Inspiring Healthy Choices: Using social comparisons and self-comparisons to nudge socially responsible decision making online



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Abstract

Online behaviour today is undoubtedly shaped by choice recommendations presented to people in nearly all aspects of online life, from consuming media to online shopping to managing finances. As everyday life and online life becoming increasingly intertwined, the purposeful design of digital choice architectures becomes even more critical. We have a responsibility to design information environments that help people make better and more informed choices, both for themselves and society more broadly. My doctoral thesis investigates how social comparisons and self-comparisons can nudge healthier choices in online grocery shopping contexts, recognizing the growing popularity of online grocery shopping and the global obesity epidemic we face today. I introduce a novel form of social comparison—the out-group social comparison—and demonstrate that it can inspire calorie reduction, particularly amongst those who are typically resistant to dieting. I then replicate the observed out-group social comparison effect under minimalist conditions while increasing the geographic sample and overall sample size in a follow-up study. I introduce the concept of Challenge Teams to allow individuals to opt-in to social comparisons and observe a high 78% organic opt-in rate. Finally, I explore if self-comparisons may serve as a viable alternative to nudge healthier food choices amongst those who do not wish to engage in social comparisons with promising results.

Acknowledgements

Special thanks go out to my doctoral supervisor, Professor Gina Neff, who encouraged me to pursue doctoral research at the Oxford Internet Institute and continue the research path I started as a doctoral student at the Kellogg School of Management at Northwestern University, where I fell in love with social psychology and the powerful impacts that other beings can have on our thoughts, feelings, emotions, and behaviours. With that, I also owe special thanks to my former supervisor at Kellogg, Professor Rima Touré-Tillery, who encouraged me to take my captivation with foundational literature on intergroup bias and explore how I might be able to apply it to make new discoveries in the field of consumer behaviour within the context of choice and decision making.

I have long been fascinated by the internet and online consumer behaviour and have managed to build a professional career around consumer experience strategy and human-centred design and feel fortunate to have had the opportunity to merge my academic interests and professional pursuits to advance research in digital nudging for social good at the University of Oxford, with the on-going supervision and support of Gina Neff as well as the wonderful faculty and staff at the Oxford Internet Institute. I have been very privileged to have had the opportunity to pursue this research as part of an industry studentship from Tesco, a leading multinational grocery retailer, who has demonstrated a sincere commitment to academic-industry partnerships that I appreciate.

A final and most important thanks go out to my mom and dad for always believing me and supporting me, even when my teachers didn't.

"Obesity is one of today's most blatantly visible – yet most neglected – public health problems. Paradoxically coexisting with undernutrition, an escalating global epidemic of overweight and obesity – 'globesity' – is taking over many parts of the world. If immediate action is not taken, millions will suffer from an array of serious health disorders."

- *World Health Organization (WHO)*

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General Introduction

There are now over 5 billion people actively connected to the internet, indicating that nearly two thirds of the global population is online (Petrosyan, 2024); the typical internet user spends over 3 hours online each day engaged in a variety of activities including watching TikTok videos, connecting to Facebook live streams, shopping and conducting Google searches (Statista, 2021). While so many of us are consumed with life online, there are numerous global crises underway that deserve our attention. Specifically, international bodies such as the World Health Organization (2021, 2023, 2024) and the World Economic Forum (2022) recognise that these crises—ranging from climate change to the growing pensions gap to the global obesity epidemic that is costing lives and straining public health systems worldwide—must be addressed by today's society to ensure future posterity. There is an opportunity for academics and practitioners to come together to design experiences that improve people's everyday lives while benefitting society more broadly, which is the core goal of my doctoral work. The primary purpose of my research is to investigate how we can develop assistive informational aids that help people make more socially responsible decisions as they live their lives online. While I am ultimately interested in studying socially responsible decision making under many contexts, my doctoral thesis focuses on exploring novel forms of digital nudges that could help people make healthier food choices in online or intelligently connected choice environments to help prevent and reduce rising rates of obesity seen around the globe (Lowell, 2004; Shugart, 2016; World Health Organization, 2024).

My research has strong links to behavioural economics and consumer behaviour but is perhaps most influenced by social psychology. As a first-year marketing doctoral student at the Kellogg School of Management at Northwestern University, I was exposed to vast amounts of literature related to consumer behaviour but was captivated most by Professor Dan Molden's 2014 graduate course on social cognition. I quickly became fascinated with literature that exposed the automatic nature of our behaviours and biases. I found work by Bargh, Chen, and Burrows (1996) so compelling that it ultimately shaped my academic interests and shifted my future research trajectory; their collective studies were able to dispel the long-held belief that we consciously control our behavioural responses to social environments, opening the doors for more research on socially-influenced decision making. Across multiple studies, these scholars were able to demonstrate that people could be primed with certain behaviours and stereotypes (e.g., rudeness, aggression) and automatically exhibit these behaviours outside of their own awareness in follow-up activities. The idea that we might complete a scrambled-sentence task using words that would prime an elderly stereotype (i.e., old, lonely, grey, retired) and then later be found to acting in accordance with that primed stereotype by walking more slowly, made me realize just how fallible our actions can be, despite feeling like we are in control and continuously acting with intent. While the exact mechanisms that drive such unconscious behavioural priming effects are under debate (Doyen et al., 2012), the notion that much of our behaviour is unconscious and driven by our environment is now well accepted in social psychology, warranting further research in contextual choice and decision making. While much of the literature we reviewed in social cognition was alarming, pointing to our innate tendency to make judgements on people based on observed behaviours without fully accounting for the situations which may be driving those behaviours (Gilbert & Malone, 1995) and highlighting how automaticity can further perpetuate prejudices and biases against other

groups of people (Blair et al., 2004; Devine, 1989; Gonsalkorale et al., 2009), I left the course motivated to understand how social categorization could be a force for social good, despite its tendency to promote undesirable stereotypes (Macrae & Bodenhausen, 2000). My first-year research project at Kellogg focused on investigating the impact that the presence of others has on our choices. Despite the large body of work related to in-group favouritism (M.B. Brewer, 1979, 1999) and the resulting strong intergroup bias (Hewstone, Rubin, & Willis, 2002), I was eager to demonstrate that the presence of out-group members could bring about positive behaviours, despite the biases and problematic attributions we typically have against out-group members (Hewstone, 1990; Pettigrew, 1979). I ran a field study at Northwestern University to understand whether people were more likely to make healthier food choices in the presence out-group members or in-group members. My initial study confirmed my hypothesis that healthy food choices would be greater in out-group situations than in-group situations, paving the way for a future publication I co-authored with my mentor on the topic (Touré-Tillery et al., 2022).

While my doctoral work at Northwestern University provided initial evidence that out-groups could be used to motivate more socially responsible decision making in traditional, real-world choice settings, it did not investigate how this would extend to digital choice environments, which is what brought me to the Oxford Internet Institute. The blurring of physical and digital worlds has never been more present than today; I sincerely believe if we want to impact consumer choice and decision making for social good, we must increasingly focus on studying virtual and hybrid choice environments that properly account for the mediating role that digital technologies play in our everyday lives (Shen et al., 2021). We cannot assume that offline and online behaviour

are equal. Many of the choices we make in more traditional real-world settings are happening in public, where impression management concerns heavily influence our actions, either consciously or unconsciously (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980). Conversely, many of our online activities are quite private and not typically exposed outwardly to others, indicating that offline behaviours motivated by self-presentation may not be replicated online, particularly when it comes to consumption (Ratner & Kahn, 2002).

The research I have conducted at the Oxford Internet Institute is still built on a rich body of literature related to consumer behaviour and social psychology, but also taps into the most recent research from human-computer interaction (HCI) and computer-mediated communication (CMC) to account for the unique affordances associated with digitally mediated choice environments, which was lacking in my research at Kellogg. Continuing in the tradition of famed behavioural economists Thaler and Sunstein (2008), my work aims to nudge individuals towards making decisions that benefit themselves and society more broadly. I seek to do so by modifying choice architectures without eliminating any options, specifically in digitally-mediated food choice. A vast amount of literature indicates that overeating and other self-regulatory failures can be attributed to a variety of factors, including:

- insufficient self-regulatory resources or internal "strength" (Baumeister, 2003)
- lack of goal activation (Fishbach et al., 2003) or goal fit (Hong & Lee, 2008)
- low motivation (Converse & DeShon, 2009; Job et al.,2010; Muraven & Slessareva, 2003; Touré-Tillery & Fishbach, 2011; Wan & Sternthal, 2008)
- mishaps in information processing (Chandon & Wansink, 2007; Chernev & Gal, 2010)

- lack of awareness or understanding of how our environment influences our decisions (Carver & Scheier, 2012; Chandon & Wansink, 2012; Wansink & Sobal, 2007)

Knowing this, my research seeks to design and test digital interventions that address many of the root causes of making unhealthy choices—lack of goal activation, low motivation, and mishaps in information processing—by using social comparisons and self-comparisons that alter online choice environments and nudge individuals to consider the healthier or more socially responsible choice. These comparison-based nudging mechanisms can be extended to the masses and enabled in a more automated, effortless way than existing forms of user-initiated self-tracking, while still offering many of the improved health and nutritional outcomes that typically come with dietary self-monitoring (Acharya et al., 2011; Burke et al., 2011).

I hope my research will help us better understand how people respond to social and self-comparisons when making choices in online contexts and uncover which types of nudging mechanisms are most effective in producing socially desirable outcomes. Such insights will be necessary to optimise digitally mediated choice environments and nudge people towards making healthier or more socially desirable choices in a variety of areas from food choice to resource consumption to long-term retirement savings. I will attempt to advance a novel form of social comparison nudging—the out-group social comparison—as current mechanisms used by recommendation agents and their embedded algorithms typically rely on in-group comparisons or recommendations generated by like-user behaviour (Benlian et al., 2012; Gomez-Uribe & Hunt, 2015). While this has worked well in a variety of contexts, whether it be on Amazon for shopping recommendations or Netflix for media recommendations, like user

comparisons will do little to push the status quo in areas where society is already challenged. For example, individuals who struggle to eat healthily will find little motivation when being compared to others who have similar struggles, making the technique that works so well for shopping and media recommendations less useful when encouraging dietary behaviour change. I will also look to resolve an ethical dilemma that currently exists in food choice nudging, which is that the most effective forms of nudging are also those that are most disapproved of by people (Cadario & Chandon, 2019). Finally, I recognize that not all people will want to engage in social comparisons, so I investigate what types of self-comparisons might be used as an alternative nudging technique for such people. In the end, I hope to uncover effective and ethical nudging techniques that people approve of that can inspire healthier choices and be applied at scale to impact real change. My core focus within this doctoral thesis is to focus on encouraging calorie reduction through novel forms of digital nudging given that my doctoral studies at Oxford were funded through an assistantship on "The Futures for Online Consumption" that was sponsored by Tesco Labs, the innovation arm of the Tesco retail group. While Tesco funded my DPhil studies at Oxford, they did not fund the individual research studies presented in this thesis or control research study design in anyway. Tesco was a collaborative partner that helped bring valuable real-world insights to my work to ensure that the work I was doing could impact academia and industry alike. Beyond this, I received additional funding from the Minderoo Foundation through the Minderoo-Oxford Challenge Fund to study artificial intelligence (AI) transparency disclosure.

When conducting nudging research, it is critical to adhere to ethical standards to ensure research is being conducted with sincere intentions and applied in ways that benefit

people without deception or misuse. I have set forth to design nudging mechanisms that are transparent and encourage a reflective mindset in an effort to nudge socially desirable outcomes that benefit individuals personally and society more broadly in each of the studies contained within my thesis. My doctoral research study designs and protocols were vetted through the Central University Research Ethics Committee (CUREC) at the University of Oxford (CUREC Reference No. SSH_OII_CIA_20_40). All studies included an introduction statement that described the purpose of a given study and informed participants they had a right to leave the study at any time for any reason. In addition, each study contained a detailed debrief about the study and provided contact information should there have been concerns about the study post-completion. No concerns were ever raised. I will further discuss the ethics of nudging throughout this thesis and reaffirm my commitment to inspiring the virtuous application of nudging techniques that I might identify through my research.

Thesis Overview

My integrated doctoral thesis will bring together three papers, some of which have already been published, to provide an in-depth review of using both social comparisons and self-comparisons to influence healthier diet choices in online grocery shopping contexts. The core focus of my research is on nudging using social comparisons, given this is a powerful and well-documented mechanism for influencing behaviour change (Caraban et al., 2019; Diel et al., 2021).

To help ground the reader before getting into details of the various studies contained within my three papers, my doctoral thesis provides a review of relevant literature from

a variety of disciplines, many of which are often disconnected—public health, consumer behaviour, and human-computer interaction. I establish the importance of my research by reviewing literature related to today's global obesity epidemic. I also highlight literature on existing interventions and point out shortcomings with previous approaches that attempt to facilitate behaviour change in health and diet. I then turn to literature from the social sciences to help us understand what motivates and persuades humans to change their behaviours. I introduce Thaler and Sunstein's (2008) work on nudge theory, as this serves as the foundation for my own doctoral work, and review more specific literature related to nudging food choice, nudging in digital environments, and nudging ethically. To fully understand the meaning and impact of my research findings, which centre around leveraging social influence to nudge healthy choice outcomes, I review a variety of literature. This literature explores how we are influenced by others, particularly in consumption settings, and how we do not respond to others the same way, bringing in a slice of literature related to intergroup bias. Finally, I review literature related to self-tracking and self-monitoring interventions in public health to set a baseline for my exploration into self-comparisons as a nudging alternative to social comparisons.

In my first paper, I investigate whether out-group social comparisons may serve as a potential alternative to the more conventional in-group or "People Like You" social comparison in inspiring virtuous choices through two studies conducted in the United Kingdom. The research presented in this paper provides initial evidence to support the notion that out-group social comparisons perform on-par with in-group comparisons. Both forms of social comparisons can be applied broadly to help inspire healthier choices online, with out-group comparisons seeming to work particularly well amongst

those who are typically resistant to dieting. In addition, this research investigated if nudging at the point of checkout would be effective, as previous studies in food choice nudging have largely focused on nudging at the point of product consideration (Forwood et al., 2015; Lawrence et al., 2001; Mollen et al., 2013; Salmon et al., 2015). The approaches I used to nudge did not involve publicly exposing actions and igniting a spotlight effect (Gilovich, Medvec, & Savitsky, 2000), but rather focused on invoking a heuristic goal to align to others (Cialdini, 1984, 2006; Festinger, 1954). The experimental techniques used in these initial studies were quite academic in nature and focused on understanding comparisons to others based on their self-identified body image (i.e., normal weight, overweight), building on existing literature that indicates we selectively allow other people's food choices to inform our food own choices depending on their body type (McFerran et al., 2010). As such, I focused on understanding whether normal weight individuals could be positively influenced by being compared to overweight individuals in contexts where their grocery basket calories were high and whether overweight individuals could be positively influenced by normal weight individuals in context where their grocery basket calories were high. While these mechanisms were never intended to be used in real-world contexts, they helped to demonstrate nudging effectiveness across broad populations in efforts that could be used to help prevent obesity (before people become overweight) or to reduce obesity (once individuals are overweight and may struggle to return to normal weight).

My second paper is my core paper and builds on the foundations of my first paper while also investigating whether goal-based self-comparisons may be a viable alternative to nudging food choice for individuals who do not want to take part in social competition. While my first paper was geared towards the HCI academic community that I most

identify with, I designed my second paper to appeal to a broader academic community, hoping this work might have a wider reach and greater impact. Within this paper, I employed a unique, organic split-study design where I allowed people to indicate whether or not they would like to join a Challenge Team as part of the overall study; participants who elected to join a colour-based Challenge Team were randomly assigned to one of the sub-experiment conditions related to social comparisons while those who indicated they did not want to join at Challenge Team were randomly assigned to one of the sub-experiment conditions related to self-comparisons. This experimental design was useful because it allowed me to naturally measure consumer acceptance of social comparison nudging. The design also helped to determine whether social comparisons would be agreeable to most people if leveraged at scale in the real world, recognizing consumers largely disapprove of effective nudging techniques employed in food choice settings today (Cadario & Chandon, 2019). I build on the social comparison findings from my first paper with increased generalizability by launching a cross-country study in the United States and United Kingdom with larger sample sizes. In doing so, I provide further confirmation that in-group and out-group social comparisons are both effective in nudging calorie reduction amongst broad populations. This holds true across geographies and amongst those who rate low in dietary control behaviours and would typically be resistant to making diet changes. In addition, by leveraging techniques from minimal group paradigm and constructing social comparisons based on colour teams, I was able to demonstrate strong social nudging effects without introducing a fear or stigma response that may have been observed in previous studies where comparisons to overweight individuals were made. Across all experimental sub-conditions, I employed more visual stimuli that were less reliant in numeric information and instead used a meter-based visualization to signal that basket calories were high, recognizing processing numbers and quantitative

information can increase cognitive load and inhibit comprehension (Harvey et al., 2011; Hutchinson et al., 2010; Tufte, 2001). Finally, I wanted to recognize that if these group comparison mechanisms were applied in real-world settings at scale, they would likely involve large data sets, algorithms, and artificial intelligent agents. When establishing my overall study design, I added another set of conditions that either made an AI disclosure statement visible or hidden to understand whether this would impact nudge impact, given scholars have called for more research in this area (Hancock et al., 2020).

In my third and final paper, I pick up where I left off at the end of my second paper and provide a deeper look into self-comparisons as an alternative nudging mechanism, comparing the effectiveness of two forms of self-comparisons—goal-based self-comparisons and historical, past-based self-comparisons. Goal-based self-comparisons are designed to provide people with a view of how well their current grocery selections match a pre-set nutritional or health goal, while past-based self-comparisons focus on alerting people when the grocery selections are less healthy than usual (i.e. contain more calories than is typical). I provide further confirmation on what subpopulations of people are most likely to benefit from self-comparison nudges, recognizing that not everyone will be interested in taking part on social comparisons. I wrap up my third and final paper by providing a recap of the overall effectiveness self-comparison nudges and articulating how they compare to the self-comparison nudges covered in earlier papers, while pointing out areas for further research.

I conclude my thesis with a discussion on my overall findings across the numerous studies detailed in my three papers, providing an overall assessment of how social and self-comparisons may be used to nudge heathier choice outcomes. I compliment my

findings by situating them with emerging literature on the topic and highlighting the specific contributions my findings make to the most current body of academic literature, noting critical gaps in the literature I have filled. I review shortcomings of my doctoral research and highlight areas where I would like to work with other scholars to bolster and build upon this foundational research to inspire more knowledge and greater impact.

Thesis Contributions

My doctoral thesis is significant in that the research presented broadens our conceptions of social comparisons and establishes the importance of considering both in-group "People Like You" social comparisons and out-group social comparisons. This is critical given my overarching goal of identifying mechanisms to encourage behaviour change in areas that are causing social strain and becoming social crises. If we want to help people eat healthier, save smarter, and consume less energy, we need effective tools and techniques to assist people who are struggling in these areas to change their behaviour. My research shows that people are largely open to being exposed to social challenges, which allows for robust social comparisons that can be dynamically generated in online or intelligently connected contexts, which helps nudge healthier decision making at points when people need the most help. Introducing and proving the effectiveness of a novel form of social comparison nudge—the out-group social comparison—is central to my thesis and should be of interest to both academics and practitioners alike.

From an academic perspective, my work is unique in that it contradicts voluminous literature on in-group bias and favouritism and demonstrates that out-groups can inspire

us to make healthier choices, which is not what we would expect given the historic body of literature in social psychology. My work also helps connect research across disciplines to generate new insights that can benefit multiple academic communities. For example, in public health, scholars have focused on using social norms and social proof points (Mollen et al., 2013; Salmon et al., 2015) to nudge healthier food choices, recognising that we will use others as reference points when we are unsure of what to do (Cialdini & Trost, 1998; Festinger, 1954). Unfortunately, the real-world limitations of relying on "what most people do" in practice inhibits the use of this powerful technique at scale because most people are not consistently exhibiting a desired behaviour, which restricts the contexts for which these broad social statements can be used. To resolve this problem, I was able to bring in literature from social psychology and consumer behaviour that establishes we respond differently to different kinds of others (M.B. Brewer, 1979, 1999; Escalas & Bettman, 2003, 2005; Kelley, 1952; White & Dahl, 2006, 2007). This literature suggests that we can and should investigate applying social comparisons at the social reference group level, rather than social norm level. Scholars in consumer behaviour have been actively researching food choice and attempting to uncover effective nudging mechanisms but have been unable to find effective nudges that people also approve of (Cadario & Chandon, 2019). Most of the research done within this field has focused on field studies that looked at modifying choice architectures within traditional choice environments, like grocery stores, cafes, and restaurants (Cadario & Chandon, 2020). To resolve the ethical dilemma raised by Cadario and Chandon (2019), I look to the HCI community. Scholars within HCI have identified 23 distinct ways to nudge people in technology-mediated environments (Caraban et al., 2019) and reviewed the various nudging mechanisms based on their level of transparency and to the degree to which they tap into our reflective mind or our automatic mind (Evans, 2008). In trying to identify nudges that people would approve

of, while not sacrificing for nudge efficacy, I wanted to rely on nudging techniques that are both transparent and trigger a reflective mindset, avoiding nudges that may go undetected. My nudge designs rely on several techniques that were both transparent and reflective: enabling social comparisons, suggesting alternatives, and reminding of consequences. In the end, my research identified effective nudging mechanisms that people approved of and were successful when applied in food choice contexts, which relied on connecting literature and techniques across disciplines.

Practically speaking, my research is important to shape the design of digital and information experiences of the future. Over the course of several experiments, I show that social comparisons can be used in a variety of information design formats, recognizing that more visual information aids may be preferred over those that rely on dense nutritional information (Campos et al., 2011; He et al., 2023). Dynamic personalization combined with advancements in artificial intelligence and machine learning points to a future where large datasets on human consumption behaviours may be used to create personalized information experiences that nudge people towards healthier choices when they engage in life online. My research shows that we can construct social comparisons based on a wide array of group comparisons. Moreover, when these comparisons are constructed automatically with well-designed algorithms and the application of large data sets, disclosing this does not impact nudge uptake, which indicates we should promote transparency of machine-generated comparisons and recommendations. My research should change the way we think about leveraging social comparisons online, influencing the type of information aids that are displayed, the disclosure of how such comparisons are constructed, and the very nature of the group comparisons that are programmed into social comparison algorithms.

Literature Review

My research seeks to understand where new opportunities may exist to help people improve their digitally mediated choices and decisions, especially in contexts where individual choices can have lasting consequences, both to themselves and to society. Within this literature review, I will highlight meaningful research from various fields including public health, behavioural economics, social psychology, consumer behaviour, and human-computer interaction. While traditionally quite disconnected, I will attempt to stitch these pieces of literature together to motivate a novel form of social nudging that can help facilitate behaviour change and improve social crises.

First, I will provide motivation for my research by reviewing literature from public health and consumer behaviour that underscores the current state of the global obesity epidemic and how existing interventions, mostly focused on awareness and education, have failed to shift problematic behaviours and meaningfully change population diets to date. Next, I will review pertinent literature related to persuasion and behaviour change given my research's focus on helping people to make healthier or more socially responsible decisions in areas where they may be struggling to exhibit positive behaviours, like eating healthily. Following that, I will review a relevant selection of work related to nudge theory as I look to employ nudging in digital contexts to encourage positive behaviour changes. Given that my research seeks to advance a novel form of social comparison nudging, I will then move into literature related to social influence and intergroup bias as to provide an overview of how we are influenced by others, particularly in consumption settings. Finally, I will review literature related to

self-tracking and self-monitoring interventions in public health as I seek to explore the promise of self-comparisons as a nudging alternative to social comparisons.

Obesity & Existing Interventions

According to the World Health Organization (WHO) (2021, 2024), worldwide obesity, caused by eating too much while moving too little, has nearly tripled since 1975 and continues to rise at an alarming rate, making the obesity epidemic one of the greatest public health challenges that we face today (Marques et al., 2020). After all, 40% of cancers and 75% of diabetes and cardiovascular disease could be avoided by tackling obesity and smoking (Marteau, 2018). Given the rapid and continued rise of obesity in nearly all parts of the world, there is an immediate need to prevent further rises in obesity, but doing so will be no easy feat given the limited effectiveness of efforts employed to date (Roberto, 2020). Findings from the field indicate that overeating, making indulgent choices, and other self-regulatory failures can be attributed to a variety of factors, including insufficient self-regulatory resources or internal "strength" (Baumeister et al., 1998), lack of goal activation (Fishbach et al., 2003) or goal fit (Hong & Lee, 2008), low motivation (Converse & DeShon, 2009; Job et al., 2010; Muraven & Slessareva, 2003; Touré-Tillery & Fishbach, 2011; Wan & Sternthal, 2008), and mishaps in information processing (Chandon & Wansink, 2007; Chernev & Gal, 2010). Poor food choices can also be due to a lack of awareness or understanding of how our environment influences our decisions (Carver & Scheier, 1982, 2012; Chandon & Wansink, 2012; Wansink & Sobal, 2007).

Despite this knowledge, T. P. Gill and Boylan (2012) point out that most modern-day efforts to control obesity have focused on education and awareness with limited effectiveness. Existing efforts have focused on shifting what we know through mass media campaigns, new media campaigns, and point of purchase interventions (T. P. Gill & Boylan, 2012). Public campaigns focused on obesity education have had minimal impact, at least in part because they are not sufficiently targeted to obese or at-risk overweight individuals (Walls et al., 2011). Beyond this, T. P. Gill and Boylan (2012) argue that existing attempts have failed because influencing what we know is not enough to curb behaviours that lead to obesity; future interventions must also focus on behaviour change. Marteau (2018) also supports the notion that a greater focus on the psychology of behaviour change is necessary to impact meaningful change in obesity, noting that future interventions should nudge behaviour change by bringing the non-conscious nature of our choices to our attention. Where educational campaigns have been successful, they have focused on children, who are more prone to behaviour change than adults (Katan, 2009; Walls et al., 2011). Perhaps the most fruitful example comes from a 12-year study conducted in France (Romon et al., 2009). The study followed 5-to-12-year-old school children in the target towns of Fleurbaix and Laventie as well as neighbouring towns from 1992 to 2004. During this time, children attending school in Fleurbaix and Laventie were encouraged to eat more healthily and move more through a combination of school-based nutrition programmes and community-based campaigns aimed to make healthy, active living more accessible, while no such programmes were offered in the neighbouring towns. When the researchers measured the weight status of school children in the target towns and neighbouring towns in 2004, they found the proportion of overweight children in the target towns had dropped to 8.8% while in the neighbouring comparison towns it rose in line with national trends to 17.8%. These results show that curbing obesity is possible when we seek to not only

shift what people know, but also modify their environments to make it easier to make healthy choices (T. P. Gill & Boylan, 2012; Katan, 2009; Marteau, 2018; Roberto, 2020; Romon et al., 2009).

When it comes to influencing people at the point of sale, front-of-package (FOP) labelling has taken centre stage among academic researchers to make nutritional information more accessible at the time and place where critical food decision-making takes place (Carruba et al., 2021; Ikonen et al., 2020; Song et al., 2021). While many countries require nutrition labels be placed on the back or sides of product packaging at a minimum, research has found that people have a hard time processing these complex labels (Campos et al., 2011). As a result, the World Health Organization (2017, 2019) recommends additional FOP labels be used to help consumers quickly identify healthier products. A recent interdisciplinary meta-analysis on over 100 articles related to FOP effectiveness found that while FOPs do help people to identify healthier products, they do not necessarily help people to make healthier food choices in practice (Ikonen et al., 2020). That said, there are many different forms of FOPs and research indicates that some are more promising than others when it comes to encouraging healthier food choices, especially in real-world settings where goals and time constraints are ever present (van Herpen & van Trijp, 2011). FOPs can generally be broken down into two major categories: interpretive or non-interpretive (Song et al., 2021). Interpretive forms rely on color-coded graphics or symbols to communicate nutritional ratings visually, such as the Nutri-Score used in France (Carruba et al., 2021) and the traffic light system used in the United Kingdom (GOV.UK, 2013), while non-interpretive forms focus on presenting guidelines or warnings that allow people to craft their own judgements based on the information presented (Song et al., 2021).

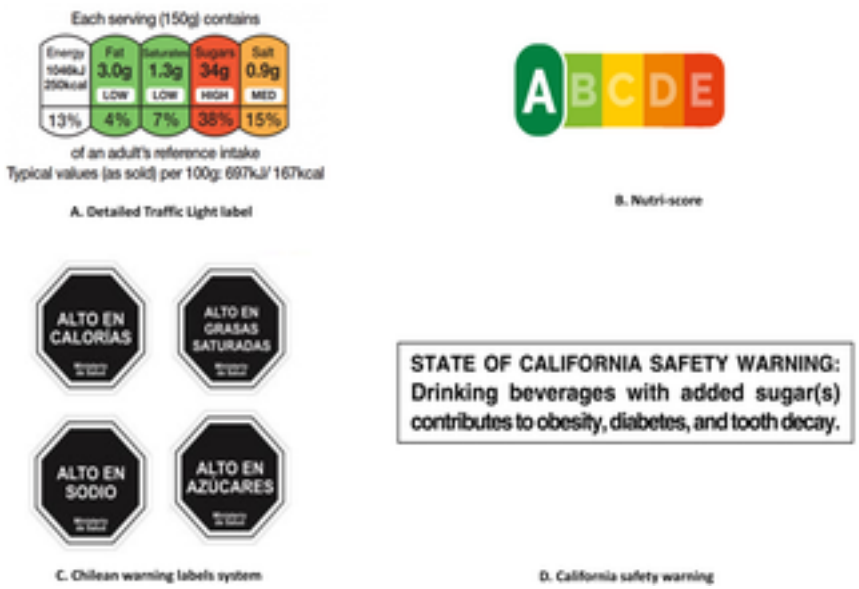


Figure 1: Interpretive (A&B) and Non-Interpretative (C&D) FOPs (Song et al., 2021)

A meta-analysis that sought to compare the effectiveness of two interpretive FOPs (the Nutri-Score and the traffic light system) and two non-interpretive FOPs (nutrition warning, health warning,) across 120 studies found that the color-coded interpretative FOPs were more successful in nudging people towards healthier products, but that the non-interpretative warning labels were more effective in discouraging unhealthy purchases (Song et al., 2021). Scully et al. (2020) administered an online experiment related to sugary drink selection at the same time as a major obesity prevention television campaign to understand the linkages between mass media campaigns and POS communication efforts. In their experiment, they exposed participants to either a control condition (no POS signage) or one of four POS signage conditions: sugar content of specific beverages; Health Star Rating of specific beverages; generic text health warning about sugary drinks; generic graphic health warning about sugary drinks. The researchers found that three of the four POS tactics—sugar content, Health Star Rating, and graphic health warning—were effective in significantly reducing sugary drink selection when compared to the control condition, but only amongst those

who did not recall seeing the current obesity campaign. These results indicate the importance of a multi-pronged approach to tackling obesity, underscoring that there is no single "silver bullet" when it comes to preventing further rises in obesity. Beyond this, much of the progress that has been made in advancing FOP and POS labelling and signposting formats to encourage healthier choices is at risk of being lost as people turn to more convenient online grocery shopping sites, where helpful nutritional information or guidance is often hidden behind more seductive product imagery (Plumbe et al.,2022)

Given that major efforts taken today around awareness, education and POS interventions have failed to prevent further rises to obesity, scholars in public health are calling for novel approaches to tackling the epidemic. First and foremost, emphasis must shift from efforts that seek to impact what people know to efforts that are more squarely focused on changing problematic behaviours, relying on principles of behavioural economics and psychology to come up with new behavioural interventions and appropriate policy measures (T. P. Gill & Boylan, 2012; Marteau, 2018; Roberto, 2020). Future interventions might work to explicitly address some of the known causes of mindless eating, such as lack of goal activation (Fishbach et al., 2003), low motivation (Converse & DeShon, 2009; Job et al., 2010; Muraven & Slessareva, 2003; Touré-Tillery & Fishbach, 2011; Wan & Sternthal, 2008), and mishaps in information processing (Chandon & Wansink, 2007; Chernev & Gal, 2010). Taking context into consideration will prove key; scholars argue that employing settings-based strategies that change our consumption environments will be necessary to impact meaningful change (T. P. Gill & Boylan, 2012; Katan, 2009; Marteau, 2018; Roberto, 2020).

Experimenting with modifications to food choice architectures through nudging has been identified as an emerging and critical research area for obesity studies that can bring together learnings from behavioural economics and psychology to change consumption environments and encourage more positive behaviours (Ensaff, 2021). There has never been a more important time for such research, given the emergence of less healthy eating practices as a result of coping with the COVID-19 pandemic (Lamy et al., 2022) and the sustained popularity of indulgent items like chocolate and champagne at the grocery store (Ryan, 2021).

Persuasion & Behaviour Change

Cialdini's (1984, 2006) six principles of persuasion—reciprocity, commitment, social proofing, liking, authority, and scarcity—provide a useful framework for understanding how people's choices are influenced based on foundational experimental studies in psychology and consumer behaviour. Given that many nudging techniques used to trigger positive behaviour change rely on these foundational principles, a brief overview of each principle is warranted. The principle of reciprocity indicates that we are inherently wired to repay, in kind, what has been paid to us. This norm is perhaps best illustrated by Kunz & Woolcott's (1976) Christmas card study which showed that 20% of people who received a Christmas card in the mail from a complete stranger sent one back in return, though returning the favour in this case was more likely when individuals could infer the sender was of a high status. The principle of commitment indicates that we are likely to "double down" on our choices just after we make them to establish internal consistency and commitment. This principle can be explained by Festinger's cognitive dissonance theory (1962) which indicates that having inconsistent thoughts, beliefs, or behaviours makes us uncomfortable, causing us to act in ways

which will allow us to restore consonance or reduce dissonance in these areas. Early research by Knox & Inkster (1968) demonstrates this principle in an experiment centred around horserace gambling; their studies showed that betters who were surveyed on their horse picks before they placed their bets were less certain their horses would win and reported being less confident in their choices than those who were surveyed just after they placed their bets. The principle of social proofing tells us that we tend to use the actions of others to guide our own behaviour when trying to determine what is appropriate, often resulting in herd behaviour or group think. This principle has been applied to help people change undesirable behaviours for decades in quite substantial ways. For example, to help children with a fear of dogs get rid of their phobias, Bandura, Grusec and Menlove (1967) had these children watch another child joyfully play with a dog for 20 minutes a day and observed that two thirds of the originally fearful children were willing to go play with a dog after just four days of the watching exercise. These reduced fear levels, driven by a social proof, held constant over time. The principle of liking indicates that we are more likely to say yes to or act in accordance with those that we know or like. Additionally, liking can be driven by a variety of factors such as physical attractiveness, similarity, flattery, familiarity, and positive associations. A field study by Suedfeld, Bochner and Matas (1971) demonstrates the power of the principle of liking driven by similarity; the researchers found that people were more likely to sign an anti-war petition when asked by someone dressed like them, and they often did so without even reading the petition. The principle of authority indicates we are likely to follow the lead of experts and engage in behaviours that are encouraged by authoritative or credible figures. While this may not seem too surprising when applied in marketing contexts, such as taking product recommendations from experts, experimental research by Milgram (1963) demonstrates just how profound and far reaching the principle is. For example, Milgram recruited 40

male Yale University students to take part in a cover study on memory and learning and found these students were willing to agree to deliver shock punishments to other students for getting an answer wrong when instructed to do so by an authority figure. The last of Cialdini's original principles—scarcity—tells us that people see items that are less available as being more important, ultimately shifting our behaviour and preference towards items that seem scarcer. A recent meta-analysis on studies related to scarcity in consumption contexts (Barton et al., 2022) documents that scarcity has been used to successfully cue high demand (e.g., empty shelves, limited quantity alerts), low supply (e.g., limited edition), and time availability (e.g., flash sale, happy hour) to successfully shift purchase intentions towards items that are more scarce.

