft drink primes. As outlined in the general discussion of Chapter 2, this could be related to the proportion of participants noticing the beverage primes in each condition. The soft drink primes were noticed by a greater proportion of participants (91%) compared to the water primes (69%), thus indicating a more obvious approach may still be needed in relation to water primes. Similarly, while choices trended towards healthier beverages in the water prime condition and less healthy beverages in the soft drink prime condition, a stronger, more obvious prime may still be needed to significantly influence the healthiness of choices. Adding credence to this idea, the discussion of Chapter 2 outlined that existing research reporting significant effects of Instagram-based nudges on food choices used obvious primes, where the nudge was the central focus of the image (e.g., Coates et al., 2019; Wilson et al., 2019). Thus, Chapter 3 sought to examine the effectiveness of a much more obvious approach to priming, while still remaining within the 'subtle and unobtrusive' realm of nudging. To achieve this aim, water and soft drink glasses were made the focal point of priming images used, but care was taken to avoid any brand-related associations in order to avoid any marketing-type influences.

The general discussion from Chapter 2, covering the outcomes of Studies 1 and 2, also indicated that perhaps a general-health related image may be more effective than item-specific primes. Previous research has found significant influences of subtle primes using body-related rather than item-specific images, which are thought to work by activating diet- or health-related goals (e.g., Brunner & Siegrist, 2012). To test this notion, a general health (runner) prime was incorporated alongside the two drink primes in Studies 3 and 4.

Further, considering previous research in the food domain has found significant

effects in food-only environments (e.g., Brunner & Siegrist, 2012; Coates et al., 2019; Wilson et al., 2019), it was proposed that perhaps an environment including both foods and beverages may be more complex to nudge, or that nudging beverage choices may be different or more complex than nudging food choices. To test this, Study 3 included beverages only, to determine whether the primes were effective in a beverage-specific environment, while Study 4 included both foods and beverages to determine whether effects differed in a combined environment.

Thus, ultimately Chapter 3 sought to examine the effectiveness of a more obvious approach to priming. Advertising posters for vending machines were used for priming, where the poster depicted a healthy drink (water), unhealthy drink (soft drink), or general-health prime (runner), as the central focus of the poster. These primes, relative to a neutral text-only control poster, were assessed for their influence on drink choices from a beverage only (Study 3) and a combined food and beverage (Study 4) environment.

In Study 3 (beverage only environment), the water prime significantly increased water choices over less healthy options, relative to the control condition, while the soft drink and general health primes had little effect. The effectiveness of the water prime indicated that when using an obvious prime in a beverage only environment, an image of a glass of water can sufficiently influence the healthiness of drink choices. Study 4 was then conducted to determine whether the effect remained once foods were added into the choice environment.

Once foods were incorporated into the vending machine environment, participants in the water prime condition in Study 4 were again the most likely to select a water over less healthy beverages, but only significantly so compared to those in the general health condition. Like in Study 3, the soft drink and general health primes had little effect. Condition did not predict the healthiness of food choices. The combined results of Studies 3 and 4 indicate that, in a beverage environment, a water image may be an effective means of

encouraging healthier drink choices (water) but may be less effective when foods are also present.

As outlined in the general discussion of Chapter 3, covering the outcomes of Studies 3 and 4, the lack of effect of the general health nudge across Studies 3 and 4 could stem from the limited relevance of the priming image to the choice behaviour. In comparison, the water prime was directly related to drink choices and did influence those choices. Health-related nudges, like the general health prime, are thought to work by triggering health- or diet-related goals (Brunner & Siegrist, 2012; Buckland et al., 2014; Stein et al., 2016; Tonkin et al., 2019). It is possible that these goals may not be considered to apply to beverage choices. For example, previous research has demonstrated that the perceived risk of future health issues resulting from sugary drink consumption emerges as the strongest predictor of intentions to reduce intake (Dono et al., 2021). Thus, it is possible that, even if the general health prime activates health-related goals, individuals may not perceive a direct link between their current beverage consumption and the activated goals. Relatedly, some studies in the nudging domain (e.g., Anschutz et al., 2008; Bourn et al., 2015; Deek et al., 2022; Tonkin et al., 2019) have found the effectiveness of general health nudges on food-related outcomes to be moderated by dietary restraint, pointing to the potential of pre-existing dietary goals and/or concerns as being an underlying mechanism of nudge success. Dietary restraint, goal activation, and perceived future health implications of beverage consumption behaviours were not measured in the empirical studies included in this thesis. These factors were, however, identified in the systematic review and meta-analysis (Chapter 4) as potential mechanisms underlying the effectiveness of nudges for influencing food or beverage consumption-related behaviours (particularly for dietary restraint). However, the review also revealed that few studies have actually tested these factors as potential moderators. Future research is recommended to determine the importance of these factors in making beverage

