Why do we overeat from larger portions? Plate-clearing tendencies and food waste concerns as potential explanations

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DECLARATION IN HIGHER DEGREE THESES

DECLARATION

This thesis is the result of my own work. The material contained in the thesis has not been presented, nor is currently being presented, either wholly or in part for any other degree or qualification.

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Abstract

This thesis investigated how plate-clearing tendencies and food waste concerns may contribute to overconsumption from larger portion sizes of food. Chapter 2 demonstrated that, irrespective of the portion size served, those who self-reported a tendency to plate-clear when eating consumed significantly more food than those who reported low plate-clearing tendencies. Chapter 3 demonstrated the reliability and validity of a new scale to measure food waste concerns in an eating context. Scores on this scale positively predicted self-reported plate-clearing tendencies, but were not predictive of objectively measured energy intake, BMI or the likelihood of having overweight. Chapter 4 reports on studies in which beliefs about food waste were manipulated. Across Chapters 3 and 4, there was little evidence that food waste concerns influenced objectively measured food intake. Chapter 5 showed that plate-clearing tendencies and food waste concerns moderate the influence portion size has on intended food consumption. Given that intended consumption predicts actual consumption, individuals who are concerned about wasting food and habitually clear their plate may be at risk of overeating, especially when faced with larger portions.

This thesis provides further evidence for a portion size effect on intended and actual consumption, with implications for policies and interventions aimed at reducing the size of portions available in our food environment. It also provides the first thorough investigation into how plate-clearing tendencies and food waste concerns influence food intake. My findings suggest that working to create a food environment in which plate-clearing would no longer constitute a maladaptive behaviour could induce widespread reductions in food intake. I also provide further evidence that food waste concerns are associated with plate-clearing tendencies. Further investigation into how food waste concerns influence plate-clearing tendencies, and how this may influence eating behaviour, is now warranted.

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Dissemination

Conferences

The contents of this thesis have been presented to the British Feeding and Drinking Group (2016-2019), The U.K. Congress on Obesity (2017), 'Downsizing' (University of Leeds, 2018), and the International Society of Behavioural Nutrition and Physical Activity Annual Meeting (2019).

Peer Reviewed Publications

The study from Chapter 2 has been published as:

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The studies reported in Chapter 3 have been submitted for publication as:

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Chapter 1: General Introduction

1.1 The Increased Prevalence of Obesity

Since the 1970s, obesity rates in both adults and children have increased across many countries (Finucane et al., 2011; Sassi, Devaux, Cecchini, & Rusticelli, 2009). Ng et al. (2014) analysed trends in overweight and obesity by country from 1980 to 2013. They found that, worldwide, the proportion of adults with a BMI of 25 and above increased from 28.8% to 36.9% in men and from 29.8% to 38.0% in women. In addition, an increase in the prevalence of obesity in children and adolescents was observed in both developed and developing countries. In 2015, approximately 19.5% of the global adult population had obesity, which ranged from less than 6% in Korea and Japan to more than 30% in Hungary, New Zealand, Mexico and the United States of America (U.S.A.) (OECD/EU, 2017). In the U.S.A., the prevalence of obesity continues to exceed 30% across adults in most sex-age groups (Flegal, Carroll, Kit, & Ogden, 2012; Ogden, Carroll, Kit, & Flegal, 2016). With regards to the U.K., the Health Survey for England 2017 estimated that 28.7% of adults in England are classified as having obesity (which has increased from 15% in 1993) and a further 35.6% are classified as having overweight (House of Commons, 2019). In addition, The National Child Measurement Programme estimated that 9.7% and 12.8% of children in Reception (aged 4-5) and 20.2% and 14.2% of children in Year 6 (aged 10-11) were classified as having obesity and overweight respectively (House of Commons, 2019). Similar rates of overweight and obesity are reported in Wales, Scotland and Northern Ireland (House of Commons, 2019).

Obesity refers to excess fat in the body, which is the result of chronic excess energy intake, otherwise known as a positive energy balance. It is typically classified in terms of BMI, although due to the heightened risk of abdominal obesity or excess visceral fat, using waist circumference or waist-height ratio as a measurement is becoming a more common diagnostic tool (NHS Choices, 2018). Despite being a major focus of public health campaigning, and the creation of various weight loss and management programmes, surveillance data indicates that obesity rates appear to not have reduced in developed countries (Flegal et al., 2012; Ogden, Carroll, Kit, & Flegal, 2012; Ogden et al., 2016), or may have slightly increased (Flegal et al., 2012). Furthermore, global obesity levels are projected to steadily increase. Wang, McPherson, Marsh, Gortmaker, and Brown (2011) forecast 65 million more adults with obesity in the U.S.A. and 11 million more adults with obesity in the U.K. by 2030. Obesity rates are predicted to be particularly high in the U.S.A., Mexico and England, where 47%, 39% and 35% of these populations respectively are predicted to have obesity by 2030 (OECD/EU, 2017).

The costs of obesity are great. Obesity has been found to be associated with reduced quality of life (Derraik, De Bock, Hofman, & Cutfield, 2014), reduced life expectancy (Fontaine, Redden, Wang, Westfall, & Allison, 2003), and early mortality (McGee, 2005), in particular cardiovascular disease mortality (Wu et al., 2014). Abdominal obesity specifically has been found to be directly associated with higher mortality (Martínez-González et al., 2014). Obesity has also been associated with increased risk and incidence of other health problems (Song et al., 2018), including coronary artery disease (Zhang et al., 2018), diabetes mellitus (Garcia-Dominic et al., 2014; Mokdad et al., 2003), osteoarthritis (Schienkiewitz, Mensink, & Scheidt-Nave, 2012), cardiovascular risk diseases (e.g. hypertension) (Sun, Zhou, Gu, Zhu, & Bi,

2018), metabolic syndrome-related risk factors (Al-Bachir & Bakir, 2017), and more recently depression (Song et al., 2018). The increased prevalence of obesity may also present economic burden to healthcare services (Cawley & Meyerhoefer, 2012), being estimated to account for 0.7-2.8% of a country's total healthcare expenditures (Withrow & Alter, 2011), and individual medical expenditures (Song et al., 2018). In 2016/17, there were 617,000 NHS hospital admissions where obesity was the primary (admissions directly attributed to obesity) or secondary (admissions where obesity was a factor) diagnosis, an increase of 18% from 2015/16 (Health and Social Care Information Centre, 2018). Along with increased prevalence of overweight and obesity in the U.K. and U.S.A. by 2030, Wang et al. (2011) also predict a consequential increase in cases of diabetes, cancer, stroke and heart disease, and a substantial increase in medical costs. Specifically, these are estimated to increase by $48–66 billion and £1.9-2 billion per year in the U.S.A. and U.K. respectively by 2030.

In summary, obesity is a serious, global, and ongoing problem. Action is needed to reduce overweight and obesity worldwide. So far, despite varied attempts, there has been no reduction in obesity rates. However, the aetiology of obesity is complex, with a variety of external and internal contributors.

1.2 Human Regulatory Systems

Our underlying physiology means that individuals are typically susceptible to weight gain in environments that allow for excess energy intake without a corresponding increase in energy expenditure. In homeostatic terms the increasing commonness of overweight and obesity would appear counterintuitive, as humans have developed a regulatory system designed to maintain energy balance (Berthoud, Münzberg, &

Morrison, 2017). However, these physiological regulatory mechanisms appear much more efficient at signalling under-consumption and protecting against starvation and weight loss than signalling over-consumption and protecting against excessive weight gain (Blundell & King, 1996; Blundell et al., 2005). Thus, chronic exposure to highly palatable, energy-dense food in large portion sizes that exceed energy requirements is likely to promote chronic overconsumption and excess weight gain (Jeffery et al., 2007; Prentice & Jebb, 2003).