These principles can be combined with Fogg's (2009) Behavioural Model (FBM) for persuasive design to create digital interventions for behaviour change. In fact, several of Cialdini's principles are embedded in the FBM, namely social proofing and scarcity. According to FBM, to motivate a person to perform a target behaviour that person must: (1) be sufficiently motivated, (2) be able to perform the behaviour, and (3) be triggered to perform the behaviour. All three factors must be present at the same time to observe the desired behaviour. FBM asserts there are three core motivators that can be used when designing behavioural interventions: pleasure/pain, hope/fear, social acceptance/social rejection. That said, only sufficient motivation needs to be reached, and more focus should be placed on ensuring people are able to perform the desired behaviour. To facilitate ability in real-world design, Fogg (2009) asserts that the focus should not be on teaching or training, but rather on making the action or desired behaviour as simple as possible to complete. Simplicity is driven by optimizing six factors: time, money, physical effort, brain cycles, social deviance, and non-routine

behaviour. While all factors are relevant and should be reduced to improve simplicity, the factor that is most scarce at the time a behaviour is trigged is most important and requires greatest optimization or reduction. Finally, effective triggers presented at the right time are a necessary and core component in persuasive design. To be considered effective, Fogg asserts that three trigger conditions must be met:

1. We must notice the trigger.
2. We must associate the trigger with the desired target behaviour.
3. We must receive the trigger when we are already motivated and able to perform the desired target behaviour.

The final condition tells us the right time to serve up a trigger, such as a prompt or call to action: after we have motivated an individual and made taking the desired action as simple as possible.

There are three kinds of triggers that can be used to drive behaviour change: spark triggers, facilitator triggers, and signal triggers. A spark trigger should be used in contexts where motivation may be lacking; a spark trigger will help combat this by building on one or more of the motivational elements previously discussed (pleasure/pain, hope/fear, social acceptance/social rejection) to create a "spark" and motivate an individual to act and perform the target behaviour. A facilitator trigger can be used to help individuals who are motivated but may not feel sufficiently able or ready to complete the target behaviour by re-enforcing just how simple taking action is. A good example of a facilitator trigger in eCommerce settings is "One Click Checkout." The final kind of trigger—the signal trigger—works best for those who are essentially ready to complete the desired behaviour (they are motivated and able to do so) and may simply need a reminder to complete the target action now. Traffic lights serve as a good

example of a signal trigger that we encounter in everyday life that work exceptionally well.

While Cialdini's principles and Fogg's model can be applied broadly to facilitate persuasion and behaviour change in a variety of contexts, Zhang et al. (2021) have developed a modern, adaptive framework for facilitating lifestyle behaviour change to help close the gap between theory and digital intervention application. Their framework is noteworthy in that it relies on integrating various learning and decision-making theories and models, from control theory of self-regulation (Carver & Scheier, 1982, 2012) to social cognitive theory (Bandura, 1989) to dual process models of cognition (Evans, 2008), to facilitate two levels of behaviour change to create lasting, lifestyle changes. The first level relates to action-level behaviour change, which represent our daily decisions, like what to eat, while the second level relates to reflection-level behaviour change, which represents decisions that tie into short-term goals, like eating more fruits and vegetables, that ladder up to more abstract long-term goals, like improving one's nutritional wellbeing. Influencing decision making across these temporal models requires using different underlying theories to inform intervention design, with daily action-level decisions being more heavily guided by dual process models of cognition (Evans, 2008; Evans & Stanovich, 2013) and higher order reflection-level decisions being driven more by reasoned action approach (Head & Noar, 2014).

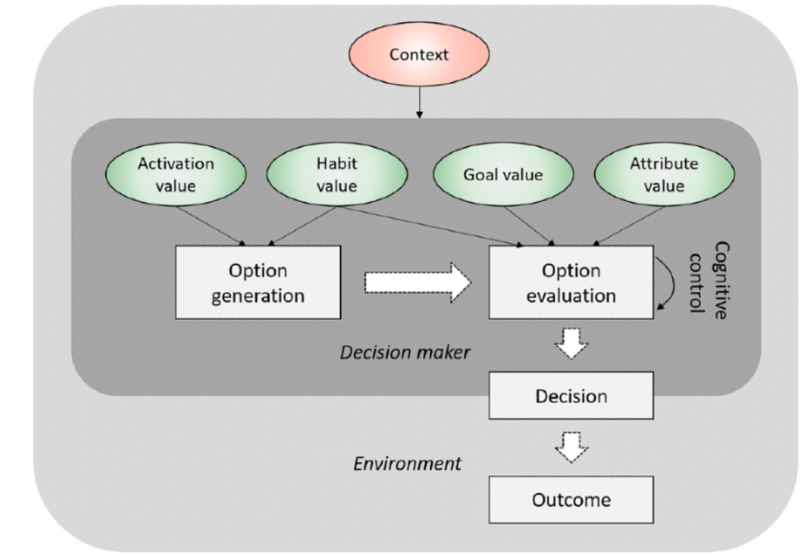


Figure 2: Two-Step Action-Level Decision Making Process (Zhang et al., 2021)

Zhang et al.'s (2021) framework can be useful to understand why many people struggle to eat healthily. When making daily decisions, we follow a two-step process that involves understanding all possible options and then evaluating the options to select the best possible option (see Figure 2). The options we consider are often driven by habit, salient goals, and external triggers. When evaluating the options in our consideration set, we are hard-wired to pick the item that best meets our goals; but in food choice contexts, our goal for hedonic pleasure can be at odds with a personal long-term goal to eat healthily or an innate goal to comply with social norms (Ajzen & Madden, 1986). Interventions that can help us slow down and direct our focus on non-hedonic goals may motivate us to exert self-control and make the healthy choice (Inzlicht & Schmeichel, 2012).

Nudge Theory

Nobel Prize-winners Richard Thaler and Cass Sunstein's (2008) work on nudging demonstrates that by better understanding how people make decisions and altering choice environments and architectures accordingly, we can make it easier for people to choose what is best for them, their families and society. Nudging can be applied when making decisions in a variety of contexts, from food choice to retirement savings. According to Thaler and Sunstein (2008), we can think of a nudge as a modification of "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (p. 6). Nudges are all around us, even if we do not always realise it. For example, Thaler's favourite example of nudging is London street signage that reminds (often foreign or visiting) pedestrians to look in the correct direction to ensure there is no oncoming traffic before crossing the street; this example is easy to appreciate and showcases the overall good that can come from making subtle shifts in choice environments (in this case, quite literally saving lives), without forbidding options or changing economic incentives.



Figure 3: Nudging in Everyday Life (London, United Kingdom)

Thaler and Sunstein's (2008) initial work on nudging within behavioural economics has inspired widespread interest in how we might be able nudge people to make healthier choices across disciplines from marketing (Cadario & Chandon, 2020) to public health (Arno & Thomas, 2016; Ensaff, 2021) to HCI (Caraban et al., 2019). A systematic review of over 400 nudging interventions across 156 studies revealed that a great deal of research on this topic exists across a variety of domains from consumer choice to health to education (Szaszi et al., 2018). The systemic review uncovered numerous nudging techniques that received significant attention across disciplines: setting a target default option, providing timely reminders, making information more visible, reducing effort for the target choice, translating information, and providing a social reference point (Szaszi et al., 2018). It is important to note that the effectiveness of these nudging techniques has been well documented and applied in a variety of settings, which is unsurprising given that they largely build on principles previously discussed from Cialdini (1984, 2006) and Fogg (2009). Given the strong evidence across fields for these nudging techniques, it is worth considering all of them as a foundation for future nudges that may rely on combining strategies to influence more significant behaviour change in public health contexts (Ensaff, 2021; Roberto, 2020).

To dig deeper into the promise of nudging positive dietary changes, Arno and Thomas (2016) conducted a more focused meta-analysis within public health contexts. Specifically, the authors leveraged 42 studies from 37 papers related to nudging healthier food choices and found that nudging results in an average 15.3% increase in healthy choice outcomes. Despite the abundance of emerging nudging research with positive results, Szaszi et al. (2018) note that the lack of common nomenclature and an integrative nudging framework limits our ability to fully understand the body of

knowledge and synthesize findings to establish the most promising areas for further nudging research in targeted areas, such as food choice.

Nudging Food Choice

To address this shortcoming and allow us to advance the body of knowledge on nudging dietary behaviour change, Cadario and Chandon (2020) recently conducted a comprehensive meta-analysis, looking at 299 effect sizes across 96 studies in 90 articles that focus specifically on nudging healthier food choices. In doing so, Cadario and Chandon were able to produce a nudging framework that identified seven kinds of nudging mechanisms grouped into three nudging categories: cognitively oriented, affectively oriented, and behaviourally oriented nudges. Their meta-analysis indicated that cognitive nudges that seek to impact what people know through mechanisms like nutrition labels, infographics, and visibility enhancements are least effective in encouraging calorie reduction. Nudges that are affective in nature and seek to influence our emotions through healthy lifestyle "call to actions" or hedonic enhancements that make healthy options look more appealing than unhealthy options, perform better than cognitively oriented nudges. That said, healthy food nudges that manipulated or influenced behaviour resulted in the greatest calorie reduction and performed best overall through mechanisms that focus on convenience, such as defaulting to healthy options automatically, or size enhancements, such as offering smaller packages or portions of unhealthy food items through offerings like "100 Calorie Snack Packs."

While Cadario & Chandon's meta-analysis is both recent and broad in focus, many other narrowly focused systematic reviews and meta-analyses on nudging food choice

exist and add to the body of knowledge on this topic. For example, a systematic review by Bucher et al. (2016) looked at how the placement of food might impact food choice and found that nudges that manipulate the order or physical proximity of food choices can be effective. Wilson et al. (2016) also conducted a systematic review on studies that used salience and priming to nudge healthier food and beverage choices and found that while each of these techniques produced mixed and lacklustre results when used alone, nudges that combined salience and priming did encourage healthier choice outcomes. These findings serve as support for Ensaff's (2021) and Roberto's (2020) claims that future food choice nudges should focus on merging multiple nudging techniques for greater impact. Nudging has also been studied extensively to try to increase fruit and vegetable intake. A systematic review and meta-analysis by Broers et al. (2017) found nudges used to encourage eating more fruits and vegetables are generally only moderately effective, though nudges that alter placement or rely on multiple techniques produce the strongest healthy choice outcomes. These findings bolster the outcomes from previous systematic reviews on proximity and placement effects (Bucher et al., 2016; Wilson et al., 2016) and again serve as support for calls to action to start integrating multiple nudging techniques (Ensaff, 2021; Roberto, 2020). Beyond this, other systematic reviews have focused on how nudges have been applied in key settings, such as self-service eateries (Skov et al., 2013), schools (Marcano-Olivier et al., 2020; Metcalfe et al., 2020; Nørnberg et al., 2016), work (Al-Khudairy et al., 2019; Allan et al., 2017), and home (Lycett et al., 2017), given the importance of environment and context on nudging effectiveness (T. P. Gill & Boylan, 2012).

The comprehensive findings from Cardio & Chandon's (2020) work indicate that future research efforts should focus on behaviourally oriented nudging, such as testing portion

size variants to optimise purchase and consumption rates of healthy foods (DiSantis et al., 2013; T. Gill et al., 2022) or making healthier options more convenient to select (Rozin et al., 2011). However, additional research on the ethics of food nudging has uncovered a dilemma: the behavioural types of food nudges that work best are least liked by people, while those that are most liked are unfortunately the least effective in encouraging calorie reduction (Cadario & Chandon, 2019). Over 75% of people indicate they are agreeable to nudges that inform what they know through descriptive nutritional labels and evaluative infographics, while less than 50% approve of the most effective food nudges which aim to shift behaviour through smaller portion or package sizes. The result is a lack of effective, people-friendly healthy eating nudging solutions that can be applied to populations at scale to meaningfully impact population diets, indicating the need for novel nudging approaches that people would approve of (Ensaff, 2021; Felsen et al.2013; Hansen & Jespersen, 2013).

Despite the challenges and lack of real-world impact seen by applying nudges to impact dietary behaviour changes in the real world, Ensaff (2021) asserts there are four core reasons to invest more effort into nudging research in this area: (1) there is strong evidence that nudges can influence people's food choices in meaningful ways, (2) implementing and maintaining nudging strategies can be cost effective, (3) when applied at scale, nudges that result even in smaller changes can cause massive shifts to population diets, and (4) nudging healthier food choices does not restrict choice in any way, potentially benefitting both consumers and businesses.

Given the promise of nudging to influence changes to population diets, public health scholars have attempted to design online and offline nudges that inspire healthy food

choices virtuously but have also experienced the same pitfalls documented by Cadario and Chandon (2019, 2020). Many researchers in public health have focused on less effective, but more agreeable forms of cognitive nudging while testing nutritional food swaps, health labels, and visibility enhancements in additional experiments not covered in Cadario and Chandon's extensive meta-analysis (2020). For example, Forwood et al. (2015) tested an online grocery shopping site that nudged users to swap out higher calorie foods for healthier, lower calorie options in the same food category using descriptive nutritional comparisons. Their intervention had mixed success. Participants were instructed to purchase 12 items and were on average offered four potential healthy food swaps which resulted in a median uptake of one healthy food swap; the researchers were unable to observe a meaningful reduction in overall energy density of the 12-item basket at checkout with these minimal results. Similarly, a field study conducted in a university cafeteria tried to nudge healthier pre-packaged food items using physical nutrition labels with limited impact (Cioffi et al., 2015). The study revealed that added nutritional labelling produces a small but significant reduction in the purchase of high calorie, high fat food items and a small but significant increase in the purchase of low-calorie, low-fat foods, adding to the body of evidence suggesting small effect sizes are typically observed with cognitively oriented nudges. Another cognitive approach to nudging calorie reduction includes visibility enhancements that make healthy items easier to see by placing them in at eye-level or near checkout lanes, which has proven successful in encouraging increased purchase of healthy food items in field studies (Gestel et al.,2018; Kroese et al., 2016) but with small comparative effect sizes (Cadario & Chandon, 2019, 2020). While these results are a step in the right direction, the limited effect sizes observed in these studies as well as other studies on nutritional labelling (Agarwal et al., 2014) have not shifted the direction of problematic behaviour. Subsequently, there has been rises in obesity, prompting governments to place stricter

bans on promotions of unhealthy food items (GOV.UK, 2020) to curb problematic behaviour while alternative forms of nudging are investigated (Ensaff, 2021).

Nudging in Digital Contexts

Scholars in HCI have also been impacted by the promise of nudging, prompting the systematic review of 71 different papers in HCI that deal with nudging, resulting in a comprehensive framework for technology-mediated nudging (Caraban et al., 2019). This framework brings together 23 forms of digital nudging, grouped in six categories:

1. Facilitate
2. Confront
3. Deceive
4. Social Influence
5. Fear
6. Reinforce

Within the category of social influence, the underlying nudging mechanisms identified—invoking feelings of reciprocity, leveraging public commitment, raising the visibility of users' actions, and enabling social comparisons—largely tie back to Cialdini's Principles of Persuasion (1984, 2006), Fogg's Behavioural Model for Persuasive Design (2009) and the higher-order framework identified by Cadario and Chandon (2020). While existing studies in HCI that involve nudging using reciprocity and public commitment did not focus on interventions that influenced public health outcomes, many of the studies that relied on raising the visibility of users' actions and leveraging social comparisons were closely related to public health topics, indicating strong promise for nudging healthy food choices using these techniques. For example,

HCI scholars were able to tap into the spotlight effect phenomenon (Gilovich et al., 2000)—our tendency to overestimate how much attention and care other people give to our own actions, prompting us to prioritise socially responsible behaviours while seeking approval from others—to socially expose our actions in areas where we might benefit from added social pressure to do the "right" thing, such as brushing our teeth (Caraban et al., 2015) or producing less waste (Thieme et al., 2012), by designing and testing digital agents that nudge positive behaviours in these areas. Self-tracking technology serves as a prime example of how embedding social influence nudges within digital devices can encourage healthier behaviours (Caraban et al., 2015; Neff & Nafus, 2016). Successful self-tracking interventions often compare users with like users that have similar goals, as is the case in *Normly,* a visual watch face that dynamically compares one's current walk distance to that of another user with the same walk or step goal (Gouveia et al., 2016). Researchers have found interventions like *Normly* are effective if the distance between one's current behaviour and the target comparison behaviour is not too great (i.e., catching up with the other like user's walk distance or step count feels within reach).

Nudging Ethically

Thus far the literature has indicated there is much promise in social forms of nudging (Caraban et al., 2019; Sunstein, 2014; Thaler & Sunstein, 2008), but has also brought forth ethical challenges (Cadario & Chandon, 2019; Sunstein, 2015). According to Sunstein (2015), for nudging to be applied ethically and virtuously, nudges must meet three conditions: (1) they should be transparent, (2) they must be easy to opt out of, and (3) they should improve the person's welfare. In addition, nudges can operate outside of our awareness, tapping into our Automatic Mind or System I processes, or consciously,

tapping into our Reflective Mind or System II processes (Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2011). As such, nudges can essentially be broken down into four categories based on whether they tap into System I or System II thinking and whether they are transparent or not (Caraban et al., 2019; Hansen & Jespersen, 2013).

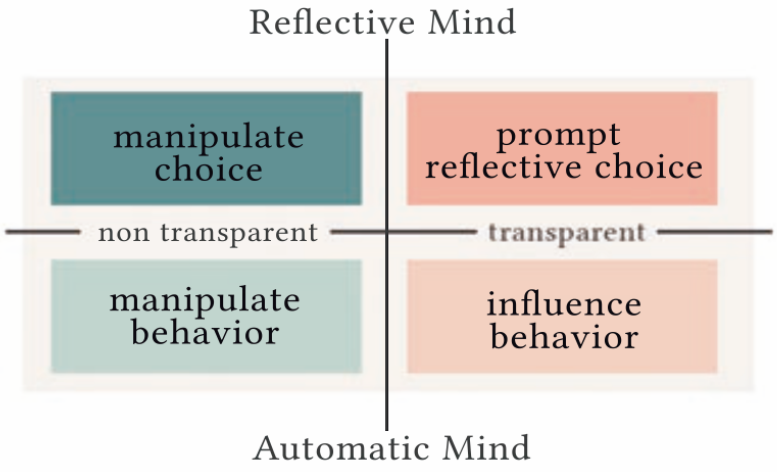


Figure 4: Four Categories of Nudging (Caraban et al., 2019)

While Sunstein has argued that nudges should always aim to be transparent (Sunstein, 2015), there is debate on whether nudges that manipulate but achieve socially desirable outcomes have merit (Hansen & Jespersen, 2013). While there has been some initial evidence that people prefer nudges that tap into reflective thinking (Sunstein, 2016), studies show that our acceptance of nudging is nuanced (Hagman et al., 2015) and that both System I and System II nudges can be deemed acceptable by people depending on context (Djupegot & Hansen, 2020). Perhaps one of the most used and extensively studied nudging strategies that seeks to manipulate behaviour outside of our awareness is the defaulting nudge (Szaszi et al., 2018; Thaler & Sunstein, 2008). Default nudges have been studied and used to help encourage socially desirable behaviours from increased organ donation (E. J. Johnson & Goldstein, 2003) to retirement savings

(Behavioural Insights Team, 2013) with great long-term success. For example, when applied to help close the growing pensions gap, a UK policy that required employers to default employees to auto-enrol in a pension plan saw pension participation rate shift from 36% to 71%, even though the opt-out option was still available to all employees (Behavioural Insights Team, 2013). The default nudge operates outside of our awareness; it is transparent but does not leverage an active prompt that requires our deliberate consideration, which has been the cause of much ethical debate (N. C. Smith et al., 2013). A recent study by Michaelsen, Johansson, and Hedesström (2021) sought to uncover how people feel about default nudges today by measuring experiences of autonomy, choice-satisfaction, perceived threat to freedom of choice, and objection to the choice architecture, given these are typically the constructs considered by scholars engaged in the ethical debate on nudging (Schmidt & Engelen, 2020). Across multiple studies, the researchers found participants who were randomly assigned to the condition that defaulted them to select the socially desirable choice (i.e., defaulted to select environmentally friendly "green" apartment appliances, donate bonus payment to charity) resulted in significantly higher socially desirable choice outcomes than other conditions. Notably, these participants consistently reported high levels of autonomy and choice satisfaction and low levels of objection to the choice architecture format. While the perceived threat to freedom of choice was low across all the studies, participants who were nudged to donate their bonus payment did report higher levels of perceived freedom of choice threat than the other conditions in that study, likely prompted by a sensitivity to money and financial health. All in all, this recent study provides solid evidence that ethically debated forms of nudging that seek to influence our behaviour for social good may not be as disliked or problematic to people as scholars have suggested. While these findings may seem to be at odds with those from Cadario and Chandon (2019) at first glance, Cadario and Chandon note a strong link

between consumer acceptance of nudging and their perceived effectiveness of that nudging strategy. This suggests that if people have developed an awareness of the promise of default nudges in facilitating positive behaviour change, their acceptance may very well be high, though again this can be heavily nuanced by context.

Regardless, consensus seems to indicate that nudges that are transparent and encourage users to slow down and tap into their reflective minds by engaging in controlled thinking is the more ethical way to nudge (Sunstein, 2015). Recognizing that most of our food choices are driven by automatic System I rather than deliberate System II processes, public health scholars have issued a call to action to focus on nudges that attack some of our System I failures, like eating impulsivity (Roberto, 2020). As a result, scholars have built and studied tools like ImpulsePal (van Beurden et al., 2021) that can encourage more mindful eating behaviours, helping us to combat automatic impulses to overindulge on unhealthy foods for hedonic pleasure rather than choose healthier options for utilitarian caloric fuel and nutrition (Dhar & Wertenbroch, 2000; Lowe & Butryn, 2007). While such digital tools are noteworthy and deserve praise, research by Marques et al. (2020) indicates that food choice nudges that alter the perceived variety of healthy foods, like vegetables, through presentation enhancements—classified by Cadario and Chandon (2020) as an affectively-oriented nudge—can be effective in prompting more healthy choice outcomes, even amongst the most impulsive eaters. This research replicates previous findings on the impact of presentation enhancements on healthy food choice outcomes (Friis et al., 2017; Thorndike et al., 2012), but more importantly indicates that nudges that are not specifically targeted at addressing a System I weakness (i.e., impulsivity) can still be effective when this weakness is intact and active.

To date, most digital nudging work by HCI scholars has focused on investigating more ethical forms of transparent, reflective nudges (see Figure 5). Caraban et al. (2019) present a useful matrix that overlays the 23 nudging mechanisms they have identified through their systematic review of HCI literature on nudging into the four categories that tie back into the definitions outlined by Hansen & Jespersen (2013).

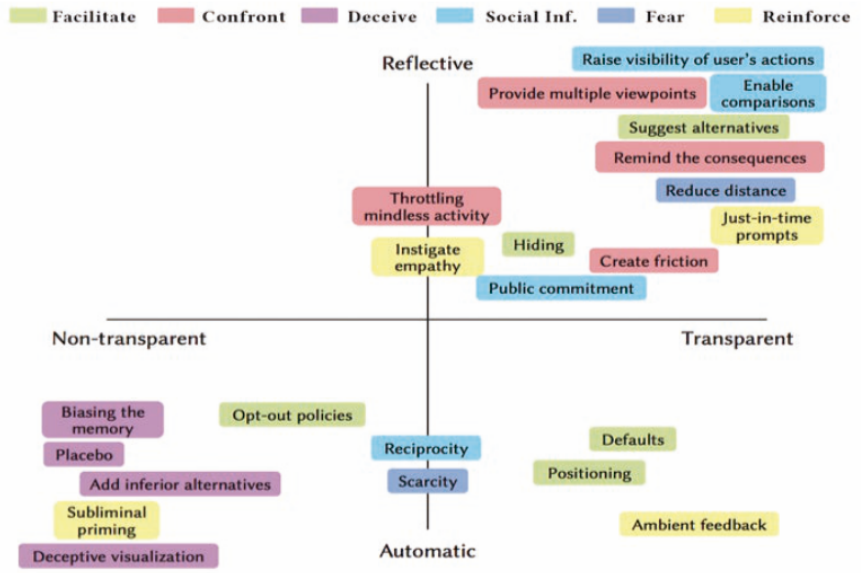


Figure 5: HCI Nudging Mechanisms Matrix (Caraban et al., 2019)

It is worth re-iterating that the HCI nudge research that has been covered in more detail within this review and has been used to inform the body of research in my thesis are those that remind users of consequences, enable social comparisons, and suggest alternatives, all of which are flagged as being transparent, reflective techniques (see Figure 5) that prompt a reflective choice (Caraban et al., 2019), while adhering to ethical guidelines outlined by Sunstein (2015). That said, in real-world practice, many of the digital choice architectures implemented by social media outlets like Facebook and Twitter lack transparency and nudge without virtuous intent, adding to the ethical

disconnect between research and practice (Schmidt & Engelen, 2020). Regardless of the specific type of nudging strategy one might use or behavioural policy one might seek to implement, Lades & Delaney (2022) present an ethical framework, FORGOOD, to enable more ethical nudging. Their framework suggests that nudging interventions and policies must consider seven ethical dimensions: Fairness, Openness, Respect, Goals, Opinions, Options and Delegation. Both researchers and practitioners can use the FOORGOOD framework the help ensure we nudge in an increasingly ethical way.

Social Influence

While the varied research on healthy food nudges across disciplines has been insightful, effective interventions that can be applied at scale to impact meaningful change remain limited. Again, much effort has gone into exploring variations of different forms of descriptive and evaluative nutrition-related labelling that can be applied to physical products or displayed along them online (Campos et al.,2011; Carruba et al., 2021; Touvier et al., 2021; Werle et al., 2022), for which there is much merit given consumer acceptance of such aids (Cadario & Chandon, 2019). This is still problematic though, given the strong body of research previously reviewed that indicates that interventions focused on educational and informational awareness alone is not enough to significantly impact our food choices; we must start to investigate nudges that layer on multiple techniques to truly impact behaviour change in this area (Roberto, 2020). Thus, there is opportunity to explore how social affordances (Caraban et al., 2019; Szaszi et al., 2018; Thaler & Sunstein, 2008) could be used to bolster the impact of accepted but less effective cognitive baseline nudges. After all, research has shown that recommender agents that add on social comparisons to like users are often effective in a variety of contexts from e-Commerce (Benlian et al., 2012), to self-tracking (Gouveia et al.,

2016), to media consumption (Gomez-Uribe & Hunt, 2015), building off the liking and consensus principles of persuasion (Cialdini, 1984, 2006) and a wide body of research related to in-group favouritism (Balliet Wu, & De Dreu, 2014; M.B. Brewer, 1979, 1999; Hewstone, 1990; Pettigrew, 1979).

A meta-analysis on digitally mediated nudging revealed that numerous methods tested and employed—invoking feelings of reciprocity, leveraging public commitment, raising the visibility of users' actions, and enabling social comparisons—relied on social influence (Caraban et al., 2019). The power of social influence nudging, particularly when applied in digital health contexts, can largely be explained by social cognitive theory (Bandura, 1989, 2004; Davis et al., 2015; Webb et al., 2010) and social comparison theory (Festinger, 1954; Goethals, 1986). Bandura's (1989) social cognitive theory explains how people can learn to demonstrate and maintain behaviours that are congruent with their goals while emphasizing the strong influence that one's social environment has on helping to both form and reinforce goal-directed behaviours. To exert healthy behaviours to achieve longer term health goals, social cognitive theory tells us that we must first have a positive view of our overall ability to be healthy, establishing self-efficacy. Beyond this, we must know how to complete desired behaviours. Whether or not we demonstrate desired behaviours repeatedly over time depends on how well a given behaviour is reinforced both internally and externally. For example, experiencing a positive internal reinforcement, such as feeling more energetic, or positive external reinforcement, such as receiving praise, after eating healthy vegetables is likely to encourage repeating of that behaviour. Finally, our willingness to demonstrate healthy behaviours is also dependent on our expectations on what will happen when we do. Both reinforcements and expectations can be heavily influenced by

social factors. Bandura's original theory (1989) has been applied to health contexts more recently (2004), demonstrating how social nudges can help facilitate health goals that encourage congruent behaviours while also making clear the pivotal role social norms have in shaping our behavioural outcome expectations.

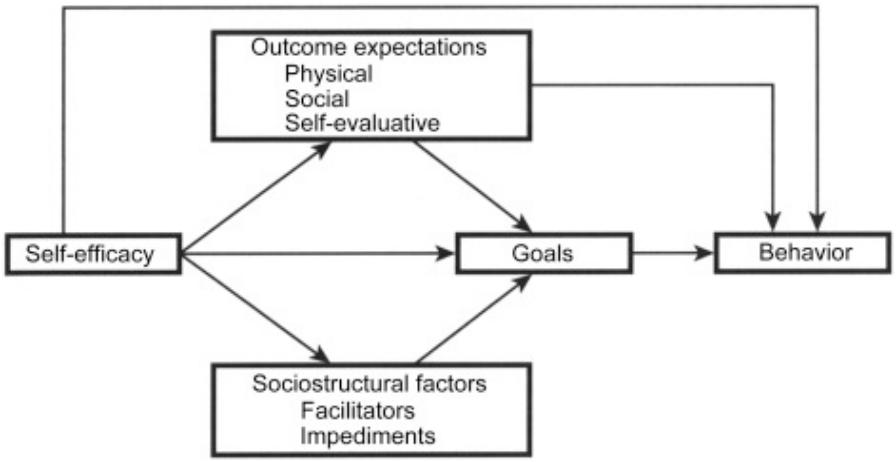


Figure 6: Social Cognitive Model for Promoting Healthy Behaviours (Bandura, 2004)

While social cognitive theory speaks to the broader impact that our social environment has on helping us to learn and maintain individual behaviours, Festinger's social comparison theory (1954) addresses how we use social information to better understand ourselves and reflect on our own abilities. According to Festinger (1954), we have an innate need to evaluate our own opinions and abilities and, absent other physical means to guide such evaluation, we will turn to others as a means for comparative evaluation. Festinger's theory added to early work on reference group comparisons that had been started by social psychologists like Hyman (1942, 1960) and Kelley (1952); his theory asserts that social comparisons will only be made to individuals deemed to be of a similar likeness, as a precise evaluation requires this. This portion of Festinger's theory can largely explain why social comparison nudges have traditionally relied on

comparisons to like others or in-groups (Bicchieri & Dimant, 2019), until my research challenged this convention (DiCosola & Neff, 2020, 2022). Taken together, Bandura's and Festinger's works underscore the pivotal role that social environments and the people contained within them have on our on-going human development.

Research in consumer behaviour has long accounted for social influence given that choice and decision-making in consumption environments is rarely done in isolation—others are almost always present (Argo, 2020). There are three well documented forms of influence that others can have on our choices: utilitarian, value-expressive, and informational. The first, utilitarian influence, tells us that people, driven by a need to belong (Allen et al., 2022; Baumeister & Leary, 1995; Maslow, 1943; Maslow & Lewis, 1987), will act in ways to maintain or strengthen their affiliation with others (Argo, 2020). Chen (2017) found that we will provide word of mouth recommendations to strangers to form new relationships, while we will do so with friends to maintain existing relationships that are important to us. The second, value-expressive influence, indicates that people will operate in ways to maintain a positive view of themselves (Steele, 1988) based on the ways they identify and connect with others (Kelman, 1958). As such, individuals will often seek to associate with a positive social presence or dissociate from a negative social presence (Argo, 2020) while engaging in impression management techniques (Leary & Kowalski, 1990; Schlenker, 1980) to help control the perceptions others have of them. Knowing that our possessions form a core part of our identity and self-concept (Belk, 1988), Berger and Heath's (2007, 2008) body of work demonstrates that people are more likely to make choices that stand out or diverge from the crowd in domains that are more symbolic of identity (e.g., hairstyles, music) as a way to signal their desired identity to others. The key difference between these two

forms of influence is that utilitarian influence is driven by a need to belong while value-expressive is driven by a need to protect and enhance one's self-concept. The final type of influence, informational, indicates that people seek to gather information from social consumption environments to inform their decision-making (Argo, 2020; Deutsch & Gerard, 1955). For example, when walking down the High Street, a person might scan cafes and restaurants and when seeing a long queue, a form of social proof (Cialdini, 1984), infer this place is high quality and superior to those nearby without queues, and will thus provide the best overall experience (Koo & Fishbach, 2010). People may also use the appearance of others to inform their decisions, including their food choices. McFerran, Dahl, Fitzsimons, and Morales (2010) studied how we use others as reference points when making food decisions. Their research revealed that the body composition of others influences the degree to which we allow others food consumption practices to impact our own; they observe that people will select larger portions if those who order before them select large portions, but this portion is significantly smaller if the person ordering previously is obese. These three forms of influence can be used to design more effective social nudges.

We know that humans innately look to others to inform our beliefs and behaviours in uncertain situations (Bandura, 1989; Cialdini, 1984, 2006; Festinger, 1954). Early research in social facilitation (Zajonc, 1965) brought forth solid evidence that people look to others when deciding what and how much to eat, inspiring a vast amount of literature on the social modelling of food intake (Cruwys et al., 2015; Vartanian et al., 2015). Given these findings, a natural next question is how we can better leverage social factors to nudge people towards making healthier food choices, building on the foundational evidence for social norm nudging brought forth by Thaler and Sunstein

(2008). As a construct, a social norm can be thought of as "rules and standards that are understood by members of a group, and that guide and/or constrain social behaviour without the force of law" (Cialdini & Trost, 1998, p. 152). We adhere to social norms in an effort to either gain approval from society or to simply act appropriately (Deutsch & Gerard, 1955). While social norm statements have been shown to be effective in persuading people to make healthier choices (Bicchieri & Dimant, 2019; Cialdini et al., 2006) they present an interesting challenge in that descriptive norm statements, which relate to what most people do, are more effective in encouraging positive food choice behaviours than injunctive norm statements, which relate to what most people would approve of or what would be most socially acceptable (Mollen et al., 2013). This is problematic given the escalating obesity crisis (Lowell, 2004; World Health Organization, 2021, 2024), the rise in popularity of unhealthy foods at the grocery store as of late (Tatum, 2020; Ryan, 2021) and the increase of mindless eating and snacking as well as overall food consumption during the pandemic (Simone et al., 2021). Highlighting what most people are doing regarding food choice will likely only lead to further rises in obesity and potentially backfire (Bicchieri & Dimant, 2019). That said, applying lower-level social proofs (Cialdini, 1984, 2006) in select contexts can be effective. For example, researchers found that adding social proofing labels to a healthier, low fat cream cheese that indicated it was the best-selling cream cheese resulted in a significantly higher purchase rate for that variant as compared to the unlabelled variant of the same cream cheese amongst participants who had low self-control (Salmon et al., 2015).

All combined, evidence from the field suggests that social reference point nudging has great potential (T. P. Gill & Boylan, 2012; Sunstein, 2014; Szaszi et al., 2018), but

effectiveness is constrained by our natural reality, with many of our common food purchases and consumption behaviours being problematic and unable to inspire positive change for the masses. That said, recent research has shown there are dominant clusters of "healthier" and "unhealthier" eaters (Lamy et al., 2022), potentially presenting an opportunity to nudge people towards healthier food choices and outcomes by showcasing the purchases and behaviours from the healthier eaters' cluster. Such an intervention would rely on social proof points (Cialdini, 1984, 2006) that are not as restrictive as social norms (Cialdini & Trost, 1998) to facilitate social comparisons that invoke social competition (Festinger, 1954; Triplett, 1898).