choices, and the link between these factors and general health nudges, to confirm whether such nudges would be relevant to, and effective for, nudging drink choices.

Interestingly, the soft drink prime did not increase unhealthy (soft drink) choices in either experiment in Chapter 3. This mirrors some research indicating healthy item-specific nudges to be more effective than unhealthy item-specific nudges, potentially due to the inherent drive towards unhealthy products in the first place (e.g., Blížkovská, 2017; Folkvord et al., 2020). However, some research using unhealthy nudges indicates they can successfully increase unhealthy consumption-related behaviours (e.g., Bodenlos & Wormuth, 2013; Neyens & Smits, 2017). Interestingly, the studies finding little effect of unhealthy nudges (e.g., Blížkovská, 2017; Folkvord et al., 2020), in line with the results of Studies 3 and 4, measured choice outcomes, while studies finding unhealthy nudges to be effective measured intake (e.g., Bodenlos & Wormuth, 2013; Neyens & Smits, 2017). This points to potential differences in the effect of nudges in different consumption-related contexts.

Considering the results of Studies 1-4 (Chapters 2 and 3), it appears that visual nudges have the potential to influence beverage choices within visual choice environments. However, it is also clear that the effectiveness of such nudges is dependent on various factors. For example, based on the results of the studies presented in Chapters 2 and 3, it appears that the subtlety of the nudge, the type of item being nudged (e.g., food versus beverage, healthy versus unhealthy), and potentially the type of nudge (e.g., item-specific versus general-health) may all influence nudge effectiveness. Similarly, nudges may be more effective in certain environments or for certain products, such as being more effective in a beverage-only versus combined environment, or perhaps some nudges may be more effective for nudging food choices rather than beverage choices. Considering this, Study 5 (Chapter 4) was designed to review the current literature with the goal of examining the efficacy of various visual nudges for shaping food and beverage consumption-related behaviours. In doing so,

Study 5 aimed to gain a comprehensive understanding of the types of visual nudges that may be most effective, the circumstances under which they work best, and for whom they are most influential.

The review presented in Study 5 (Chapter 4) evaluated a range of visual cues and primes across 63 studies, drawn from 50 articles, comprising a total of 182 condition comparisons. Nudge comparisons were categorised into seven groups for separate analyses: (1) healthy food-specific and (2) healthy body-related nudges (versus neutral controls); (3) unhealthy food-specific and (4) unhealthy body-related nudges (versus neutral controls); (5) mixed-health food-specific and (6) mixed-health body-related nudges (healthier versus less healthy nudges), and (7) nudges not inherently related to health (e.g., colour, perceived social pressure, perceived portion size; relative to control or comparison conditions).

Overall, the systematic review and meta-analysis conducted in Chapter 4 revealed that visual nudging interventions seem to be an effective means of nudging consumption-related behaviours. Healthy (food- and body-related), unhealthy (food- and body-related), mixed-health (body-related only) nudges, and nudges not inherently related to health all had significant small-moderate overall effects on consumption-related behaviours, in the expected directions. Effect sizes were similar across all categories but were largest for healthy body-related nudges (compared to neutral controls; Hedges' $g = 0.32$) and unhealthy food-specific nudges (compared to neutral controls; Hedges' $g = 0.28$).

Moderator analyses were conducted to assess the influence of a range of study, participant, condition, and outcome characteristics, on consumption-related behaviours. Study and participant moderators included participant source and study setting, participant age, gender, weight status, and restraint status. Nudge characteristics included nudge timing (i.e., prime or cue), medium (e.g., image, video), and interaction (e.g., actively attended, incidental). Outcome-related mechanisms included the outcome measure (consumption,

choice), type (food, beverage, meal), healthiness (healthy, unhealthy, mixed), taste (sweet, savoury), and tangibility (i.e., whether participants actually consumed or received their chosen products, or the outcome was hypothetical).