1.3 Changes to the Food Environment Contributing to Obesity

The observed increased prevalence of obesity may be explained by changes to the environment. The food environment has changed over the past century into one characterised by a variety of convenient, relatively inexpensive, highly energy-dense and palatable foods. These are packaged, sold and served in large portion sizes (Smiciklas-Wright, Mitchell, Mickle, Goldman, & Cook, 2003; Young & Nestle, 2002, 2003), which deviate drastically from recommended serving sizes (Young & Nestle, 2003). Improvements to public transport, increased use of vehicles, limited time for exercise, the widespread advent of elevator and escalator conversions, and the increase of sedentary jobs and leisure activities suggest that physical activity has, if anything, decreased (Hill, Wyatt, Reed, & Peters, 2003). However, McCormack and Shiell (2011) found that the associations between specific elements of the built environment and physical activity were generally mixed. In addition, Swinburn et al. (2011) argue that changes in physical activity cannot account for the global upward trend of obesity. However, it has been argued that changes to daily energy expenditure may have played some role in the obesity epidemic. For instance, Church et al. (2011)

estimated that occupational-related energy expenditure in the U.S. has decreased by more than 100 calories over the past 50 years, which could account for a proportion of the increase in mean body weight for men and women (Church et al., 2011; Hill et al., 2003). Therefore, although physical activity is not directly relevant to this thesis, it is still relevant to a holistic understanding of the development of, and how to tackle, obesity.

Changes to the food environment present a significant challenge as individuals appear to respond more to external signals, such as social influence, portion size, tableware size, and variety, than internal signals, such as hunger and satiety (Ello-martin, Ledikwe, & Rolls, 2005; Rolls, Engell, & Birch, 2000; Vartanian, Sokol, Herman, & Polivy, 2013). Thus, it is suggested that we should arm individuals with strategies to resist environmental pressures to overconsume (Rolls, 2014). Given the importance of food intake and diet in the development of obesity, studying eating behaviour – in particular why individuals overeat – is vital to understanding and tackling obesity. Even small reductions in conscious energy intake may reduce excessive weight gain (Hill, 2009), and even modest weight reductions can have substantial positive effects on associated health risks and lifetime health (Wing et al., 2011). Therefore, investigating ways to reduce the impact of external influences on consumer's intake is of great importance. The external influence on food intake I will be focussing on in this thesis is portion size, as systematic increases in portion size have been implicated in overconsumption, weight gain and obesity.

The food environment has changed to one characterised by a surplus of food. Snacking behaviour has become common place (Benson, 2009); the number of supermarkets, fast food restaurants, take-away restaurants and cafes has grown, and eating out of the home is now a regular, relatively affordable occasion for many people

(Adams et al., 2015; Food Standards Agency, 2019). Using data from the National Diet and Nutrition Survey 2008-2012, Adams et al (2015) found that a fifth to a quarter of adults and children in the U.K. eat meals prepared outside of the home once a week or more, with one fifth eating take-away meals at home this frequently. Also, a recent survey by the Food Standards Agency (2019) found that 11%, 29% and 27% of adults report eating breakfast, lunch and dinner respectively outside of the home at least once a week or more. The food available in these eateries and supermarkets has become more processed, with commercial energy-dense foods becoming cheaper and more readily available (Matthiessen, Fagt, Biltoft-Jensen, Beck, & Ovesen, 2003). Lachat et al (2012), in a systematic review, highlight eating outside of the home as a risk factor for higher energy and fat intake, and lower micronutrient intake. In support, Nielson (2002) investigated trends in energy intake between 1977 and 1998 in the U.K. and reported an increase in total energy intake over this time, with a shift from meals to snacks, and from at-home to away-from-home consumption. Similar shifts were seen across age groups, which the authors suggest highlights the role of the environment in these shifts. More recently, Drewnowski and Rehm (2013) found that restaurants, including fast food, accounted for 16.9-26.3% of total energy intake. In support, Robinson, Jones, Whitelock, Mead, and Haynes (2018), in a recent investigation into U.K. restaurants, found that the percentage of meals that met public health recommendations of 600kcal at lunch and dinner was low (9%) and smaller than the percentage of meals with excess energy content (47%). Taken together, these changes to the environment have important implications for energy balance.

1.4 Portion Size

1.4.1 Increases in portion sizes

Portion sizes have steadily increased over the past 50 years. A number of studies in the U.S.A. highlight that portion sizes of both foods served at and away from home have been increasing since the 1970s, and marketplace food portions now exceed nutritional recommendations (Smiciklas-Wright et al., 2003; Young & Nestle, 2002, 2003). Portion sizes of numerous foods appear to have increased (Young & Nestle, 2007, 2012), particularly energy-dense foods and fast food portions (Piernas & Popkin, 2011). With the advent of 'super-sizing', some portions offered by fast food restaurants are 2-5 times larger than their original size (Young & Nestle, 2003). These increases in portion sizes appear to have gone largely unnoticed. For instance, Condrasky, Ledikwe, Flood, and Rolls (2007) found that, although the majority (76%) of restaurant chefs believed they served regular portions, the actual portions of steak and pasta they reported serving were 2-4 times larger than recommendations.

Although not to the extent of those in the U.S.A., portion sizes have also been increasing in Europe. Steenhuis, Leeuwis, and Vermeer (2010) report a trend towards larger portion sizes, particularly of energy-dense foods, throughout the past decade in the Netherlands. This often included discontinuing smaller portion sizes and replacing them with larger portion sizes, or adding even larger portion sizes to the selection available for a particular product. Matthiessen et al. (2003) report increases in the portion sizes of commercial energy-dense foods, beverages, and fast food meals in Denmark, with a notable increase in the 1990s and the introduction of the 'mega meal' in 2001, containing half of an adult's habitual daily energy intake. Although the Foods

Standards Agency (Church, 2008) noted a definite increase in portion sizes in the U.K. since the 1980s, only a small number of studies have been conducted on changes in U.K. portion sizes. Two studies have highlighted a trend towards larger portions, with significant increases in confectionary and fast food portion sizes (Benson, 2009; Wrieden, Gregor, & Barton, 2008).

Notably, research indicates an association between increasing portion sizes and the prevalence of overweight and obesity (Nielsen et al., 2003; Rolls, 2003; Young & Nestle, 2002, 2003), which supports the argument that increased portion sizes could be a contributor to obesity (Ledikwe, Ello-Martin, & Rolls, 2005). Although it is difficult to discern how changes in portion size have influenced intake over time, Piernas and Popkin (2011), using survey data from 1977 to 2006, report that increased portion sizes of energy-dense foods were important contributors to excess energy intake for U.S.A. children and adolescents. Furthermore, Duffey and Popkin (2011), using data from various U.S.A. national health surveys, report changes in portion sizes to be among the environmental factors that accounted for most of the change in daily total energy over the last 30 years. Thus, historical increases in portion sizes have been identified as a potentially important contributor to the increased prevalence of overweight and obesity (Ledikwe, Ello-Martin, & Rolls, 2005; Nielsen et al., 2003; Rolls, 2003; Young & Nestle, 2002, 2012).

1.4.2 The Portion Size Effect

The notion that historic increases in portion size may have caused increased energy intake at the population level is supported by robust evidence that people consume more food and energy when presented with larger portions, which is termed the

'portion size effect' (Zlatevska, Dubelaar, & Holden, 2014). According to a recent meta-analysis of portion size studies by Zlatevska et al. (2014), for a doubling of portion size consumption increases by 35% on average. Effect sizes of at least 30% higher consumption due to portion size are reported frequently, with larger effects for larger portion sizes (Steenhuis & Vermeer, 2009). Also, Hollands et al. (2015) investigated the influence of exposure to different sizes or shapes of portions, packages, or individual items on selection or consumption of food products. Their meta-analysis found moderate quality evidence that exposure to larger portion sizes increases food consumption among adults and children, with a larger effect found in adults than children.

The portion size effect has been reliably observed across different participant populations, including children (Fisher & Kral, 2008; Fisher, Liu, Birch, & Rolls, 2007; Reale et al., 2019; Rolls et al., 2000), young adults (Levitsky & Youn, 2004; Piernas & Popkin, 2011) and adults. The effect of portion size has also been evidenced in laboratory (Levitsky & Youn, 2004; Rolls, Roe, Meengs, et al., 2004), restaurant (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Hinton et al., 2013; Reinders, Huitink, Dijkstra, Maaskant, & Heijnen, 2017) and free-living settings (French et al., 2014). Furthermore, the effect operates irrespective of who determines the amount of food on the plate (i.e. subject or experimenter) (Levitsky & Youn, 2004; Rolls et al., 2002), participant characteristics such as BMI (Kral, Remiker, Strutz, & Moore, 2014; Smith, Conroy, Wen, Rui, & Humphries, 2013), dietary restraint scores, disinhibition scores, or gender (Fisher, Arreola, Birch, & Rolls, 2007; Hollands et al., 2015; Rolls et al., 2002; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, & Meengs, 2007; Rolls, Roe, Meengs, et al., 2004; Zuraikat, Roe, Privitera, & Rolls, 2016). However, although the effect operates in both men and women (Rolls et al., 2002), the magnitude of the portion size

effect has been observed to be greater in men compared to women (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, & Meengs, 2006a; Rolls, Roe, Meengs, et al., 2004).