Reference Groups & Intergroup Bias

We know from foundational literature in social psychology that we engage in social comparisons (Festinger, 1954) and that when doing so, we seek to compare ourselves to others who are like us and exist within the same social circles as we do (Jones & Gerard, 1967). Tajfel's & Turner's social identity theory (1979) tells us that we take great internal pride in the social groups we belong to, causing us to engage in social categorization that allows us to pit our own groups (us) against outside groups (them) to establish a positive social identity. We use reference groups (Hyman, 1942, 1960; Kelley, 1952) to not only better understand ourselves (Festinger, 1954) but also shape our purchase decisions (Moschis, 1976). When making group comparisons, we typically try to focus on positive traits from our own groups (in-groups) and negative traits from outside groups (out-groups) to protect our self-image and bolster our self-esteem, recognizing the groups we belong to are a part of who we are and core to our self-concept (Tajfel, 1974; Tajfel & Turner, 1979). We seemingly demonstrate an innate preference towards in-group members (M.B. Brewer, 1979, 1999); we form harsher

judgements and make more negative attributions towards out-group members than in-group members (Hewstone, 1990; Pettigrew, 1979). This intergroup bias was originally thought to be driven by innate prejudice (Allport et al., 1954) that could arise through historical experience (Sherif, 1961) or learned stereotypes (Devine, 1989), but experimental research that employed minimal group paradigm (Tajfel et al.,1971), where participants are randomly assigned to groups where they have no prior experience with group members, demonstrated that in-group favouritism can exist even when there is no basis for such intergroup bias. This bias towards the in-group, or people like us, has been shown impact our evaluations (Rabbie & Horwitz, 1969), behaviours (Tajfel et al., 1971), and even our emotions (Shteynberg et al., 2014). For example, we are more likely to have intense emotional responses to a variety of media (advertisements, positive and negative images, amusing and sad videos) when consuming such media with in-group members than when we consume the same exact media with out-group members. Research by Ashburn-Nardo, Voils, and Monteith (2001) found that our intergroup bias develops automatically and under minimal conditions. The researchers were able to use the implicit association test (Greenwald et al., 1998) over a series of three experiments to show that we will automatically associate positive words with our in-group and negative words with out-groups, even when we are unfamiliar with the out-group or when the groups are meaningless or fictitious. Their research findings can be explained by Cadinu and Rothbart (1996) process model for in-group favouritism which suggest that we tend to anchor in-group judgements to our positive sense of self and then form differentiated judgments towards other groups. The key takeaway from this rich line of literature is that we do engage in social categorization (Allport et al., 1954; Tajfel, 1974; Tajfel et al., 1971; Tajfel & Turner, 1979), resulting in an automatic in-group bias (M.B. Brewer, 1979, 1999), even when we have no history or ties to an in-group (Ashburn-Nardo et al., 2001; Tajfel et al., 1971), which ultimately influences how

we feel (Rabbie & Horwitz, 1969; Shteynberg et al., 2014) and behave (Tajfel et al., 1971).

Understanding how different groups of people impact our preferences and choices has been an active inquiry for scholars in consumer behaviour. Escalas and Bettman (2003, 2005) found that people form positive connections with brand images tied to in-group members or aspirational group members but form negative self-connections with brand images tied to out-group members. Follow-up studies by White and Dahl (2006, 2007) reveal that people evaluate products more negatively when they are tied to dissociative reference groups rather than out-groups in general. While these studies clearly show a strong link between our identity, group memberships, and preference formation, we also look at reference groups when making decisions on how we should behave. Oyserman's identity-based motivation model (2009) indicates we take actions that are congruent with our identities, which are heavily influenced by the groups we belong to (Tajfel & Turner, 1979, 1982). As a result, we often exhibit unhealthy behaviours like indulgent eating, regular smoking, or being sedentary when we believe it characterizes or is representative of one or more of the groups we belong to (Oyserman et al., 2007). Research by Gino, Ayal, and Ariely (2009) found that individuals were willing to mimic the unethical behaviour of a confederate who posed as an in-group member but did not do so when the confederate posed as an out-group member. Within the context of food choice, Ariely and Levav (2000) found that we often make choices to maximize group variety at the expense of our own preferences when we eat out with others, but we seek to satisfy our own tastes and see no such in-group effect when we make food or drink choices alone. Luo (2005) found that participants are more likely to exhibit impulsive shopping behaviours when shopping with friends, rather than family members. Luo's research indicates that the "kind" or "type" of in-group member we engage with (i.e.

friend versus family member) impacts our behaviours, likely due to differing impression management goals (Leary & Kowalski, 1990; Schlenker, 1980). These studies illuminate that we are inherently concerned with how others perceive and evaluate us and that we often act in ways to control the impressions others form of us, depending on the situation.

However, people do not always have to physically interact with others to be influenced by them while making decisions in consumption contexts. Multiple studies have shown that the mere presence of others, rather than physical interaction with others, can influence both our choices and behaviours in consumption settings. Early research in social facilitation by Zajonc (1965) documents that we eat more in the presence of others who are also eating because of co-action effects. Ratner and Kahn (2002) found that people have a lay belief that others will approve of their purchases more if they contain greater variety. As a result, people demonstrate variety-seeking behaviour when shopping in public but not in private. This finding has huge implications as people increasingly go online to shop for a variety of items, including groceries (East, 2022; Saphores & Xu, 2020), as it indicates people are less likely to purchase balanced meals and food sets in private online settings than they would in public grocery stores. These findings indicate that our preferences and behaviours are influenced by social factors in consumption contexts, without requiring interaction with real people.

Given the significant impact that social reference points can have on our preferences and behaviours in traditional everyday life outlined in the literature to date, it is reasonable to expect social references will play an important part in helping to shape online behaviour as well. As more people have come online and information has

become more readily available on the internet, search engine developers and eCommerce website operators have had to figure out novel ways to prioritise information in order to reduce the burden of choice on end users who would otherwise be overwhelmed with options and unable to make a choice (Bonhard & Sasse, 2006; Iyengar & Lepper, 2000; Schwartz, 2004). In response to this dilemma, recommender systems, such as those made popular by early internet giant Amazon, largely rely on noticing and predicting patterns in user behaviours between a given target user and other system users who the recommender system deems to be like the target user (Bonhard & Sasse, 2006). This form of information prioritisation often manifests itself in the form of a "people like you" recommendation or in-group comparison. Again, these techniques have proven effective in a variety of contexts from eCommerce (Benlian et al., 2012), to self-tracking (Gouveia et al., 2016), to media consumption (Gomez-Uribe & Hunt, 2015).

The widespread application of in-group comparisons is not surprising given that we know people have an innate preference towards those who are like them (M.B. Brewer, 1979, 1999) and that people look to in-group members to inform product preferences and determine choice strategy (Escalas & Bettman, 2003, 2005; McFerran et al., 2010; White & Dahl, 2006, 2007). However, very little work has been done to explore how out-groups may influence our choices and behaviours for the better. Cocanougher & Bruce (1971) provided initial evidence that we can be influenced by socially distant reference groups when we aspire to be a part of that group or associate with them, which is not too surprising. Other scholars have been able to provide emerging evidence to support the counter-intuitive argument that out-groups can inspire people to demonstrate positive behaviours. Specifically, White, Simpson, and Argo (2014) found

that information about benevolent dissociative reference groups motivated people to demonstrate positive behaviours in public settings. Recent research by Vives et al. (2021) also found that while we will often mimic unethical in-group behaviour (Gino et al. 2009), we become more honest when observing virtuous out-group members than virtuous in-group members. Research by Touré-Tillery, Steinmetz, and DiCosola (2022; 2020) found that individuals are more likely to make virtuous choices when they are being observed by out-group members than when they are being observed by in-group members because we believe out-group members will judge us more harshly than in-group members. Stakes are high when we are representing our group, as we know that people often form group judgments from the behaviour of a single group member (E. R. Smith & Zarate, 1992). These studies provide initial baseline evidence that out-groups can spur socially desirable choice outcomes, motivated by impression management concerns (Leary & Kowalski, 1990; Schlenker, 1980) and the need to belong (Allen et al., 2022; Baumeister & Leary, 1995; Maslow, 1943; Maslow & Lewis, 1987), despite the rich body of literature that equates the out-group with negativity, dissociation, or discrimination (Allport et al., 1954; Ashburn-Nardo et al., 2001; Berger & Heath, 2008; Devine, 1989; Escalas & Bettman, 2003, 2005; Hewstone, 1990; Pettigrew, 1979; Tajfel et al., 1971). While the plausibility of using out-groups as a force for social good may seem counterintuitive given our intergroup bias, we do know this bias is driven more by in-group favouritism than it is by a distaste for the out-group (M.B. Brewer, 1979, 1999) and that environmental factors and experiences can cause in-group favouritism to dissipate (Sherif, 1961), opening the door for more studies on positive out-group effects.

The research contained in my thesis seeks to add to the body of knowledge on social comparisons with a specific focus on broadening the application of social comparisons

beyond the in-group, building on what we know about social comparisons and social competition (Deutsch, 1949; Festinger, 1954; D. W. Johnson & Johnson, 1989; Triplett, 1898) and reference group behaviour (Escalas & Bettman, 2003, 2005; White & Dahl, 2006, 2007; White et al., 2014). That said, we know from existing studies in technology design that people have varied need states and that often, a one-sized-fits all approach won't work (Ackerman, 2000), particularly when it comes to meaningful behavioural interventions (Spiel et al., 2018). As such, it is imperative that we research alternative nudging techniques that could be offered to populations that may be resistant to social comparisons or individuals who may simply prefer not to engage in social comparisons, prompting us to consider self-comparisons as a source for motivational nudging.

The Self as a Source of Motivation

Deci and Ryan's self-determination theory (SDT; 1985, 2012) asserts that we strive to achieve a self-determined state where we are intrinsically or internally motivated and fulfilled as we seek to find autonomy, competence, and relatedness in all that we do. While it is natural for us to be motivated by internal and external factors in pursuit of self-determination, those who are "self-determined" are self-motivated and look to themselves, not others, to establish values, goals, and future directions in life (Deci & Ryan, 1985, 2012). SDT can explain why we seek to track and monitor our actions and behaviours as we look for better ways to understand ourselves on our path to self-realization and supreme happiness (Miquelon & Vallerand, 2006; Ryan & Deci, 2001). While advancements in technology have made it easier for people to record and keep track of various elements of their everyday life—from spending habits to exercise performance, and dietary trends—the activity of self-tracking is hardly new (Lupton, 2014; Neff & Nafus, 2016). As Neff and Nafus (2016) point out, Benjamin Franklin

engaged in forms of self-tracking dating back as early as the Eighteen Century. In the domain of food and nutrition, public health scientists have been studying self-monitoring strategies employed by obese and at-risk populations for decades, well before personal digital assistants and smartphones were popularised (Burke et al., 2011). Dozens of scientific papers point to a link between engaging in dietary or nutritional self-tracking and healthy outcomes, such as weight loss or adherence to dietary regimens, regardless of whether the self-monitoring is done manually with paper and pencil (Abtahi et al., 2020; Burke, Wang, & Sevick, 2011) or more advanced forms of technology (Beasley et al., 2008; Burke, Wang, & Sevick, 2011; Wharton et al., 2014). A recent systematic review was conducted to assess the impact of digital self-monitoring as part of digital health interventions for overweight and obese adults; an analysis of 39 studies from 2009 to 2019 revealed that digital self-monitoring is consistently associated with weight loss (Patel, Wakayama, & Bennett, 2021). These findings point to the promise of nutritional self-monitoring, particularly in digital health contexts.

Self-Comparisons & Goal-Based Nudging

The over abundant amount of evidence that links self-monitoring to improved health outcomes provides strong rationale for exploring the use of self-monitoring techniques in more varied digital contexts, such as online grocery shopping. While most self-tracking technologies studied by academics have typically centred around user-initiated, user-controlled forms of self-tracking (Acharya et al., 2011; Beasley et al., 2008; Luo Liu, & Choe, 2019; Lupton, 2014; Neff & Nafus, 2016; Wharton et al., 2014), more recent research in HCI is pushing towards more automatic forms of self-tracking

technology (Y.H. Kim et al., 2017; Lu, Chen, & Epstein, 2021), recognising that episodic or inconsistent usage of self-tracking devices or apps is a persistent issue with existing, more manual forms of self-tracking (Gorm & Shklovski, 2019). As such, there may be an opportunity to help individuals monitor irregular shifts in the healthiness of their shopping baskets based on historical trends. These types of self-comparisons would help individuals compare their current behaviour to their past behaviour. Alternatively, given that literature indicates that overeating and other self-regulatory failures can be attributed to lack of goal activation (Fishbach et al., 2003) or goal fit (Hong & Lee, 2008), offering self-comparisons that help individuals assess how their current behaviours match their current or future goals could be even more motivating and quite effective in promoting healthier choices. Such interventions might leverage personalised goal-based messaging in conjunction with other nudging techniques that have shown to be effective in helping users progress towards their goals, such as the endowed progress effect (Nunes & Drèze, 2006). In a series of experiments, Nunes & Drèze (2006) found that a loyalty card that required 10 purchases but had two stamp slots already filled out performed significantly better than a loyalty card that required eight purchases without any stamp slots filled, even though both stamp cards effectively required eight more purchases for a reward. This "endowed progress" effect is driven by perceived (even if not real) progress towards a goal, which is motivating to people.

Existing research has shown that goal-based strategies can be effective when applied in health contexts. Building on Higgins's (1997) regulatory focus theory, Buhrau (2020) found that when participants have set an ideal weight goal, approach strategies focused on promoting healthier options that should be considered encouraged more positive behaviours amongst those struggling with their weight. Conversely, avoidance strategies

focused on highlighting unhealthy options to stay away from were more effective amongst those who are close to their ideal weight, preventing indulgent choices. Achieving our goals often requires us to exert consistent self-control and place more attention on our goals to avoid more immediate temptations (Fishbach & Shen, 2014; Trope & Fishbach, 2000). Revisiting the adaptive decision-making framework for lifestyle behaviour change (Zhang et al., 2021), we see that we set short-term goals to guide our overall behaviour in the reflection level of the model. As we go about our day-to-day lives, we move into the action level, and evaluate how well our options tie back to our goals to help us make appropriate choices. Over time, we need to understand the cumulative impact of these individual choices, so we self-monitor and reflect on how well we are progressing towards our goals and whether we need to update our goals or change our behaviours.

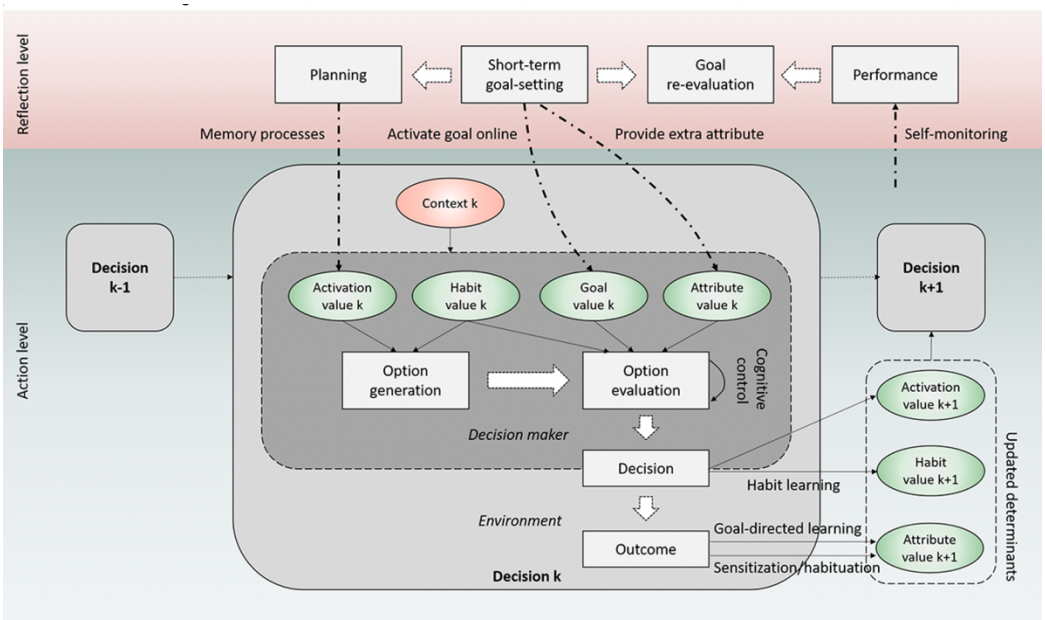


Figure 7: Adaptive Decision-Making Framework (Zhang et al., 2021)

While we may have the best intentions and digital interventions can help us self-monitor more regularly (Patel et al., 2021) and avoid impulses (van Beurden et al., 2021), we can still easily justify deviations from goal-congruent actions and go astray, preventing

us from ever fully reaching our goals (De Witt Huberts et al., 2012; Fitzsimons et al., 2007). Building on foundational principles from self-determination theory (Deci & Ryan, 1985, 2012) and social identity theory (Tajfel, 1974; Tajfel & Turner, 1979), Dominick & Cole (2020) show that individuals with identities that are more strongly tied to goals (i.e., individuals having a strong healthy eater identity) are more likely to exhibit goal-congruent behaviours than those with weaker identity-goal links. Furthermore, they show in a series of longitudinal studies that having people think of their goals as identities (i.e., I am a healthy person) rather than the goal alone (i.e., I want to make healthy choices) helps them make more healthy food choices over time, while also reporting a greater sense of ease and success when working towards their goals. The findings from these studies indicate that future digital health interventions that can help frame goals as identities could be effective.

Addressing Gaps in the Literature

The overarching goal of my doctoral research is to identify new nudging techniques that can facilitate socially responsible decision making at the individual level, that when applied at scale could have a broader impact. The World Health Organization (WHO) (2024) has stated that "an escalating global epidemic of overweight and obesity – 'globesity'– is taking over many parts of the world" (p. 1) and "if immediate action is not taken, millions will suffer from an array of serious health disorders" (p. 1). While the nudges I design and test can be applied in a variety of contexts, I focus on nudging healthy eating in response to calls for action from the public health community (Ensaff, 2021; Roberto, 2020) and WHO for a renewed focus in this area, as current interventions have failed to stem the rise of "globesity." I believe my doctoral research

is not only timely and critical, but it should also resolve two critical gaps identified in the literature. First, there is an opportunity to create effective nudging techniques that majority of people also approve of, resolving the ethical dilemma surfaced by Cadario & Chandon (2019) which suggests a trade-off between transparency and effectiveness of nudges. Second, there is an opportunity to broaden the scope of social comparison nudging used in the field (Caraban et al., 2019). Practitioners should continue to use social norms (Bicchieri & Dimant, 2019; Cialdini et al., 2006; Mollen et al., 2013), social proofs (Salmon et al., 2015), and in-group or like user comparisons (Benlian et al., 2012; Caraban et al., 2019; Gomez-Uribe & Hunt, 2015; Gouveia et al., 2016) where appropriate. That said, there is an opportunity for practitioners to leverage out-group social comparisons to influence socially responsible decision making and healthy choice outcomes in digitally mediated contexts. In many instances, applying social norms in real-world settings is not possible or practical because it will not typically lead to optimal choice outcomes in food choice contexts. In-group or like user comparisons becomes a more practical solution to nudging in the field but doesn't necessarily help curb problematic behaviours or promote behaviour change in a meaningful way amongst populations who need help making healthier food choices. Given these limitations, scholars have noted that new approaches to nudging are needed to influence population diets (Ensaff, 2021). Over the course of three papers, I advance a transparent, effective, accepted form of out-group social comparison nudging while also validating alternative self-comparison nudging solutions for sub-populations that may not wish to engage in social comparison nudging.

Chapter 1: Investigating In-Group and Out-Group Social Comparisons

DiCosola III, B. M., & Neff, G. (2020). Using Social Comparisons to Facilitate Healthier Choices in Online Grocery Shopping Contexts. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*.

DiCosola III, B. M., & Neff, G. (2022). Nudging Behavior Change: Using In-Group and Out-Group Social Comparisons to Encourage Healthier Choices. In *CHI Conference on Human Factors in Computing Systems (CHI '22).*

Abstract

This paper revisits concepts of nudge in the context of helping consumers to make healthier food choices. We introduce a novel form of social influence nudge not yet investigated by HCI scholars, the out-group social comparison, and test whether this form of nudging works at the point of checkout rather than the more conventional point of product consideration. Across two online experiments, we measure the effectiveness of using nutritional information nudges with added in-group (people like you) and out-group (people unlike you) social comparisons. Our preliminary findings suggest that out-group social comparison nudges can be effective in encouraging both normal weight and overweight adults to reduce calories, even when these adults indicate that they do not typically change their diet behaviours. This research has implications for digital information design, interactive marketing, and public health.

Introduction

A recent systematic analysis of nudging research conducted within the Human Computer Interaction (HCI) community documented 23 distinct nudging mechanisms that have been developed and refined by HCI scholars over the past 10 years (Caraban et al., 2019). These mechanisms were clustered into six contextual categories— (1) facilitate, (2) confront, (3) deceive, (4) social influence, (5) fear, and (6) reinforce. Such work has established a framework for how and why we might employ nudging mechanisms in online interactions, but previous research fails to address the critical question of when these mechanisms might be most effective to end users. While the HCI community has tried to expand nudge research, there is still much we do not know about how to best nudge within these six contexts, including when it comes to social influence (Cruwys et al., 2015). This paper seeks to address two gaps in the HCI literature. First, we investigate a novel form of social influence nudge not yet studied in nudge research—the out-group social comparison. Second, we investigate whether placing social influence nudges at the point of checkout, rather than at the more conventional point of product consideration, meaningfully works for end users in an online grocery shopping context. Our research aims to connect nudging research within the FoodCHI and broader CHI community (Altarriba Bertran et al., 2018; Raturi et al., 2017) and responds to recent call to actions from the public health community for nudges to promote healthier and more sustainable diets (Ensaff, 2021).

Why nudge? Thaler and Sunstein (2008) argue that by understanding how people make decisions and altering their choice environments and choice architectures accordingly, we can nudge individuals, making it easier for them to choose what is best for them,

their families and society. Thaler and Sunstein (2008) define a nudge as a modification of "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (p. 6). Nudging may help people make optimal decisions that benefit themselves while benefitting society more broadly.

Whether organisations should be using nudges to change consumer behaviour is subject to ethical and normative debate. Recent work by governments during COVID-19 and in other public health contexts may inspire confidence in how to approach nudging in a positive and ethical manner. For example, the UK government's Behavioural Insights Team (BIT) found that their nudges encouraged Britons to make healthier drink choices, drive more safely on public roads and achieve higher exam scores, which points to some of the positive benefits of nudging when harnessed for good (*BIT Publications*, 2022; Partington, 2017). For nudging to be applied ethically and virtuously, nudges must meet three conditions: (1) they should be transparent, (2) they must be easy to opt out of, and (3) they should improve the person's welfare (Sunstein, 2015). Dark patterns in online behaviour have rightly dimmed the reputation of nudge research, making it important to reaffirm our commitment to ethical nudging. Additionally, there is still work to be done on how to design systems to support people's goals in the domain of food choice (Ensaff, 2021). The nudges detailed in this research adhere to these three guidelines, while responding to calls by scholars in public health to help design effective, ethical, and virtuous nudges to help shape healthier population diets.

Related Work

Given the promise of nudging, scholars in consumer behaviour, behavioural economics, public health, and human computer interaction (HCI) have worked to develop nudges for social good. A recent meta-analysis of field experiments on healthy eating interventions (Cadario & Chandon, 2020) found that nudges in traditional brick-and-mortar eateries, cafeterias, and grocery stores have produced mixed results. Interventions that focus on manipulating behaviour, rather than influencing what consumers know or how they feel, were most effective. For example, nudges that placed healthier food options in easy-to-reach purchase locations resulted in greater uptake of healthy foods than nudges that called out the nutritional benefits of such healthier food options. HCI researchers have been exploring how to best design and employ digital nudges to encourage positive behaviour change across a variety of domains, not just food choice (Caraban et al., 2019). The HCI community has been able to design noteworthy nudging interventions that get consumers (or users) to slow down and tap into conscious, effortful, reflective thinking, thus allowing people to overcome their cognitive biases and mishaps in automatic information processing (Evans, 2008; Evans & Stanovich, 2013). Our goal is to address some of the limitations of traditional food nudges that have been identified by applying some of these more so-called virtuous techniques of nudging.

Facilitating Behaviour Change in Private Settings

BJ Fogg's model of persuasive design (2009) presumes people have three things: sufficient motivation, the ability to perform the desired behaviour, and adequate triggers to perform it. People, however, often lack an inherent motivation to eat healthily (Munt

et al., 2017; van Herpen & van Trijp, 2011). Fogg's model suggests that interventions for healthier eating can encourage behaviour change among people who lack motivation by focusing on making the behaviour change as simple as possible and making the triggering mechanism transparent, meaningful, and contextually relevant to individuals. The challenge for the CHI community is that a one-size-fits-all approach to nudging for health might further encourage a social-technological gap, failing to prioritize the complex and nuanced interventions that we know are needed to support people (Ackerman, 2000). As such, it is important we seek to understand when nudges work best, who they work for, what the next best alternatives might be to ensure we meet the needs and demands of broad and diverse populations.

Our approach to nudging involves delivering personalized communications in a private setting to prompt users to consider a change in behaviour that is completely optional. This makes our approach fit with the criterion for virtuous nudging. Our approach is distinct from the many existing health and fitness interventions that seek to initiate behaviour change through connected communities or peer support (Conroy et al., 2014; Ren et al., 2018). Social support and community sensemaking can help individuals achieve success (Neff & Nafus, 2016), and people often make more deliberate, thoughtful choices when they are in public settings (Ariely & Levav, 2000; Ratner & Kahn, 2002). While literature exists that suggests people often make virtuous choices in public settings where their choices are exposed to others (Touré-Tillery et al., 2022; White et al., 2014), there is not yet evidence to suggest the same holds true in private settings where impression management is of little concern. As such, our approach to nudging seeks to invoke a heuristic goal to align to others (Cialdini, 1984, 2006;

Festinger, 1954), rather than activating impression management goals (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980).

Designing Novel Social Comparison Nudges

Social influence can be harnessed to nudge consumers towards making optimal choices through mechanisms like invoking reciprocity, leveraging public commitment, making user actions more visible, and enabling social comparisons (Caraban et al., 2019). Social information is important and meaningful to end users because people look to others to inform their own behaviour when the best course of action is unclear (Cialdini, 1984, 2006; Festinger, 1954), even when deciding how much to eat (Cruwys et al., 2015; Vartanian et al. 2015). People seek out such social information in a purposeful way. People care about what most people do (Zajonc, 1965) or what most people might approve of (Jacobson et al., 2011; Mollen et al., 2013) demonstrating a tendency to adhere to social norms (Cialdini & Trost, 1998) based on demonstrated social proof points (Cialdini, 1984, 2006). HCI scholars have found employing social proofs to be very effective in nudging consumers to exhibit positive behaviours in contexts like fitness self-tracking (Gouveia et al., 2016) and gaming (Colusso, Hsieh, & Munson, 2016), provided people felt that such comparisons were easy to understand, and the desired behaviour was within reach. Scholars in public health have found that social norm and social proofing statements can impact food choice positively (Mollen et al., 2013; Salmon et al., 2015). Statements regarding “what most others do” (Cialdini, 1984, 2006) work better than injunctive norm statements on “what most others approve of” (Jacobson et al., 2011) in prompting healthy food choices. However, generic social comparisons may not work in all conditions (Salmon et al., 2015) and can be difficult to leverage at scale in the real-world. This is because most people are rarely exhibiting all

the desired behaviours that we would want to promote to more healthy and nutritious food choice, highlighting the need for alternative forms of social nudging that work under a broader set of conditions (Ensaff, 2021).

The influence that in-groups can have on our thoughts, feelings, emotions and decisions is well studied within social psychology (M.B. Brewer, 1979, 1999) and marketing (Escalas & Bettman, 2003, 2005; Kurt et al., 2011; Shteynberg et al., 2014). Research on minimal group paradigm was pivotal in demonstrating we have an innate desire to align with the in-group, even when preconceptions about an out-group fail to exist (Ashburn-Nardo et al., 2001; Tajfel et al., 1971). In the context of food choice, the "in-group effect" will prompt us to select foods we don't prefer when dining in social settings to maintain our status within our in-group (Ariely & Levav, 2000). These well-documented in-group effects have caused digital designers to focus almost exclusively on in-group or "people like you" social comparisons, especially when the broader trend on "what most people are doing" might not be available, easy to tap into, or beneficial to expose (Benlian et al., 2012; Gomez-Uribe & Hunt, 2015).

Consider how we might compare food choice to Netflix recommendations. Netflix's personalized recommendation engines generate over $1 billion a year in value from customer retention because 80% of views come from the engine's recommendations (Gomez-Uribe & Hunt, 2015). Netflix's "What's Trending Now" recommendation is essentially a social norm visualization applied at the country-level (see Fig.1).



Figure 1: Netflix "What's Trending in USA" Social Norm Recommendation

While such broad recommendations on what is trending might work for Netflix (Gomez-Uribe & Hunt, 2015) or in e-Commerce (Benlian et al., 2012), it is potentially risky when applied in a grocery store setting with beer, high-fat sausages and bacon, soda, and chocolate candy bars being some of the most commonly purchased grocery products today in the US and UK (*Top Selling Grocery Items*, 2021; Tatum, 2020; Wood, 2020). To help combat the rise in the popularity of these items, the UK introduced legislation that restricts the promotion of unhealthy foods (GOV.UK, 2020), effectively preventing this type of recommendation from being applied in real-world grocery shopping contexts.

Netflix's "Because You Watched" recommendations tie together genre expectations and patterns in what like-users have subsequently watched and enjoyed, thus creating an "in-group" recommendation based on what other "people like you" have watched and liked (Gomez-Uribe & Hunt, 2015). This approach could also be problematic when applied in a food choice context. The popular selection of soda would pair more frequently with salty snacks, based on typical like user behaviour, than healthier fruits or vegetables. This example highlights why nudging out-group comparisons might be desirable, even necessary, in some situations. However, the effectiveness of out-group comparisons for nudging has yet to be studied.

Designing Effective, Ethical, and Desirable Nudges

Our research aims to test transparent nudging mechanisms that highlight or bring attention to possible choices and healthier alternatives, causing us to tap into our conscious mind and more deliberate thinking (Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2011). Many food choice nudges employed in the field today focus on manipulating or influencing behaviour by making changes to choice architectures that the consumer cannot detect (Cadario & Chandon, 2020). These undetectable behavioural nudges tend to work well, although consumers largely reject this form of nudging (Cadario & Chandon, 2019). In addition, nudges that manipulate choice and behaviour fail the first condition of ethical nudging: (1) they should be transparent (Sunstein, 2015). Recent studies in marketing suggest that organizations that want to nudge healthier food choices face a dilemma: they must make a trade-off between using nudges that work best, those that tap into the automatic mind, and nudges that people approve of, those that are transparent and force a reflective mindset (Cadario & Chandon, 2019). Our research seeks to test healthy food nudges that are both effective and acceptable to end users by prompting a reflective choice, transparently.

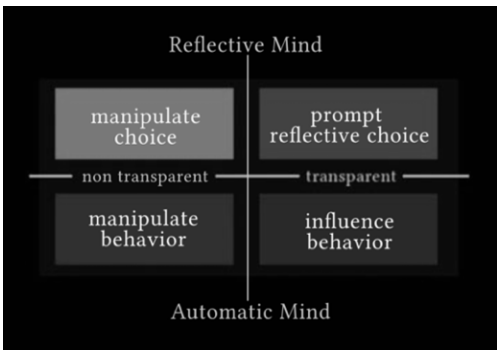


Figure 2: Nudging Mechanism Options (Caraban et al., 2019)

Focusing on nudges that prompt a reflective choice is worthwhile as this form of nudging is transparent and causes a user to reflect on his or her choices (see Fig. 2), which is what consumers indicate they prefer (Cadario & Chandon, 2019; Felsen et al., 2013) and fits with the drive for ethical and virtuous nudging (Sunstein, 2015). Designing nudges that prompt a reflective choice and still produce strong healthy choice outcomes is a challenge, though; existing field studies show that these types of nudges typically have smaller effect sizes and limited consumer impact (Cadario & Chandon, 2020).

Effective nudging mechanisms already identified by the HCI community include suggesting alternatives and reminding consumers of choice consequences, both of which prompt users to deliberately consider their options (Caraban et al., 2019; Evans, 2008; Evans & Stanovich, 2013). Research in food choice is calling for new thinking and novel approaches that can bring about more significant impact than these mechanisms do as their effectiveness in food choice contexts has proven limited. For example, an experimental grocery shopping site nudged consumers to swap out higher calorie foods for healthier, lower calorie options in the same food category, but had mixed results and did not lead a significant reduction in overall calories (Forwood et al., 2015). Traditional nudge research conducted in a real-world setting within a university eatery setting found small but significant increases in purchase of low-calorie, low-fat foods after using food labels that prompted students to consider their choices (Cioffi et al., 2015). To combat these shortcomings, we test if adding social dimensions to existing nudging interventions can improve nudge uptake, using willingness to reduce calories as our key measure. Calorie reduction is commonly studied in public health experiments on food choice (Cioffi et al., 2015; Forwood et al., 2015) because of the

policy and health concerns about rising obesity in the UK (Academy of Medical Royal Colleges, 2013), USA (Brownell & Horgen, 2004), and around the globe (Boseley, 2017; Lowell, 2004). Our research has the potential to shape more broadly how policymakers view nudging mechanisms that are transparent, effective, ethical, and more widely accepted than those used in current behavioural policy interventions (Hern, 2021).

Nudging for Greater Impact

The HCI community has explored what type of nudges work and why but has done less research on when nudging can have the greatest impact. A key difference in the nudging approach we take is that it is applied at the point of checkout and at a global (i.e., grocery basket) level. Current standard practice for online shopping nudges provides personalized item-level product recommendations as people shop or browse (Forwood et al., 2015; Lawrence et al., 2001; Mollen et al., 2013; Salmon et al., 2015). There are two good reasons for considering global, basket-level recommendations at checkout. First, healthy food nudges at the point of checkout in traditional brick-and-mortar stores have been successful (Gestel et al., 2018). Second, this approach may be more meaningful to consumers because they see the overall impact of their collective food choices and not simply of single items. The timing of nudges may also matter. Constantly nudging healthy food products during the browse-and-shop process could create a lot of undue friction. Nudging at the end of shopping could help users better assess their choices in context. Our holistic, basket-level approach to nudging fits with recent findings by marketeers showing the impact of real-time aggregation of total calorie count on encouraging healthier meal choices (VanEpps et al., 2021). That said, there are trade-offs by introducing a nudge later in the process, namely that it could be

seen to require more effort at a time when users are simply ready to checkout. We believe this can be addressed through effective design and by helping to automate and highlight recommended food swaps at the time of nudge, building on existing food swap designs tested in public health (Forwood et al., 2015), rather than asking users to go back and shop again. We believe both forms of nudging (e.g., in process, at checkout) can be effective and should be part of a designer's overall toolkit to design experiences that benefit end users.

Research Overview

Our research tests two types of social comparisons—in-group comparisons and out-group comparisons—displayed prior to final checkout when grocery basket calories are high, providing greater insight in how and when to nudge food choice for greater effectiveness. We hope to demonstrate that novel out-group comparisons serve as a worthwhile alternative to in-group comparisons within the context of social nudging. When testing nudges that could prevent obesity, we target normal weight individuals to understand if there is any differential impact of comparing their basket calories to other healthy weight adult baskets (in-group comparison) versus comparing their basket calories to typical overweight adult baskets (out-group comparison). When testing nudges that could be used to reduce obesity, we target overweight adults to understand their response to a variety of nudges, including those that add in-group or out-group social comparisons. Below, we discuss the findings across two studies and highlight future directions for follow-up research.

Study One: Pilot Experiment on Social Comparisons with Normal Weight Adults

Study Design

We designed a simple online experiment on Qualtrics with a single factor (social comparison) and two levels (in-group comparison, out-group comparison) to test the hypothesis that out-group comparisons may be equally or more effective than in-group comparisons in encouraging healthier choices. Our pilot study was designed to test a conceptual intervention that could be applied to broad populations to help prevent obesity before it starts by detecting calorie-dense shopping baskets that could result in the consumption of too many calories.

We recruited 100 normal or healthy-weight adults living in the United Kingdom (UK) from Prolific.co, an online panel designed for academic research. Prolific was used as the recruitment platform for all studies because it has a broad geographic reach, has the ability to source population representative samples in the United States and the United Kingdom, has strong screening tools to identify high quality participants that meet study screener conditions, and ensures research quality as all individuals in the participant pool are fully vetted and verified. Prolific allowed us to pre-screen participants based on their Body Mass Index (BMI). Participants with a BMI of less than 25 were contacted via e-mail through Prolific and notified they could participate in a four-minute online study on health and nutrition in the UK. Participants were offered a payment of £0.50 for their participation in this short study that was designed to take just a few minutes. The overall study design is shown in Table 1.

Table 1: Study 1 Design

Study Sample	100 Normal Weight UK Adults (BMI < 25)
Study Design	Single Factor (Social Comparison), Two-Level, Between Subjects
Study Conditions	In-Group Social Comparison Out-Group Social Comparison

After giving their consent, participants completed a 10-question survey that asked about their demographics (age range, occupational status, national identity, living location) and their perspectives and practices related to health and nutrition (whether they were interested in healthy eating, exercise, dieting; whether they had used online food delivery services, meal kit delivery services, or online grocery shopping; whether they viewed themselves as being under weight, about right in weight, or overweight). As part of this survey, participants rated their interest in trying new diets on a sliding scale (0 = no interest, 100 = high interest). Then, participants were asked to imagine that they were buying groceries from an online grocery store where they had previously setup a profile to allow the grocery store to know their specific health and nutrition goals. They were then asked to imagine they were buying one week's worth of groceries and were about to complete the online checkout process. At this point, participants were randomly assigned to one of the two experimental conditions: an in-group comparison condition or an out-group comparison condition (see Fig. 3).