Moderator analyses revealed that the effectiveness of healthy and unhealthy food- (or beverage) specific nudges compared to neutral controls, and body-related mixed nudge comparisons were moderated by several factors, particularly for unhealthy food-specific nudges versus neutral control comparisons. Healthy food-specific nudges were moderated by nudge timing with healthy consumption-related behaviours increasing when primed (i.e., nudge presented prior to outcome measurement) but decreasing when cued (nudge presented during outcome measurement). This roughly aligns with some nudging research finding priming to be more effective than cueing for encouraging healthier consumption behaviours (e.g., Tonkin et al., 2019). The effectiveness of healthier body-related nudges compared to less healthy body-related nudges was moderated by participant age, with healthier consumption-related behaviours increasing among children but not adults in response to this type of nudge. This could potentially align with research indicating that preferences for thin bodies decline with age (e.g., Han et al., 2021) but further research is needed to determine if there are age differences in response to all body-related nudges.

The effectiveness of unhealthy nudges compared to neutral controls were influenced by several factors. Most notably, the unhealthy nudges significantly increased unhealthy consumption but not choice. The lack of effect on choice outcomes mirrors the results from Chapter 3 (Studies 3 and 4) where the unhealthy (soft drink) nudge had little effect on choices. Further, unhealthy nudges significantly increased unhealthy consumption-related behaviours when participants were asked to actually consume the outcome food, or received chosen product, but significantly decreased unhealthy behaviours when the outcome was hypothetical. If this result is replicated, it could have important implications for the nature of

hypothetical research in the nudging domain moving forwards. In hypothetical scenarios, without the immediate consequences of consumption, consumers may prioritise health considerations more, thereby potentially activating a counteractive control approach, similar to as discussed in the general discussion of Chapter 3 (Fishbach et al., 2010). When faced with real choices, however, consumers are committing to the consumption of the product, and thus may increase unhealthy consumption behaviours when nudged with these products as they are largely considered more appealing and inherently rewarding (Lemos et al., 2022; Olszewski et al., 2019). Interestingly the real/hypothetical nature of studies did not influence the effectiveness of healthy nudges on healthy food/beverage choices. This may indicate that relative to unhealthy nudges, healthy nudges may be more robust in influencing consumer behaviours for products that are not as inherently rewarding, regardless of the decision context.

While significant moderator effects were only found across a few analysis groups (healthy and unhealthy food-specific nudges versus neutral controls, and mixed health body-related nudge comparisons), the generally limited variability between studies within each category limited our ability to truly determine the role of many characteristics in nudge effectiveness, particularly among participant and nudge characteristics. Thus, a narrative review of tested and proposed mechanisms and moderators was also conducted within Study 5 (Chapter 4) to provide a broader overview of the characteristics thought to explain or underly the effectiveness of such visual nudges. Many participant, nudge, and outcome characteristics were noted as potential mechanisms and/or moderators. Results, however, were largely mixed, and many were not tested but simply proposed as potential explanations, and/or were only mentioned in a few studies, indicating the need for further research.

The most commonly noted participant characteristics in Study 5 (Chapter 4) that were thought to determine the effectiveness of visual nudges were dietary restraint, which was

largely supported, as well as participant weight, and gender. Nudge characteristics were not commonly noted as potential moderators, but outcome characteristics were, particularly outcome health (healthy, unhealthy, mixed) and taste (sweet, savoury). However, results for outcome characteristics were largely mixed. For example, six articles found outcome health and/or taste moderated nudge influence while six articles reported no moderating effect. A range of potential mechanisms thought to explain how nudges influence choices were also proposed, but rarely tested. For example, the most commonly suggested mechanisms were that nudges, particularly body-related nudges, work by reminding participants of pre-existing diet- or weight-related goals, or that they activate social norms or normative standards around eating. However, research has yet to determine whether these types of images do in fact activate such social norms or normative standards.