The portion size effect is observed at various eating occasions with various food types, including meals (Diliberti et al., 2004; Levitsky & Youn, 2004; Reinders et al., 2017; Roe, Kling, & Rolls, 2016; Rolls, Roe, Meengs, et al., 2004), snacks (Girju & Ratchford, 2018; Rolls, Roe, Kral, et al., 2004), and beverages (Flood, Roe, & Rolls, 2006; Papies, 2018). The portion size effect operates with amorphous food (Cavanagh, Vartanian, Herman, & Polivy, 2014; Slawson & Eck, 1997), and in cases when people cannot physically see their portion size (Burger, Fisher, & Johnson, 2011; Scheibehenne, Todd, & Wansink, 2010). However, the portion size effect is especially pronounced with energy-dense foods (Hollands et al., 2015) and individuals have been found to consume more when the portion size of a snack food as opposed to a non-snack food is doubled (Zlatevska et al., 2014). Furthermore, the portion size effect has been found to be curvilinear (Vandenbroele, Van Kerckhove, & Zlatevska, 2019; Zlatevska et al., 2014). From a study perspective, this may also mean that the magnitude of the portion size effect depends on the baseline portion against which intake from larger portions is being compared. This is important to consider when comparing the results of portion size studies. Nonetheless, the current body of research into the portion size effect indicates that it is a robust and widely observed effect.

Participants have been found to consume more from larger portions, even when asked to focus on their body signals in a prior mindfulness task (Marchiori & Papies, 2014), and with a mindfulness intervention that encouraged participants to focus on the taste of the food they were consuming and their internal hunger and satiety signals (Cavanagh et al., 2014). Interestingly, changes in portion size appear to go largely unnoticed by consumers. For example, Rolls et al. (2002) served participants 4

different portion sizes of a meal over a 4-week period (one lunchtime a week) and found that less than half (45%) of participants reported noticing differences in the lunches served. In addition to this, increased intake does not appear to be compensated for by subsequent reductions in intake; often reported ratings of hunger and satiety do not significantly differ despite an increase in consumption from larger portions (Herman, Polivy, Pliner, & Vartanian, 2015; Kral, Roe, & Rolls, 2004; Rolls et al., 2002; Rolls, Roe, Meengs, et al., 2004).

In 2 further studies, Rolls and colleagues found that increasing portion sizes of all foods and beverages by 50% and 100% over 2 consecutive days increased daily energy intake by 16% and 26% respectively (Rolls et al., 2006) and 50% increases in portion sizes of all foods served over 11 days led to a mean increase in daily energy intake of approximately 423kcal, resulting in intakes that exceeded energy requirements for both men and women (Rolls, Roe, & Meengs, 2007). Roe, Kling, and Rolls (2016) also found that serving all foods in large portion sizes led to increased intake of the entire meal and of each food, and there was no indication that they accounted for the increased portion sizes by adjusting their intake of any of the foods.

However, there are limitations to these studies suggesting that increases in portion size are not compensated for. For example, Benton (2015) argues that the laboratory is too artificial a situation to reflect whether compensation occurs, as there is limited choice over the meals the individual consumes. In the typical eating environment, where individuals are free to choose from a variety of foods, compensation may be more likely to occur. However, a study by Jeffery et al. (2007) found no indication of compensation for increased lunch intake over 4 weeks of exposure to larger portions, despite meal intake being higher in larger than the smaller portion condition. There was also evidence of slightly higher weight gain over the 4

weeks in the larger compared to smaller portion condition in this study. Furthermore, French (2014) exposed a free-living sample of working adults to differing portion sizes of a lunchtime meal over 6 months, whereby participants would pick up a lunchbox of 1 of 3 portion sizes every working day. Lunch intake was significantly higher with successive portion sizes and this effect persisted over 6 months. In addition, participants in the largest portion size group demonstrated significant weight gain over the 6-month period compared to the medium and small portion groups.

These studies demonstrate how increased portion sizes could lead to excess energy intake that is not fully compensated for. In summary, eating from larger portions could contribute to weight gain.

1.4.3 Why do we overconsume from larger portions?

There is a wealth of research showing how and when the portion size effect may occur. However, the underlying basis of this effect remains poorly understood, and no research to date has provided conclusive evidence regarding why people overeat when more food is served (Almiron-Roig, Navas-Carretero, Emery, & Martínez, 2018; Benton, 2015; English, Lasschuijt, & Keller, 2015; Herman et al., 2015; Steenhuis & Poelman, 2017; Zuraikat, Smethers, & Rolls, 2019). Understanding why portion size affects energy intake may aid intervention approaches to reduce energy intake and weight. A variety of potential underlying mechanisms explaining why portion size influences food intake have been proposed, but the general lack of supporting evidence means that these underlying mechanisms remain unclear and widely debated. Steenhuis and Poelman (2017) cite dual-process theory (Kahneman, 2003) as important in distinguishing between automatic processes that result from external

influences on intake that may affect the portion size selected (i.e. monetary value) and consumed (i.e. distractions), and more deliberate processes that my reflect mechanisms that steer portion size selection and consumption, such as norms relating to appropriateness and prior experience.

1.5 External Factors Explaining the Portion Size Effect

1.5.1 Monetary value of larger portions

Consumers recognise that larger portions represent better economic value and they get more for their money by purchasing and consuming larger portions (Steenhuis & Vermeer, 2009; Vermeer, Steenhuis, & Seidell, 2010). Burger et al (2011) found that individuals rated larger portions as more appealing and desirable to eat than smaller portions. However, in a controlled restaurant-style setting, Zuraikat, Roe, Smethers, Reihart, and Rolls (2018) demonstrated that although portion size influenced food intake, there was no influence of food cost on food intake, and no food cost by portion size interaction effect. Furthermore, several studies demonstrate that portion size affects food intake even when participants are provided with food they did not have to purchase, for example in laboratory studies (Levitsky & Youn, 2004; Rolls et al., 2002; Rolls, Roe, Meengs, et al., 2004). As people do not fully compensate for increased intake from larger portions in experimental sessions, there are no savings made (Herman et al., 2015). Moreover, if participants wanted "the most for their money" they would presumably eat as much as possible irrespective of being given normal or large sized portions. This, and the fact that the portion size effect is observed in settings where money is irrelevant suggests that value for money alone cannot explain overconsumption from larger portions (Zuraikat et al., 2019). Thus, although value for

money may partly explain why consumers are more likely to choose to purchase larger over smaller portions, this explanation appears less well-suited to explaining why the amount of food served during a meal biases how much people eat.

1.5.2 Distractions

People often consume food in the presence of distractions, such as when dining with others, watching television, or playing computer games. Eating while distracted (sometimes referred to as 'mindless eating' (Steenhuis & Poelman, 2017)), and not focused on the food being consumed, may impair an individual's ability to accurately observe and make conscious decisions about how much to consume (Moray, Fu, Brill, & Mayoral, 2007) and may therefore contribute to passive overconsumption from larger portions. Bellisle, Dalix and Slama (2004) found that both television viewing and listening to an audio story were associated with increased lunchtime energy intake compared to control conditions. Also, Oldham-Cooper, Hardman, Nicoll, Rogers and Brunstrom (2011) found that individuals who were distracted by playing a computer game reported feeling less full after lunch, had a less accurate memory for the lunch, and consumed significantly more biscuits in a subsequent taste test than non-distracted individuals. Furthermore, individuals report lower degrees of fullness and greater desire to eat when distracted by a computer game while eating (Brunstrom & Mitchell, 2006). A review by Robinson et al. (2013) reported that eating whilst distracted is associated with a moderate increase in immediate intake and increased intake at a later point in time, and this effect was independent of dietary restraint.

Given that there is evidence to suggest that individuals are poor judges of portion size or changes in portion size in situations devoid of distraction (Rolls et al., 2002),

frequently eating from large portions in situations where distractions are present may increase the risk of excess energy consumption that goes largely unnoticed. However, there is also evidence that the portion size effect is present before people start eating. Robinson, te Raa, and Hardman (2015) found evidence for a pre-consumption portion size effect; male participants reported that they intended to eat the majority of the meal served, which equated to a large difference in intended energy consumption and actual consumption between portion size conditions. This indicates that people are planning from the outset to eat more from larger portions, as opposed to mindlessly continuing to eat.