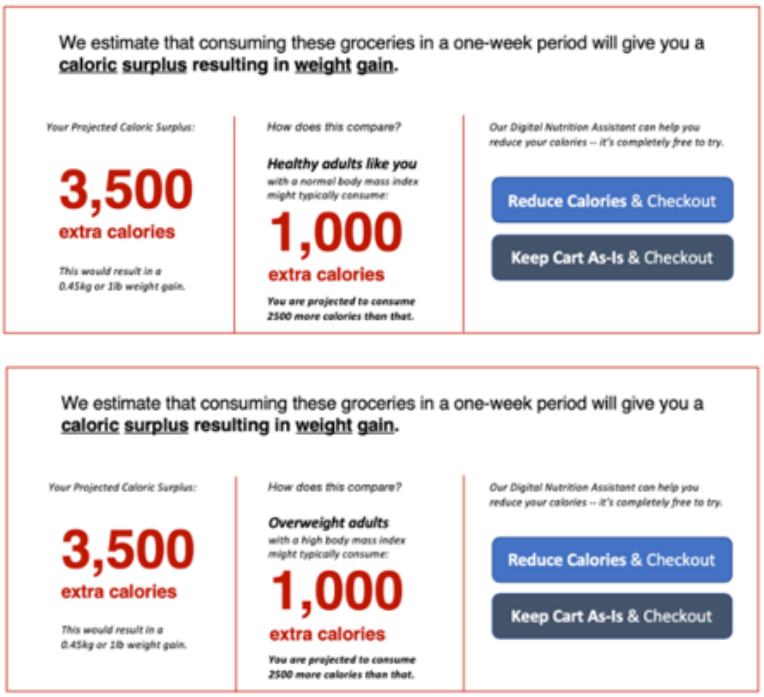


Figure 3: Experimental Condition Stimuli

Participants were shown a nutritional analysis with added social comparison and then asked if they would like to keep their shopping basket as-is and checkout or to reduce the calories in their basket and checkout using a free digital nutrition assistant. This choice is the key dependent measure. The stimuli were designed to be consistent across conditions with only text labels changing across the social comparison conditions. Guerilla research methods were used to pre-test study stimuli to make sure individuals were able to comprehend the stimuli and demonstrate understanding of the key messages delivered through the stimuli. The final stimuli were designed to provide helpful health and nutrition information (i.e. consuming these calories in a one-week period will give you a caloric surplus resulting in weight gain) and then layer on an additional social comparison, in which case all individuals were told they were projected consume 3,500 extra calories whereas other individuals typically were projected to consume 1,000 extra calories, indicating the participant was projected to consume 2,500 more calories than the typical person from that social comparison

reference group. Individuals who elected to reduce calories were asked a follow-up question related to the number of total calories they wished to reduce their basket by—they indicated this by using a sliding scale from 0 calories to 5,000 calories. After completing this step, all participants were shown a closing page that debriefed them and revealed more details about the study. The last page of the experiment also included a manipulation check that asked participants to recall what type of individual they were compared to. Twenty-six participants failed the manipulation check and were removed from the study results, leaving 74 possible valid observations in the experimental data set. Nine individuals self-identified as overweight or underweight, despite having a healthy body mass index, and were omitted from the study analysis, leaving 65 final responses.

Study Predictions

The overarching goal of this simple pilot experiment was to provide some initial evidence that out-group comparisons could serve as a worthwhile alternative to the more common in-group social comparison employed by recommendation engines in e-Commerce today. Going beyond "people like you" comparisons would give digital designers and grocery retailers more varied (and possibly more practically meaningful) options to socially nudge consumers towards healthier choices, such as nudging calorie reduction when basket calories are high, as was the case in these scenarios.

We know from existing research on social facilitation that people will inherently look to others when deciding how much to eat (Zajonc, 1965). Building on foundational anchor and adjustment models on purchase decisions from the field of marketing and consumer

behaviour (Sherif et al., 1958), we posit that both in-group comparisons and out-group comparisons will provide a desirable social anchor point that users can latch onto to inform their decision around whether to keep basket calories as-is or to reduce them. We expect that in-group comparisons will trigger users to assimilate or move close to the reference point to align to their in-group while an out-group comparison will produce a contrast effect as group members seek to stand out or differentiate from other groups (Wansink et al., 1998). To put this in concrete terms, if consumers are told that in-group members typically consume 2,500 calories, we would expect them to try match this and reduce their basket to be around 2,500 calories so their behaviour is in accordance with group norms. Conversely, if consumers are told that out-group members typically consume 2,500 calories, we expect they may try to distance themselves from this amount and seek to improve upon it, potentially reducing even more calories so that their basket may be closer to say 2,000 calories instead of 2,500 calories, in effort to be better than the out-group. This anticipated matching effect for the in-group and distancing or contrast effect for the out-group is shown in Fig. 4, where we can see that both in-group and out-group comparisons cause a reduction of calories from the initial calorie amount by using a social reference point, but that the effect could be more pronounced in the out-group condition given the desire to stand out from rather than match the social reference point.

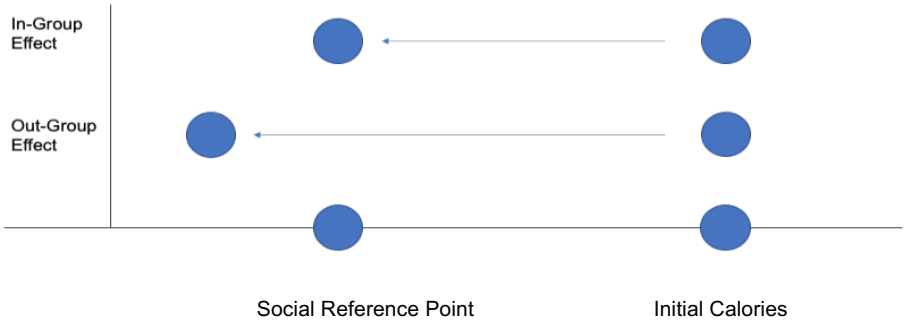


Figure 4: Visualization of Anticipated In-Group vs. Out-Group Effect

We believe that when consumers are presented with an out-group comparison, it may trigger dual motivation—individual-level motivation and group-level motivation—such that the individual and group impacts of one's decision becomes more salient. In other words, when prompted with an out-group comparison, we believe individuals will be incentivized to help themselves while also helping their group perform better than the out-group. This dual motivation triggered by an out-group comparison could help produce a contrast or distancing effect, as depicted in Fig. 4.

Study Results

Although we recruited 100 participants, there were 65 valid responses that could be analysed after data cleansing was complete. VanVoorhis & Morgan (2007) have indicated that when conducting statistical analyses to measure group differences, a reasonable cell size is 30, assuming a power level threshold of 80%. Our final cleansed data set had 65 observations, with cell sizes greater than 30, thus meeting the threshold set forth by VanVoorhis & Morgan. That said, we recognize the total number of observations after cleansing was less than optimal, even if sufficient.

A statistical model that included the key discrete dependent measure (choice: unhealthy/keep basket as-is and checkout vs. healthy/reduce calories and checkout) along with two independent variables—level of interest in trying new diets and social comparison type (in-group vs. out-group) as well as the interaction between these two variables—was established. A nominal logistic regression analysis was conducted on the model. The overall model was found to be highly significant, X^2 (3, n = 65) = 15.62, p = .0014. The coefficient of determination (R^2) value of the model was .1770

(17.70%), indicating that we have identified a medium to large experimental effect within this statistical model (Draper, 2011). Our overall model results are in Table 2.

Table 2: Study 1 Statistical Model Summary

Chi-Square Value	X^2 (3, n = 65) = 15.62
p-Value	*p* = .0014
R^2 Value	R^2 = .1770 (17.70%)

There was a significant main effect of level of interest in trying new diets on unhealthy/healthy choice, X^2 (1, n = 65) = 4.68, *p* = .03, such that those who were more interested in trying new diets were more likely to select the healthier option, which is intuitive and not surprising. That said, there was a more significant interaction effect between level of interest in trying new diets and the type of social comparison used, X^2 (1, *n* = 65) = 7.50, *p* = .006, such that those who were less interested in trying new diets (and thus more at-risk for over-consuming) but assigned to the out-group condition were more likely to reduce calories (see Fig. 5).

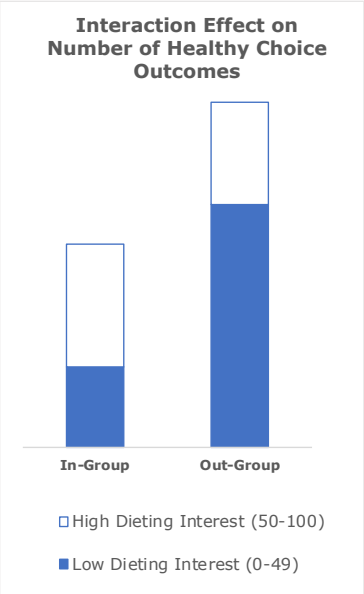


Figure 5: Interaction Effect

The main effect of social comparison type did not prove to be statistically significant, X^2 (1, n = 65) = 2.67, p = .10, indicating that out-group comparisons performed on par with social comparisons.

Table 3: Study 1 Effects

Variable	Degrees of Freedom	Chi-Square Value	p-Value
Interest in Trying New Diets (IV1)	1	4.68	p = .03
Social Comparison Condition (IV2)	1	2.67	p = .10
Interaction (IV1 x IV2)	1	7.50	p = .006

However, the pattern of results indicated that healthy choice outcomes were more abundant in the out-group condition. An analysis of variance (ANOVA) using the continuous measure of calorie reduction revealed the mean number of calories reduced in the in-group condition was 486 compared to 841 in the out-group condition (see Fig. 6), which provides some baseline support for our hypothesis that out-group comparisons may be as effective if not more effective than the more frequently used in-group comparisons. However, the difference between social comparison types was not found to be statistically significant in the ANOVA model either. The key effect tests are summarized in Table 3.

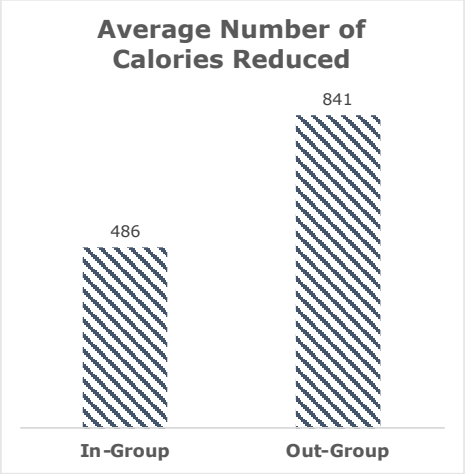


Figure 6: Interaction Effect

Study Discussion

Our pilot study revealed two statistically significant findings. There was an overall main effect of level of interest in trying new diets on healthy choice outcomes such that participants who were interested in trying new diets were also likely to consider reducing calories, regardless of the type of social nudge they were exposed to. More critically, there was a strong interaction effect between people's interest in dieting and the type of social comparison that was used, indicating that the out-group comparison was effective in nudging individuals who had a low interest in dieting to make the healthy choice. These findings are important as they contradict findings from field studies that show individuals are more likely to be influenced by thin rather than obese individuals when making food choices (McFerran, Dahl, Fitzsimons, & Morales, 2010); our findings show that normal weight adults can be influenced by overweight adults in very positive ways.

Our pilot results indicate that the nutritional basket summary with an added social comparison was an effective intervention among normal weight adults who are open to

trying new diets, regardless of whether they were shown comparisons to people like or unlike them, while those who less open to dieting were more likely to make the healthy choice when shown a comparison to overweight adults. The interaction effect that we observed seems to indicate that we have identified a novel way to reach people who are not interested in trying new diets or changing their eating behaviours. Our findings reveal that a shopping basket nutritional analysis paired with an out-group comparison—rather than the standard "people like you" comparison—resulted in an increase in the healthier choice amongst more resistant individuals. That said, the lack of a no comparison control condition in this simple pilot study limits our ability to decipher whether this effect is due to the social comparison element of our experimental stimuli. We will address this limitation in future studies.

It is worth noting the medium-to-large effect size we observed with our overall model returning an R^2 value of .1770 or 17.70% (see Table 2, 4). In Cadario and Chandon's (2020) meta-analysis of field studies exploring healthy eating nudges taking place in traditional brick-and-mortar settings, the researchers found that the effect sizes for healthy eating nudges were small, on average, across all seven studies they looked at. The medium-to-large effect size we observed in our online experiment points to the potential promise of digital nudging to influence healthier food choices.

Table 4: Effect Size Comparison (Draper, 2011)

Measure	Small Effect	Medium Effect	Large Effect
Cohen's *d*	0.2 - 0.3	0.5	0.8
R^2	1%	9%	25%

Another key difference in our approach was nudging at the point of checkout rather than point of product consideration and asking participants to reduce the overall basket-level calories. Participants exposed to an in-group comparison indicated they were willing to reduce their basket calories by 486 calories, on average, while those who were exposed to an out-group comparison were willing to reduce their basket calories by 841 calories. Cadario and Chandon (2020) found that existing healthy eating nudges, primarily taking place at the product or item level, produce (not surprisingly) smaller effects when it comes to calorie reduction. Nudges that focused on improving awareness, or what people know or understood about their food choices, resulted in a mean calorie reduction of only 64 calories, while those that aimed to influencing emotions, or how people felt about their food choices, resulted in a mean calorie reduction of 129 calories. The most effective nudges were those that focused on manipulating behaviour change (typically outside of consumer awareness); these behaviourally oriented nudges resulted in a mean calorie reduction of 209 calories, which is much lower than the amount of intended calorie reduction observed in our experiment. While there may be a significant gap between the number of calories consumers say they are willing to reduce their calories by and actual calorie reduction that would be observed in a real-world context, these results point to the potential positive impact that shifting towards basket-level recommendations might have on healthy choice outcomes.

While our pilot study revealed some promising results, there are numerous limitations that must be addressed. It is important to note that we recruited adults with a body mass index of under 25 to be able to assign participants to an in-group (i.e., normal weight adults) or out-group (i.e., overweight adults). As such, we cannot over-generalize our

findings and assume these results would be observed among overweight adults. Given that we know from previous research in public health that normal weight adults and overweight adults often exhibit different responses to nutrition interventions (Campos et al., 2011; van Herpen & van Trijp, 2011). Different goals may require different designs, especially in health-related tracking (Spiel et al., 2018) and this context is no different. To address this shortcoming, our next experiment will be run on participants with a body mass index over 25 who view themselves as being overweight and will provide an in-group comparison to overweight adults and an out-group comparison to normal weight adults. We will also add a no comparison control condition, increase the sample size moving forward and increase the participation incentive to foster stronger participation outcomes. Finally, we want to reiterate that these explorations are still academic and conceptual in nature and designed to test novel forms of social comparisons as nudging mechanisms in controlled lab settings. Should our future studies be successful, we will need to design and test other forms of in-group and out-group comparisons that do not involve body image or body weight, as such comparisons would not be appropriate in real-world settings. All in all, we believe our pilot study demonstrates that social comparisons, particularly out-group comparisons, may serve as effective nudging mechanisms in online grocery shopping contexts and gives sufficient motivation for further exploration.

Study Two: Follow-up Experiment on Social Comparisons with Overweight Adults

Study Design

The study recruited 350 overweight adults in the United Kingdom with a body mass index over 25 on Prolific.co for a 1 GBP incentive. This core experiment on social comparisons builds upon preliminary pilot research on the topic but employs a four-cell experimental design that aims to help us understand whether calorie information alone, calorie information paired with possible weight gain implications, or calorie information paired with possible implications and an additional social comparison, is most effective in nudging overweight consumers to consider reducing basket calories when in a caloric surplus situation. While the pilot experiment focused on normal weight adults to help prevent obesity, this core experiment is focused on recruiting overweight adults to help design and test social nudging mechanisms that might be used to help reduce obesity through behaviour change. The overall study design is summarized in Table 5.

Table 5: Study 2 Design

Study Sample	350 Overweight UK Adults (BMI > 25)
Study Design	Four-Level Between Subjects
Study Conditions	1. Baseline: Caloric Surplus Amount 2. Control: Baseline + Weight Gain Implication 3. Control + In-Group Social Comparison 4. Control + Out-Group Social Comparison
Additional Measures	Dietary Control Behaviors (DCB) Scale
Dependent Variable	Discrete Choice: Keep Calories As-Is & Checkout (Unhealthy Choice) Reduce Calories & Checkout (Healthy Choice)

Participants were contacted via email by the Prolific subject pool and given a URL to access the study from a device and location of their choosing. This survey flow and design was similar to the one employed in the pilot study but included multiple statements from the Dietary Control Behaviour (DCB) scale (Liu et al., 2015), a proven scale used by the marketing and consumer behaviour community to measure the extent to which individuals are willing to change their eating behaviours in an effort to control their weight (Bruner, 2017), rather than the self-constructed question on Interest in Trying New Diets used in the pilot. Participants responded to the dietary control statements like "I eat low-calorie foods in an effort to avoid weight gain" using a 7-point Likert scale from "Strongly Disagree" to "Strongly Agree" and an average score was computed based on their mean response to all statements. This important measure allows us to understand how consumers with varying levels of dietary control may

differentially respond to alternative forms of nudging. Critically, we want to show that social comparison nudges are effective in encouraging harder to reach individuals to make healthier choices.

After completing the short survey, participants were told to imagine they were buying groceries from their preferred online grocery store. They were also told to imagine that they had previously set up a profile with this grocery store which allowed the grocery store to know who they were and what their specific health and nutrition goals might be. Participants were then told to imagine they are about to complete the online checkout process after selecting one week's worth of groceries for themselves alone. Up to this point, all participants followed the same steps and had seen the same study materials. After this point, participants were randomly assigned to one of the four experimental conditions with different stimuli (see Fig. 7).



Figure 7: Representative Experimental Condition Stimuli (Control vs. Social Comparison)

The stimuli designed for this study were updated to be more visually appealing and less busy as compared to the stimuli used in the earlier pilot study, following feedback received during pre-testing, though all of the information and reference point numbers remained consistent with the earlier pilot study. All participants, regardless of condition, were asked to make a discrete choice: they could either elect to keep their shopping basket as-is and complete checkout or reduce the calories in their basket and checkout. This discrete, binary choice represents the dependent variable that will be measured and compared across all four conditions. Individuals who elected to reduce calories were asked a follow-up question related to the number of total calories they wished to reduce their basket by; they were shown a sliding scale from 0 to 5,000 calories and could select any value between 0 and 5,000. They also completed a manipulation check to ensure they processed the social comparisons accurately. After completing this final step, all participants were shown a closing page that debriefed them and revealed more details about the study; participants were given code to give to Prolific to confirm study completion and initiate payment for participating.

Research Questions and Associated Hypotheses

We had three questions we wanted to answer in this follow up study:

1. Does adding a weight gain implication statement (i.e., this equals 0.45kg of weight gain) to the baseline caloric surplus amount increasingly nudge consumers towards the healthy choice?
2. Does adding a social comparison to the caloric surplus amount and implication statement increasingly nudge consumers towards the healthy choice?

3. Are social comparison nudges effective amongst harder to reach populations or individuals who do not typically modify their eating behaviours to control weight gain?

We expect that making the calorie surplus more "real" and translating into what it means in terms of potential weight gain will make it more meaningful to the end user and, as a result, increase uptake of the nudge to reduce calories. That said, we also think providing additional social context to this nudge will be even more effective and that the two social comparison conditions that provide this added social reference point will perform better than the control condition. Finally, we hypothesize that social comparisons will add an external source of motivation that will encourage individuals who may lack sufficient intrinsic motivation to make the healthy choice; in essence nudging consumers who would otherwise be unlikely to make the healthy choice. Our hypotheses are outlined in Table 6.

Table 6: Study 2 Hypotheses

Hypothesis 1	There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the control condition (caloric surplus + weight gain implication) as compared to the baseline (caloric surplus only) condition.
Hypothesis 2	There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the social comparison conditions as compared to the control condition.
Hypothesis 3	There will be an interaction effect between the experimental condition and DCB rating on choice such that those who rate low to moderate on DCB will be more likely to pursue the healthy choice when presented with a social comparison nudge as compared to the control condition.

Study Results

Of the 350 participants recruited, 349 of them successfully completed the entire study; one participant dropped out. However, 63 participants failed the manipulation check, leaving 286 valid results. Finally, a check was done on self-report of body weight to ensure only overweight adults were included to ensure proper analysis of in-group (overweight) vs. out-group (normal weight) comparison. Thirty-eight remaining adults who viewed themselves as being “about right” in weight but were assigned to either an in-group (overweight) or out-group (normal weight) were omitted due to mismatch between their view and the comparison category stimuli. In the final dataset, 248 participants were included, which exceeded the number of participants recommended in an a priori G*Power analysis by 16 participants.

A statistical model that included two independent variables (experimental condition, average DCB rating) and our key dependent measure (discrete choice: keep calories/reduce calories) was constructed. A nominal logistic analysis was conducted on the model. The overall model was found to be highly significant, X^2 (4, n = 248) = 20.08, p = .0005. The coefficient of determination (R^2) value of the model was .0596 (5.96%) indicating a small to medium effect of the model (Cohen, 2013; Perdices, 2018) which is improved but in line with existing field studies on healthy eating nudges (Cadario & Chandon, 2020). Our overall model results are summarized in Table 7.

Table 7: Study 2 Statistical Model Summary

Chi-Square Value	X^2 (4, n = 248) = 20.08837
p-Value	p = .0005
***R*² Value**	R^2 = .0596 (5.96%)

Both predictors in our model proved to be significant (see Table 8).

Table 8: Study 2 Effects

Variable	Degrees of Freedom	Chi-Square Value	p-Value
Average DCB Rating	1	11.2221711	p = 0.0008
Experimental Condition	3	8.64311251	p = 0.0344

There was a highly significant main effect of average dietary control behaviour (DCB) rating on healthy choice outcomes, X^2 (1, n = 248) = 11.22, p = .0008, such that those with higher average dietary control score ratings were more likely to make the healthy choice, regardless of the type of nudge they were exposed to. Critically, there was a significant main effect of the experimental condition on healthy choice outcomes, X^2 (3,

$n = 248) = 8.64$, $p = .0344$, such that all conditions (baseline condition and both social comparison conditions) produced more healthy choice outcomes than the control condition. The interaction between DCB rating and experimental condition was not significant and thus not included in the model, though general trends between these two variables will be discussed in due course.

Study Discussion

The first question we sought to answer was: does adding a weight gain implication statement to the baseline caloric surplus amount increasingly nudge consumers towards the healthy choice? We expected that it would, but our results proved otherwise (see Fig. 8). Healthy choice outcomes were more prevalent in the baseline (caloric surplus only condition) than in the control condition (caloric surplus + weight gain implication statement). In our experiment, participants were told they were projected to consume 3,500 extra calories across all study conditions. This amount was apparently alarming enough to cause participants to consider reducing calories without any further information. When participants were told this surplus equated to 0.45kg of weight gain in the control condition, they were more likely to keep their basket as-is than to reduce calories, which indicates that 3,500 extra calories are perceived to be more worrisome than 0.45kg of weight gain by the UK consumers in our experiment. That said, it is hard to know if this trend would hold with different figures; there is good reason to believe once weight gain starts to equate to a full unit of weight gain or more (i.e., 1kg or 1lb) that this pattern of results would dissipate. This will be tested in our next set of experiments. In any case, we cannot confirm our hypothesis (see Table 9).

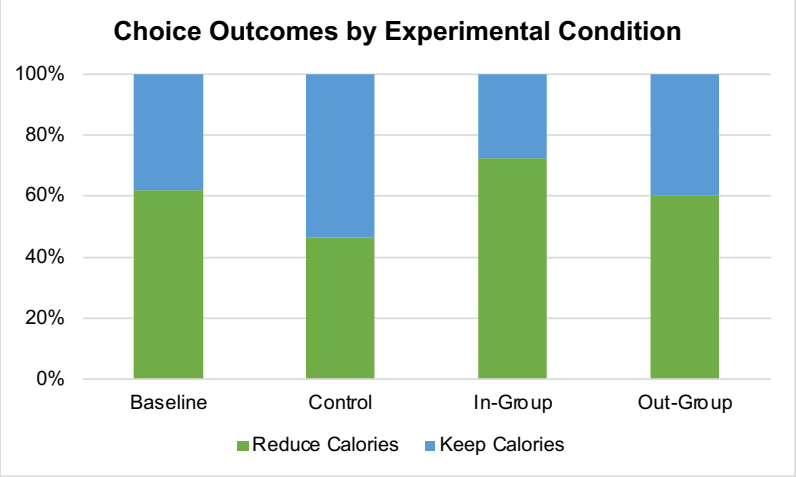


Figure 8: Choice Outcomes by Experimental Condition

The next question we sought to answer was the following: does adding a social comparison to the caloric surplus amount and implication statement nudge the consumer towards the healthy choice? We expected that it would, and our results confirmed this (see Fig. 8). Both the in-group and out-group comparison conditions perform better than the control condition, though it appears comparing overweight adults to other overweight adults (in-group comparison) was more effective than comparing them to normal weight adults (out-group comparison) in inspiring nudge uptake. We cannot be certain this is because in-group comparisons are more meaningful to participants in general; it is possible that seeing "overweight" in the stimuli in the in-group condition might have caused a fear or stigma response that is driving the added effect. This will be addressed in our next study.

If we collapse the in-group and out-group conditions and analyse them as a collective set of social comparisons, we see that participants are much more likely to make the healthy choice when exposed to a social comparison nudge as compared to the calorie information nudge used in the control condition. To be more specific, less than half of participants (46.5%) decide to reduce calories when exposed to the control condition

stimuli but more than half of participants (66.7%) participants decide to reduce calories when the social comparison is added (see Fig. 9). A Pearson's pair test reveals these differences are significant with a Pearson Chi-square p-value of .0102. We confirm our hypothesis (see Table 9).

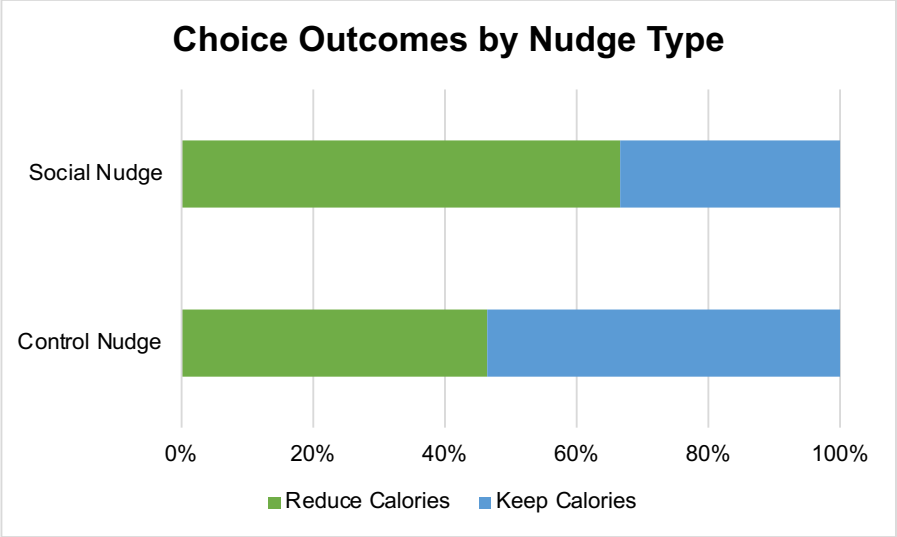


Figure 9: Choice Outcomes by Experimental Condition

We also found that amongst those who decide to take up the nudge and reduce basket calories, mean calorie reduction was 1944 calories in the control condition, 2366 in the in-group condition, and 1900 in the out-group condition. While the differences in intended calorie reduction were not statistically different across conditions, the level of intended calorie reduction observed across our experiments was quite high, pointing to the promise of nudging basket-level change at the point of checkout.

The final question was whether social comparison nudges are effective amongst harder to reach populations or individuals who do not typically modify their behaviours to control weight gain. In other words, do social nudges help get people who would otherwise not reduce calories to consider doing so? Our data showed that those who had

a low average rating on the Dietary Control Behaviours (DCB) scale were much less likely to reduce calories on average than those who had a high average DCB rating (see Fig. 10).

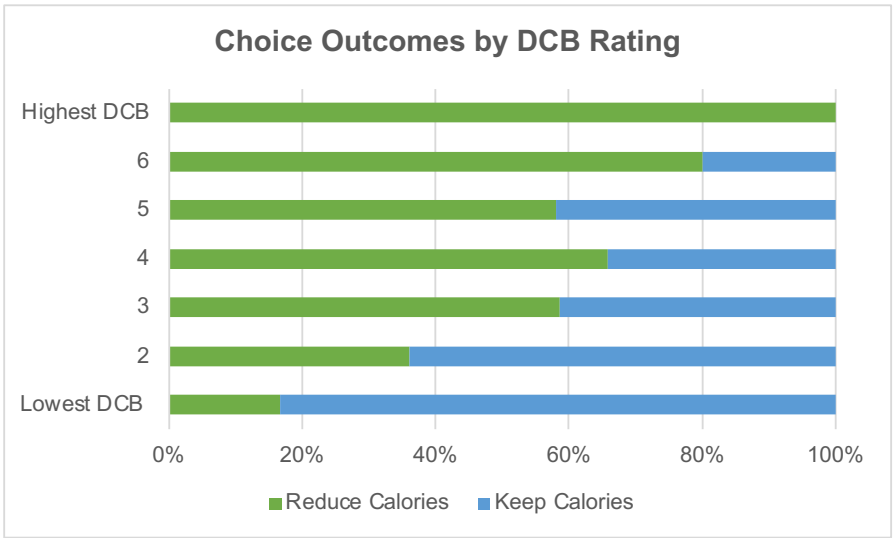


Figure 10: Choice Outcomes by DCB Rating

Amongst those who rate low (1 or 2) to moderate (3 or 4) in DCB, we notice that healthy choice outcomes are much more likely if these participants were exposed to a social comparison nudge than the health information nudge in the control condition. Only 39% of participants low to moderate in DCB decide to reduce calories in the control condition, while 67% of participants low to moderate in DCB reduce calories if exposed to the same nudge with an added social comparison (see Fig. 11).

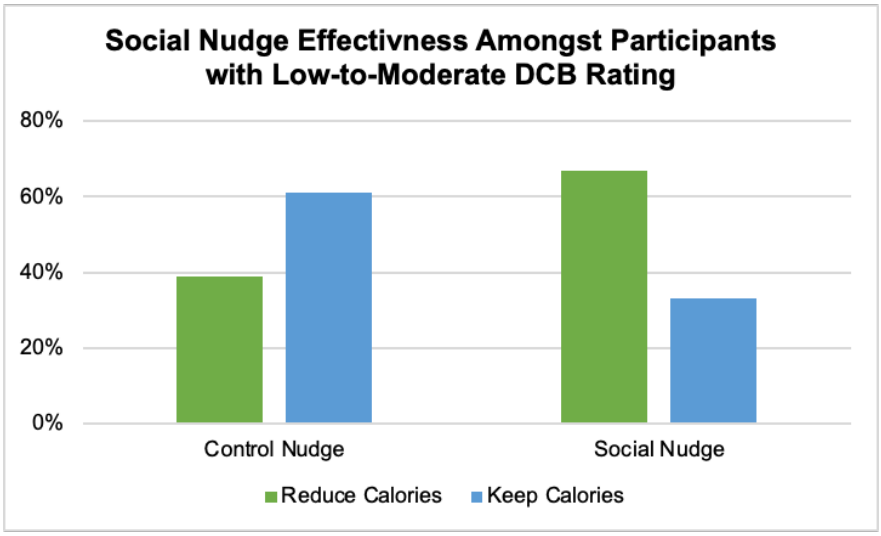


Figure 11: Nudge Performance Amongst Low to Moderate DCB Participants

A Pearson's comparison test was run to assess if there was a meaningful difference between the control condition and the social comparison conditions on healthy choice outcomes amongst those who rate low to moderate in dietary control behaviours. The results were highly significant with a Pearson Chi-square p-value of .0028. We indicate that there is a promising trend that supports our third and final hypothesis (see Table 9), but we do not confirm our hypothesis given the interaction was not found to be significant in our overall model, due to a lack of movement at the top end of the DCB scale where participants are likely to reduce calories no matter what.

All in all, our core experiment on social comparisons as nudging mechanisms gives us good reason to believe that both in-group and out-group social comparisons can effectively be used to nudge overweight adults to consider reducing calories in appropriate contexts, even among people who rate low in dietary control behaviours and may thus be more resistant to dieting.

Table 9: H1/H2/H3 Results

Hypothesis 1 Statement	H1 Result
There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the control condition (caloric surplus + weight gain implication) as compared to the baseline (caloric surplus only) condition.	Not Confirmed
Hypothesis 2 Statement	**H2 Result**
There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the social comparison conditions as compared to the control condition.	**Confirmed**
Hypothesis 3 Statement	**H3 Result**
There will be an interaction effect between the experimental condition and DCB rating on choice such that those who rate low to moderate on DCB will be more likely to pursue the healthy choice when presented with a social comparison nudge as compared to the control condition.	**Promising Trend**

There are several limitations that should be addressed. First, we cannot overgeneralize the potential reach of the nudge effects given this study focused on overweight adults living in the United Kingdom. Second, the stimuli used in these experiments were appropriate for a controlled academic study but would not be recommended for use in the real world given the sensitivity around comparing individuals by body weight or body image. In this experiment we found that comparing overweight adults to other overweight adults (an in-group comparison) produced greatest nudge uptake, though our pilot experiment with normal weight adults found that an out-group comparison (to overweight adults) produced better choice health outcomes, indicating that a fear or stigma associated with being overweight might be contributing to the observed in-group and out-group comparison effect. Our next experiment will address this shortcoming by

taking a nod from minimal group paradigm and allowing participants to join teams based on colours, a technique that is well documented in social psychology literature (Charness & Chen, 2020; Tajfel et al., 1971). In this approach, a participant might elect to join Team Blue and would see comparisons to other Team Blue members (an in-group comparison) or comparisons to Team Red members (an out-group comparison). Should we be able to replicate results, we can be more confident that it is the social group comparison driving the results, not any fear or stigma response. Third, our experiment revealed that consumers responded quite differently to stimuli that displayed a caloric surplus amount (i.e., you are projected to consume 3,500 extra calories) and stimuli that displayed the same exact caloric surplus amount but indicated this could result in weight gain (i.e., this could result in 0.45kg of weight gain), indicating that using nudges with specific numbers could produce varying and unexpected results. Our next experiment will move away from using raw numbers and we will seek to design and test cleaner, visual nudges that should be easier to employ and adopt at scale in real-world settings. These visual stimuli will provide a relative social comparison using a visualization and corresponding text assessment (i.e., your grocery basket calories are very high), rather than call out specific caloric figures. Finally, although this experiment shows us that social comparison nudges seem to work across the board, we do not yet fully understand what underlying mechanisms might be driving the observed effects or who these nudges are most well-suited to.

Discussion and Next Steps

The goal of this research was to design and test novel nudging mechanisms to encourage healthier choices and facilitate behaviour change. We leveraged what we already know about nudging based on 10 years of learning on the topic (Caraban et al.,

2019). We sought to challenge conventional nudge practices employed in the field by asking HCI scholars to consider a novel form of social influence nudging (the out-group social comparison) that has not been tested in the behavioural sciences, prior to our own experiments. We tested our nudges at the point of checkout, rather than point of product consideration, as we believe doing so could produce healthy choice outcomes and less is known about nudging at checkout rather than nudging during the shop or browse experience. We also aimed to resolve an ethical dilemma that has been documented in the literature on healthy food choice nudging: namely, the nudges that have proven to be most effective tend to manipulate consumer behaviour outside of their awareness, a practice that consumers neither appreciate nor approve of.