Interestingly, while the results of Chapters 2 and 3 (Studies 1-4) indicated that perhaps less implicit nudging approaches may be more effective, nudge characteristics such as level of engagement with the nudge, salience of the nudge, and association between nudge and outcome behaviour did not emerge as significant moderators in the meta-analyses (Study 5; Chapter 4). However, while the nudges included in the review did vary in their degree of implicitness, they were all relatively implicit considering the focus of the review was on subtle environmental nudges. This limited our ability to determine the role of implicitness in nudge effectiveness, however, both very subtle (including subliminal) and more obvious nudging approaches included in the review did effectively influence consumption behaviours. It is possible that the findings from the empirical studies (Chapter 2-3) and the review (Chapter 4) may indicate potential differences between food and beverage consumption-related behaviours. The empirical studies, which indicated that less implicit nudges may be more effective for influencing behaviours, focussed primarily on beverage choices while most of the studies included in the review were focussed on foods; consumers do not tend to

have strong health- and/or diet-related goals in relation to beverages in the same way they do for foods. Unfortunately, due to the limited number of studies investigating pictorial nudges for influencing beverage choices, we were unable to assess this in the present review. Further research is needed in the beverage domain.

Considering the limited testing of mechanisms and moderators, it remains unclear under which circumstances and for whom certain nudges may be most effective. It is clear, however, that further research is warranted to understand these factors to enable the development of strong, targeted visual nudging methods.

Theoretical implications

The findings of the present thesis have some important theoretical implications. Firstly, the results of the studies conducted in Chapters 2 and 3 (Studies 1-4) support the Dual Processing Theory (Evans, 2008), outlined in Chapter 1. The theory posits that individuals have two distinct modes of decision making. One process is quite slow, deliberate, and analytical. This is the process that education-based approaches for encouraging healthier consumption behaviours rely on, but have had limited success in changing behaviours through this approach (Baghurst & McMichael, 2010; Thakur & Mathur, 2021; Walls et al., 2009). However, consumption-related behaviours are thought to be primarily made through faster, intuitive, and automatic thought processing (Houlihan, 2018). Across Chapters 2 and 3 (Studies 1-4), habitual consumption and liking were strong predictors of food and/or beverage choices, supporting the notion that consumption-related behaviours are made largely based on attitudes and heuristics, rather than being more considered choices. However, the effectiveness of nudges, which are generally considered to operate relatively unconsciously through the automatic processing channel (Harris et al., 2009), for influencing choices may be more complex. For example, the results of Chapter 2 (Studies 1 and 2) indicate that the visibility and clarity of nudges play a crucial role in their influence on choice

behaviours. In Study 1, where the nudges were rarely noticed and were difficult to identify, the nudges did not significantly influence choices. In comparison, when the nudges were made more noticeable in Study 2, nudges influenced choices. Also, in Study 2, the soft drink primes, which were noticed and correctly identified by most participants, significantly influenced choices, while the water primes, which were noticed by fewer participants, did not influence choices. Future research would benefit from exploring this further. It could be that the clarity of the nudge is the important factor and that if the nudges had been clearer, they would influence choices even if not consciously noticed. Alternatively, it could be that some level of conscious awareness is needed for this type of choice, indicating the potential of a complex interplay between automatic and analytical processing to influence choices.

While Dual Processing Theory offers insight into the decision-making process of consumption-related behaviours, other theories also provide insight into how nudges influence such behaviours. The review presented in Study 5 (Chapter 4) found Goal Conflict Theory (Stroebe et al., 2013) and Food Cue Reactivity Theory (Jansen, 1998) to be the most commonly noted theories across the included visual nudging articles. Both theories, similar to Dual Processing Theory, relate to the decision-making process. Goal Conflict Theory posits that decision making occurs within the context of an individuals' goals, and particularly the conflict between short- and long-terms goals (Stroebe et al., 2013). For example, while one might have the long-term goal of maintaining a healthy diet, presenting them with tempting highly palatable foods or beverages might activate a conflicting short-term goal of enjoying the tasty item. While food choices are often made based on short-term goals, similar to the automatic processing in Dual Processing Theory, articles suggest that a healthy nudge may work by activating existing long-term health-related goals over the hedonic short-term goals, thus increasing healthy consumption-related behaviours (Deek et al., 2022; Kemps et al., 2016; Tonkin et al., 2019). Unhealthy nudges, in comparison, may strengthen the short-term,

hedonic, eating goals, thereby increasing unhealthy consumption-related behaviours.