1.6 Potential Mechanisms Underlying the Portion Size Effect

1.6.1 Unit bias

Unit bias refers to people's tendency to eat one unit of food irrespective of its size (Geier et al., 2006; Herman et al., 2015), and has been proposed as a potential explanation for why individuals consume more from larger portions. A unit of food could be a serving of a homogenous food such as a plate of pasta, or a more discrete food item such as a biscuit. People consider a single unit to be an appropriate amount to eat, and thus eat more when served a larger unit (Geier et al., 2006). In support, individuals have been found to consume significantly less when served a food in a small unit size compared to a larger size (Marchiori, Waroquier, & Klein, 2011; Weijzen, Liem, Zandstra, & De Graaf, 2007). Chang et al (2012) served participants 500g of fried rice as either small rice balls, large rice balls or an amorphous portion, and found that individuals consumed significantly less when served the fried rice as small rice balls compared to large rice balls and the amorphous portion of rice. This

theory proposes that consumers are sensitive to the number of units when eating, but relatively insensitive to the size of those units. In support, Rolls, Roe, Meengs, et al. (2004) found that significantly more was eaten when the size, but not the number, of sandwiches served was increased. Also, Marchiori, Waroquier, and Klein (2011) found that individuals served full-sized sweets consumed more energy than those served half-sized sweets, but the number of pieces eaten did not vary by group.

Most recently, Vandenbroele, Van Kerckhove, and Zlatevska (2019) specifically separated increases of food unit size and number of units and found that the portion size effect on consumption was determined more by unit size than unit number, with participants eating more when exposed to larger food units as opposed to more food units. Thus, the size of the unit(s) presented appears to be driving increased consumption in these studies. In support, Almiron-Roig, Solis-Trapala, Dodd, and Jebb (2013) found that when participants were asked to estimate how many portions were in a given portion of a food, despite a wide range of answers the number of estimated portions fluctuated around 1 for many foods, which is consistent with the concept of unit bias. Furthermore, a meta-analysis by Hollands et al. (2015) found a small to moderate effect of individual unit size on food intake. However, Raynor and Wing (2007) found no effect of unit size on food consumption. In their study, participants were given a box of food containing 4 different snacks to consume at home. The package unit size (small or large single-serving packets of each snack provided) and amount of a snack food (amount of snacks providing either 4350kcal or 8750kcal) were varied across 4 participant groups. Although an effect of amount of food was found, with a 100% increase in the amount of food provided producing an 81% increase in energy consumed from the snack food, no effect of package unit size

was found. This indicates that the portion size of the food influences intake independent of unit size.

Moreover, Kerameas, Vartanian, Herman, and Polivy (2015) found no evidence that people prefer to eat a single unit, and instead argue that the unit bias may be better categorised as a segmentation effect; people eat less when a quantity of food is separated into multiple smaller units. Finally, Oldham-Cooper, Wilkinson, Hardman, Rogers, and Brunstrom (2017) found that foods presented in multiple smaller units were expected to deliver significantly greater satiety than when presented in a single unit, which could provide part of an explanation as to why people consume less when food is presented in smaller units. They also found that segmentation effects did not explain the portion size effect, as portion size influenced food intake regardless of how the portion was presented. Thus, unit bias may only partly explain the portion size effect.

1.6.2 Appropriateness

In many situations the appropriate amount to eat is unclear and, as internal signals are often unreliable guides, consumers may rely on external cues like portion size to guide their food intake (Herman & Polivy, 2005; Herman et al., 2015; Vartanian, Herman, & Polivy, 2016). If people are served larger portions this may indicate that a larger amount of food is appropriate to consume, resulting in increased food intake. Marchiori, Papies, and Klein (2014) propose that an automatic decision-making process of anchoring and adjustment describes the portion size effect. The portion size works as an anchor or reference point to determine how much to eat, and adjustments

away from this anchor are then made based on additional information such as hunger, variety or liking of the food.

There appears to be a surprisingly wide range of portion sizes that we are prepared to accept as appropriate (Herman & Polivy, 2005). In support, Diliberti et al. (2004) found that smaller (standard) and larger (150% of standard) portion sizes were perceived as equally appropriate; in other words, increasing the portion size by 50% did not render it any less appropriate. Also, Kerameas, Vartanian, Herman, and Polivy (2015) found that participants served 90g of cookies thought that it was appropriate to eat more than did those served 30g of cookies, and that perceived appropriateness mediated the effect of portion size on food intake. Marchiori et al. (2014) asked participants to imagine being served either a small or large portion of food (i.e. low and high 'anchors') and to indicate how much they would consume. Interestingly, these portion size anchors impacted intake estimates even when participants were told that these were randomly chosen and not informative (Marchiori et al., 2014). The fact that portion size informs beliefs about appropriate intake, even when portion sizes vary widely or individuals are told that the portion is not an indicator of appropriateness, suggests that individuals are using the physical amount of food served as a heuristic to determine what is a normal amount to eat. Research into labelling and portion size training supports this. Brown, Rollo, de Vlieger, Collins, and Bucher (2018) report mixed findings with regarding to the influence of labelling on the portion size effect, with no apparent consistent effect of any type of label on food intake. Also, increasing awareness of portion size at a single session (Cavanagh et al., 2014), and as part of a 1-year weight loss programme (Rolls, Roe, James, & Sanchez, 2017) did not mitigate the portion size effect. Thus, the amount of food served (portion size) has a more

powerful influence on how much food people choose to eat, than information about portion size.

This further highlights the recent problem of "portion distortion"; continued exposure to larger portion sizes means that people perceive larger portion sizes to be an appropriate amount to consume in a single eating event (Herman et al., 2015; Schwartz & Byrd-Bredbenner, 2006; Steenhuis & Vermeer, 2009), which in turn may encourage consumption of large portion sizes. Larger portions have become standard and consequently, consumers have difficulty selecting amounts of food that are appropriate for their weight and activity levels. For example, even though supermarket portions are often 3 to 4 times larger than recommended portion sizes, consumers perceive them to be standard portions (Steenhuis & Vermeer, 2009). Schwartz and Byrd-Bredbenner (2006) found that typical portion sizes reported were significantly different from those selected by individuals in a similar study conducted 20 years ago.

This is compounded by the fact that people typically incorrectly estimate amounts of food (Nørnberg, Houlby, Jørgensen, He, & Pérez-Cueto, 2014) – even those with expertise in nutrition (Japur & Diez-Garcia, 2010) – and are largely unaware of reference and recommended portion sizes, often citing portions as 'normal' that deviate from recommendations (Almiron-Roig et al., 2013; Brogden & Almiron-Roig, 2011; Burger, Kern, & Coleman, 2007). Thus, larger portion sizes may be altering consumer perceptions of what is a normal portion size. Robinson et al. (2016) investigated this in 3 experimental studies, and although they found that visual exposure to larger portions sizes influenced perceptions of what constitutes a 'normal' portion, there was no evidence that this altered food intake. Furthermore, in a more recent study, Robinson and Kersbergen (2018) found that being served and consuming a smaller portion influenced both perceptions of normality and led to the selection of

smaller portions and reduced consumption at a subsequent eating occasion 24 hours later. This suggests that portion sizes may indicate to consumers what constitutes a 'normal' portion. This supports findings from Herman and Polivy (2005), who argue that while hunger and satiety play a small role in everyday eating, the principal regulatory influence on food intake is exerted by norms which inform us how much is appropriate to eat.

However, the normative explanation alone seems unlikely to fully explain the portion size effect. A meta-analysis by Zlatevska et al. (2014) highlighted that a 100% increase in portion size led to a 35% increase in intake. This is lower than we would expect if individuals were following an appropriateness norm. If individuals perceive a given portion size as appropriate we would expect them to finish or attempt to finish this larger portion, equating to closer to a 100% increase in intake as opposed to 35%. In addition, although Kerameas et al. (2015) found that norms of appropriate intake mediated the effect of portion size on intake, there was not evidence of full mediation. Likewise, Versluis and Papies (2016) report that appropriateness only partially mediated the effect of portion size in their study investigating portion size, social norms and the portion size effect. This indicates that the portion size effect is not fully explained by social norms of appropriateness.

1.6.3 Pre-meal planning

Pre-meal planning may outweigh within-meal influences such as the onset of fullness and contribute to overeating from larger portions (Brunstrom, 2011; 2014; Fay et al., 2011). Several studies demonstrate that individuals plan the amount of food that they are going to eat before a meal begins (Fay et al., 2011; Hinton et al., 2013). Fay et al.