Across two experiments, we focused on testing out-group social comparisons to understand if they could perform on par with the more conventional in-group social comparison. Our results show that both kinds of transparent social comparison nudges work. These social nudges worked particularly well among people who indicated they do not typically change their diet behaviours to control weight gain, as measured by the Dietary Control Behaviour scale (Bruner, 2017; Liu et al., 2015). Our point-of-checkout, basket-level social comparison nudges also encouraged users to make greater calorie reductions compared to healthy eating nudges employed in the field today (which find reduction averages between 64 calories to 209 calories).

We believe these results have potentially strong implications for experience design. Social nudges should be harnessed in new ways to help people better achieve their goals in a variety of areas, not just food choice. Our initial findings seem to indicate that out-group comparisons may be just as effective as in-group comparisons in encouraging

socially responsible decisions and should be further explored, in academia and the field alike. When trying to help individuals change behaviours for social good (e.g., eating healthier, saving more for retirement, using less energy), out-group social comparisons become critical as in-group social comparisons are likely to promote the status quo, which is not helpful given alarming trends in obesity, retirement readiness, and climate change in various parts of the world. Some may argue that individuals may feel bad about themselves after being exposed to upward social comparisons that pit them against others who perform better than they do in areas such as healthy eating or saving for retirement. However, existing literature suggests that is not necessarily true. After reviewing a series of studies looking at the impacts of upward social comparisons, Collins (1996) asserts that "upward comparison is not in conflict with the desire for positive self-regard and indeed serves it indirectly (through self-improvement) and sometimes directly (by enhancing the self)" (p. 51). Further nudge studies that prompt upward social comparison should seek to validate this. We hope our work inspires scholars and designers to think of social comparisons more broadly and employ comparisons that go beyond "people like you" in contexts where it makes sense, particularly when broad sweeping social norm statements on what most people are doing would not be appropriate.

These preliminary findings could not come at a better time. The rise and adoption of online grocery shopping brings about opportunities in digital food choice nudging that were not possible just a few years ago (East, 2022; Meena, 2018; Mintel Press, 2021). We know that online recommendation agents can influence consumer choice in meaningful ways (Benlian et al., 2012; Gomez-Uribe & Hunt, 2015; Haubl & Trifts, 2000; Lawrence et al., 2001; Yuan et al., 2016), giving us reason to challenge

conventional approaches and consider new ways to optimize recommendation algorithms. Our research suggests that embracing novel forms of social comparisons and nudging consumers later in their shopping experiences and at a higher order could promote nudge uptake in meaningful ways. Future research should go beyond calorie reduction and nudge other healthy diet choices and test how out-group comparisons might have other positive benefits for public health or policy outcomes. Our results suggest that there may be more tools available to designers to create effective, ethical, transparent nudges that help people achieve goals for themselves in a way that suits them, while also benefitting society more broadly.

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Chapter 2: Using Social & Self-Comparisons to Nudge

Abstract

Public health scholars have indicated that new nudging research is needed to help avert a global obesity crisis. We test a new form of social influence nudging—out-group social comparisons—as well as goal-based self-comparisons to encourage calorie reduction. We recruited 650 adults in the United Kingdom and United States to participate in our study on health and nutrition. Participants who opted into a Challenge Team were directed to a sub-experiment on social comparisons while those who opted out were directed to a sub-experiment on self-comparisons. 78% of participants opted to join a Challenge Team, while 22% opted out. Our results showed that those randomly assigned to either the in-group or out-group social comparison condition were significantly more likely to reduce calories than those in the control condition (*p=.0041*). Furthermore, the effect was more pronounced among people who are typically resistant to dieting. We did not find a statistically significant difference in nudge uptake between the self-comparison and control conditions, but we did observe a significant interaction effect between affiliative motive score and self-comparisons, such that those with low-to-moderate desire to affiliate with others were more likely to make healthy choice outcomes in the self-comparison nudge condition.

Our study indicates that both in-group and out-group social comparisons can be used to nudge calorie reduction among broad populations, including people who are typically

less willing to modify their diets. We find Challenge Teams serve as an optimal way forward for nudging social comparisons. Finally, we show that goal-based self-comparisons may be an effective alternative for individuals who have a low-to-moderate desire to affiliate and may not wish to join Challenge Teams.

Introduction

Current attempts to curb obesity have largely focused education and awareness campaigns and have not produced meaningful change to date (Marteau et al., 2011; Roberto, 2020). As a result, public health scholars have been actively researching behavioural interventions to help stem the global rise of obesity (Arno & Thomas, 2016; Lowell, 2004), using mechanisms like healthy food swaps, nutrition labels, and social norm or social proofing statements to encourage healthier diets (Cioffi et al., 2015; Forwood et al., 2015; Mollen et al., 2013; Salmon et al., 2015). Studies show that these kinds of interventions can be effective, but they either produce small effects or have a limited ability to scale in the real world (Cadario & Chandon, 2020). Human behaviour in context and the growing popularity of unhealthy, indulgent foods has trigged a need for fresh research on this urgent topic to prevent further rises to obesity seen around the globe (Ensaff, 2021; Tatum, 2020; World Health Organization, 2021, 2024).

We present research that builds on what researchers know about social facilitation and social modelling within food choice (Cruwys et al.,2015; Vartanian et al., 2015; Zajonc, 1965). We anchor our studies in human-computer interaction (HCI) research on social influence nudging (Caraban et al., 2019) and enhance this by testing conventional in-

group ("people like you") social comparisons as well as novel out-group ("people unlike you") social comparisons. To our knowledge, out-group social comparison nudges have not been studied before outside of our own previous research on the topic (DiCosola & Neff, 2020, 2022), as outlined in the previous chapter. We continue to focus on nudging participants towards calorie reduction at the point of online grocery shopping basket checkout in contexts where overall basket calories are high, given this approach was proven to be successful in our previous studies. We introduce Challenge Teams as a mechanism to facilitate both in-group (same team) and more varied out-group (different team) social comparisons and use colour-based teams to establish minimal conditions for social reference group comparisons.

We believe social comparison nudging effectiveness will be driven by our innate human desire to affiliate with others (Festinger, 1954; Maslow, 1943), while building on foundational principles of social competition (Triplett, 1898) that have shown to be fruitful when applied in other digital health contexts (Cruwys et al., 2015; Gouveia et al., 2016). Recognizing that not everyone will want to engage in social comparisons or social competitions with others, we also investigate whether goal-based self-comparisons may be a viable nudging alternative for such individuals. We do not wish to embrace a "one-size-fits-all" approach to nudging calorie reduction in digital contexts, given we know this is a common pitfall of technology-enabled interventions, particularly in digital health and fitness (Ackerman, 2000; Spiel et al., 2018).

Related Work

Our research focuses on investigating nudges that can encourage healthier and more socially responsible decision-making with a central focus on social influence nudging and a secondary focus on goal-based self-comparison nudging. Literature related to social influence and goal setting will be reviewed at a high level to ground our studies more concretely and to illustrate gaps in the literature that we seek to fill with our work.

Social Influence Nudging

Literature on social facilitation within social psychology has long demonstrated the impact that the *presence* of other individuals can have on our behaviours in a variety of domains, including food choice (Cruwys et al., 2015; Ruddock et al., 2019; Zajonc, 1965). That body of work tells us that we not only eat more in the presence of others, but we look to others as a reference point to understand what and how much to eat. There is no shortage of literature demonstrating the varied responses that *present others* can have on our food choices, many of which are quite surprising. For example, we will make choices to maximize group variety at the expense of our own preferences when dining in group contexts, but not when we dine alone (Ariely & Levav, 2000). Similarly, we will demonstrate variety-seeking behaviour when shopping in public view but not in private (Ratner & Kahn, 2002). When we look to others to determine how much we should eat through social modelling (Cruwys et al., 2015; Vartanian et al., 2015), we will mirror the behaviour of others and follow social norms that we can easily perceive (Rubenstein et al., 2022). Beyond this, we also factor in the body composition of others when using them as a reference point for deciding what or how much to eat

(McFerran et al., 2010). A meta-analysis of experimental studies on social modelling of food choice has found that modelling is increased when individuals view themselves as being like present others or when individuals want to affiliate with present others (Cruwys et al., 2015). We seem to allow in-group members or aspirational group members to influence our food choices, but what about out-group members?

Scholars in consumer behaviour have found that we are differentially influenced by in-group members *and* out-group members. For example, we form positive connections with brands images tied to in-group members or aspirational group members but form negative self-connections with brand images tied to out-group members (Escalas & Bettman, 2003, 2005). We are willing to mimic the unethical behaviour of confederates who poses as an in-group member but fail to do so if they pose as an out-group member (Gino et al., 2009). When it comes to considering products, we evaluate products most negatively when they are tied to dissociative out-groups rather than out-groups in general (White & Dahl, 2006, 2007). Foundational literature on intergroup bias demonstrates that we are inherently more concerned with in-group members and aspirational group members than out-group members and that our automatic bias towards the in-group is driven by a preference for the in-group, rather than a distaste for the out-group (Ashburn-Nardo et al., 2001; M. B. Brewer, 1979, 1999; Cocanougher & Bruce, 1971; Tajfel et al., 1971). Despite our well documented intergroup bias, there is some reason to believe we may be able to harness dissociative reference groups or out-groups as a force for social good. Research by White, Simpson, and Argo (2014) tells us that when we learn about dissociative out-groups that are demonstrating positive behaviours, we are motivated to improve our individual behaviour as well. We do this

to bolster our group's overall image in comparison to the dissociative out-group. More recent research by Touré-Tillery, Steinmetz, and DiCosola (2022; 2020) found that the mere presence of out-group members can cause us to make healthier food choices. Across multiple experiments that leveraged various types of group memberships such as race, university affiliation, and work affiliation, we found participants were consistently more likely to make the healthier food choice in the presence of an out-group member (different race or affiliation) than an in-group member (same race or affiliation). The observed effect is driven by a belief that we will be judged more harshly by out-group members than in-group members. These results demonstrate that reference groups can differentially shape our behaviours and that out-groups can inspire us in virtuous ways, though these effects were observed in public rather than private settings, given the impression management tendencies we typically demonstrate in public (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980). In summary, these combined findings indicate that out-groups can spur socially desirable choice outcomes, driven by impression management (Leary & Kowalski, 1990; Schlenker, 1980) and our need to belong (Allen et al., 2022; Baumeister & Leary, 1995; Maslow, 1943; Maslow & Lewis, 1987), despite the rich body of literature would indicate otherwise (Ashburn-Nardo et al., 2001; Berger & Heath, 2008; Escalas & Bettman, 2003, 2005; Hewstone, 1990; Pettigrew, 1979; Tajfel et al., 1971).

Public health scholars have found that social comparisons are broadly effective in encouraging behaviour change and should be further researched and applied in more targeted ways (Shakya et al., 2015), paving the way for our research on out-group social comparisons. While the concept of nudging was founded by scholars in behavioural

economics (Sunstein, 2014; Thaler & Sunstein, 2008), HCI scholars have applied nudging to digital contexts by designing "systems that introduce subtle changes in the way choices and information are presented with the goal of guiding users towards desired choices and behaviors" (Caraban et al., 2019; p. 2) and our research will continue in this tradition. Although there has been an abundant amount of research on food choice nudging, most of these studies have been focused on how we behave in traditional real-world settings (Broers et al., 2017; Bucher et al., 2016; Caraban et al., 2015; Gestel et al., 2018; Kroese et al., 2016; Wilson et al., 2016), with research related to digital nudging (Weinmann et al., 2016) in online settings only recently gaining traction (Fuchs et al., 2022; Howe et al., 2022; Piper et al., 2021; S Howe et al., 2019; Valenčič et al., 2022). Given the surge in popularity of online grocery shopping that emerged during the pandemic (East, 2022), understanding how to nudge healthy food choice in technology mediated settings is more critical than ever. A meta-analysis of HCI studies found that social influence was one of six key mechanisms that can be used to nudge users and help them improve their decision making in technology mediated contexts (Caraban et al., 2019). Researchers have been able to use social influence to nudge users by invoking feelings of reciprocity (R. N. Brewer & Jones, 2015; Cialdini, 2006; Gamberini et al., 2007), leveraging public commitment (Cheng et al., 2013; Hansen & Jespersen, 2013; Staw, 1981), raising the visibility of users' actions (Caraban et al., 2015; Gilovich et al., 2000; Hansen & Jespersen, 2013; Thieme et al., 2012), and—most importantly to our research— by enabling social comparisons (Colusso et al.,2016; Eckles et al., 2009; Gouveia et al., 2016). That said, current literature on social comparison nudging does not tap into the rich literature on intergroup bias and fails to investigate how making comparisons to different groups of people may alter our choices, which is a known shortcoming in behavioural research to date (Wood & Hayes,

2012). Existing research on social influence nudging in technology mediated settings focuses on "People Like You" or in-group comparisons (Benlian et al., 2012; Caraban et al., 2015; Colusso et al., 2016; Gouveia et al., 2016); our research will address this critical gap in the literature by further exploring the impact of out-group comparisons to nudge healthier choices, seeking to broaden our conception of how to apply and use social comparisons.

Goal-Based Nudging

While goal-based self-comparisons may not produce as broad sweeping or powerful results as social comparisons, given they rely on autonomous individuals to set health goals for themselves, research has shown that goal seeking under such conditions is positively correlated with both happiness and self-realization, which can promote physical health (Miquelon & Vallerand, 2006). It is relatively well established that much of consumer behaviour is goal-directed (Bagozzi & Dholakia, 1999; Baumgartner et al., 2008) and that we often have multiple conflicting goals, particularly when it comes to making food choices (Stroebe, 2022; Stroebe et al., 2013; Tezer & Sobol, 2021). We often justify hedonic pursuits over more utilitarian choices (Dhar & Wertenbroch, 2000; Kar, 2022; Lowe & Butryn, 2007; Tezer & Sobol, 2021), making the current state of obesity even more alarming. That said, digital tools and systems can help people set goals, stay on track, and influence how they feel about their goal performance (Papadimitriou et al., 2016), particularly in areas of health and fitness (Gouveia et al., 2016; Lupton, 2017; Neff & Nafus, 2016).

Bagozzi & Dholakia (1999) establish a framework for goal-directed consumer behaviour that follows a six-step process: (1) goal setting, (2) forming a goal intention, (3) action planning, (4) action initiation and control, (5) goal attainment or failure, and (6) feedback reactions (see Fig. 1).

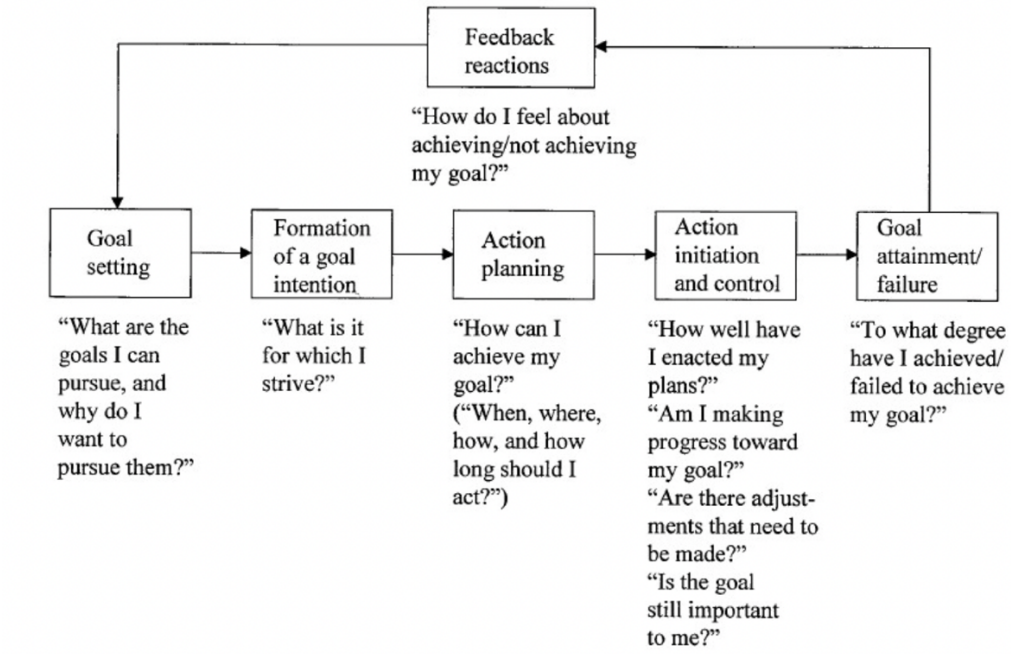


Figure 1: Goal Setting and Goal Pursuit in Consumer Behaviour (Bagozzi & Dholakia, 1999)

Digital tools and systems can help facilitate all six steps in the process while digital nudging is critical to shaping action control and goal attainment (steps 4 and 5 of the six-step process). Digital tools play a crucial role in helping to individuals to establish health goals, which can help foster and strengthen one's healthy-eater identity, leading to improved efforts towards goal pursuit (Dominick & Cole, 2020). Nudging with goal progress can be used in a complementary fashion to help people stay on track and achieve a desired end state (Nunes & Drèze, 2006), especially considering that we often pursue goals quite flexibly ourselves, easily justifying going off track to pursue

temporary temptations and hedonic pleasures (Stroebe et al., 2013; Tezer & Sobol, 2021), even though we would not expect others to do the same (Scott & Williams, 2022).

Literature Contributions

The primary goal of our research is to identify new ways to help consumers make healthier decisions in digital contexts through nudging. The research presented in this paper first looks to build on what we know about social facilitation and social modelling within food choice and build on existing work by HCI scholars on social comparison nudging to understand if we can use both in-group and out-group social comparisons as reference points to nudge consumers towards making healthier decisions within the domain of food choice. We challenge conventional practice and wisdom that focuses solely on the in-group and argue that out-group comparisons may be an equally effective nudging mechanism that could prove more impactful in inspiring healthier diets in practice. While literature shows that social proofs (Cialdini, 1984, 2006) presented to establish social norms (Cialdini & Trost, 1998; Durkheim, 1938) work to inspire healthier choices in food choice contexts (Bicchieri et al., 2022; Croker, Whitaker, Cooke, & Wardle, 2009; Mollen et al., 2013; Rubenstein et al., 2022), in practice they are difficult to implement because people are increasingly purchasing unhealthy items like beer, high-fat sausages and bacon, soda, and chocolate candy bars when grocery shopping as of late (Tatum, 2020; Wood, 2020), making the norm all but healthy. As such, we introduce the concept of colour-based Challenge Teams as a mechanism that would facilitate both in-group (same team/same colour) and out-group

(different team/different colour) social comparisons that would nudge consumers to make heathier or more socially desirable choices in private, digital contexts. Recent research has revelated that there are two clusters of eaters: healthy and unhealthy eaters (Lamy et al., 2022). While comparing unhealthy eaters to other unhealthy eaters through an in-group social comparison would likely do little to change the status quo, comparing unhealthy eaters to healthy eaters could very well encourage positive behaviour change through an upward social comparison (Collins, 1996), making the effectiveness of out-group comparisons a focal point of our research. While the initial experiments outlined in our first paper relied on body image and body type to establish baseline group comparison effects, the more minimal approach used in this paper was leveraged to ensure the effects are real and can be applied to varied group constructs. For example, if our colour-based Challenge Team social comparisons are successful in nudging healthy choice outcomes, more practical Challenge Teams could be constructed based on factors like location or geography (e.g., London vs. Manchester; New York vs. Los Angeles) or hobbies or interests (e.g., Team Gardening vs. Team Reading; Manchester City Fans vs. Manchester United Fans), likely having broader reach and appeal than health-focused group definitions that may not be appropriate or desirable to apply in real-world settings.

While the few existing studies that have documented the positive aspects that out-groups can have on our behaviours have taken place in public (Touré-Tillery et al., 2022; White et al., 2014) and have been motivated by self-presentation and impression management (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980), our research is focused on shifting private online behaviours. Rather than relying on impression

management goals to drive virtuous public behaviour, our social comparison nudges rely on social competition (Deutsch, 1949; D. W. Johnson & Johnson, 1989; Triplett, 1898) to encourage healthier choices in private. Our work thus not only adds to a limited but growing set of emerging literature that suggests out-groups can be a force for social good and positive behaviour but will be the first to our knowledge that demonstrate such an effect in a private setting that would not be prone to impression management concerns.

Recognizing that all people may not wish to engage in Challenge Team competitions with others, we also investigate whether goal-based self-comparisons may be a viable nudging alternative for such individuals, as we do not wish to embrace a "one-size-fits-all" approach to nudging calorie reduction in digital contexts, given we know this is a common pitfall of technology-enabled interventions, particularly in digital health and fitness (Ackerman, 2000; Spiel et al., 2018). This line of work adds to a large body of literature that points to positive impacts of dietary self-monitoring (Acharya et al., 2011; Burke, Wang, & Sevick, 2011) and provides additional clarity on conditions under which nudged dietary goal monitoring may be effective.

Study: Social Comparison & Self-Comparison Nudging

Study Overview

Our research aims to test novel nudging mechanisms that highlight or bring attention to possible choices and healthier alternatives through social influence, tapping into a reflective rather than automatic mindset (Caraban et al., 2019; Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2011). Many healthy food choice nudges employed in the field today focus on manipulating behaviour by making changes to environments that people cannot easily detect, such as offering less healthy foods in smaller package sizes (Cadario & Chandon, 2020). These kinds of undetected behavioural nudges tend to work well, although people largely reject this form of nudging (Cadario & Chandon, 2019). Our research aims to uncover a form of social nudging that is both effective and acceptable to end users.

Focusing on nudges that prompt a reflective choice is worthwhile as this form of nudging is transparent and causes a user to reflect on his or her choices, which is what consumers indicate they prefer (Felsen Castelo, & Reiner, 2013). Designing nudges that prompt a reflective choice and produce strong healthy choice outcomes is an uphill battle, however, as existing field studies in consumer behaviour that show these types of nudges have smaller effect sizes and limited consumer impact (Cadario & Chandon, 2019). Public health scholars have found similar limitations in their nudge studies. For example, when public health researchers constructed an experimental grocery shopping site to nudge consumers to swap out higher calorie foods for healthier, lower calorie

options in the same food category, they found that the limited number of accepted swaps did not lead a significant reduction in overall calories (Forwood et al., 2015). Similarly, traditional nudge research conducted in a real-world setting within a university eatery setting found small but significant increases in purchase of low-calorie, low-fat foods after implementing health labels on foods sold in university dining halls that prompted students to consider their food choices (Cioffi et al., 2015).

To have greater impact, we test if adding social comparisons to health labels (albeit in a digital infographic format) can improve the acceptance of nudging interventions in online grocery shopping contexts. We believe that social comparison nudges-—both in-group social comparisons and out-group social comparisons—will perform better than nudges based on health information alone given documented success that broader social proofing and social norms statements can have on healthy food choice (Mollen et al., 2013; Salmon et al., 2015) and previous work that links social comparison processes to positive behaviour changes that can reduce obesity (Shakya et al., 2015). We believe there is power in social nudges because the social comparison (like social proofs or social norm statements) creates an additional source of motivation for the consumer, a core requirement for behaviour change (Fogg, 2009) while also increasing the diagnostic, or informational, value of the health information being presented. When it comes to the relative performance of social comparison nudges, we anticipate that out-group comparisons could prove superior to in-group comparisons because in-group comparisons will elicit a less pronounced assimilation or matching effect while out-group comparisons will elicit a more pronounced contrast or distancing effect to help one's in-group stand out from the referenced out-group (Sherif et al., 1958). We expect to see such an out-group effect regardless of whether the out-group is an aspirational

out-group or dissociative out-group because in both instances the individual will need to go "above and beyond" to either win entrance to the group (if it's an aspirational out-group) or to stay dissociated or distinct from that group (if it's a dissociative out-group). That said, if the out-group one is compared to is unknown or not of interest, then no meaningful effect would be observed. These anticipated effects are visualised in Figure 2 below, where we see calorie reduction facilitated by the social reference point, which is perhaps more pronounced in the out-group condition due to the desire to stand out or "do better" than the out-group, rather than merely match to fit in with the in-group.

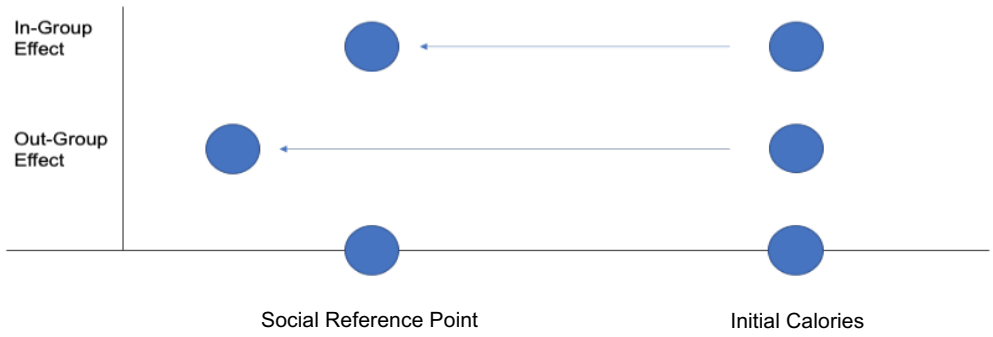


Figure 2: Anticipated In-Group vs. Out-Group Effect

We focus on nudging calorie reduction given it has been a core focus for public health scholars as obesity becomes a global crisis (Cioffi et al., 2015; Forwood et al., 2015; Lowell, 2004; World Health Organization, 2021, 2024). Future studies may focus on nudging other positive dietary changes like reducing unhealthy fats, added sugar, and unsustainable food sources to have wider impact (Ensaff, 2021).

We aim to show a critical gap in the literature (and real-world practice) by limiting social influence nudging to mechanisms like social norms, which focus making comparisons to what most people do, or social comparisons involving in-group

comparisons, which focus on making comparisons to people who are like you (Caraban et al., 2019; Thaler & Sunstein, 2008). These types of comparisons make sense in many digital contexts, like making interesting movie recommendations based on what's widely trending or what people who are like you are watching lately (Gomez-Uribe & Hunt, 2015), but they do little to help change behaviour when applied in meaningful digital health contexts. For example, social norm statements will do little to inspire healthy eating given the most popular grocery store items purchased in the US and UK are largely unhealthy (Tatum, 2020; Wood, 2020). Similarly, comparing the baskets of shoppers that have a large proportion of unhealthy items to similar shoppers is unlikely to produce many helpful, healthy recommendations. Given this, research into the effectiveness and acceptance of both in-group and out-group social comparisons becomes necessary, as the out-group comparison would allow comparisons between those who largely select unhealthy items to those who select largely healthy items (Lamy et al., 2022)., promoting more healthy food choices through social influence (Cialdini, 1984, 2006) at the reference group level.

We constructed our study to answer three key questions:

1. Do both forms of social comparisons (in-group, out-group) effectively nudge the healthy choice (i.e., choosing to reduce calories when basket calories are high)?

2. Are social comparison nudges effective against those who rate low to moderate on dietary control behaviours (DCB) and may otherwise be unwilling to modify their dietary habits?

3. Are self-comparisons a viable alternative to social comparisons for those who have a low-to-moderate desire to affiliate with others and may not wish to engage social competition?

Our split study was designed to allow participants to opt-in to a Challenge Team if they so desired. While we anticipated that most individuals would opt to join a Challenge Team given our innate desire to affiliate with others (Maslow, 1943), we wanted to offer a viable alternative. As such, participants who indicated they did not wish to join a Challenge Team were directed to our sub-experiment on self-comparison, goal-based nudging.

Study Predictions

Our hypotheses are:

H1: There will be an overall main effect of social comparison condition on healthy choice outcomes such that increased healthy choice will occur in both in-group and out-group social comparison conditions as compared to the control condition.

H2: There will be an interaction effect between the social comparison condition and DCB rating on healthy choice outcomes such that those who rate low to moderate on DCB will be more likely to pursue the healthy choice when presented with a social comparison nudge as compared to the control condition.

H3: There will be an interaction between affiliative motive score and self-comparison experimental condition such that participants with low-to-moderate affiliative motive scores will be more likely to take up the healthy choice in the self-comparison condition than the control condition when compared to participants that have higher affiliative motive scores.

Study Methods

The study recruited 650 adults in the United Kingdom and United States to participate in this combined split study on social comparison and self-comparison nudging on Prolific.co for a 1 GBP or local equivalent incentive. Participants completed a short survey regarding demographics and health, nutrition, and fitness perspectives and practices. The survey included multiple statements from the Dietary Control Behavior (DCB) scale, a proven scale used by the consumer behaviour community to measure the extent to which individuals are willing to change their eating behaviours in an effort to control their weight (Bruner, 2017; Liu et al., 2015) .The final part of the survey leveraged the Communal and Agentic Motives with Standards (CAMS) scale to help us measure participants desire to affiliate with others (Cannon & Rucker, 2020), which is critical to understand if high affiliative scores are correlated with the decision to join a social Challenge Team.

After completing the initial survey, participants were told that their preferred online grocery store had set up a new social initiative to allow customers to join Challenge

Teams to respond to grocery shopping and nutrition challenges to encourage healthier and more varied, nutritious eating. Participants could decide to take part in this social initiative or choose not to.

When consulting with a major grocery retailer in the United Kingdom in the design of this experiment, they indicated it may be beneficial to allow participants to opt-in to social comparison challenges as this would mimic their intended approach and allow us to better understand:

A) the percentage of people that would willingly sign up for Challenge Teams

B) predictors that correlate with the Challenge Team opt-in.

As such, we did not pre-assign participants to Challenge Teams, which would be a form of defaulting nudge (E.J. Johnson & Goldstein, 2003; Thaler & Sunstein, 2008), but instead allowed them select whether they wanted to opt-in or opt-out of joining a Challenge Team naturally.

We constructed Challenge Teams based on arbitrary colour selection, a practice well documented within social psychology literature when seeking to form groups under minimal group paradigm conditions (Charness & Chen, 2020; Tajfel et al., 1971). Participants could either elect to join the Blue Team or the Red Team or indicate they did not wish to join any Challenge Team. A quota system was used in Qualtrics to help balance team sizes while allowing for organic team selection. The Blue Team reached the max quota before recruitment was complete, giving impacted late-stage participants

the option to join either the Red Team or opt-out of joining a Challenge Team altogether.

Participants who elected to join a Challenge Team were randomly assigned to the control condition or one of four social comparison conditions. The four social comparison conditions were based on two factors: team comparison (Blue Team comparison versus Red Team comparison) and a fictitious artificial intelligence algorithm disclosure statement (AI disclosure statement shown versus AI disclosure statement hidden). Participants who elected not to join a Challenge Team were randomly assigned to either the control condition or self-comparison condition as part of our secondary sub-experiment on self-comparisons (see Fig. 3).

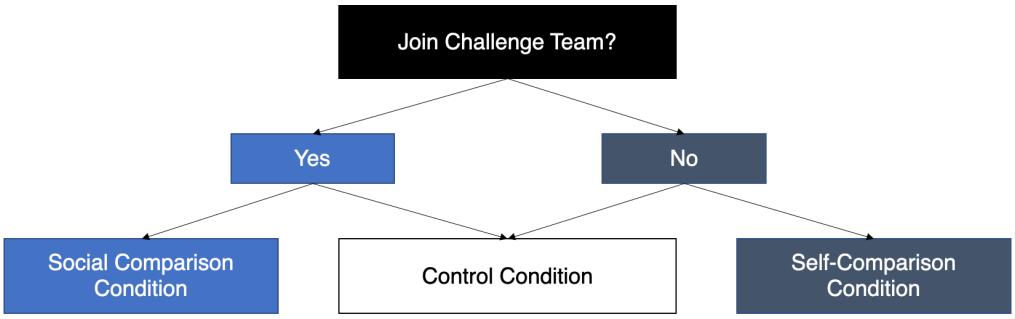


Figure 3: Split Study Conceptual Design

All participants were told to imagine they had just finished shopping for groceries online and were about to complete the checkout process with their preferred online grocery store, where they had previously setup a personal profile. Participants were shown a consistent visual stimulus that indicated that the number of calories contained in their basket was very high and that this could result in weight gain. The design of this

stimulus was designed to be simplified from previous experiments while still providing key health information (i.e. the amount of calories in your cart is very high, this could result in weight gain) as well as a social comparison or a self-comparison, depending on the study condition. The stimuli used in this study did not contain specific caloric numbers that participants could reference and anchor to, but instead used a visual meter to indicate cart calories were very high. These stimuli were designed to be easier to comprehend in a quick manner and were vetted through guerilla pre-testing. Participants in the control condition saw the baseline stimuli without any social comparison. Participants in the social comparison condition were told this amount was high relative to what was typical for the Blue Team or Red Team, while participants in the AI disclosure shown sub-condition saw a small disclaimer that indicated the above analysis relied on an artificial intelligence algorithm and many data points (see Fig. 4). Participants in the self-comparison condition were told this amount was high relative to their goal amount.

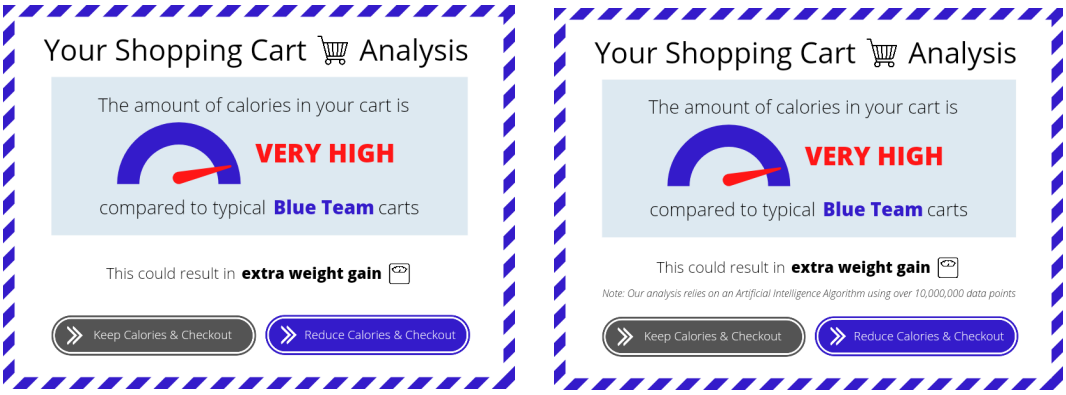


Figure 4: Representative Study Nudge Stimuli

All participants were asked to make a discrete choice: they could either elect to keep calories and checkout (unhealthy choice) or reduce calories and checkout (healthy choice). Individuals who elected to reduce calories were asked a follow-up question

related to the number of total calories they wished to reduce their basket by using a sliding scale from 0 to 5,000 calories. Participants also completed a manipulation check. Finally, participants were shown a closing page that debriefed them and provided a code to initiate payment for participation.

While we were intentional in the design of this split study, it is important to note one key drawback our approach: we cannot pit social comparisons directly against self-comparisons in our analysis, we can only assess how each type of comparison performed against the control condition.

Study Results

Of the 650 participants we recruited, 649 of them gave their consent to complete our study. 78% of participants (N=504) opted to join a Challenge Team while 22% (N=145) did not, indicating the vast major of participants were open to being exposed to social nudges through Challenge Team participation, as we expected. The mean affiliative motive score was 5.82/7.00, indicating that participants generally had a high desire to affiliate with others, as we would expect from longstanding literature on the matter (Maslow, 1943).

To assess whether affiliation motive ratings and other demographic factors influenced participants' decision to join a Challenge Team or not, we built a model with our target predictor variable (Affiliative Motive Score) and other possible demographic predictors (Age Group, Location, Employment Status, Body Mass Index) and dependent binary

measure of Joining Challenge Team (Yes/No). A nominal logistic analysis was conducted on the model. The overall model was significant, X^2 (24, n = 636) = 49.01, p = .0019. The link between affiliative motive score and deciding to join a Challenge Team was positively correlated, as expected, and highly significant (p = .0005). Age Group proved to be another significant predictor (p = .0061) with the likelihood of joining a Challenge Team being lower amongst older age groups, particularly those aged 55 or older. Finally, location was also significant (p = .0165) with opt-in more likely in the United States (86%) than in the United Kingdom (76%). Employment status and body mass index (BMI) were not found to be statistically significant predictors of deciding to join a Challenge Team.

The 78% overall opt-in rate indicates that social comparison nudging through Challenge Teams may be a viable form of nudging that people are largely interested in, far exceeding the 56% average approval rating of current food choice nudging mechanisms used to date (Cadario & Chandon, 2019), but will both in-group and out-group social comparison nudges work equally well? To answer this pivotal question, we built a new model to understand the impact of the social comparison experimental condition (control vs. in-group comparison vs. out-group comparison) on nudge uptake, while controlling for dietary control rating and body image happiness. Seventy-four participants failed the manipulation check and were excluded before proceeding with analysis. A nominal logistic analysis was conducted on the model and the overall model was found to be highly significant, X^2 (11, n = 498) = 69.67, $p < .0001$. The coefficient of determination (R^2) value of this model was .1033 (10.33%). All predictors in our model proved to be significant.