Goal conflict or goal activation were not measured in the empirical studies conducted as part of this thesis, and the results of the studies do not clearly support or challenge this theory. However, it was proposed in the general discussion of Chapter 3, that general-health related nudges, which could be considered to work through a goal-activation process, may not have influenced drink choices in Studies 3 and 4, despite success in food environments, because peoples' health goals may not relate to beverage choices. People tend to have strong food-related health goals (Grimmelt et al., 2022), but this is not necessarily the case for beverages. Thus, it stands to reason that the effectiveness of goal activating nudges may depend on the presence of pre-existing goals relevant to the consumption-related outcome. This is supported by findings of articles included in the review (Chapter 4) which found and/or suggest that goal-related nudging may be more effective for restrained eaters, who are concerned about their diets, compared to unrestrained eaters, who are not concerned about their diets (Anschutz et al., 2008; Bourn et al., 2015; Deek et al., 2022; Kemps et al., 2016; Stämpfli et al., 2017; Tonkin et al., 2019).

Relatedly, Food Cue Reactivity Theory (Jansen, 1998) posits that individuals vary in their sensitivity to food-related cues, but that overall, exposure to food related cues can result in automatic physiological and psychological responses, including increased cravings for foods, or increased hunger. These changes are then thought to change consumption-related behaviours. This theory helps to explain the influence of our food environment, which is largely geared towards unhealthy foods, on our eating behaviours. The constant exposure to unhealthy foods in our physical and digital environments can increase consumption of such foods because we have more chances to react to them.

Food Cue Reactivity Theory could also potentially explain the influence of food-specific nudges like those used in Studies 1-4 (Chapters 2 and 3). It is possible that the

nudges increased cravings for products depicted in the priming images. This may also explain why in Study 1 (very subtle primes) where participants struggled to identify the depicted beverage, particularly for the soft drink, the prime failed to influence choices. The item depicted in the prime was not clearly identifiable as a specific beverage so therefore may not have triggered specific automatic responses in order to influence subsequent choices. While pre-post changes in hunger and thirst, and cravings or desire for products were not measured across the empirical studies included in this thesis, Food Cue Reactivity Theory holds promise as a potential explanation of how food-specific nudges such as those used in the present experiments may influence choices in a way that does not require pre-existing health- or diet-related goals that link in with the specific choice behaviour being measured. As such, future research should explore these relationships further to determine the underlying mechanisms of item-specific cues to ascertain whether such nudges may be effective in the absence of pre-existing health goals.

Practical implications

In addition to the theoretical implications mentioned above, the findings from the present thesis have several practical implications, particularly for encouraging healthier consumption behaviours. First, the empirical studies included in this thesis (Studies 1-4; Chapters 2 and 3) demonstrate that visual beverage-related nudges can effectively influence drink choices, particularly when employing a more obvious, but still implicit approach with the prime as the central focus of the nudging image. Moreover, the comprehensive review of various visual nudges presented in Chapter 4 demonstrates that visual nudges, overall, can be valuable tools for influencing food and beverage consumption-related behaviours.

While there were some mixed results, this thesis provides clear evidence supporting the potential of visual cues and primes for nudging healthier consumption-related behaviours. Further understanding the mechanisms behind why certain nudges are effective in particular

contexts and for specific individuals would enhance the design of more targeted and efficient nudges for specific situations and target audiences.

Visual nudges, especially those applied to the external food environment as explored in this thesis, are a particularly promising avenue for practical interventions. These visual nudges can be easily integrated into existing settings, for example through social media platforms (Chapter 2) or advertising posters (Chapter 3). Importantly, such external nudges do not require the same level of involvement and approval from industries or businesses as other approaches like taxing, on-package labelling, product placement strategies, or visual nudges incorporated directly onto product packaging or purchase settings (e.g., vending machine wraps; Calabro et al., 2023). Thus, visual nudging approaches have the potential to be easily incorporated into a wider suite of approaches for encouraging healthier dietary behaviours.