(2011) found that people usually plan to consume most or all of a portion and this plan is typically adhered to once made, even if this means eating past the point of fullness. Pre-meal planning was found to be the strongest predictor of intake, whereas within-meal consumption factors were weaker predictors, supporting the suggestion that satiation plays a secondary role in determining how much food is consumed. These pre-meal plans were resistant to modification over the course of the meal, with only 18% reporting consumption that deviated from planned. Also, Robinson, te Raa, et al. (2015) found evidence for a pre-consumption portion size effect and that people tended to eat in accordance with these pre-meal intentions, which translated to a portion size effect on actual consumption in male participants, indicating that people decide how much of a portion to consume before a meal commences. However, there was no evidence of a pre-consumption portion size effect in females in this study, suggesting pre-meal planning is unlikely to fully explain the portion size effect.

1.6.4 Individual differences and the portion size effect

As mentioned previously, the portion size effect has been reliably observed across different situations and participant populations, and operates irrespective of various individual differences including BMI (Kral et al., 2014; Smith et al., 2013), dietary restraint scores, disinhibition scores or gender (Fisher, Arreola, Birch, & Rolls, 2007; Hollands et al., 2015; Rolls et al., 2002; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, & Meengs, 2007; Rolls, Roe, Meengs, et al., 2004). Some moderating factors were identified by Zlatevska et al. (2014) in a recent meta-analysis which reported that the portion size effect is smaller among children, women and people with higher BMI.

However, these findings should be treated with some caution, as they may in part be caused by differing methodology in different studies.

Recent literature indicates that individuals with low socio-economic status (SES) are more susceptible to overconsuming from larger portions. Best and Papies (2019) found that individuals identified as having lower SES intended to consume significantly more from larger portions of unhealthy snack foods, which translated into 15-22% increase in energy intake, whereas there was no difference in the intended consumption of healthy snack foods. This difference in susceptibility is suggested to result from increased exposure to unhealthy food environments (Burgoine et al., 2016) and particular psychological processes that predispose them to overconsume in these environments (Best & Papies, 2018). For instance, Best and Papies (2018) found that the effect of SES on intended consumption was mediated by perceptions of how much is appropriate to eat and trait impulsiveness.

Satiety responsiveness, how well individuals can regulate their food intake in response to physical feelings of fullness, has also been highlighted as influencing the effect of portion size on food intake. Zuraikat, Roe, Smethers, Reihart, et al. (2018) reported that serving larger portions led to increased intake in individuals with lower satiety responsiveness scores but did not affect intake in those with higher scores. Thus, the portion size effect was attenuated for individuals who are good at regulating their food intake in response to feelings of fullness. A similar response has been identified in children, with Mooreville et al. (2015) finding that serving larger portions led to greater increases in food intake in children with lower satiety responsiveness and greater food responsiveness compared to children with high satiety responsiveness scores and lower food responsiveness. Kling, Roe, Keller, and Rolls (2016) also found that children rated higher in food responsiveness showed a larger portion size effect

on meal intake, although they did not replicate the finding regarding satiety responsiveness. The mixed results here may be due to the children's satiety and food responsiveness being reported by their parents.

1.6.5. Summary and thesis focus

To summarise, there is a plethora of proposed explanations for why people overconsume from larger portions. Although there is evidence to support some of these explanations, none appear to fully explain the effect of portion size on food intake. Determining the mechanisms underlying the effect of portion size has applied relevance to public health, as it would clarify what interventions may be worthwhile and effective targets to reduce intake from larger portions. This thesis will focus on investigating 2 factors that may explain why people eat more from larger portions, specifically plate-clearing tendencies and food waste concerns.

1.7 Plate-clearing

1.7.1 Plate-clearing tendencies

A tendency to clear one's plate when eating out of habit ("plate-clearing") could explain why larger portion sizes promote overeating. When given larger portions, individuals who habitually plate-clear may be more likely to attempt to finish the portion, and so will be more likely to consume more food, which arguably leads to the portion size effect. Many people plate-clear. Robinson and colleagues found that a large proportion of both U.K. and U.S. participants reported plate-clearing tendencies (Robinson & Hardman, 2016; Robinson et al., 2015), with the majority (77.9%) of

U.K. participants agreeing that they 'always tend to clear [their] plate when eating' (Robinson & Hardman, 2016). Fay et al. (2011) found that participants reported plate-clearing at most meals (91%) and planning to do this in most cases (92%). Also, 2 restaurant-based studies report high incidences of plate-clearing, with Hinton et al. (2013) reporting that in the majority of meals (83%), most or all of the food weight was consumed (90% or more), and Lorenz et al. (2017) reporting that most (72%) participants indicated that they had no food leftovers when eating. These findings demonstrate that clearing one's plate is a common tendency. Furthermore, Fay et al. (2011) reported that, of the 91% who reported clearing the plate at their previous meal, 28% reported plate-clearing despite reaching satiation earlier in the meal. This indicates that plate-clearing tendencies are a common influence on meal intake, potentially overruling within-meal influences on intake. Although research into how plate-clearing tendencies affect food intake in an obesogenic food environment is currently sparse, parental encouragement to clear the plate in childhood and food waste concerns have been highlighted as potentially important in the development of plate-clearing tendencies (Fay et al., 2011; Robinson & Hardman, 2016).

1.7.2 Encouragement to plate-clear in childhood

Plate-clearing tendencies may be cultivated from an early age as a result of parenting practices (Birch, McPhee, Shoba & Steinberg, 1987; Rolls et al., 2000). This may potentially reduce reliance on internal satiety cues and shift attention to external environmental cues, such as portion size (Birch et al., 1987). If children are socialised to respond to environmental cues, then large portions could encourage children to over-eat, thus contributing to weight gain (Rolls et al., 2000). In support, mothers who

were more controlling in their feeding practices, for example encouraging children to eat only at mealtimes or to finish all of the food given to them, had children who displayed less evidence of self-regulating intake (Johnson & Birch, 1994). Also, Birch et al. (1987) encouraged children to focus on either external cues (including the amount of food left on the plate) or internal cues of intake (such as hunger and satiety) and gave them either a low or high calorie density preload before allowing *ad libitum* consumption of snacks. The children encouraged to focus on internal cues showed evidence of responsiveness to the caloric density of the preload, eating less following the high-calorie compared to the low-calorie preload, whereas those encouraged to focus on external cues did not adjust their intake in response to the caloric density of the preload. Also, when the children were rewarded for consumption, they consumed more food. This demonstrates how encouraging children to focus on external cues could contribute to these individuals being more susceptible to overeating from larger portions. Furthermore, parental encouragement to plate-clear during childhood (retrospectively reported) was found to predict current plate-clearing tendencies (Robinson & Hardman, 2016) and to be associated with overeating in adulthood (Brunstrom, Mitchell, & Baguley, 2005). However, these studies involved retrospectively reporting on experiences of parental encouragement, so there is a potential for biased responses. Interestingly, Benson (2009), in a focus group study, found that many participants reported feeling guilty if they leave food on their plates, as they had been encouraged from an early age to finish their food. Therefore, being served a large portion, along with encouragements such as ‘clear your plate’ or ‘finish all your food if you want dessert’ may result in the development of susceptibility to the influence of larger portion sizes on food intake (Brunstrom et al., 2005).

1.7.3 Plate-clearing, weight gain and overconsumption

In the current obesogenic environment, where large portion sizes are plentiful and common, plate-clearing may be a maladaptive behaviour which could contribute to overeating (Robinson & Hardman, 2016). In support of this idea, research has linked plate-clearing to obesity, showing that individuals with overweight and obesity are more likely to clear their plate when eating than individuals with a healthy body weight (Dodd, Birky, & Stalling, 1976; Krassner, Brownell, & Stunkard, 1979; Le Bow, Chipperfield, & Magnusson, 1985). More recently, Robinson and colleagues found plate-clearing to be predictive of heavier body weight in a sample of young adults, suggesting that a tendency to plate-clear is a risk factor for obesity (Robinson & Hardman, 2016; Robinson et al., 2015).