There was a highly significant main effect of dietary control behaviour (DCB) rating on healthy choice outcomes, X^2 (6, n = 498) = 27.69, p = .0001, such that those with higher average DCB ratings were more likely to make the healthy choice, regardless of the type of nudge they were exposed to.

There was a significant main effect of body image happiness, X^2 (3, n = 498) = 12.64, p = .0055, such that participants who indicated they were unhappy with their body image were more likely to take up the nudge than those who had other views.

Critically, there was still a highly significant main effect of social comparison condition on healthy choice outcomes, X^2 (2, n = 498) = 10.99, p = .0041, such that both social comparison conditions (in-group and out-group) produced significantly more healthy choice outcomes than the control condition, while controlling for DCB and body image happiness (see Fig. 5). A more detailed analysis showed that 45% of participants in the control condition decided to reduce calories as compared to 67% in the in-group comparison condition and 63% in the out-group comparison condition. The fact that out-group comparisons performed in line with in-group comparisons is noteworthy given this contradicts a large body of literature related to our strong, innate in-group preference (Ashburn-Nardo et al., 2001; Balliet, Wu, & De Dreu, 2014; M.B. Brewer, 1979, 1999; Tajfel et al., 1971). We can confirm H1 (see Table 1).

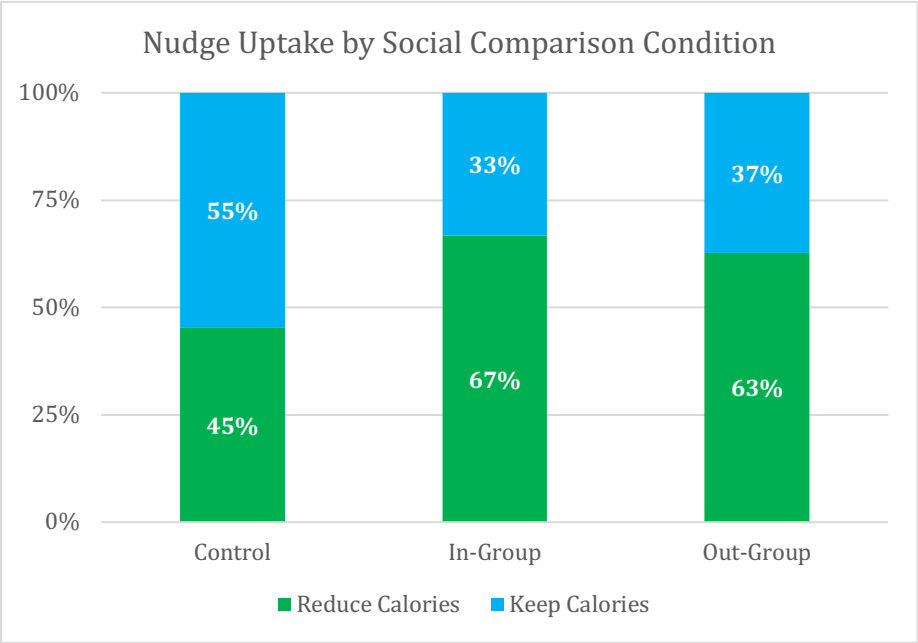


Figure 5: Hypothesis 1 Results

Table 1: Hypothesis 1 Results

Hypothesis	Result
H1: There will be an overall main effect of social comparison condition on healthy choice outcomes such that increased healthy choice will occur in both in-group and out-group social comparison conditions as compared to the control condition.	**Confirmed**

We can now shift gears to our second hypothesis, which is that social comparisons (both in-group and out-group comparisons) work particularly well for those who rate low in dietary control behaviours. Our data provides solid evidence to support this hypothesis. For example, when individuals who rate low in dietary control behaviour are exposed to the control condition, only 20% decide to reduce calories; when these individuals are exposed to a nudge that displays the same information but adds a social comparison, they decide to reduce calories 50% of the time (see Table 2). The differences between

the control and social comparison conditions amongst those who rate low (1-2) or low to moderate (1-4) on dietary control are statistically significant for both in-group* and out-group** social comparison types. We cannot confirm H2 due to lack of movement at the high end of the DCB rating scale but instead note a promising trend (see Table 3).

Table 2: Impact of Social Comparison Condition by DCB Rating

Social Comparison Condition	% Making Healthy Choice		
	Low DCB (1-2)	Moderate DCB (3-4)	High DCB (5-7)
Control	**20%**	57%	64%
In-Group	**50% ***	67%	78%
Out-Group	**50% ****	65%	76%

* difference between control p = .0184 ** difference between control p = .0089

Table 3: Hypothesis 2 Results

Hypothesis	Result
H2: There will be an interaction effect between the social comparison condition and DCB rating on healthy choice outcomes such that those who rate low to moderate on DCB will be more likely to pursue the healthy choice when presented with a social comparison nudge as compared to the control condition.	**Promising Trend**

There was no meaningful difference in the intended calorie reduction across experimental conditions. This is likely driven by the lack of a numeric anchoring point (Sherif et al., 1958; Tversky & Kahneman, 1974); the numeric anchoring point used in the previous studies covered in our first paper was omitted in this study to see if a

simpler, more visual nudge format could produce more consistent but equally strong effects, which it did. As with previous studies, the number of calories our participants indicated they would choose to reduce their basket by was still very high for both in-group (M = 1597) and out-group (M=1729) nudge uptake conditions when compared to healthy eating nudges employed in the field today, where mean calorie reduction is typically between 64 calories and 209 calories. This effect is likely driven by the basket-level approach used in our digitally focused experiment as compared to more common product-level approach used in brick-and-mortar field settings (Cadario & Chandon, 2020).

While not a core focus of our study, we recognize that the interventions tested in this academic lab experiment would likely be powered by artificial intelligence agents when implemented in real-world settings. Given this, we wanted to understand whether being transparent and including AI disclosure statements might influence nudge uptake, given this is a known gap in the literature that needs more exploration (Hancock et al., 2020). We received grant money from the Minderoo Foundation as part of the Minderoo-Oxford Challenge Fund in AI Governance to investigate this additional experimental factor. Statistical analysis revealed that nudge uptake was not meaningfully influenced by showing (68% nudge uptake) or hiding (62% nudge uptake) AI disclosure statements. This data provides rationale for being more transparent and disclosing when recommendations or predictions are being driven by AI algorithms as it suggests there is no harm (and potentially gain) in doing so.

To answer our third and final question on the effectiveness of self-comparisons as a nudging alternative, particularly for those who rate low-to-moderate in their desire to affiliate with others, we built a new model. This model included our self-comparison experimental condition variable (self-comparison vs. control condition), affiliative motive score variable (as calculated by the CAMS scale), and, critically for our hypothesis, the interaction between these two variables as the independent variables and our key dependent variable (discrete choice: keep calories/reduce calories). The overall model was significant, X^2 (10, n = 227) = 20.89, p = .0219. The coefficient of determination (R^2) value of this model was .0667 (6.67%).

The overall main effect of experimental condition was not significant, indicating that the self-comparison condition performed on par with the control condition. This contrasts with our other sub-experiment for Challenge Team participants where both forms of social comparisons performed significantly better than the control condition. This indicates that social comparisons work across broad populations to nudge calorie reduction, while self-comparisons do not. This is in line with our expectations as self-comparisons were designed to be studied as a possible (less powerful) alternative for those who do not wish to engage with social comparisons.

There was a significant main effect of affiliative motive score category on healthy choice outcomes, X^2 (5, n = 227) = 12.46, p = .0290, such that those with higher average affiliative motive scores were more likely to make the healthy choice and reduce calories, regardless of the type of nudge they were exposed to. This finding is interesting and suggests that participants with strong affiliation goals seem to be

influenced by a pervasive social norm for more healthy eating (Ball et al., 2010; Fisher & Katz, 2000).

Critically, there was a significant interaction effect between affiliative motive score and self-comparison experimental condition on healthy choice outcomes, X^2 (4, n = 227) = 12.10, p = .0166, driven by a reversal in trends where those who with a moderate affiliative motive score rating (4 out of 7) were more likely to select the healthy choice when exposed to the self-comparison nudge than the control condition as compared to those with higher affiliative score rating (5 out of 7; see Fig 6).

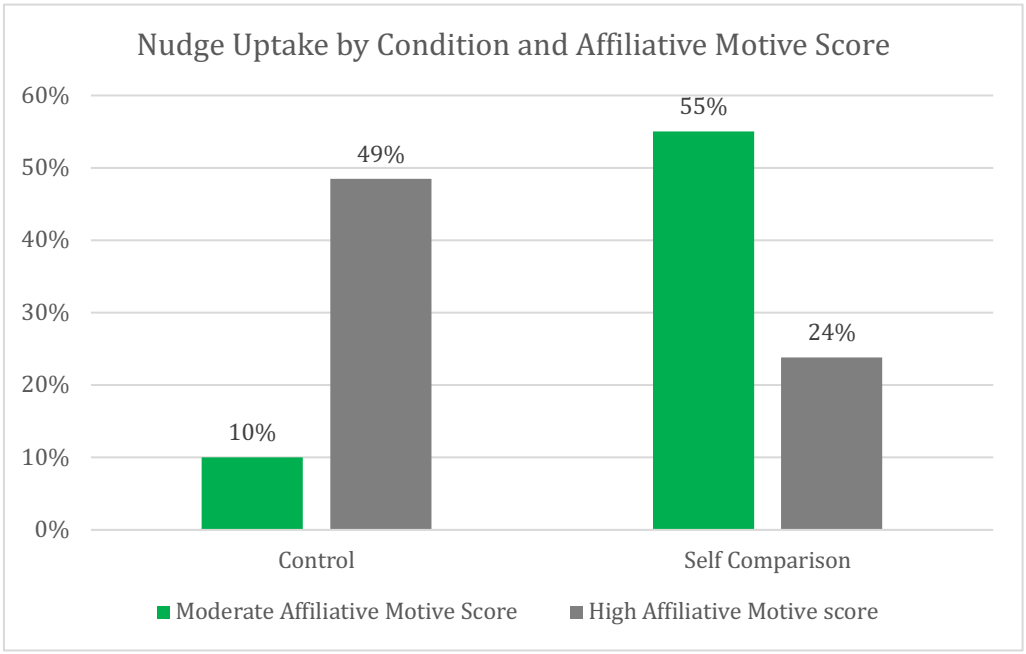


Figure 6: Self-Comparison Interaction Effect

Although the interaction proved to be statistically significant, we recognize that the overall sample size was quite limited (because of our organic choice, split study design) and that fewer than 30 participants had low to moderate affiliative motive scores; as

such, we are hesitant to confirm our hypothesis (H3), but instead accept there is a promising indicative trend to be validated in a follow-up study (see Table 4).

Table 4: Hypothesis 3 Results

Hypothesis	Result
H3: There will be an interaction between affiliative motive score and self-comparison experimental condition such that participants with low-to-moderate affiliative motive scores will be more likely to take up the healthy choice in the self-comparison condition than the control condition when compared to participants that have higher affiliative motive scores.	**Promising Trend**

General Discussion and Next Steps

The overall goal of this research was to understand if a novel social influence nudge—the out-group social comparison—could perform on-par with in-group or "people like you" comparisons that are more commonly used in digital contexts today, popularized by the likes of Amazon and Netflix (Gomez-Uribe & Hunt, 2015). We found that they did, which is promising, but constructing agreeable in-group and out-group comparisons could prove difficult in real-world settings, especially if we base them on innate customer characteristics. Such comparisons may also prove to be unethical or illegal. To counter this, we introduced Challenge Teams as way to organically empower people to engage in social challenges and opt-in to both in-group and out-group comparisons. We test our Challenge Team mechanism under minimalist conditions based on colour teams (i.e., Red Team, Blue Team). Our results seem to indicate that people are largely open to joining Challenge Teams, with an 86% opt-in rate observed amongst US participants

and a 76% opt-in rate observed amongst UK participants. Deciding to join a Challenge Team is positively correlated with one's desire to affiliate with others, which is generally quite high.

Previous research has outlined an ethical dilemma in healthy food choice nudging: nudges that people largely approve of, such as informational nudges that seek to influence what we know (i.e. descriptive and evaluative labelling), are not very effective while behavioural nudges that people largely disapprove of, such as manipulating package sizes, are most effective (Cadario & Chandon, 2019). Our research suggests that nudging using Challenge Teams could be an optimal way forward. The 86% approval rate observed in the US exceeds approval rates observed by any other food choice nudges while the 76% approval rate observed in the UK is in line with highly approved cognitive, informational nudges (Cadario & Chandon, 2019), suggesting combining health information with social comparisons is something that people are in fact interested in. The results from our studies seem to indicate that applying a combined nudge that merges health information and social comparisons could be highly effective, with intended calorie reduction rates that far exceed those observed in more traditional field studies that focused on product-level nudging (Cadario & Chandon, 2020). Our results support hypotheses from public health scholars that hybrid nudges that merge techniques could be the way forward (Ensaff, 2021; Roberto, 2020), particularly with a focus on targeted social comparisons (Shakya et al., 2015).

Our overall results indicate that both in-group and out-group social comparisons work extremely well in encouraging people to take up the calorie reduction nudge when

compared to the control condition while also controlling for body image happiness and dietary control behaviour rating, indicating that these factors are not influencing the observed effects. Our results show that both forms of social comparison nudging work remarkably well for those who rate low-to-moderate in dietary control behaviours and may otherwise be less willing to modify their food choices. That said, the power of social comparisons was felt across nearly all populations, which indicates they should be applied in targeted ways (Shakya et al., 2015) and with caution. We found that those who rate high in dietary control behaviours and may be prone to eating disorders will largely take advantage of any opportunity to reduce calories, whether that be the control nudge based on calorie information alone or the added social comparison nudge. Luckily, the dynamic nature of digital nudging may allow us to apply different kinds of nudges with different framings to help different subpopulations achieve different outcomes; we can even hide nudges all together in situations where it could prove undesirable or unhealthy.

While the central focus of our work was to understand whether out-group social comparisons could perform on par with more conventional in-group social comparisons, we recognize that not everyone will want to participate in social challenges. As such, we tested a goal-based self-comparison nudge on those who decided not to join a Challenge Team and investigated whether this type of nudge may be an effective alternative in encouraging healthier choices. We found that while self-comparisons do not work as well as social comparisons do amongst broad populations when compared to our control condition, they seem to work well amongst those who have a low-to-moderate desire to affiliate with others. The results of our sub-experiment on self-comparisons should be

taken with caution given low sample and cell sizes; a more robust follow-up study with a larger sample is needed. We have run this study and our results from this sub-experiment were replicated with a much larger sample size (N=750) and promising results.

All in all, participants exposed to social comparison nudges in our experiment indicated they largely wanted to reduce calories before checking out, and our future studies will put this to the test, recognizing that intended behaviour does not always match observed behaviour. Even so, we believe this research points the promise of intelligently using both in-group and out-group social comparisons in digital contexts to help nudge healthy choices amongst broad populations. While more work must be done to understand the boundary conditions that might limit the effectiveness of these seemingly powerful nudging mechanisms when applied in real-world contexts, we hope this research may inspire academics and practitioners alike to engage in additional related research to expand our concept of social influence nudging, particularly in digital health contexts.

Chapter 3: Further Exploration of Self-Comparison Nudging

Abstract

Scholars have called for public policy change and new behaviour interventions to help stem the rise of obesity we are witnessing around the globe. In this research we look to test two forms of self-comparison nudges—goal-based self-comparisons and past self-comparisons—as an alternative to previously tested social comparison nudges. We investigate whether adding self-comparisons to nutritional information nudges improves healthy choice outcomes related to calorie reduction.

Our results indicate that while self-comparisons nudges do not perform better than simpler informational nudges amongst broad populations, goal-based self-comparison nudges encourage more healthy choice outcomes amongst those who rate low-to-moderate in their desire to affiliate with others, when compared to other forms of self-comparison nudging and simple nutritional information only information aids. The pattern of results observed in this study, along with our previous study on the matter, seem to indicate that goal-based self-comparisons may be a viable alternative to social comparisons for some groups of people in nudging calorie reduction and other healthy choice outcomes.

We review our findings in more detail and discuss directions for future research.

Introduction

Worldwide obesity has nearly tripled since 1975 and continues to grow at an alarming rate even though obesity is preventable (World Health Organization, 2021, 2024). Longitudinal studies have shown that over a multi-year period only 3% of dieters will successfully achieve and maintain their desired weight, highlighting just how difficult sustained weight management is (Kramer et al., 1989). The recent COVID-19 pandemic has brought about problematic eating behaviours, such as engaging in emotional eating and the overconsumption of unhealthy comfort foods, that if sustained over time will only worsen the obesity epidemic (Asghar & Khalid, 2022; Salazar-Fernández et al., 2021). Scholars have argued that public policy must drive systemic change, but that new forms of behavioural interventions that go beyond education and awareness are also needed (Ensaff, 2021; Loewenstein & Chater, 2017; Roberto, 2020). The practice of nudging or making modifications to "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler & Sunstein, 2008, p. 6) has been studied extensively by scholars across fields in order to encourage healthier food choices and help stem the rise of obesity that might be caused by eating too much (Arno & Thomas, 2016; Cadario & Chandon, 2020; Lindstrom et al., 2022; Marcano-Olivier et al., 2020; Metcalfe et al., 2020). We agree work is needed at the policy level to influence meaningful change, but that individual behaviour change, if influenced at scale, could also meaningfully contribute to a shift on the obesity epidemic we face today (World Health Organization, 2021, 2024).

Our work focuses on nudging individual behaviour change and builds upon our previous work that investigated the effectiveness of using in-group and out-group social comparisons to encourage calorie reduction in appropriate contexts. The overarching results of that body of work, some of which has been previously published (DiCosola & Neff, 2020, 2022) and some of which is still forthcoming, suggest that social comparison nudges are effective in encouraging healthier choices across broad populations, including those who rate low in dietary control behaviours (Bruner, 2017; Liu et al., 2015). Moreover, they suggest that the inclination to engage in social comparisons is positively correlated with one's desire to affiliate with others. As such, we want to understand what nudging alternatives may exist for those who rate low-to-moderate in their desire to affiliate with others and may be less likely or willing to join social challenges that invite social comparisons (Taylor & Lobel, 1989).

A recent scoping review has suggested that behaviour change techniques applied in digital health interventions that seek to improve eating behaviours mostly rely on one of five techniques: (1) goals and planning, (2) shaping knowledge, (3) natural consequences, (4) feedback and monitoring and (5) comparison of behaviour (Ronteltap et al., 2022). Scholars have indicated that nudging mechanisms applied to date have had minimal impact and that future research should combine nudging or behaviour change techniques for further reach and impact (Ensaff, 2021; Roberto, 2020; Ronteltap et al., 2022). Within this paper we will look to investigate two forms of self-comparison nudges. The first form of self-comparison nudge would invoke the concept of a future state ideal self and look to alert people when their current food behaviours may prevent them achieving their future state goal to encourage positive behaviour change (Oettingen, 2012). This form of nudge would combine multiple techniques related to

goals, consequences, feedback and monitoring, and comparison. It is our central focus. In addition to this, we will look to study a secondary self-comparison nudge based on the past self. Such comparisons would essentially provide a more automated form of nutritional self-tracking, alerting people when their current behaviour is different from some of their healthier past behaviours to encourage positive behaviour change. This technique builds off current practices in human-computer interaction that seek to facilitate positive health change through more effortless assistive tracking technologies (Y.H. Kim et al., 2017; Lu et al., 2021). This form of nudge would combine fewer techniques but still rely on consequence, feedback and monitoring, and comparison.

Related Work

To better ground our study on using self-comparisons nudge healthier choices, we will review pertinent literature related to goal-directed behaviour, self-monitoring, and designing for sustained behaviour change, all with a focus on food-related behaviours.

Goal-Directed Behaviour

Nearly all our purposive behaviours are driven by goals (Bagozzi & Dholakia, 1999; Baumgartner et al., 2008; Heckhausen & Gollwitzer, 1987), making goal setting and goal pursuit progress common focal points in behaviour change techniques, particularly in dietary change (Ronteltap et al., 2022). Reaching our goals does not happen automatically; it is quite an evolved process that involves multiple steps, deliberate effort, and reflection (Bagozzi & Dholakia, 1999; Zhang et al., 2021). Achieving our goals requires us to set a goal, establish goal intentions, develop a plan for achieving

that goal, and to begin to action against our goal plan by exhibiting goal-consistent behaviours; we either reach our goal or fail to get there as intended, reflect on how that makes us feel and then formulate an appropriate personalised response (Bagozzi & Dholakia, 1999). While this may seem like a relatively simple process, we have multiple higher order goals that require our attention and may often conflict with one another, such as saving money (Shefrin & Thaler, 1988) and eating healthy, nutritious foods (Bagozzi & Edwards, 2000). Achieving weight loss has been a perplexing focal point for consumer psychologists as multiple studies have shown that having strong weight loss intentions does not significantly predict actual weight loss (Netemeyer et al., 1991; Schifter & Ajzen, 1985). To address this shortcoming, Bagozzi & Edwards (1998) advanced a framework for goal-driven weight management based on self-regulation (Bagozzi, 1992; Baumeister et al., 1998; Carver & Scheier, 2001) and models of action phases (Gollwitzer, 1990; Gollwitzer & Bargh, 1996; Heckhausen & Gollwitzer, 1987) and found that weight goal success is largely determined by how well we initiate and sustain actions that relate to our goal intentions, namely dieting and exercise (see Fig. 1).

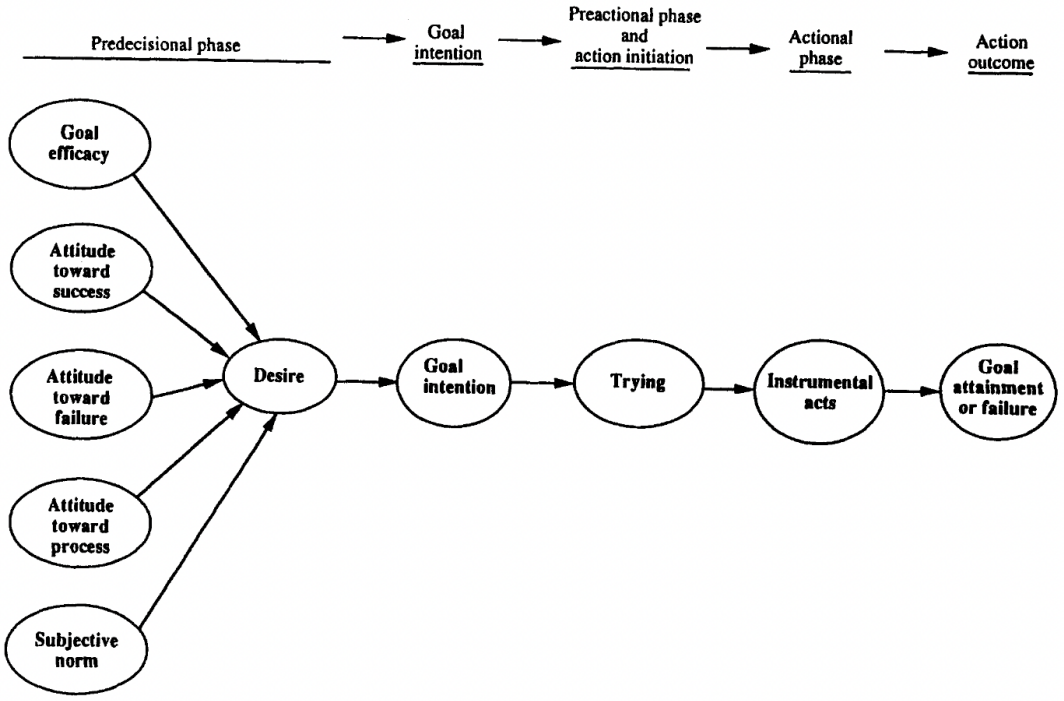


Figure 1: Framework for Self-Regulation of Body Weight (Bagozzi & Edwards, 1998)

There are many reasons people may go off track, including lack of proper standards and lack of sufficient monitoring (Baumeister & Heatherton, 1996). Multiple studies have shown that resisting vices and temptations is cognitively taxing (Baumeister et al., 1998; Muraven & Baumeister, 2000), particularly when it comes to food choice (Vohs et al., 2008). Vohs & Heatherton (2000) conducted an experiment that had dieters and non-dieters watch a video while sitting close to or far from a bowl of chocolate candies that were either free for taking or restricted. The researchers predicted that dieters that had to watch the video near the bowl of candies that were free for taking would experience the greatest amount of temptation which in turn would cause significant depletion of internal self-regulatory resources and cause subsequent self-control failure in food choice. This is exactly what the researchers found when they asked participants to complete an ice cream taste testing exercise following the video; dieters that sat

closest to the candies available to be eaten lacked self-control and ate the most ice cream. Non-dieters' ice cream consumption was not impacted by proximity of the candies or their availability, highlighting the uphill battle that dieters face when trying to exhibit healthy eating practices as compared to non-dieters. While overeating and engaging in indulgent food choices can thus be attributed to our inability to exert self-control, Muraven & Slessareva (2003) have found that motivation can counteract our depleted cognitive and internal strength resources and allow us to re-exert self-control to achieve desired outcomes. Recognizing that we can often justify our indulgent food choices (Tezer & Sobol, 2021) and that we have a tendency to value the hedonic pleasures of food over more utilitarian eating (Dhar & Wertenbroch, 2000; Kar, 2022; Lowe & Butryn, 2007; Stroebe, 2022), finding motivation to eat healthily and stay on track in situ becomes necessary to turn around the problematic eating trends that have emerged as of late. Luckily real time nudges that combine multiple behaviour change techniques are well-positioned to provide this motivation by making health goals salient, providing a clear standard for desired behaviour, and taking the work out of regular, manual self-monitoring.

Self-Monitoring & Electronic Health

While obesity has now become a global epidemic (World Health Organization, 2021, 2024), the issue of sustained healthy weight management is hardly new. Burke et al. (2011) conducted a systematic review of literature published between 1993 and 2009 that focused on diet, exercise, or self-weighing as key self-monitoring techniques used to support weight loss. They found that there was a consistent link between regular self-monitoring and weight loss across the body of studies, most of which focused on dietary self-monitoring. Not surprisingly, self-monitoring has become central to modern

behavioural weight loss interventions and efforts, with the positive links self-monitoring and weight loss replicated by a more recent systematic review that focused solely on digital self-monitoring for weight loss (Patel et al., 2021).

These findings seem to suggest digitally aided self-monitoring may be the key to sustained healthy weight management moving forward, particularly as our daily lives become more intertwined with the internet of things (Greengard, 2021; Novak & Hoffman, 2019). The Quantified Self movement surfaced our inherent desire to learn about ourselves through our own self-generated data, made increasingly accessible to the masses through the popularization of connected wearable devices and smart apps (Lupton, 2016; Nafus & Sherman, 2014; Neff & Nafus, 2016). Digital self-tracking tools focused on health and well-being that emerged over the past decade (Neff & Nafus, 2016) hit the mainstream during the COVID-19 pandemic (Tong et al., 2022; Zhang et al., 2021). Studies have shown that individuals who leaned into digital or electronic health (eHealth) technologies like apps, digital communities, and connected devices during the pandemic experienced significantly better health outcomes than those who did not (Marchant et al., 2021; Mutz et al., 2021). New advancements in wearable nutrition technologies are starting to emerge that may make nutritional self-monitoring much less effortful and relatively automatic (Shi et al., 2022; Zhao et al., 2021). While all these developments are quite positive, we also know that digital self-tracking is characterised by episodic usage rather than consistent, sustained usage (Gorm & Shklovski, 2019). All evidence combined, eHealth technology and digital self-monitoring tools are well-positioned to tackle the two root causes of obesity—moving too little and eating too much—if only we can find a way to motivated sustained engagement in such practices.

Designing for Sustained Behaviour Change

Perhaps the best way to make a positive behaviour sustained is to make it a habit, particularly in health contexts (Verplanken & Wood, 2006; Wood & Rünger, 2016). Charness & Gneezy (2009) wanted to see if they could invoke a habit to exercise regularly amongst irregular gym-goers to spur positive health outcomes. They conducted an experiment where people were incentivized to go to the gym regularly, one time, or not at all during a one-month period. They found that those incentivized to go more often continued to go to the gym at a higher rate once the one-month incentivized period was over and showed improvements on key health indicators such as weight, waist size, and pulse rate over time; these results indicate that incentivized regular behaviour created a lasting habit that induced positive, lasting health change. Verplanken & Orbell (2022) argue that behaviour change has historically been too focused on shifting attitudes but should instead focus on changing habits. Volpp & Loewenstein (2020), recognizing the link between habit formation and sustained behaviours, document eight additional habit related mechanisms that should all be considered when designing new interventions for sustained behaviour change: (1) learning-by-doing, (2) acquiring new beneficial information, (3) inertia or desire to keep a new routine, (4) discovering new preferences, (5) technology or acquiring new goods or expertise that make desired behaviour more accessible (6) commitment devices (7) social influences and (8) changes to choice environments. To make more sense of these mechanisms we can apply them to the exercise habit induced by Charness & Gneezy (2009). While the incentivized gym-going may have created a habit over the one-month period, these regular gym-goers may have also learned new exercises, such as how to use a kettle bell, and mastered this with increased practice and repetition. Over time,

they may find that their gym routine with kettle bells puts them in a state of flow, a state of supreme enjoyment where one feels sufficiently challenged and fully engaged while being able to demonstrate success (Csikszentmihalyi, 1991), which helps to create the sustained behaviour. Beyond this, the gym goers may have lacked some pieces of information before that made regular gym attendance less feasible or desirable. For example, imagine after going to the gym after several times the gym goers gain information about extended gym hours and a free fitness monitoring offering they did not know about before; this could motivate them to keep going to the gym in the future. Once the habit and routine are established, finding a new routine may feel difficult, causing them to stick to this new fitness-focused regimen given an inherent bias towards the status quo. While going to the gym, the gym goers may have experienced new activities or elements of the gym that they unexpectedly liked, such as certain group fitness classes, shifting their tastes, and encouraging sustained gym attendance to cater to this new preference. As part of their new gym routine, some individuals may have purchased new items, like new gym shoes or fit-for-purpose fitness apparel, or additional services, like personal training sessions, that enhanced their experience or expertise and provides additional motivation to continue their gym activities, now more accessible than before. Some gym goers may have decided to complete a contract, either with themselves or with the gym itself, which establishes a longer-term commitment. During their gym visits, gym goers may have regularly seen the same people working out, establishing a social proof or norm for a more regular gym cadence that encourages them to maintain it due to social pressures. Finally, after more regular attendance the gym goers may have noticed elements of the choice environment that suits their lifestyle and goals, such as having access to healthy ready-made meals and protein shakes within the gym itself, triggering sustained gym going behaviour. When put into context, it is

easy to see how these mechanisms can work alongside classic habit formation to create sustained behaviours.

The last mechanism discussed by Volpp & Loewenstein (2020), making changes to choice environments, conceptually mirrors the ambitions of nudging. Scholars have asked for future nudging research to focus on interventions that combine multiple nudging or behaviour change techniques (Ensaff, 2021; Roberto, 2020; Ronteltap et al., 2022). As such, future interventions could combine elements from Cadario and Chandon's (2020) framework for food choice nudging with commonly used behaviour change techniques (BCTs) in digital or electronic health (Ronteltap et al., 2022) and Volpp & Loewenstein's (2020) mechanisms for sustained behaviours (see Table 1).

Our primary goal-based self-comparison nudge brings together evaluative nutrition information and a healthy eating call to action from Cadario & Chandon's (2020) framework paired with goal setting, natural consequences, feedback and monitoring, and comparison of behaviour techniques from eHealth (Ronteltap et al., 2022). This form of nudge leverages a goal commitment device and supports new information acquisition while changing the choice environment itself (Volpp & Loewenstein, 2020).

Our secondary self-comparison nudge based on past behaviours also brings together evaluative nutrition information and a healthy eating call to action from Cadario & Chandon's (2020) framework. However, it only leverages natural consequences, feedback and monitoring, and comparison of behaviour techniques from eHealth; it does not explicitly tap into goal setting or actioning (Ronteltap et al., 2022). As a result, it doesn't leverage any sort of goal commitment device like our goal-based self-

comparison, but it does still support new information acquisition while modifying the digital choice environment (Volpp & Loewenstein, 2020).

Table 1: Techniques and Mechanisms for Nudging Behaviour Change

Food Choice Nudging (Cadario & Chandon, 2020)	**BCTs for eHealth (Ronteltap et al., 2022)**	**Habit Mechanisms (Volpp & Loewenstein, 2020)**
1. Cognitive Nudges a. Descriptive Nutrition Labelling b. Evaluative Nutrition Labelling c. Visibility Enhancements 2. Affective Nudges a. Healthy Eating Calls b. Pleasure Enhancements 3. Behavioural Nudges a. Convenience Enhancements b. Size Enhancements	1. Goals and Planning 2. Shaping Knowledge 3. Natural Consequences 4. Feedback & Monitoring 5. Comparison of Behaviour	1. Learning 2. Information Acquisition 3. Status Quo Bias 4. Taste Discovery 5. Technology 6. Commitment Devices 7. Social Influences 8. Concomitant Changes to Choice Environments

When designing and implementing such combined nudges, we can leverage Fogg's (2009) Behavioural Model (FBM) for persuasive design to help promote nudge uptake. In doing so, we can create nudge environments that help ensure (1) people are sufficiently motivated, (2) they will be able to perform the behaviour and (3) are triggered to perform the behaviour at an optimal time.

Study: Goal-Based and Past Self-Comparison Nudging

Study Overview

The overall purpose of this study is to understand if self-comparison nudges can encourage healthier and more socially responsible choices in digitally mediated choice environments, such as an online grocery shopping sites, particularly for those who have

a lower-than-average desire to affiliate with others and may thus be opposed to social comparisons. We are primarily interested in testing goal-based self-comparisons that would rely on a user's self-set health and nutrition goal to alert them when they are going off-track, helping them to avert goal failure. That said, we will also look to test past self-comparisons in this study, which would essentially alert users when their current behaviours are dangerously different from some of their healthier and more consistent past behaviours for a similarly sized grocery shopping trip. We decided to broaden the scope of our study to include past-focused self-comparisons based on the promise of nutritional self-monitoring (Burke et al., 2011, Patel et al., 2021), though recognise that past peformance may not be meaingful, particularly amongst those who are currently unhappy with their body image or eating habits. We were further motivated after consulting with our industry partner, a leading online grocery retailer in the United Kingdom, as they expressed an interest in such an intervention as it would be relatively easy to implement, given they largely have this sort of historical shopping data. Although we do not believe this form of self-comparison nudge will perform exceedingly well, we also want to investigate it given that a more automated form of self-tracking of calories could be very meaningful for some users and mirrors trends we are seeing coming out of the human-computer interaction community (Y.H. Kim et al., 2017; Lu et al., 2021). Beyond this, we also want to use this study to gain clarity on whether adding outcome-oriented statements related to potential weight gain, a natural consequence of excess calories (Ronteltap et al., 2022), rather than calorie information alone, is beneficial in nudge design by encouraging more healthy choice outcomes in contexts where basket calories are exceedingly high. We expect that it would, but when we tested this in a previous study (DiCosola & Neff, 2022), we got unexpected results. We believe that weight gain outcome statement effectiveness is likely correlated with higher unit outputs (e.g., a warning that tells you that you are at-risk for gaining 4kg of

weight gain would be more effective than a warning telling you that you are at risk for gaining .45kg of weight gain). In other words, we believe a single- or double-digit figure of weight gain rather than a fractional unit of weight gain will prove more meaningful, so we will test that in this larger scale study.

Thus, we approach this study with three very focused objectives:

First, we want to understand if adding outcome-oriented, natural consequence information related to potential weight gain rather than calorie information alone would nudge people towards the healthy choice, given unexpected results from previous experiments.

Second, and most importantly, we want to understand if goal-based self-comparisons effectively nudge individuals who have a low-to-moderate desire to affiliate with others towards the healthy choice. This would replicate our results from a previous experiment and suggest that goal-based self-comparison nudging could be an alternative to more robust social comparison nudges for this subpopulation, given that desire to joining to social challenges was shown to be positively correlated with affiliation motive scores.