As outlined in Chapter 1, while more traditional public health approaches such as taxing and mass media campaigns have demonstrated some degree of success in encouraging healthier consumption behaviours, they are clearly not sufficiently encouraging healthier consumption behaviours (Bucher et al., 2016). Compared to more restrictive approaches (e.g., taxes), nudges are better supported by consumers and maintain freedom of choice, thus avoiding backlash effects sometimes seen in response to restrictive policies (e.g., actively seeking out taxed products to reassert autonomy; Laurin et al., 2012). Further, while softer approaches such as educational campaigns can successfully increase knowledge and awareness around healthy dietary behaviours, this knowledge often fails to be translated into behaviour change (Bucher et al., 2016). Consumption behaviours tend to be relatively habitual and automatic in nature, based more on short-term reward than long-term impacts (Hofmann et al., 2009). Nudges, in comparison, are thought to work relatively unconsciously and have been shown to influence even habitual behaviours (including across the empirical

studies included in this thesis; Chapters 2-3). Thus, nudges have the potential to influence behaviour change in the moment; they are thought to affect change in this way by activating mental representations, normative behaviours, or pre-existing health- or diet-related goals (Lindsey et al., 2020). As such, nudging and education-based approaches would likely nicely complement each other. Educational approaches can be used to develop knowledge and awareness, and inform social norms around dietary behaviours, which can then be activated in the consumption-related environment via nudges. The combination of these approaches may help to strengthen their effect on dietary behaviours. However, as outlined in Chapter 4, further work is needed to elucidate the mechanisms by which nudges work to influence behaviours to aid in the development of the most effective nudging techniques for encouraging healthier dietary behaviours.

Relatedly, as outlined in Chapter 4, some research indicates that nudges may be more effective for certain consumers, reporting differences in nudge effectiveness according to participant characteristics (e.g., age, gender, weight/BMI, dietary restraint status). However, the review also demonstrated that further research is needed to determine the role of demographic characteristics in nudge effectiveness. Demographic characteristics were not associated with vending machine choices in any of the empirical studies conducted as part of this thesis (Chapters 2-3), although it is worth noting that we used young adult samples (as they are the core consumers of sugary drinks) which may limit our ability to detect age-related effects. Habitual consumption and liking were, however, associated with consumption-related behaviours which may indicate that nudges may be more effective among less regular consumers. If nudges designed to encourage healthier consumption behaviours are only effective among those not regularly consuming unhealthy products, then nudging has the potential to exacerbate health inequalities. However, in the present thesis, the reported nudge effects across all empirical studies (Chapter 2-3) were found when controlling

for habitual consumption and liking. Nudges are thought to work relatively unconsciously and thus able to influence even habitual behaviours, unlike many traditional public health approaches (Bucher et al., 2016). Thus, these nudges may have the potential to influence consumption across a wide range of consumers.

From a public health perspective, the cumulative findings of this thesis, demonstrate that visual nudges have the potential to contribute to encouraging healthier diets particularly if implemented as part of a suite of public health initiatives for encouraging healthier dietary behaviours. Even modest enhancements in consumption-related behaviours, like those observed in the empirical studies and review in this thesis, can yield significant population-level improvements over time. For example, a one percent decrease in BMI (which could be achieved through dietary changes) has been reported to potentially reduce weight-related burden of disease potential by 14% (AIHW, 2017). Therefore, the gradual progression towards healthier eating behaviours through nudging, in combination with other public health approaches such as educative campaigns, may contribute to mitigating diet-related health issues like type II diabetes, cardiovascular diseases, and some cancers, and as a result lead to overall improvements in health and wellbeing.

Strengths and limitations

The studies included within the present thesis have some notable strengths and limitations. First, a major strength of most of the included empirical studies (Study 1 and 2, Chapter 2, and Study 4, Chapter 3) were the large samples used. As evidenced in the review presented in Study 5 (Chapter 4), to date much of the visual nudging research has been conducted in small samples with limited representativeness, particularly involving university-only samples. In contrast, the empirical studies included in the current thesis involved large, and nationally representative samples. However, the samples were limited to young adults, since they are the core consumers of sugary drinks and hence the core target audience of the

types of beverage-related nudges used across the empirical studies conducted as part of this thesis. It is possible that results may differ among younger and/or older samples.