These associations between plate-clearing tendencies and weight status suggest that plate-clearing may be associated with overconsumption, and thus may contribute to weight gain. Plate-clearing tendencies may therefore explain why people eat more from larger portions. A small number of portion size studies have examined in secondary analyses whether plate-clearing tendencies moderate the influence that larger portions have on food intake, and have reported that there is no evidence that plate-clearing tendencies statistically moderated the influence of portion size on food intake (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). However, the extent to which plate-clearing tendencies could explain the influence that portion size had on food intake was not the primary focus of these studies, resulting in a limited sample size for moderation analysis, along with limited information regarding how plate-clearing tendencies were measured and whether the sample included a substantial

number of participants with and without plate-clearing tendencies. Thus, there has been no research to date that has primarily examined whether plate-clearing tendencies are associated with increased *ad-libitum* food intake.

1.7.4 Summary

In summary, the tendency for most people to clear their plates when eating may explain why people tend to eat more from larger portions of food. Plate-clearing tendencies may lead people to habitually consume more from larger portions in an attempt to clear the portion they are served. Parental encouragement during childhood to clear the plate at mealtimes and concerns about food going to waste may in part explain widespread plate-clearing tendencies. Although plate-clearing tendencies have been shown to be associated with increased BMI, little research has examined the influence of plate-clearing tendencies on food intake and the effect of larger portion sizes on eating behaviour.

1.8 Food Waste Concerns

1.8.1 The global problem of food waste

Food waste is a growing problem, with an estimated one third of all food produced for human consumption being wasted at great economic and environmental cost (Food and Agriculture Organization of the United Nations, 2014; Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011). This equates to around 1.3 billion tonnes of food wasted annually, with an estimated cost of $750 billion (Food and Agriculture Organization of the United Nations, 2013). High levels of food waste exacerbate

environmental impacts such as greenhouse gas emissions, nutrient loss, and the inefficient use of resources, all of which have substantial economic costs (Food and Agriculture Organization of the United Nations, 2014). As the majority of preventable food waste occurs at the household level in medium to high income countries (Gustavsson et al., 2011; Quested, Ingle, & Parry, 2013), various campaigns and schemes to raise awareness of household food waste are in operation. A famous example is the "Love Food Hate Waste" campaign (The Waste and Resources Action Programme, 2019). Since the campaign's launch in 2007, tackling food and drink waste has received much attention worldwide, with innovations from governments, businesses and local authorities. Furthermore, there was a reduction of 1.3 million tonnes (15%) of household food and drink waste between 2007 and 2012. However, there is still a huge problem: of the 7 million tonnes still wasted, 60% was identified as avoidable (Quested et al., 2013).

Rather than a standalone behaviour, wasting food results from interactions between a myriad of behaviours and attitudes related to purchasing, storage and preparation of food, as well as consumption (Abdelradi, 2018; Aktas et al., 2018; Ganglbauer, Fitzpatrick, & Comber, 2013; Gjerris & Gaiani, 2013; Parizeau, von Massow, & Martin, 2015; Quested, Parry, Easteal, & Swannell, 2011). The literature highlights misunderstanding use-by dates (Abeliotis, Lasaridi, & Chroni, 2014), the pressures of family, time and the need for a convenient lifestyle (Mallinson, Russell, & Barker, 2016; Parizeau et al., 2015), food expiring or being thrown out without being prepared into a meal and over-purchasing (Gaiani, Caldeira, Adorno, Segrè, & Vittuari, 2017) as relevant to food waste at the household level. Even 'green' consumers – such as those who value organic food and vegetarianism – waste a lot of

edible food, providing reasons such as spoilage, short shelf life, forgotten in the fridge, or eating outside of the home (McCarthy & Liu, 2017).

1.8.2. Public opinion on food waste

Individuals are aware of this global issue, with most consumers citing food waste as a serious issue with individual responsibility. Principato, Secondi, and Pratesi (2015) found that the majority (84.1%) of respondents reported being aware of the economic and environmental problems liked to food waste. Parizeau et al. (2015) reported that although many cited food waste as an environmental (68%) or economic (72%) problem, it was most commonly cited as a social problem (83%). Importantly, most individuals report being concerned about food waste (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015). Specifically, Setti, Falasconi, Segrè, Cusano, and Vittuari (2016) found that the majority of their sample reported being concerned about food waste from an ethical standpoint (86%) and were aware of the environmental consequences (82%). Also, Gaiani et al. (2017) found that most (64.7%) of their respondents considered the environmental impact of food while shopping, with some (30.8%) taking it into account occasionally, and only few (4.3%) not considering it at all. Most of their respondents considered food waste a serious issue (90%) and reported being worried about food waste (78%).

Many consumers are averse to waste (Bolton & Alba, 2012), particularly food waste (Gjerris & Gaiani, 2013), and the ‘waste not want not’ attitude “appears to be embedded in the [British] public’s consciousness” (Benson, 2009, page 4). A number of surveys highlight that consumers are aware that their purchasing behaviour is wasteful and associate wasting formerly usable food with negative emotions, most typically guilt (Evans, 2011, 2012; Quested, Marsh, Stunell, & Parry, 2013; Quested

et al., 2011; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013). Wasting food is cited as wrong (Graham-Rowe, Jessop, & Sparks, 2014), inappropriate, unacceptable, and irresponsible (Lorenz et al., 2017), whereas engaging in behaviours to reduce food waste is good, beneficial, pleasant and satisfying (Russell, Young, Unsworth, & Robinson, 2017), as well as being the 'right' thing to do (Graham-Rowe et al., 2014). Parizeau et al. (2015), investigated the guilt associated with different household wasting behaviours and found that the most guilt-inducing practice was wasting food, with most respondents (85%) agreeing wasting food made them feel guilty. Furthermore, Abeliotis, Lasaridi, and Chroni (2014) found that, while the majority (90%) of their sample reported that they care 'a great deal' about the amount of food wasted in their household, only few (10%) reported that they cared 'a little' or 'not very much', and no one selected 'I don't care'. Visschers, Wickli, and Siegrist (2016) found that Swiss responders typically reported strong negative attitudes towards food waste, and held subjective and personal norms opposed to wasting food. Thus, there appears to be a strong 'feel bad' factor around wasting food (Abeliotis et al., 2014).

Given that consumers are generally averse to food waste (Bolton & Alba, 2012), it is reasonable to predict that intentions drive food waste behaviours. However, the literature is mixed on how these emotions translate into action. Visschers et al. (2016) found that intentions to reduce food were rather high, and related to less food waste. However, it has also been found that intentions are negatively associated with food waste behaviour (Aktas et al., 2018; Russell et al., 2017), or do not have a significant effect on reported food waste (Stefan et al., 2013). This counter-intuitive finding may reflect individuals being aware that they waste a lot of food, which creates stronger intentions to reduce food waste although their actual food waste behaviour may not change. Interestingly, Graham-Rowe, Jessop, and Sparks (2015) found that

intentions were significantly associated with increased likelihood that participants had reduced their household fruit and vegetable waste a week later. However, they did not look at behaviour any further than one week later, and the self-reported nature of the study could reflect demand characteristics.

In summary, it appears that individuals are typically aware of the problem posed by food waste. Wasting food breeds negative feelings such as guilt and concern and individuals are motivated to reduce food waste, albeit with questionable levels of success.

1.8.3 Food waste concerns and overconsumption

Given that concerns about food waste may be common (Evans, 2011, 2012), one obvious action an individual can take to waste less food is to eat more or all of the food that is served to them. Thus, when served larger portions of food consumers may try to eat more food in order to ensure that less food is wasted. Concerns about food waste may therefore contribute to increased food intake from larger portions and weight gain. Although food waste concerns have not been investigated in the context of food intake before, Hall, Guo, Dore, and Chow (2009) suggest a link between surplus food, food waste and overeating. Using the U.S.A. as an example, they argue that the obesity epidemic has been the result of a 'push effect' of increased food availability and marketing, with individuals being unable to match their food intake with the increased supply of cheap, readily-available food. Thus, addressing the surplus of food in our food environment may reduce both food waste and obesity rates. This is supported by Roe, Apolzan, Qi, Allen, and Martin (2018) who analysed plate waste under free-living conditions. Although participants wasted more food from larger portions, they still

overconsumed from these larger portions. This indicates that larger portions paradoxically contribute to both overconsumption and wasting of food (Hall et al., 2009).