Third, we want to understand if past self-comparisons could be meaningful in encouraging healthier choices among the same target population. Although we do not anticipate this form of self-comparison will prove as effective as goal-based comparisons and would not be as useful in real-world settings in curbing problematic

behaviours leading to and sustaining obesity, it is still worth investigating as it could prove useful for some contexts.

Study Design

In this study, 750 adults in the United Kingdom and United States were recruited to participate in this additional study on self-comparisons on Prolific.co for a 1 GBP or local equivalent incentive. Participants completed a short introductory survey with demographics and questions related to health, nutrition, and fitness and then completed the Dietary Control Behaviour (DCB) scale (Bruner, 2017; Liu et al., 2015) and Communal and Agentic Motives with Standards (CAMS) scale (Cannon & Rucker, 2020) questionnaires. Participants were asked to imagine they were buying groceries from their preferred online grocery store, where they had previously setup a profile and indicated their health and nutrition goals, including whether they might like to gain or lose weight in the future. Participants were told they were purchasing one week's worth of groceries for themselves only and were about to complete the checkout process.

At this point in the study, participants were randomly assigned to one of four experimental conditions by Qualtrics:

- **Baseline:** a no comparison, nutrition information only condition that told them they were projected to consumer 3,500 extra calories this week.
- **Control:** a no comparison condition that used the baseline stimuli that added a natural consequence statement that indicated that the 3,500 extra calories could result in 0.45kg or 1lb of weight gain.

- **Past Self:** a self-comparison condition that used the control stimuli but added a "How Does This Compare?" statement that indicated they normally have 1,000 extra calories for a weekly shop and that this basket has 2,500 calories over that amount.
- **Goal-Based:** a self-comparison condition that used the control stimuli but added a "How Does This Compare?" statement that indicated their current goal allows for 1,000 extra calories for a weekly shop and that this basket has 2,500 calories over that target goal amount.

It is worth nothing that we constructed the baseline and control condition in this study to resolve an anomaly that we observed in a previous study where the baseline condition performed better than the more informative, outcome-oriented control condition, which was unexpected. The control condition stimuli in this study included a conversation of 0.45kg to 1lb which we anticipate may eliminate the baseline effect; participants in the previous study may have scanned the screen and saw a fractional figure (0.45kg) in the control stimuli which caused them to interpret the weight gain as insignificant, whereas now the single digit conversion (1lb) may prove more significant and meaningful. That said, it could be that 0.45kg or 1lb of weight gain is still not perceived to be drastic enough to encourage taking up the nudge. The design of the stimuli used in this study was consistent with stimuli used in Chapter 2 and followed the same design and review process.

All participants, regardless of condition, were asked to make a discrete choice: they could either elect to keep calories as-is and checkout (unhealthy choice) or reduce calories and checkout (healthy choice). This discrete, binary choice represents the

dependent variable that will be measured and compared across all experimental conditions. Participants also completed a manipulation check to ensure they processed the comparison statements that varied across experimental conditions accurately. After completing this final step, all participants were shown a closing page that debriefed them and revealed more details about the study; participants were given code to give to Prolific to confirm study completion and initiate payment for participating in the study.

Study Hypotheses

We have three hypotheses directly linked to our three core objectives of the study:

> **H1:** There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the control condition (caloric surplus + weight gain implication) as compared to the baseline (caloric surplus only) condition.

> **H2:** There will be an interaction between affiliative motive score and the goal-based self-comparison experimental condition such that participants with low-to-moderate affiliative motive scores will be more likely to take up the healthy choice in the goal-based self-comparison condition than the control condition when compared to participants that have higher affiliative motive scores.

> **H3:** The past self-comparison condition will perform on par with the control condition and thus prove inferior to the goal-based self-comparison condition for those who have a low-to-moderate desire to affiliate with others.

Study Results

All 750 participants gave their consent and successfully completed the study. That said, a significant number of participants failed the manipulation checks, yielding 451 valid participants in our final data set. While we were a bit surprised by the large number of failed manipulation checks, this is a likely due to the fact the stimuli in this experiment contained a lot of information and were relatively complex and the participant incentive was still relatively low at 1 GBP; the average time to complete the study was just under 5 minutes, though participants were asked to take 6-8 minutes to complete the study, indicating a large number of participants did rush through the study to some degree.

To answer our first question and assess whether there were significant differences between the experimental conditions, with a key focus on differences between the baseline condition and control condition, we built a statistical model using experimental condition as our key independent variable and our discrete choice (keep calories as-is and checkout, reduce calories and checkout) as the key dependent measure, while also controlling for dietary control behaviour and body image happiness.

The overall model was highly significant, X^2 (6, n = 448) = 100.26, p < .0001. Unfortunately, the main effect of experimental condition was not significant (p=.8609), indicating that healthy choice outcomes did not statistically differ across the four experimental conditions (see Fig. 2). We cannot confirm our first hypothesis (See Table 2).

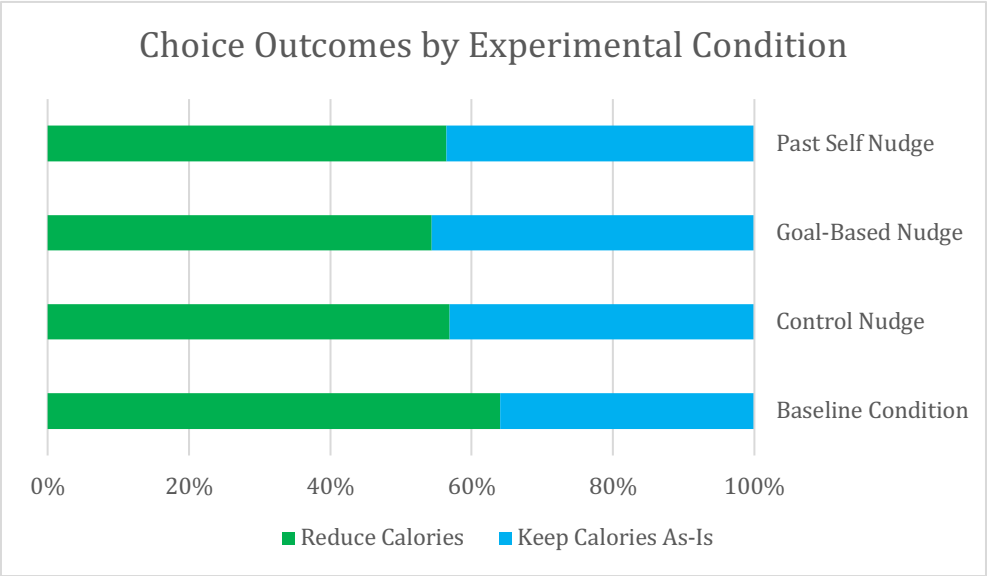


Figure 2: Comparison of Choice Outcomes Across Experimental Conditions

Table 2: Hypothesis 1 Results

Hypothesis	Result
H1: There will be an overall main effect of experimental condition on choice outcomes such that increased healthy choice will occur in the control condition (caloric surplus + weight gain implication) as compared to the baseline (caloric surplus only) condition.	Not Confirmed

We built a refined statistical model to assess the interaction of the self-comparison condition (control versus past self-comparison versus ideal self-comparison) and participants affiliative motive score had on healthy choice outcomes, while still controlling for dietary control rating and body image happiness, recognising that these factors will strongly predict whether one is likely to reduce calories or not.

A nominal logistic analysis was run and indicated that the overall model was highly significant, X^2 (8, n = 361) = 87.37, p < .0001 (see Table 3). The coefficient of determination (R^2) value of this model was .1761 (17.61%), indicating we have

identified a large effect in our experiment (Cohen, 2013). It is worth noting that although our complete data set yielded 451 valid results, this model has a smaller sample (N=361) because the baseline condition was omitted as it is not directly comparable to the self-comparison nudge conditions which include the consequence statement added to the control condition.

Table 3: Self-Comparison Statistical Model Results

Chi Square Value	X^2 (8, n = 361) = 87.37374
p-Value	p < .0001
R Square Value	R^2 = .1761 (17.61%)

The main effect of experimental condition was not significant (as expected), but all other variables included proved to be significant, including the critical interaction effect.

There was a highly significant main effect of dietary control behaviour rating on healthy choice outcomes ($p < .0001$), such that those with higher average dietary control behaviour score ratings were more likely to make the healthy choice, which is what we would expect.

There was a highly significant main effect of affiliative motive score on healthy choice outcomes ($p < .0001$), such that those with higher average affiliative motive scores were more likely to make the healthy choice. This replicates our previous findings and is not too surprising given those who have a higher desire to align with other people are also more likely to demonstrate socially desirable choices (Fisher & Katz, 2000).

There was a significant main effect body image happiness on healthy choice outcomes (p = .0162), such that those who indicated they were unhappy with their body image or unsure of how they felt were more likely to make the healthy choice, whereas those who indicated they were happy with their body image were more likely to keep calories as-is. These results are expected and not surprising, but give help give confidence that the data set is robust and sufficiently representative, even though our final sample size was smaller than anticipated.

The core focus of this experiment was to gain confidence in our hypothesis that self-comparisons, specifically ideal self, or goal-based self-comparisons, would serve as a useful nudging mechanism for those who rate low-to-moderate in their desire to affiliate with others when compared to the control nudge condition based on nutrition information alone. There was a significant interaction effect between experimental condition and affiliative motive score on healthy choice outcomes, X^2 (2, n = 361) = 7, p = .0302. Our data show that goal-based self-comparison nudges work particularly well for those who rate as low-to-moderate in their desire to affiliate with others as compared to both the control nudge condition and the alternative past self-comparison nudge condition (see Fig. 3). The contrast across conditions disappears as we look at groups of individuals who rate higher in their desire to affiliate with others, where social comparison information will be more valuable. A likelihood-ratio Chi-square pair test reveals the difference between the control nudge condition and goal-based nudge condition in encouraging healthy choice outcomes amongst those with a low-to-moderate desire to affiliate with others approach statistical significance (p = .0653) but the individual cell sizes for this lower-level analysis are below minimum desired thresholds (Wilson VanVoorhis & Morgan, 2007). Interpretation must be taken with caution; we note a promising trend despite the significant overall interaction effect.

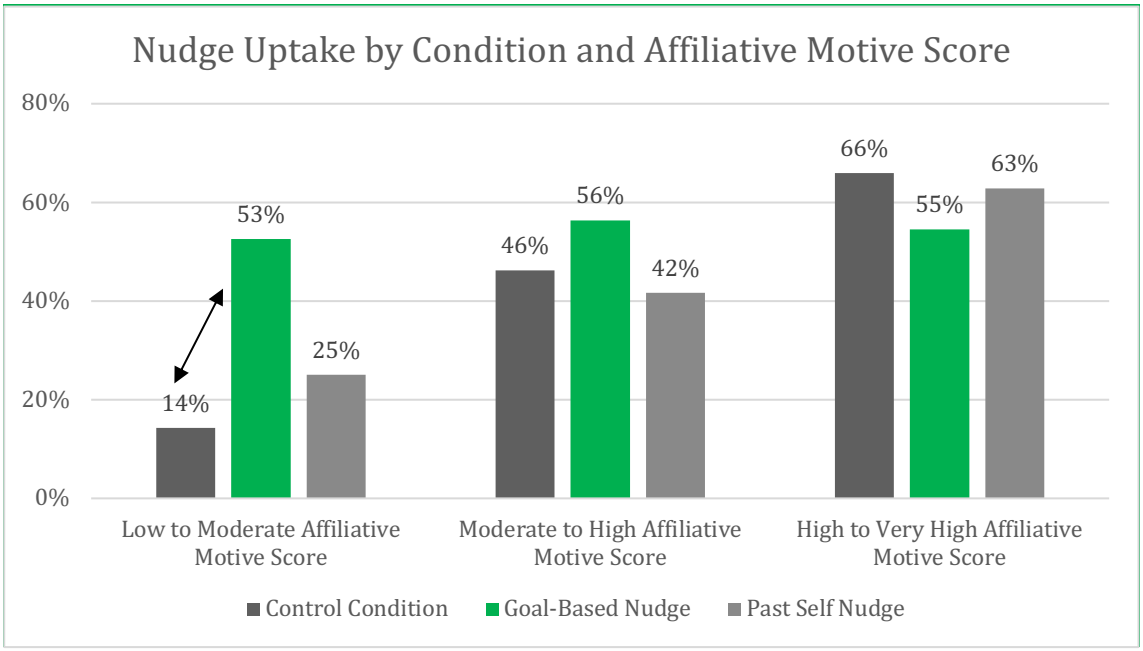


Figure 3: Self-Comparison Interaction Effect

Table 4: Hypothesis 2 Results

Hypothesis	Result
H2: There will be an interaction between affiliative motive score and the goal-based self-comparison experimental condition such that participants with low-to-moderate affiliative motive scores will be more likely to take up the healthy choice in the goal-based self-comparison condition than the control condition when compared to participants that have higher affiliative motive scores.	**Promising Trend**

Our third and final question related to whether past self-comparisons perform in line with the control condition for those who rate low-to-moderate in their desire to affiliate with others. Our results show that 14% of such participants elect to reduce calories in the control nudge condition compared to 25% in the past-self comparison nudge condition and 53% in the goal-based self-comparison nudge condition. A likelihood-ratio Chi-square pair test reveals there is no meaningful difference between control nudge outcomes and past-self nudge outcomes on healthy choice outcomes amongst

those with low-to-moderate affiliative motive scores (p = .5721). While we would ordinarily confirm our hypothesis, cell sizes are below minimum desired thresholds (Wilson VanVoorhis & Morgan, 2007), so we note a promising trend instead.

Table 9: Hypothesis 3 Results

Hypothesis	Result
H3: The past self-comparison condition will perform on par with the control condition and thus prove inferior to the goal-based self-comparison condition for those who have a low-to-moderate desire to affiliate with others.	**Promising Trend**

General Discussion and Next Steps

Our previous efforts on developing novel nudging techniques to influence healthy choice outcomes have been primarily focused on using social comparisons, given the body of work that suggests such comparisons can be meaningful for behaviour change (Caraban et al., 2019; Volpp & Loewenstein, 2020), specifically when targeting obesity (Shakya et al., 2015). While the results from our studies on social comparisons are quite promising, we wanted to focus this study on finding an alternative nudging mechanism that could work for those who do not wish to take part in social comparisons. Given the strong correlation between one's desire to affiliate with others and one's desire to participate in social challenges highlighted in our previous work, we specifically tried to test multiple forms of self-comparisons amongst those who have a low-to-moderate desire to affiliate with others in this study, hoping to find a viable nudging alternative for this target subpopulation. What that overall goal in mind, we approached this study with three focused objectives.

Our first objective was to resolve an unexpected result from our previous study (DiCosola & Neff, 2022), outlined in the first chapter of this integrated thesis, which showed that a baseline nudge condition with nutritional information alone (i.e., 3,500 extra calories) fared much better than the control nudge condition which included the same exact information in the same format but added a weight gain statement, reminding users of the consequence of excess calories, which is a known behaviour change technique that has been successfully used in other kinds of eHealth interventions (Ronteltap et al., 2022). Our previous work only included a fractional figure of weight gain (i.e., 0.45kg) in this implication statement. In this experiment, we included an additional conversion to pounds that would surface a single digit (i.e., 1lb) which we thought would prove more meaningful than the fractional figure and allow the control condition to prove superior to the baseline condition. Our results showed the baseline condition and control condition performed similarly with no meaningful statistical difference between the two in encouraging healthy choice outcomes. When these results are compared to our previous results, this would seem to suggest that weight gain statements with larger single- or double-digit figures are more meaningful than those with fractional figures in encouraging healthy choice outcomes, as in previous studies the baseline condition without weight gain statement performed significantly better than the control condition with a fractional weight gain statement (i.e. 0.45kg of weight gain). Even so, presenting excess calorie information alone seems to be quite motivating without a stated consequence, at least in these use cases where the number presented was quite large (i.e., 3500 extra calories). That said, we anticipate that when working with nutritional nudges that focus on displaying calorie information, with or without implication or consequence statements, results will vary depending on the specific

figures used, and should be approached with caution unless heavily tested. A more visual approach to information visualisation may very well be preferable (Tufte, 1985, 2001; Tufte et al., 1998), given literature suggests people have hard time understanding calories and have varied preferences on how calorie information is best displayed (Bleich & Pollack, 2010; Miller et al., 2015).

Our second and most critical goal was to see if goal-based self-comparison nudges performed better than our control nudge in encouraging healthy choice outcomes amongst those who rate low-to-moderate in their desire to affiliate with others. Such findings would suggest that goal-based nudges could be a potential alternative to the powerful and more broadly applicable social comparison nudges tested in Chapters 1 and 2. Our goal-based nudge invokes a comparison to one's ideal-self goal, as it pertains to nutrition and weight management, and relies on combining several nudging and behaviour change techniques and mechanisms: evaluative nutrition information and a healthy eating call to action (Cadario & Chandon, 2020); goal setting, natural consequences, feedback and monitoring, and comparison of behaviour (Ronteltap et al., 2022); and goal commitment and new information (Volpp & Loewenstein, 2020). This approach is in response to calls from academics for more nudging studies that combine multiple nudging and behaviour change techniques to yield more impactful outcomes (Ensaff, 2021; Loewenstein & Chater, 2017; Roberto, 2020). Our results showed that only 14% of participants with low-to-moderate affiliation scores elect the healthy choice in the control condition, but 53% of them elect the healthy choice when exposed to a goal-based self-comparison nudge, which is quite an impressive contrast. These findings largely mirror the key pattern of results observed in our previous experiment outlined in Chapter 2, albeit with a larger overall sample. While our experiment

revealed a statistically significant interaction effect between affiliative motive score and the three experimental conditions (p = .0302), our lower-level pair test between the control nudge condition and goal-based nudge condition amongst those who rate low-to-moderate in their desire to affiliate only approached significance (p = .0653). The overall results are indeed promising, but very few people in our study had a low-to-moderate desire to affiliate; only 48 participants in our cleansed data set fit within this affiliation category. As a result, the lower-level analysis comparing how this specific set participants performed by experimental condition yielded smaller than desired cell sizes, which proves problematic when interpreting statistical results (VanVoorhis & Morgan, 2007). We noted a promising trend given the strong pattern of results observed over multiple studies. Future studies may seek to focus on recruiting participants with low-to-moderate affiliation scores and even more robust sample sizes to help validate the efficacy of goal-based self-comparisons for this important subpopulation.

Our third and final goal was to see if self-comparison nudging based on comparisons to one's past behaviours was meaningful for our target subpopulation in encouraging healthy choice outcomes. This form of nudge was investigated as it would leverage historic grocery shopping data and allow for a more effortless form of digital self-monitoring, which has been shown to be useful in dietary control contexts (Patel et al., 2021; Ronteltap et al., 2022). We designed this nudge to also combine multiple nudging techniques and behaviour change mechanisms, though it naturally does not tap into as many as our goal-based nudge. As a result, we expected this form of self-comparison nudge to perform on par with control condition and thus prove inferior to the goal-based nudge condition based on our previous hypothesis. Our pattern of results largely matched this prediction. 25% of participants with low-to-moderate affiliation scores

elected the healthy choice when exposed to a past-self comparison nudge, whereas 14% do so when presented with a control nudge. A pair test revelated there was no meaningful difference between these two conditions in encouraging healthy choice outcomes ($p = .5721$), but again our results are impacted by small cell sizes due the fact that most individuals tend to rate high to very high in their desire to affiliate with others. The results would be best validated in a follow-up study with a sample more narrowly focused on our target subpopulation.

Beyond these three core objectives, we also felt this study, when taken in context with our other work presented earlier in this thesis, would help provide a sense of direction for future food choice nudging research based on expected impact. Our results in this study showed that neither form of self-comparison nudge performed significantly better than nutritional information nudges across broad populations. This is in contrast with results from our other studies across Chapters 1 and 2, which showed that social comparison nudges do perform significantly better than nutritional information nudges, both for broad populations and those who rate low in dietary control behaviours and may typically be less willing to modify their dietary choices. We believe our collective studies show that social comparisons hold the most promise for nudging healthy choice outcomes at scale and amongst populations that may typically be the most difficult to reach. That said, we also think that social comparisons will not be agreeable to all people; self-comparisons do hold promise for nudging select subpopulations, particularly those who rate low-to-moderate in their desire to affiliate with others. Our results show that goal-based self-comparisons perform very well amongst this target subpopulation, which warrants further exploration. Future studies should look to expand study populations beyond one or two country locations, with a focus on diverse

countries that have an obesity crisis in common. While these online lab experiments follow traditions from psychology and social psychology (Augustine, 2017), future work might test these nudges in real-world field settings to measure actual choice rather than intended choice, an approach commonly used by marketing and behavioural economics communities (Holden et al., 2021).

General Discussion

The Rise of Obesity and Behavioural Interventions

The overarching goal of my thesis research was to uncover novel approaches to nudging healthier or more socially responsible decision making in online or digitally mediated contexts. Nudging research has been applied across domains to help improve people's lives in a variety of ways ranging from improving personal health and finance to encouraging environmental awareness and increased pro-social behaviour (Mertens et al., 2022; Szaszi et al., 2018). While the nudging mechanisms tested across the body of my research would likely be useful in any of these contexts, I have taken a focused approach and applied my nudges in food choice contexts to help curb or reduce obesity for a variety of reasons. First, the nature of the obesity epidemic is global in reach and growing with no signs of dissipating unless new measures are taken (Ensaff, 2021; Marques et al., 2020; Marteau, 2018; Roberto, 2020); the scale of the epidemic will cause serious illness and death while also straining public health systems and costing trillions of dollars to governments each and every year until corrected (Boseley, 2017; Matthews-King, 2019; World Health Organization, 2021, 2024). Second, there is a strong body of evidence to support that nudging works particularly well in food choice contexts (Arno & Thomas, 2016; Cadario & Chandon, 2020), with food choice architecture interventions being up to 2.5x more effective than similar nudges applied in other settings (Mertens et al., 2022). Finally, my doctoral studies were supported by Tesco, a leading British multinational grocery retailer, through an assistantship that was launched in partnership with the Oxford Internet Institute to research the future of online consumption.

While scholars have argued that the obesity epidemic requires both new policy measures and behavioural interventions to impact meaningful change (T.P. Gill & Boylan, 2012; Loewenstein & Chater, 2017; Marteau, 2018; Roberto, 2020), my research focuses squarely on nudging behaviour change in digitally mediated contexts. I am focused on impacting micro-level change while macro-level policy levers are pulled in the UK (GOV.UK, 2020) and other countries where obesity worsens as I believe a multi-pronged approach is needed to first slow the rise of obesity and eventually push trends in the opposite direction. The more immediate application of my research is to apply food choice nudges to online grocery shopping sites, like Tesco.com. There is much promise in doing so, given the popularity of online grocery shopping that emerged because of the COVID-19 pandemic and only continues to grow (East, 2022; Mintel Press, 2021). A recent McKinsey & Company report based on Euromonitor data and multiple other sources predicts that online grocery shopping could account for 18-30% of all grocery sales in some leading European countries by 2030 (Simmons et al., 2022). That said, there is room for digital food choice nudges to also impact in-store sales as new technologies emerge, such as smartphone-assisted augmented reality (AR) for in-store shopping (Ahn et al., 2015; Fagerstrøm et al., 2020), not unlike a more advanced version of Sainsbury's SmartShop app, which continues to gain more advanced features (Nott, 2022), extending the reach and potential impact of my thesis.

My research comes at a time where there is not only a pressing societal need for such research, given the growing obesity epidemic combined with increasingly problematic eating behaviours that have surfaced as a result of the COVID-19 pandemic (Asghar & Khalid, 2022; Lamy et al., 2022; Ryan, 2021), but also at a time where academics are

placing a strong emphasis on nudging research, which has grown exponentially in popularity since originally introduced by Thaler and Sunstein in 2008 as illustrated in Figure 1 (Mertens et al., 2022).

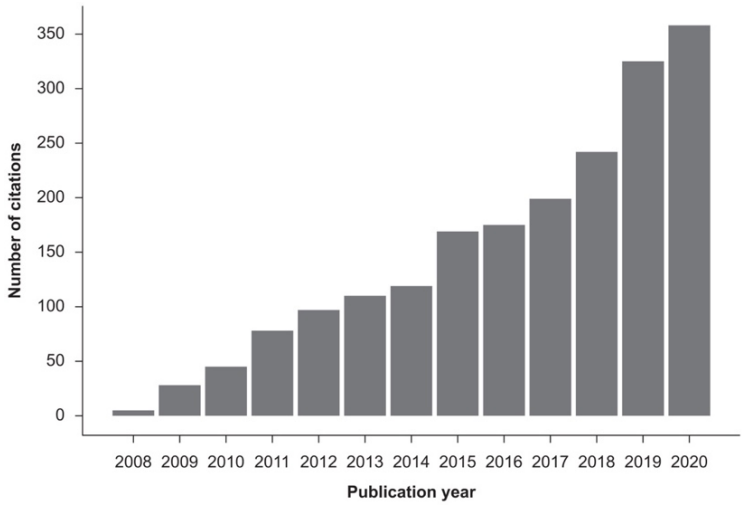


Figure 1: Citation Count for Thaler and Sunstein (Mertens et al., 2022)

Current Understanding in Food Choice Nudging

With the abundance of nudging research being conducted as of late, it is important to highlight where my research fills critical gaps in the existing literature. In Chapter 1, I perform an initial investigation into whether a novel form of social nudging—the out-group social comparison—would perform on par with more conventional in-group social comparisons that encourage behaviours based on what other "People Like You" are doing. Recognizing that we often engage in social comparisons to help guide our decisions and behaviours (Festinger, 1954; Gerber, 2020), that we specifically use social reference points to decide what and how much to eat (Cruwys et al., 2015; Vartanian et al., 2015; Zajonc, 1965), and that we allow the body composition of social reference points to influence our food-related decisions (McFerran et al., 2010), I ran two separate studies—one with adults in the United Kingdom who viewed themselves

as being a normal, healthy weight and one with adults in the United Kingdom who viewed themselves as being overweight—to understand how these adults may differentially respond to various kinds of social comparisons. More specifically, I looked to understand if out-group social comparisons could encourage calorie reduction amongst both populations in contexts where grocery basket calories were higher than usual for a weekly shopping trip, with a focus on reaching adults who would typically be resistant to dieting. Results indicated that out-group comparisons were extremely effective for normal, healthy weight adults who do not typically diet and that both forms of social comparisons (in-group and out-group) perform significantly better than the control condition in encouraging calorie reduction amongst overweight adults, with social nudging effectiveness being most pronounced amongst those who rate low to moderate in their dietary control behaviours. The two studies taken together tell us that social nudging, particularly with the help of out-group social comparisons, could work extremely well in encouraging positive behaviours to prevent and reduce obesity amongst broad populations, particularly those who are typically unwilling to modify their diets to control their weight.

Following these promising results, Chapter 2 introduced a split-study on social and self-comparisons that accomplishes several things. First, it allows us to understand how agreeable social nudging would be to adults in the United Kingdom and United States by introducing the concept of Challenge Teams, recognizing the positive effects that intergroup competition can have on intrinsic motivation and performance in other contexts (Tauer & Harackiewicz, 2004). This is important given the ethical dilemma that exists in food choice nudging (Cadario & Chandon, 2019), with the most effective nudges typically being those that people disapprove of, highlighting the need for new

forms of food choice nudges that are both effective and agreeable. Second, it allows us to understand if Challenge Teams could serve as a mechanism to flexibly introduce social comparisons with similar outcomes that were observed in Chapter 1. This is important because the social comparison nudges based on body composition tested in Chapter 1 were academic in nature and, while seemingly effective, would not be appropriate to use in real-world settings. Finally, while I hoped that Chapter 2 would reveal that social comparisons induced through Challenge Teams would be both agreeable and effective, I recognized that not all people would wish to take part in social competitions and as such wanted to understand what other types of mechanisms might help nudge these populations towards healthier choices. In the end, Chapter 2 provided robust results that demonstrated in-group and out-group social comparisons based on Challenge Teams could be effectively used to nudge all sorts of adults, including those who rate low-to-moderate in their dietary control behaviours, and that adults in both the United States and United Kingdom were largely happy to engage with this sort of nudging, with over 78% of participants willing to opt-in to receive Challenge Team comparisons. The high level of acceptance for social nudging was shown to be positively correlated to one's desire to affiliate with others, which is generally quite high in general, given we are social creatures with an innate need to belong (Festinger, 1954; Maslow, 1943; Maslow & Lewis, 1987). While these results were encouraging, open questions remained about how we might reach those who do not have a strong desire to affiliate with others and may be less willing to engage in social comparisons.

To help fill this gap in knowledge, the organic split study design I employed allowed individuals who indicated they did not wish to join a Challenge Team to instead participate in a sub study on goal-based self-comparisons. The sub study leveraged

nudges that were essentially identical to the social nudges tested in the other part of the split study, but instead compared current basket calories to their own personal goal amount, which was collected earlier on in the study. The pattern of results seemed to indicate that goal based self-comparisons could be effective, but only amongst those who have a moderate (rather than high) desire to affiliate with others. These results matched my hypothesis, but the results had to be treated with caution given this portion of the split study had so few participants due to the high opt-in rate to the Challenge Team portion of the split study. As such, a more elaborate study on self-comparisons was run with a much larger dedicated sample size, which I detailed in Chapter 3. The results from that broader study replicated the results from the previous study in Chapter 2, indicating that goal-based self-comparisons are likely a useful tool to nudge those who have a low-to-moderate desire to affiliate with others. Unfortunately, the number of participants randomly assigned to each study condition remained low because many participants failed manipulation checks and because so few people rate low-to-moderate in their desire to affiliate with others, indicating that further research is still needed in this area.

While the findings from the studies covered in Chapters 1, 2, and 3 are noteworthy and logically build off one another, it is important to position them within the context of the wider set of related literature that exists on this topic. My research differs from the bulk of the existing food choice nudging literature in three keyways: I focus on nudging in digital choice environments instead of traditional real-world settings; I focus on basket-level nudging instead of product-level nudging; and I focus on creating “super nudges” that bring together elements from individually proven nudging mechanisms (i.e.,

cognitive + affective nudging) to create more effective nudging outcomes. I will discuss each of these contributions in more detail.

The bulk of all food choice nudging research conducted to date has been focused on impacting our behaviours in traditional, real-world consumption settings (Arno & Thomas, 2016; Broers et al., 2017; Cadario & Chandon, 2020), like:

- *grocery stores and supermarkets* (Cawley et al., 2015; Chandon et al., 2009; de Wijk et al., 2016; Foster et al., 2014; Gamburzew et al., 2016; Salmon et al., 2015)
- *eateries and restaurants* (Anzman-Frasca et al., 2018; Auchincloss et al., 2013; Bollinger et al., 2011; Brissette et al., 2013; Dayan & Bar-Hillel, 2011; Downs et al., 2013; Dumanovsky et al., 2011; Elbel et al., 2011; Ellison et al., 2013; Finkelstein et al., 2011)
- *school cafeterias and university dining halls* (Bartholomew & Jowers, 2006; Buscher et al., 2001; Chu et al., 2009; Cioffi et al., 2015; Cohen et al., 2015; DiSantis et al., 2013; Donnelly et al., 2018; Dubbert et al., 1984; Elsbernd et al., 2016; Ensaff et al., 2015; Freedman & Larner, 2011; Marcano-Olivier et al., 2020; Metcalfe et al., 2020; Mollen et al., 2013; Nørnberg et al., 2016),
- *workplaces* (Al-Khudairy et al., 2019; Allan et al., 2017; Baskin et al., 2016), and home settings (Lycett et al., 2017).

These studies have focused on nudges that vary in form and effectiveness. Cadario & Chandon (2020) present a framework for food choice nudging based on a meta-analysis they conducted and suggest that current food choice nudges can be broken down into three categories: cognitively-oriented nudges, affectively-oriented nudges, and behaviourally-oriented nudges. In other words, food choice nudges can be classified as

nudges that impact what we know, how we feel, and how we act. Cognitively-oriented nudges include things like descriptive labelling (i.e., back/side of box nutrition labels), evaluative labelling (i.e., front of packaging nutrition score), and visibility enhancements (i.e., making healthy items easier to see than unhealthy items). These nudges seek to help educate people and make individuals reconsider their choices with easier to decipher information. These kinds of nudges are generally least effective when compared to other forms of nudging, but people seem to believe these nudges are effective and are generally happy to be nudged this way (Cadario & Chandon, 2019). Affectively-oriented nudges include things like healthy eating call to actions or hedonic enhancements that make healthy items seem more appealing or attractive. These kinds of nudges are moderately effective when compared to other forms of nudges (Cadario & Chandon, 2019) and work by tapping into the emotional side of eating, which has generally driven unhealthy eating behaviours, if left unchecked (Zwierczyk et al., 2022). Behaviourally-oriented nudges include convenience enhancements (i.e., making unhealthy items hard to reach) or size enhancements (i.e., offering larger portions of healthy items and smaller portions of unhealthy items to reduce their appeal). Behavioural nudges tend to be the most effective in encouraging meaningful, positive behaviour changes, but consumers largely reject this form of nudging (Cadario & Chandon, 2019, 2020), creating an ethical dilemma where choice architects must balance designing for what people want and approve of or designing for what produces the most socially desirable outcomes.

My research differs from these prior investigations in that I focus on nudging in digital contexts, where dynamic personalization can play a more meaningful role than physical real-world spaces (at least without technology augmentation of those traditional

environments). This distinction is critical as the conceptual dynamic information aids I am testing in my work simply would not be possible in a traditional brick-and-mortar grocery store without digital in-store technology and vary drastically from other types of cognitive nudges, such as fixed nutrition labels, and affective nudges, such as generic healthy eating call to actions, in that my nudges and information aides are intended to be context-aware and personalized to the end user, where as traditional informational aids in grocery stores typically must take a one-sized-fits-all approach and displayed in the same way to all people. I am certainly not the first scholar to suggest there are unique affordances associated with digital choice environments that are worth investigating; my work builds on a limited but growing set of literature related to digital food choice nudging. Scholars in both consumer behaviour and public health have started to explore the promise of nudging in online supermarket settings, focusing on product-level swaps (Forwood et al., 2015), digital nutrition food labelling (Fuchs et al., 2022), and product-level information, ordering and placement (Howe et al., 2022; Stuber et al., 2022) in grocery eCommerce sites. The results of these investigations indicate that the use of digital nutrition information and labels to encourage individual product swapping rarely produced meaningful behaviour change, while making modifications to individual product ordering and placement within online search results and display pages did impact consumer choice in positive ways. In many ways these findings mirrored findings from similar studies that took place in traditional brick and mortar settings, with behavioural nudges like convenience enhancements being more effective than most other kinds of nudges, despite the fact consumers disapprove of these more manipulative nudging practices (Cadario & Chandon, 2019).

This brings to light the second differentiator of my research: my focus on basket or basket-level nudging, rather than product-level nudging. While literature has traditionally demonstrated that cognitive nudges that aim to shift what people know about the healthiness of their individual food choices is not enough to shift behaviours (T.P. Gill & Boylan, 2012), I argue that this is because it can be difficult to understand how all the various food choices we make add up and influence our overall health and wellbeing. Product-level information and labels can be easy to ignore when we (wrongfully) assume that our combined actions and choices are healthy overall. Of course, if we only saw food as fuel and a means to meet a singular healthy eating goal, using the effective front-of-package labels (He et al., 2023) might help us choose healthy items time and time again. But we know that eating isn't just utilitarian, it's also hedonic (Dhar & Wertenbroch, 2000; Kar, 2022), and heavily influenced by social factors (Cruwys et al., 2015; Ruddock et al., 2019; Warde & Martens, 2000). As such, it seems reasonable that people will place limited emphasis on product information or warning labels, if selecting a few unhealthy items is not seen as a problem and can be justified, especially when life gets tough (Tezer & Sobol, 2021). However, basket-level nudging challenges this mishap and provides a holistic view and assessment and encourages change based on understanding the collective choices that are being made. We know from recent studies that seeing the cumulative calorie count of our selections can help people to decide to reduce their overall meal calories (VanEpps et al., 2021), indicating that there is power in helping people understand how their choices add up and fit together. Leading online grocery retailers like Walmart have started to investigate the power of basket-level analysis (Yuan et al., 2016), indicating more academic research in this area, like my own, is warranted. A key benefit of this approach is the potential for more significant effects, such as increased calorie reduction. For example, Cadario & Chandon (2020) found that product-focused

interventions produced relatively small effects, with average calorie reduction ranging from 64 to 209 calories depending on the type of nudge that was used in the study. The intended calorie reduction observed across my studies, which had a multi-product or basket-level focus, was significantly higher; participants exposed to out-group social comparison nudges indicated they would seek to reduce their basket calories by up to 1900 calories in Chapter 1 and 1729 calories in Chapter 2.