Further, in Chapter 2 (Studies 1 and 2), while it was a methodological strength to present the priming and choice tasks as separate and unrelated, this may have weakened the inherent link between primes and outcomes, potentially compounding the issue of nudge subtlety (i.e., using a subtle nudge may mean a slightly more tenuous link between nudge and outcome compared to a more obvious prime). In Chapter 3, however, this was rectified with the priming nudges being presented as potential vending machine advertising posters and the choice task involving making a choice from a vending machine-style display.

Relatedly, in Studies 1, 2 and 4, where both foods and beverages were present in the choice environment, choices were kept as naturalistic as possible, and no direct instructions were made to choose a beverage. While this was a methodological strength, it did limit the number of participants selecting a beverage, potentially limiting our ability to detect influences on the healthiness of drink choices compared to in Study 3 where only beverages were present in the choice environment.

Further, we acknowledge the hypothetical nature of choice outcomes across the conducted studies. Hypothetical studies are commonly conducted in research. However, the meta-analysis results (Chapter 4) comparing healthy nudges to neutral controls found differing results for studies measuring tangible (i.e., actual consumption) outcomes, where unhealthy nudges significantly increased unhealthy consumption-related behaviours, compared to when outcomes were hypothetical, where unhealthy nudges significantly decreased unhealthy consumption-related behaviours. This result indicates a potential intention-behaviour gap, at least for unhealthy nudges, since the moderator was not significant in the meta-analyses including healthy nudges (healthy versus control, healthy versus less healthy). However, research directly assessing the relationship between

hypothetical and real behaviours does indicate that hypothetical outcomes are similar to actual consumption behaviours (e.g., Zlatevska & Spense, 2016). Further research is needed to determine the implications of hypothetical versus real outcomes in response to unhealthy nudges, but if replicated the findings have important implications for future research.

Lastly, analysis and consideration of underlying mechanisms and moderators in Chapter 4 were limited by the degree of variability and/or reporting of certain characteristics (e.g., dietary restraint). While the review focussed on studies including consumption-related outcomes, which was a methodological strength, it is likely that studies exist that investigate underlying mechanisms and moderators, without including consumption-related outcomes, which may help to provide a more comprehensive overview of the mechanisms and moderators determining nudge effectiveness.

Future research recommendations

Overall, the results of Studies 1-5, presented across Chapters 2-4, indicate that visual nudging techniques hold promise for nudging food and/or beverage consumption-related behaviours. It is also clear that certain nudges may be more effective for certain consumers, in certain settings, and/or for certain types of products. However, the most effective visual nudges for various settings and consumers remain unknown at this stage. Further research is needed to clearly understand how and why certain nudges are effective under a variety of different constraints. Future research to increase understanding of the underlying mechanisms and moderators of visual nudges will aid in the development of more effective, targeted nudges with the greatest potential for encouraging population-level change.

In addition, further research is also warranted to determine the relationship between unhealthy choices following visual nudges, and the subsequent consumption of such foods. This research will help to determine if perhaps nudges influence the amount consumed of the chosen product, without changing the chosen product itself. If consumers still choose the

unhealthy products but consume less in response to visual nudges, then such an approach still has potential to encourage healthier dietary behaviours by reducing consumption of unhealthy foods over time.

Further, research examining the potential intention-behaviour gap in studies with hypothetical outcomes is needed. If behaviour occurs differently in hypothetical settings compared to those with tangible outcomes, this could have important implications for research in the nudging domain moving forwards, as research is often hypothetical in nature. Some research, outside of the nudging domain, indicates that eating habits have less impact on hypothetical versus tangible consumption-related outcomes indicating the potential for an intention-behaviour gap (e.g., Herziger & Hoelzl, 2017). However, other studies indicate that hypothetical outcomes do predict actual consumption-related behaviours (e.g., Robertson & Rasmussen, 2018; Steele et al., 2019). As such, more research is needed to directly compare the effectiveness of the same nudges with both hypothetical and real outcomes to determine how reliable hypothetical measures are for predicting actual consumption-related behaviours.