There has currently been very little research into how food waste concerns can influence food intake, but one study found that the most common reason given for why people continued eating past the point of fullness was “to avoid wasting food” (Fay et al., 2011). Also, Robinson and Hardman (2016) found that people with personal food waste concerns were more likely to report being plate-clearers. Therefore, food waste concerns may promote plate-clearing tendencies, which in turn would be hypothesised to increased food intake from larger portion sizes. In addition, 2 studies have found that presenting participants with a take-away container, a method to save surplus or leftover food from going to waste, reduced how much food they consumed. Bates and Shanks (2015) found that participants provided with a take-away container at the start of a lunchtime meal consumed an average of 90kcal less of the meal than participants who were not given a container. In support, Zuraikat, Roe, Smethers and Rolls (2018) followed a similar paradigm over 4 laboratory sessions with 4 portion sizes (100%, 125%, 150% and 175% of baseline) but instead informed participants that leftover food would be packaged to take away after the meal. Participants provided with this information consumed less than those in a control condition without a take-away option. It could be argued that in these 2 studies the availability of a take-away container reduces how much people eat in that sitting by reducing concerns about food waste, although this explanation was not directly tested.

In the aforementioned study by Robinson and Hardman (2016), personal food waste concerns were measured via a single non-validated question: “I don’t like to see food going to waste”. In order to measure food waste concerns in the studies reported

in this thesis, a food waste concerns scale was created and validated. Aktas et al. (2018) created a 4-item scale to measure personal attitudes towards food waste, including items such as “I feel bad when uneaten food is thrown away”, but it does not measure food waste concerns in relation to eating behaviour. This is also true of a scale created by Stancu et al. (2016) to measure attitudes towards food waste. Graham-Rowe et al. (2015) also created a scale to measure attitudes towards wasting food. However, this was in a very specific context, addressing a specific behaviour (“to reduce the amount of fruit and vegetables that gets thrown away from my household…”) (Graham-Rowe et al., 2015, page 197). In comparison, our scale was designed to measure concerns towards food being wasted generally, rather than in a specific context. Therefore, although there are some existing scales that measure attitudes towards food waste, these focus more specifically on engaging in food waste behaviours (Graham-Rowe et al., 2015; Russell et al., 2017) or do not include a food intake element (Aktas et al., 2018; Stancu et al., 2016). Therefore, we created a scale to measure food waste concerns in the context of food intake.

1.8.4 Summary

In summary, food waste remains a global problem, with many reporting feelings of guilt around wasting food and desires to reduce the amount of food they waste. Individuals may be encouraged to consume more food from larger portions to reduce the amount of food that goes to waste at an eating occasion. This could encourage overconsumption, particularly when consumers are frequently faced with larger portion sizes. So far, there has been no research directly investigating the influence of food waste concerns on food intake.

1.9 Summary and Thesis Aims

This thesis examines 2 factors that have received little empirical attention to date, plate-clearing tendencies and food waste concerns, both of which have not yet been explored in relation to overeating from large portions of food. Plate-clearing tendencies may lead people to habitually consume more from larger portions in an attempt to clear the portion they are served, and food waste concerns may encourage people to consume more from larger portions to reduce the amount of food that is wasted. Furthermore, whether these factors interact to influence overconsumption, and how they may moderate the portion size effect, is unknown. Desires to plate-clear when given a portion of food may explain why people overeat from larger portions, and food waste concerns may encourage plate-clearing habits and thus overconsumption. Therefore, the overarching aim of this thesis is to investigate how plate-clearing tendencies and concerns about food waste may contribute to overconsumption from larger portions. See Figure 1.1 (page 37) for a schematic of the structure of this thesis and the aims informing each study, and Figure (page 38) for a schematic demonstrating how each study addresses the overarching objectives of this thesis.

Chapter 2 examines whether plate-clearing tendencies explain why people overeat from larger portions. It describes a laboratory study in which participants were categorised as plate-clearers and non-plate-clearers (using a question from a 5-item plate-clearing scale (Robinson, Aveyard, et al., 2015)) before attending a single session, during which they were served a lunchtime meal of either a normal or larger portion of pasta in tomato sauce. I tested the hypothesis that portion size would have a stronger influence on food intake for plate-clearers than non-plate-clearers, and that

portion size and a tendency to plate-clear would be independently associated with increased food intake.

Chapter 3 investigates the reliability and validity of the food waste concerns scale, a 5-item scale that we devised. The first aim was to investigate the factor structure, test-retest reliability, the convergent and divergent validity of this scale. In the first study, participants completed the same questionnaire, which included the food waste concerns scale, measures of attitudes, intentions and emotions towards food waste, and measures of hunger and overeating, on 2 separate occasions with a 2-week gap. In the second study, a large cohort of participants answered the food waste concerns scale, the plate-clearing scale (Robinson, Aveyard, et al., 2015) and their BMI was objectively measured. The association between food waste concerns, plate-clearing tendencies and measured BMI, was investigated. The second aim of Chapter 3 was to investigate the relationship between food waste concerns, plate-clearing tendencies and overeating from larger portions. The third study examined whether food waste concerns and plate-clearing tendencies are predictive of eating more from large portions in the laboratory. Responses on the plate-clearing and food waste concerns scales were obtained before participants attended a laboratory session, during which they were served a larger-than-normal portion of pasta in tomato sauce for lunch and their meal intake was measured. I investigated whether food waste concerns would be associated with increased food intake directly and via plate-clearing tendencies.

Chapter 4 investigated how food waste concerns influence food intake, specifically whether intake is affected by being explicitly told that leftover food will be wasted through 2 laboratory studies. In the first study, participants were presented with a control message or told that leftover food will be saved, wasted or available for them to take home at the end of the study. In the second study, participants were either

presented with a control message or told that leftover food would be wasted in a more rigorous design and with a larger sample size. Participants were then given a large portion of a snack food to consume whilst watching TV. I investigated the hypothesis that participants would consume more if they are told that leftover food will be wasted.

Finally, Chapter 5 investigated how plate-clearing tendencies and food waste concerns are associated with intended consumption from larger portions. Chapter 5 describes an online study in which participants were shown images of pasta in tomato sauce served in a range of portion sizes and asked how much of each portion they would intend to eat at a hypothetical meal. Self-reported plate-clearing tendencies and food waste concerns were also measured. I investigated whether individuals would intend to consume more from larger than smaller portions, and whether plate-clearing tendencies and food waste concerns would moderate the effect of portion size on intended consumption.

Figure 1.1. Flowchart showing the overall thesis structure and aims of each individual study