Finally, the approach I took in my research differs from the bulk of existing nudge studies in that my nudges are multifaceted and combine elements of cognitive and affective nudges, where typically nudges used to prompt healthier food choices have been one dimensional. The one-dimensional nature of historic nudging approaches in food choice has been noted as a short coming (Ensaff, 2021; Roberto, 2020), with scholars calling for fresh approaches that merge multiple nudging techniques. There is empirical research that indicates that when it comes to nudging, particularly in food choice, two techniques may very well be better than one in encouraging positive behaviour change (Broers et al., 2017; Wilson et al., 2016), but the results are not consistent and are heavily dependent on the techniques being combined (Stuber et al., 2022). Literature has indicated that salience and priming work better together than they do alone (Wilson et al., 2016), and that nudges that modify both placement and properties, such as labelling, sizing, and functional design, are effective while those that modify only properties are not (Broers et al., 2017). My research adds to this limited but necessary body of research that seeks to understand how combining various forms of nudging techniques may produce more impactful outcomes that can more meaningfully shift individual diets in mass and in turn improve broader population diets. The nudges I test across all my studies bring together elements of cognitive and affective nudging.

First and foremost, I created nudges that seek to impact what people know by highlighting the caloric nature of their shopping baskets, in effecting summing the nutrition labels of each of the product items and bringing a potential caloric surplus to the forefront. The nudging mechanisms used in Chapter 1 and Chapter 3 relied on precise, numeric calorie information (i.e., your basket contains 3,500 extra calories) while Chapter 2 took a non-numeric approach (i.e., the amount of calories in your basket is very high) and relied on a visual meter infographic design. In addition, I layered in an affective element of nudging through social comparisons (Chapter 1 and 2) and self-comparisons (Chapter 2 and 3) that help people assess how they feel about their choices by comparing them to other people (Chapters 1 and 2), their own personal goals (Chapter 2 and 3) or their typical past behaviours (Chapter 3). Given that consumers approve of cognitive and affective forms of nudging over behaviourally oriented nudges, my goal was to see if I could create effective combined nudges that people would also largely approve of, seeking the resolve the ethical dilemma that currently exists in food choice nudging (Cadario & Chandon, 2019). These combined "super nudges" produced statistically significant positive choice outcomes across multiple studies, with more than 78% of participants indicating they would be happy to engage with social comparisons in food choice contexts, far exceeding the 56% average approval rating of existing food choice nudging mechanisms being tested in the field (Cadario & Chandon, 2019).

The Promise of Social Comparison Nudging

The human-computer interaction (HCI) community has placed much on emphasis on digital nudging (Bergram et al., 2022; Caraban et al., 2019; Weinmann et al., 2016),

paving the way for more studies on how to inspire healthier decisions in online or technology mediated environments (DiCosola & Neff, 2020, 2022; Forwood et al., 2015; Fuchs et al., 2022; Howe et al., 2019, 2022; Lee et al., 2011; Piper et al., 2021; Valenčič et al., 2022; Yuan et al., 2016). Caraban et al. (2019) conducted a comprehensive systematic review of nudging literature conducted by HCI scholars and identified six effective forms of digital nudging: facilitate, confront, deceive, social influence, fear, and reinforce. These six higher order forms of nudging each contain sub-mechanisms or techniques that can be used to nudge in digital contexts, revealing 23 ways to nudge in technologically mediated environments. While the scholars screened 2136 papers, 71 were included in the systematic review, and only a few of the sampled papers included studies that focused on food choice-related nudging. The small subset of papers that dealt with food choice nudging help us to understand how nudges can be used to facilitate (Forwood et al., 2015; Lee et al., 2011), deceive (Adams et al., 2015; Lee et al., 2011), and reinforce (Barral et al., 2014; J. Kim et al., 2016) to encourage more positive food-related behaviours, adding to our understanding of how to nudge in food choice settings while also highlighting open areas for more food choice nudging research (see Table 1).

Table 1: 23 Ways to Nudge (Caraban et al., 2019)

Nudge Type	Nudge Mechanism	Applied in Food Nudging?
Facilitate	Default	No
	Opt-Out Policies	No
	Positioning	No
	Hiding	**Yes** (Lee et al., 2011)
	Suggesting Alternatives	**Yes** (Forwood et al., 2015)
Confront	Throttling Mindless Activity	No
	Reminding Consequences	No
	Creating Friction	No
	Providing Multiple Viewpoints	No
Deceive	**Adding Inferior Alternatives**	**Yes** (Lee et al., 2011)
	Biasing Memory of Past Experiences	No
	Placebos	No
	Deceptive Visualizations	**Yes** (Adams et al., 2015)
Social Influence	Invoking Feelings of Reciprocity	No
	Leveraging Public Commitment	No
	Raising Visibility of Users' Actions	No
	Enabling Social Comparisons	No
Fear	Make Resources Scarce	No
	Reducing (Psychological) Distance	No
Reinforce	**Just-in-Time Prompts**	**Yes** (J. Kim et al., 2016)
	Ambient Feedback	No
	Instigating Empathy	No
	Subliminal Priming	**Yes** (Barral et al., 2014)

In summary, the papers covered in the review help us understand how we might use product ordering techniques, alternative product suggestions, deceptive product visualisations, just-in-time prompts, and subliminal priming to help encourage healthier food choices, but do not tell us how social influence, confrontation, or fear, or any of the numerous techniques or mechanisms that sit within those broader nudging categories, can be used to nudge in food choice contexts, thus highlighting that critical gaps that remain.

HCI scholars have since engaged in new research related to digital nudging (Bergram et al., 2022), but again with a limited focus on food choice and health. Bergram et al. (2022) recently conducted an updated systematic review on digital nudging to capture new research that has emerged in the field since Caraban et al.'s 2019 study and found that social nudging is the most investigated area across HCI nudging studies as of late. While this seems promising, they also found that HCI scholars are applying their nudge research to areas like privacy, marketing, and social media, rather than areas like education or health, which are understudied. In fact, while the systematic review included 73 papers, only four of those papers applied nudges in health contexts. My publication (DiCosola & Neff, 2020) was the only health-related paper that investigated social nudging. Other health-related studies looked at how we could promote hydration through improved product design with feedback nudging mechanisms (Beddoe et al., 2020), how fear-related nudges that seek to reduce our screen time and associated digital overload may negatively impact our mental health (Prasad & Quinones, 2020), and how reinforcement and feedback nudges can be used to promote physical activity with mobile phone-based health tracking tools (Sengupta et al., 2020).

The results from this updated systematic review (Bergram et al., 2022) and my own review of the most recent health-related nudging literature in HCI highlights that there is still a need for more research on how social nudging can be used to facilitate healthier choices and behaviours. Newer studies add to the body of literature by filling gaps related to placement effects within the facilitation category of digital nudging and giving us more understanding of how confrontation and fear can be used to nudge healthier choice outcomes. For example, Starke et al. (2021) find that positioning items that are less healthy (i.e., high sodium) lower in search results pages is an effective and agreeable way to help guide users to the healthier choice, adding to existing public health literature on how positioning techniques can help facilitate more desirable decision making (Broers et al., 2017; Harbers et al., 2020). Nakamura (2021) studies how we can nudge healthy behaviours using Internet of Things and suggests that reframing behaviours using easier to understand analogies that promote multiple viewpoints and then providing ambient feedback can be useful to prompt self-reflection and encourage behaviour change, helping to shape our understanding of how we might use nudges to confront users in food choice contexts. All combined, the body of work on health-related nudging within the HCI community published to date helps us understand how we can facilitate, reinforce, confront, deceive, and invoke fear to nudge positive behaviour changes, but fails to address how social influence may be used to do.

My research fills this remaining critical gap and investigates how we can use social influence to nudge food-related behaviour changes by levering multiple kinds of social comparisons. My research challenges current conventions which rely on social norms (i.e., what most people do) and in-group comparisons (i.e., what people like you do) because these approaches have limited effectiveness given current human behaviour,

particularly when trying to reach at-risk populations who struggle with weight gain or changing the status quo. While recent field experiments in traditional brick and mortar grocery stores across both North America and Europe show that nudges that rely on social norms can be effective in encouraging more fruit and vegetable purchases (Gonçalves et al., 2021; Suleman et al., 2022), applying these nudges at scale in real-world settings based on actual human behaviours will prove a challenge, given that only 1 in 10 adults gets enough fruits and vegetables (CDC, 2021) and that dietary changes trigged by the COVID-19 pandemic have caused further reductions in vegetable intake (Jordan et al., 2021). Influencing behaviour change to curb obesity means that we must focus on individuals who are obese or at risk of becoming obese. Providing food choice recommendations based on what "like users" typically select, a common tactic in eCommerce recommendation systems (Benlian et al., 2012), is unlikely to help these populations make heathier choices. Across multiple experiments covered in Chapters 1 and 2, I introduce and test a new form of social comparison—the out-group social comparison—and demonstrate its effectiveness in food choice contexts. The social comparison nudges I created also confront users by reminding them of consequences (i.e., weight gain) and facilitate healthier outcomes by suggesting alternatives (i.e., assisted calorie reduction). We learned from studies in Chapter 1 that individuals who see themselves as being normal weight and overweight both respond well to social comparisons. The initial pilot study in Chapter 1 revealed that individuals who see themselves as being a normal, healthy weight but have a low interest in dieting are much more likely to reduce calories and make the healthy choice when compared to out-group members (i.e., overweight adults) than in-group members. The follow-up study in Chapter 1 that focused on adults who see themselves as overweight showed us thus that both forms of social comparisons (in-group comparisons to overweight adults and out-group comparisons to standard weight adults) were significantly more effective

in encouraging healthy choice outcomes than the control condition, which still provided basket calorie feedback, reminded of consequences, and suggested considering calorie reduction but without any sort of social cue or social reference point, amongst this population. These results build off a large body of work on social facilitation and social modelling in food choice (Cruwys et al., 2015; Vartanian et al., 2015; Zajonc, 1965), which tells us that we do use others as reference points when deciding how much to eat in real-world settings and that we generally eat more in the presence of others, but now provide evidence that social comparisons (rather than actual people) can serve as effective reference points that also shift our food-related behaviours in digital choice contexts. My research on leveraging social comparisons to influence positive behaviour change has been used by HCI scholars, along with other HCI studies that use social comparison techniques in other domains like gaming and energy consumption, to define a blueprint for how to design for behaviour change using social comparison processes (de Vries et al., 2023). This recent application of my research underscores how my research into social nudging in food choice contexts is having an immediate and broader impact within the HCI academic community, just as I had hoped and intended.

Moving Towards More Ethical Nudging

While I said early on I would not focus my thesis discussion on the ethics of nudging, which is widely debated (Lades & Delaney, 2022; Schmidt & Engelen, 2020; Sunstein, 2015) and could be a dissertation in and of itself, I did make a commitment to creating nudges that are transparent and prompt a reflective mindset in an effort to nudge virtuously for the benefit of people and society more broadly, ensuring my work is not used to create dark patterns or dark nudges that potentially harm people for

organizational benefit (Mills et al., 2023). I also set out to create "super nudges" that combine multiple, individually proven nudging techniques to spur stronger behavioural outcomes, responding to open calls from the academic community to do so (Ensaff, 2021; Roberto, 2020). When looking at 23 distinct digital nudging mechanisms identified by the HCI community positioned across transparent vs. non-transparent and reflective vs. automatic mindset axes (See Fig 2.), we can see that the mechanisms I selected (e.g., enabling social comparisons, reminding users of consequences, and suggesting alternatives) are amongst the most transparent and reflective, positioned in the top far right corner of the grid. In addition, they represent three out of the six higher order forms of nudging (social influence, confront, facilitate), coming together to form a unique "super nudge" that is both cognitively-oriented and affectively-oriented.

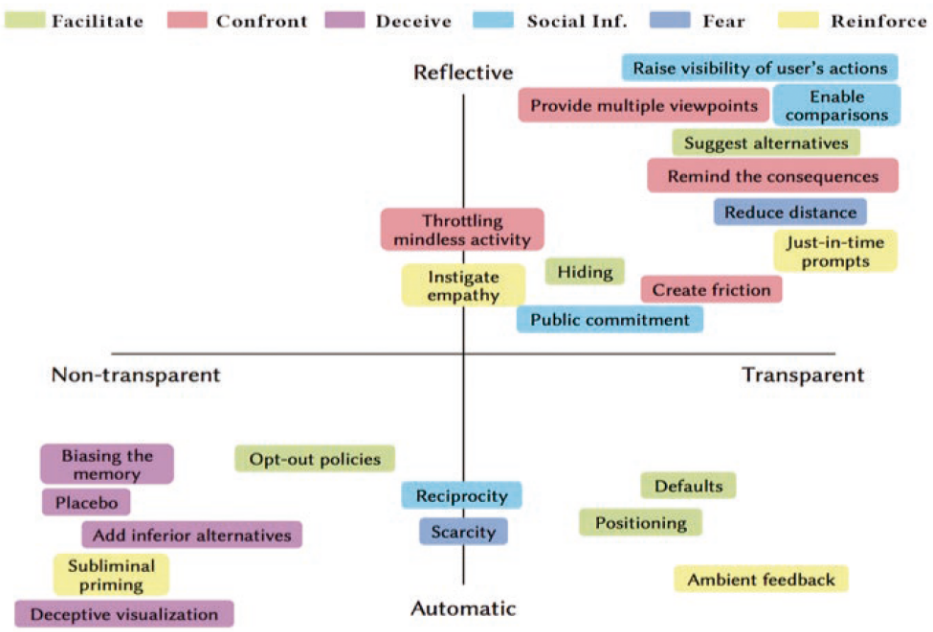


Figure 2: Nudging on Transparency and Reflective-Automatic Mindset Axes (Caraban et al., 2019)

I decided to focus my research on new forms of digital nudging that could be employed in online grocery shopping sites or in hybrid environments, such as digitally assisted in-

store shopping contexts, because the potential impact that this sort of personalized nudging could have and because these sorts of nudges could either be applied in mass or selectively to certain people dependent on context. While nudges applied through traditional means, such as on a physical product label or store shelf label, are generally made available to everyone, the fact that a digital nudge can be shown, hidden, or modified at the individual level is critical as it helps avoid a "one-sized-fits-all" approach to digital health interventions that have proven problematic (Ackerman, 2000; Spiel et al., 2018). That said, this hyper personalised form of nudging must be applied responsibility to ensure we do not nudge individuals to make choices that benefit nudge designers, but rather we design nudges to benefit the individuals being nudged and ideally society more broadly. The reputation of nudging has been questioned given the rise of nudging that promotes dark patterns that benefit vendors while harming users (Mills et al., 2023) and while my nudges could potentially applied in such ways, I hope this is not the case. Any use of nudging techniques, including my own, should apply an ethics framework for consideration to ensure proper use. The FORGOOD framework presented in the Literature Review is one such framework that can be used by focusing on Fairness, Openness, Respect, Goals, Opinions, Options and Delegation to inspire virtuous nudging while avoiding dark patterns (Lades & Delaney, 2022).

I also recognized that while social influence and social comparisons have been identified as powerful nudging mechanisms that benefit people (Caraban et al., 2019; Gupta et al., 2020), not all people will be interested in seeing social comparisons or being prompted to take part in social competitions. As such, I conducted explorations into self-comparisons as alternative nudging mechanisms in Chapters 2 and 3, adding to emerging literature on self-nudging (Reijula & Hertwig, 2022) in food choice and

health-related behaviour change (Michels et al., 2023; Torma et al., 2018). While the core focus of my doctoral research has always centred around understanding the impacts in-groups and out-groups can have on our choices, extending my focus to understand the role that "the self" could play in nudging seemed necessary to reach the most people in the most ethical and agreeable way as possible.

Self-Comparison Nudging

If individuals rate low in their desire to affiliate with others, it stands to reason they may wish to instead connect to themselves to become a better version of their self, rather than looking to others, despite the longstanding literature that indicates we have an innate tendency to compare ourselves to others (Festinger, 1954; Gerber, 2020). In addition, from a theoretical perspective, we know that people are motivated to achieve in order to improve their self-concept, which is in turn recognised by others, and that achievement motivation is driven by two factors: learning and performing (Diveck & Molden, 2005). What evidence do we see in the real world that people are seeking opportunities to learn and perform in the context of health and wellbeing by better understanding themselves? The Quantified Self movement documents how some groups of people are fascinated by their own personal data and use this data to learn about themselves and in many cases change their behaviours (Lupton, 2016). As more and more digital devices and applications that enabled this sort of fitness and nutritional self-tracking data became available, from the original introduction of the Fitbit in 2009 to Apple's introduction of Apple Health in 2014, the practice of self-tracking and of understanding, interpreting, and using one's own data to inspire reflection and behaviour change began to hit the mainstream (Neff & Nafus, 2016). The COVID-19

pandemic accelerated the trend, as people looked to home fitness and self-tracking devices and apps to keep healthy and stay motivated during a time where much activity was constrained (Tong et al., 2022). My doctoral research looked to see if we could introduce more automated forms of self-tracking practices to the online grocery shopping experience to nudge individuals towards healthier choice outcomes, building on existing research on semi-automated self-tracking technologies (Y.H. Kim et al., 2017) that seek to combat the episodic use of more manual and effortful forms of self-tracking (Gorm & Shklovski, 2019). After all, people have become accustomed to setting health and fitness goals on digital apps and devices and using these apps and devices to monitor their behaviours to achieve better health or well-being outcomes (Abtahi et al., 2020; Ren, Yu, Lu, & Brombacher, 2018; Tong et al., 2022), so it stands to reason taking similar approaches in online grocery shopping contexts may also be effective, particularly if they foster learning and give people an opportunity to demonstrate improved performance (Diveck & Molden, 2005). The benefit of taking this self-nudging approach is that it deeply engages people and ultimately gives them more control over their nudging experience, allowing individuals to shape the design of their decision environments (Reijula & Hertwig, 2022), but is less effortful than fully manual forms of self-tracking, such as manually recording what you eat in apps like MyFitnessPal. Within the realm of better understanding self-comparison nudging, my main focus was to see if goal-based self-comparisons that automatically calculate the calories in one's shopping basket and compare this against what we might expect based on their health goal and shopping trip size (i.e., one week) could nudge people towards calorie reduction when they were going off track, while my secondary focus was to see if self-comparisons based on one's historical data could be used to nudge behaviour change in contexts where people had a shopping basket that was "high calorie" in

comparison to their more typical basket for a similarly sized shopping trip (i.e., one week).

In Chapter 2, I investigated goal-based self-comparisons by allowing people to fill out some information about themselves and indicate whether they wished to gain weight, lose weight, or maintain weight. These individuals were later presented with an analysis at checkout that would assess their shopping basket and let them know if the calories contained in their basket were too high based on their individual goal. Results indicated that while goal-based self-comparisons did not meaningfully change behaviours for all people, they did work well in inspiring calorie reduction for those who rated moderate (rather than high) in their desire to affiliate with others. In Chapter 3, I broadened the scope to also investigate if self-comparisons based on comparing current basket calories to past basket calories for similarly sized shopping trips could be effective, in much the same way that health trackers use better past performance to motivate positive future performance. Results indicated that neither of the self-comparison nudging techniques—goal-based or history-based self-comparisons—performed significantly better than the control nudge condition as a main effect, a stark contrast from the results observed in my previous social comparison studies. That said, a deeper look at the data did reveal that goal-based self-comparisons worked particularly well for those who rate low-to-moderate in their desire to affiliate with others. The pattern of results in Chapter 3 largely replicated the findings observed in Chapter 2, using a larger sample and more numeric stimuli. The combined findings from Chapter 2 and Chapter 3 seem to indicate that goal-based self-comparisons may be a useful self-nudging technique for individuals who do not wish to affiliate with others and may not wish to engage in Challenge Team social comparisons.

Practical Implications

My research was designed to be academically significant, by filling key gaps in academic literature, but also practical, with the ability to impact real-world change and hopefully shift digital and information design practices looking to the future. My primary contribution was to introduce a novel social nudge—the out-group social comparison—and demonstrate that it could perform equal to, if not better than, the more commonly used "People Like You" in-group social comparisons in facilitating healthier choice outcomes amongst broad populations, including those who are typically harder to reach. Digital designers now have a new tool in their arsenal to help shape online consumer behaviour that allows them to go beyond social norm comparisons and in-group comparisons, which aren't always going to help elicit desired behaviours, particularly when targeting behaviours where people are struggling to achieve optimal outcomes based on the status quo, like healthy or sustainable eating, retirement savings, or reduced energy consumption. The social comparisons I introduced in Chapters 1 and 2 are already being used to create behaviour change design patterns in HCI that can be applied across a variety of domains (de Vries et al., 2023), which is promising.

While this broadened conceptualisation of social comparisons may be appealing, putting it into practice may feel quite difficult to practitioners. Creating in-group or out-group social comparisons based on personal characteristics or demographics such as age, race, gender, or body image would not be advisable, as such practices are not ethical and, in some cases, could even be illegal. To combat this, I provide both academics and practitioners with a viable way to induce out-group social comparisons through Challenge Teams. I was able to construct Challenge Teams in Chapter 2 by using

minimal group paradigm (Tajfel et al., 1971), allowing individuals to join their own desired team based on an arbitrary colour selection (i.e. red or blue). As a result, we can be confident that more useful and relevant teams would be equally, if not more, effective in producing the observed social comparison nudging effects. For example, digital designers might create Challenge Teams based on hobbies or interests (e.g., Team Reading versus Team Gardening; Team Travel versus Team Sports), favourite foods (e.g., Team Ice Cream versus Team Pizza; Team Fruits versus Team Vegetables), sports team affiliations (e.g., Team Chelsea versus Team Arsenal; Team New York Yankees versus Team Boston Red Sox); the possibilities are truly endless and there is room to allow people to create or nominate their own Challenge Teams to prompt deeper engagement and bring elements of self-nudging and social nudging together (Reijula & Hertwig, 2022). Comparisons can be made to essentially any group, one's own in-group or a different out-group, based on context and desired behaviour, to nudge the healthier choice outcome.

Given these contributions, I believe practitioners should be motivated to seriously consider broadening their conception of social comparison nudging, which largely centres around using "People Like You" in-group social comparisons today (Benlian et al., 2012; de Vries et al., 2023; Gomez-Uribe & Hunt, 2015), given the positive results observed across Chapters 1 and 2 that demonstrate out-group comparisons perform on par or better than in-group comparisons. And while there may be some natural hesitation around how people may respond to new forms of social comparisons, given the general dissatisfaction that people have with the most effective forms of food choice nudging practices employed as of late (Cadario & Chandon, 2019), results from Chapter 2 tell us that people generally seem quite happy to participate in Challenge Teams, with

an 86% acceptance rate observed in the United States and a 76% acceptance rate observed in the United Kingdom. While these acceptance rates are quite high and extremely promising, they aren't 100%, which means a significant chunk of people would opt-out from Challenge Teams and social comparisons, indicating that another form of nudging would be needed if we wish to reach these populations.

While my research did not investigate all of the potential nudging alternatives we might employ reach those who opt-out of Challenge Teams, it did investigate several different forms of self-comparisons we could use to reach such populations across Chapters 2 and 3. While the overall results indicate that self-comparisons do not meaningfully work across broad populations in the same way that social comparisons do, goal-based self-comparisons seem to work particularly in helping to nudge healthy choice outcomes amongst those who rate low-to-moderate in their desire to affiliate with others. This is good news, as Chapter 2 revelated that there is a strong positive correlation between one's desire to affiliate with others the decision to join a Challenge Team ($p=.0019$), indicating that those with a low-to-moderate desire to affiliate are less likely to opt-in to Challenge Teams, and would thus likely benefit from a nudging alternative like goal-based self-comparisons.

Research Limitations & Future Directions

While I have outlined the key findings and contributions of my research, highlighting how my work fills critical gaps in our academic body of knowledge while also highlighting how my work could be used by practitioners to create new kinds of digital experiences that benefit people, my research is not without shortcomings. A recent

review of digital nudging studies by Bergram et al. (2022) noted the limitations of this recent nudging research being conducted in the field, and my work is no exception. The scholars found that HCI researchers have focused too heavily on too few areas when conducting digital nudging research, have conducted studies that are too limited in geographic scope, have not embraced field experiments enough, have focused too heavily on desktop on mobile digital experiences instead of adopting a broader view of digital devices and channels, and have failed to provide proof that nudges can have a sustained impact on long-term behaviour change. I will discuss how each of these shortcomings applies to my own research.

While I set out to conduct research that could be applied to a variety of contexts to shape more socially responsible decision making, my doctoral research was purposely focused on nudging healthier food choices. Furthermore, I specifically narrowed in on nudging calorie reduction, given the key role that sustained excessive calorie consumption plays in the formation of obesity (World Health Organization, 2021, 2024), but recognise that future health-related studies can and should investigate how social comparison nudging can be used to motivate other healthy food choices such as increased fruit and vegetable selection, increased selection of positively rated foods according to FOP labels, such as green coloured or A rated food items (Martini et al., 2023), or reduced selection of products that contain large amounts of unhealthy fats or added sugars. While health is one of the understudied areas within HCI digital research (Bergram et al., 2022), and my work helps contribute to this understudied space in a very focused way, the impact of my work is further limited by the fact that I have not shown how my results could extend to other important understudied areas, such as education, personal finance, or sustainability, for example. Given that my nudges are

designed to help nudge more socially responsible decision making in areas where people are struggling to make optimal choices, extending my research to understand how in-group and out-group social comparisons could be used to help people save more for retirement to help avoid the looming pensions crisis or how Challenge Teams could be applied to help people consume less energy in an effort to be improve sustainability and curb impacts of global warming would be natural extensions of my work. I would be happy to work with scholars from a variety of fields to apply my nudges to these and other important contexts and hope to conduct this work in the future. As my work is being used to help influence the creation of design blueprints for behaviour change (de Vries et al., 2023), it will be interesting to see how this work can be applied to understudied areas like education, health, finance and sustainability (Bergram et al., 2022).

Regarding the common pitfall of having a very limited or narrow geographic focus when conducting digital nudging studies in HCI, I did attempt to recruit participants from multiple countries across my research studies to improve the generalizability of my research findings. My research purposely focused on the United Kingdom and United States; these countries were promising focal points for my research given that more than half the population in each of these countries intends to grocery shop online in the near future (Retail Insight Network, 2022), and that my familiarity with each of these countries reduced barriers to entry when compared to conducting research with other populations. That said, my decision to focus on these two English-speaking Western cultures is limiting and does not guarantee we can necessarily expect to see similar results in other Western cultures and does not provide a view into how these nudging techniques would be received in Eastern cultures, where online grocery

shopping is actually much more popular as of late, with over 85% of people in China, Thailand, and South Korea reporting they intend to grocery shop online in the next several months, according to recent Retail Insight Network data (2022). A broader global exploration on the effectiveness of in-group and out-group social comparisons on inspiring healthier food choices would be worthwhile. Future studies could consider Hofstede's cultural dimensions (2011) and provide insight into which of the six dimensions— Power Distance, Uncertainty Avoidance, Individualism/Collectivism, Masculinity/Femininity, Long/Short Term Orientation, and Indulgence/Restrain—might predict social nudge acceptance. This information could be used to design more effective, multifaceted nudges for use across diverse cultures, which is an area of research I hope to engage in looking to the future.

As previously stated, a key aim of my research was to produce research that was novel and academically rigorous, but also well positioned to influence industry practice and real-world behaviours. I conducted my research in partnership with a leading multi-national grocery retailer to gain their perspectives and ensure I was conducting research and formulating research questions that would be of interest to practitioners. While I originally intended to conduct a field experiment with an online grocery store retailer, recognizing this experimental approach is commonly used in fields like consumer behaviour (Cadario & Chandon, 2020) and experimental economics (Samek, 2019) to boost the generalizability of my research and increase confidence that my findings fully extend to the real-world practice, this never came to fruition during the period of my doctoral studies. As a result, my research at this stage is inherently limited as it is based on lab experiments tied to intended behaviour, rather field experiments tied to actual observed behaviour. While an optimal way forward would be to run a field experiment

with real choice outcomes by collaborating with an industry sponsor, academic-industry partnerships have historically been challenging in the social sciences (King & Persily, 2020). Another possible way forward would be to leverage open source online grocery shopping software developed by academics (Howe et al., 2022) and design online shopping experiments that have real choice outcomes, which could be made possible by fulfilling orders by local vendors. Obviously, the resources and complexity involved in such constructing and executing such field studies is a barrier, particularly within the constraints of doctoral research, but large-scale research grants could be applied to these kinds of worthwhile experiments, which will become quite expensive, particularly as focus shifts from studying single product nudging to multi-product nudging to have greater impact.

Up to this point, I have discussed three primary limitations of my doctoral research: the fact that it has been applied to only one context—nudging healthier food-related choices—but could be applied to other contexts where socially responsible decision making is paramount; it has been tested in two English-speaking Western geographies (the US and the UK) and thus has limited generalizability outside of these two areas; and that is based on academic lab experiments that measure intended behaviour rather than real-world field studies that measure actual behaviour. While I believe these three shortcomings deserve the most attention and I would invite academics and practitioners alike to apply my research findings to new contexts, additional geographies, and real-world field experiments sooner rather than later, two other limitations remain that constrain the impact and application of my nudge research.

First, my research involved the design of digital information nudges that were designed to be displayed on desktop or mobile form factors while grocery shopping online. This is not too surprising, given that grocery shopping today may often be thought of as "in-store" or "online," and conducting studies that account for the unique affordances of online environments is worthwhile (Fuchs et al., 2022; Howe et al., 2022; Valenčič et al., 2022; Yuan et al., 2016). That said, technological innovations that are starting to take shape will start to blur the line between these environments as digital devices play a more prominent role to create "augmented in-store experiences" of the future. For example, Amazon has introduced "Just Walk Out" technology at its physical Amazon Fresh and Amazon Go grocery stores that allows individuals to purchase groceries without ever having to go through any kind of checkout lane, while it's Dash Basket includes a digital screen to aid in-store shopping, in essence making digital nudging techniques possible through a smart basket (Wallace, 2020). Future food choice nudging experiments might consider applying digital nudges on smart shopping basket displays or within in-store shopping assistants on mobile devices, either as part of laboratory studies or real-world field studies, for example, to account for the rapidly changing retail environment and better inform grocery stores of the future.

Second, my research, like much digital nudging research (Bergram et al., 2022), looks at the nudge effectiveness at a single point in time. The results of my research indicate that novel out-group social comparison nudges work just as well as more traditional in-group social comparison nudges in inspiring healthier choice outcomes in digital environments, but research does not address if these positive effects would persist over a sustained period of time. Recognizing that the episodic use of other digital health tools has historically prevented consistent, sustained behaviours (Gorm & Shklovski, 2019),

investigating how well social nudges and other forms of nudges perform over time in various contexts is critical to help academics and practitioners understand which nudges may result in sustained behaviour change and have the greatest impact across domains over time. Using longitudinal studies that measure nudge acceptance over a prolonged period could help address this shortcoming and would certainly fill critical gaps in the literature. While interest in nudging has grown exponentially since it was incepted 15 years ago (Thaler & Sunstein, 2008; Mertens et al., 2022), securing investment from academia, grant-funding institutions, and the private sector is likely going to become increasingly dependent on demonstrating how nudging can be used to not just motivate positive behaviour at a single point in time, but can actually trigger repetitive positive behaviours or sustained behaviour change.

Beyond this, there is another important consideration worth discussing given that my current research deals with nudging calorie reduction, which has to do with balancing the potential benefits and risks associated with nudging in health contexts. Across my studies, it became apparent that those who rate very high in their dietary control behaviours or have an over willingness to modify their diets to control calories were quick to take up any type of nudge that allowed them to reduce calories, including baseline or control nudges as well as social comparison nudges. This indicates that nudging, if not applied with caution and precision, could be problematic for those with eating disorders. When designing digital interventions to encourage more healthy eating, it is important that designers and choice architects investigate techniques that work for all people, offering different digital aids or nudges to those who tend to overconsume as compared to those who tend to under consume, given a more desirable end state for these two populations would look quite different. The benefit of designing

in digital environments is that this level of personalisation and customisation is possible, but it must be accounted for by leveraging human-centred design (Graham et al., 2023). While my doctoral research was squarely focused on the investigating a broader set of social comparison nudging techniques and applying them to contexts to help curb or prevent obesity through calorie reduction, future investigations might look to understand how these nudges could be reframed to help encourage increasing calories in one's shopping basket or basket to help those who struggle to eat enough.

Concluding Thoughts

Reflecting on my doctoral journey, which started at the Kellogg School of Management at Northwestern University and ended at the Oxford Internet Institute within the University of Oxford, I feel thankful for how one seemingly simple idea I had coming out of Dan Molden's Social Cognition course during my first term at Kellogg has evolved to inspire a stream of academic articles that has the potential to, and in many ways already is, shaping various academic communities. That single provocation I had—what if our fascination and love for in-groups and our neglect and distaste of out-groups could be challenged, harnessed and actually become a force for social good, rather than triggering intergroup bias, conflict, prejudice and other negative factors (Allport et al., 1954; M.B. Brewer, 1979, 1999; Hewstone et al., 2002)—has resulted in the publication of academic articles that tells us that our choices can be positively impacted by others who are different than us, in traditional choice settings as well as digital choice environments.

My first-year doctoral paper at Kellogg evolved into a published piece of work in marketing that shows when we make food choices in the presence of others that we are in fact more likely to make the healthier choice in the presence of out-group members than in the presence of in-group members (Touré-Tillery et al., 2020, 2022). This tendency is driven by the fact that when we are making decisions in public and in front of others, we are inherently concerned about what other people think (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980) and, as a result, we have meta perceptions that those from out-groups will judge us more harshly if we indulge than those from our in-group will, prompting us to select the more healthy choice in the presence of out-group members. While these findings were illuminating and quite satisfying, providing solid evidence that engaging with different others can inspire good things, we know that people behave differently in public than they do in private, particularly in food choice contexts (Ratner & Kahn, 2002). This prompted me to raise a new follow-up question: how could this positive "out-group effect" that seems to naturally occur in real-world choice settings, which are inherently social with present others, sustain in digital choice environments, which are inherently private? Perhaps the most natural response would be to begin exposing our online food choices to others as a way to nudge more responsible decision making, but this type of technique would likely induce guilt or shame and rely on fear, which did not feel like the most promising way forward to me, even if literature seems to indicate sort of nudging could be effective if designed the right way (Agrawal & Duhachek, 2010; Caraban et al., 2019; Duhachek et al., 2012; Prasad & Quinones, 2020).

Taking a different approach, I investigated if we could use in-group and out-group social comparisons to nudge healthier or more socially responsible decision making in

online choice environments. Recognizing that we use social comparisons to guide our actions and behaviours (Festinger, 1954), and that this is particularly true in the area of food choice (Cruwys et al., 2015; Vartanian et al., 2015; Zajonc, 1965), it seemed that likely that the powerful "out-group effect" observed in traditional choice settings could in fact be replicated online, relying on social competition and team dynamics (Deutsch, 1949; Tauer & Harackiewicz, 2004) rather than impression management (Leary, 1995; Leary & Kowalski, 1990; Schlenker, 1980). Across multiple studies, I show that both in-group and out-group social comparisons perform well in encouraging nudge uptake, particularly amongst harder to reach populations. The promising results from my initial research covered in Chapter 1 were published in HCI venues (DiCosola & Neff, 2020, 2022) are now being used by HCI scholars to advance future directions digital nudging (Bergram et al., 2022) and to form new digital design patterns for behaviour change (de Vries et al., 2023). The more conclusive work I presented in Chapter 2 is being targeted for publication in a broader reaching journal.

In the end, I hope and believe that my doctoral research can inspire and spur broad impact across disparate academic communities, like marketing and consumer behaviour, HCI, and public health, but also be of use to governments and the private sector when looking to nudge and motivate positive behaviour change in an ethical, effective, and acceptable manner.

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