The meta-analysis and systematic review of visual nudges for influencing consumption-related behaviours (Chapter 4) also indicated a lack of research around nudging beverage choices, with only six studies (9.7%) reporting beverage-specific outcomes. The results of the empirical studies conducted in Chapters 2 and 3 (Studies 1-4) indicate that nudging beverage consumption-related behaviours may require a slightly different approach than nudging food choices, potentially due to different levels of understanding and/or goals around healthier beverage consumption. One approach may be to look further into goal activation in relation to nudging beverage choices. If this were to indicate a disconnect between health goals and beverage choices, this could indicate the need to implement knowledge increasing measures to complement nudging techniques. Indeed, considering the small to moderate effect of visual nudging, pairing such an approach with other policy

options, such as education-based approaches to increase knowledge, would likely be beneficial. Future research could examine the effect of combining policy approaches to determine the most effective combination of methods for encouraging healthier food and beverage consumption-related behaviours.

Conclusion

The present thesis addressed the overarching aim of investigating the efficacy of implicit visual nudges for influencing beverage and food consumption-related behaviours. This was first addressed by a series of empirical experimental studies investigating the effectiveness of increasingly less subtle visual priming nudges for influencing beverage choices from beverage-specific, and combined food and beverage environments (Studies 1-4; Chapters 2 and 3). These studies were then followed by a systematic review and meta-analysis (Chapter 4) evaluating the efficacy of a range of visual cues and nudges for influencing food and beverage choices. This was combined with a narrative review of proposed and tested underlying mechanisms and moderators, in order to gain deeper insight into how, when, and for whom nudges may be most effective. Overall, the empirical studies and meta-analyses conducted as part of this thesis, demonstrate that implicit visual nudging interventions can successfully influence consumption-related behaviours, but that these nudges may have relatively small effects. Considering nudges are thought to work by activating health- or diet-related goals, nudges may be complemented by educative approaches such as health campaigns that may help to develop and/or strengthen goals for subsequent activation through nudging. In addition, results indicated that nudges be more effective under certain conditions. For example, the empirical studies indicated that visual nudges, while remaining implicit, need to be clearly visible and easy to identify (Studies 1 and 2). They also indicated that nudging beverage choices may be more effective in a beverage-specific environment (Study 3) than in an environment containing both foods and

beverages (Study 4), and that perhaps consumers may not apply health- and diet-related goals to beverage intake (Studies 3 and 4), again indicating the potential benefit of implementing nudges alongside educative approaches. Further, the systematic review and meta-analysis demonstrated a wide range of potential participant, nudge, and outcome-related characteristics that may influence choices. Results indicated, for example, that participant characteristics like dietary restraint (linked to the existence of diet- and/or health-related goals) moderate nudge effectiveness. Perhaps most notably, the review also pointed to potential differences in behaviours when outcomes are tangible versus hypothetical, at least for unhealthy nudges, which could have important implications for further research, if this finding is replicated. Greater understanding of the mechanisms and moderators underlying the (in)effectiveness of visual nudging approaches is needed to aid in the development of nudging approaches with the greatest potential for widespread influence of diet-related behaviours.

Theoretically, the results of the present thesis indicate that nudges have the potential to influence unconscious and automatic choices. For example, the empirical studies revealed effects of priming nudges over and above habitual consumption behaviours. These results support a range of decision-making theories including Dual Processing Theory (Evans, 2008), Goal Conflict Theory (Stroebe et al., 2013), and Food Cue Reactivity Theory (Jansen, 1998), which all highlight the automatic nature of decision making around foods. From a practical perspective, the present findings provide valuable insights for the development of effective public health strategies, such as simple changes to visual environments that do not require industry involvement, that can be implemented as part of a suite of diet-related interventions. Future studies should seek to further understand the mechanisms and moderators underlying the effectiveness of visual nudges to further our ability to develop the most effective means of encouraging healthier food and beverage consumption-related

behaviours. Ultimately, the findings of the present thesis indicate that implementing implicit visual nudging techniques in the external food environment could help to encourage healthier consumption-related behaviours, thereby contributing to improvements in population health by continually nudging people towards healthier dietary behaviours, and consequently helping to reducing rates of diet-related health concerns.

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