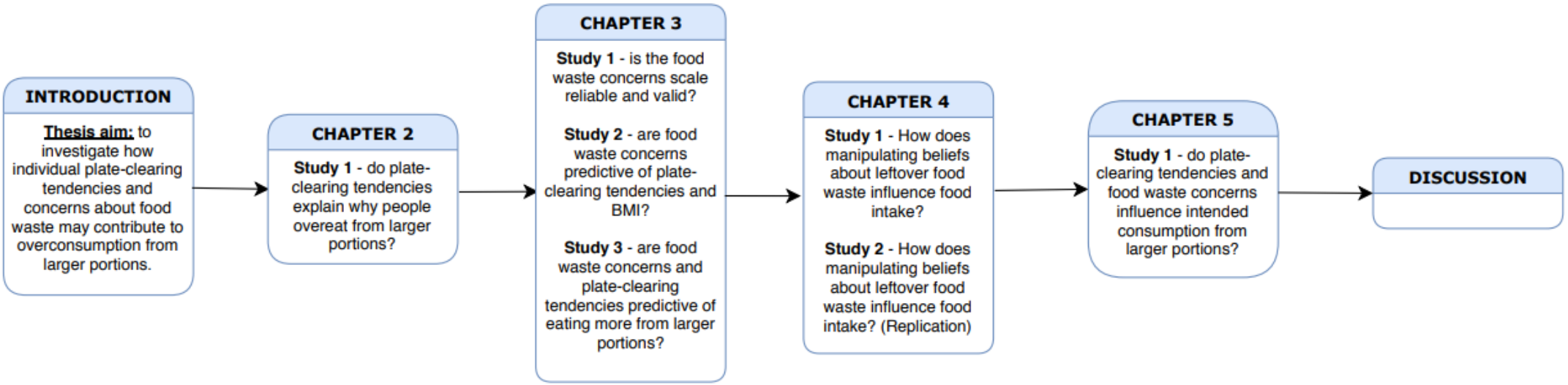
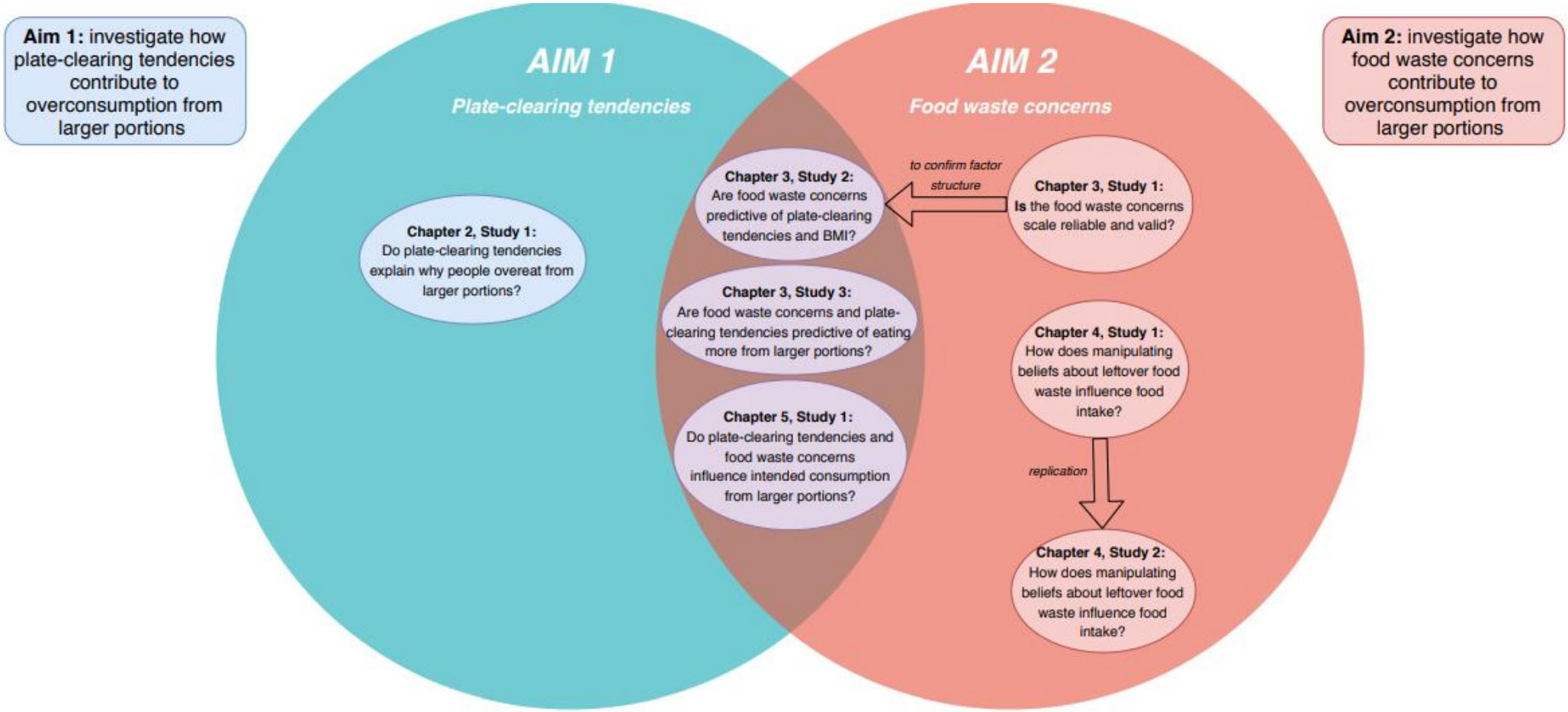


Figure 1.2. Venn diagram showing how each study addresses the overarching thesis aim



Chapter 2: Plate-clearing tendencies and overeating from larger portions

2.1 Chapter Introduction

This chapter addresses the following question: do plate-clearing tendencies explain overconsumption from larger portions? It has been reliably demonstrated that larger portions lead to increased consumption (Zlatevska et al., 2014). However the mechanisms underlying the effect of portion size remain unclear and a myriad of potential explanations and mechanism have been proposed (Almiron-Roig et al., 2018; Benton, 2015; English et al., 2015; Herman et al., 2015; Steenhuis & Poelman, 2017). No research to date has provided a conclusive explanation of the portion size effect; the ubiquitous tendency to clear the plate when eating could in part explain why people eat more from larger portions.

The study reported in Chapter 2 has been published as:
Sheen, F., Hardman, C. A., & Robinson, E. (2018). Plate-clearing tendencies and portion size are independently associated with main meal food intake in women: A laboratory study. *Appetite*, *127*, 223-229.

2.2 Introduction

The tendency for larger portion sizes of food to promote increased food intake, the 'portion size effect', has been observed across multiple food types (Diliberti et al., 2004; Levitsky & Youn, 2004; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004), situations (e.g. laboratory (Rolls, Roe, Meengs, et al., 2004) and restaurant setting (Diliberti et al., 2004)), and participant populations (Levitsky & Youn, 2004; Rolls et al., 2000, 2002). The portion size effect occurs irrespective of who determines the amount of food on the plate (Rolls et al., 2002) and individual differences such as BMI, dietary restraint, disinhibition or gender (Rolls et al., 2002, 2007; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). Since the 1970s, portion sizes of foods served both in and outside of the home have been increasing and marketplace portions now exceed nutrition recommendations (Matthiessen et al., 2003; Nielsen & Popkin, 2003; Smiciklas-Wright et al., 2003; Young & Nestle, 2007). Because of this, it has been suggested that increases in portion size may be partly responsible for population level weight gain (Rolls, 2003; Steenhuis & Vermeer, 2009; Young & Nestle, 2002).

A variety of potential underlying mechanisms explaining why portion size influences food intake have been proposed, but the general lack of supporting evidence means that these underlying mechanisms remain unclear and widely debated (see Herman et al. (2015) and Benton (2015) for recent reviews). A normative explanation suggests that consumers rely on external cues such as portion size to inform on what is a 'normal' or 'appropriate' amount to eat (Herman & Polivy, 2005; Herman et al., 2015; Vartanian et al., 2016); if people are served larger portions this indicates that a larger amount of food is appropriate to consume and this results in increased food intake. In a similar vein, Marchiori, Papies, and Klein (2014) propose that an anchoring

and adjustment process may explain the portion size effect. Portion size serves as a cognitive 'anchor' or reference point to determine how much to eat, and adjustments away from this anchor are then made based on additional information such as hunger or liking of the food.

A tendency to clear one's plate when eating out of habit ('plate-clearing') could explain why larger portion sizes promote overeating, as we reason that individuals who attempt to plate-clear will be more influenced by the amount of food served to them (i.e. they are less reliant on internal signals of satiety). Past research has linked plate-clearing to obesity, showing that individuals with overweight and obesity are more likely to clear their plate when eating than their normal weight counterparts (Dodd et al., 1976; Krassner et al., 1979; Le Bow et al., 1985). More recently, 2 studies (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016) have shown that self-reported plate-clearing tendencies are positively associated with BMI, suggesting that a tendency to plate-clear is a risk factor for obesity. Moreover, in these studies (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016) a large proportion of participants reported plate-clearing tendencies, suggesting that plate-clearing is relatively common. In support of this, a study by Hinton et al. (2013) found that in 83% of meals, 90% or more of the food weight was consumed. Fay et al. (2011) found that plate-clearing was reported for 91% of meals and pre-planned in 92% of cases. Furthermore, 28% of these participants reported plate-clearing despite reaching satiation earlier in the meal. Thus, the tendency to plate-clear when eating appears to be common and this behavioural tendency could in part explain why consumers eat more when served larger portions of food.

A small number of portion size studies have examined in secondary analyses whether plate-clearing tendencies moderate the influence that larger portions have on

food intake, and have found no evidence that plate-clearing tendencies statistically moderated the influence of portion size on food intake (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). However, the extent to which plate-clearing tendencies could explain the influence that portion size had on food intake was not the primary focus of these studies, resulting in a limited sample size for moderation analysis, along with limited information regarding how plate-clearing tendencies were measured and whether the sample included a substantial number of participants with and without plate-clearing tendencies. Thus, there has been no research to date that has primarily examined whether plate-clearing tendencies are associated with increased *ad-libitum* food intake.

The aim of the present study was to examine whether the tendency to clear one's plate when eating is associated with greater food intake in response to increased portion size. We recruited participants who self-reported a tendency to clear their plate when eating (plate-clearers) and participants who did not self-report this tendency (non-plate-clearers) into a laboratory study. Participants were served either a normal or large sized lunchtime meal and meal food intake was objectively measured. This design allowed us to examine whether the influence that portion size has on food intake is moderated by plate-clearing tendencies (portion size*plate-clearing tendency interaction effect), to replicate the effect that portion size has on food intake (main effect of portion size), and to examine whether the tendency to clear one's plate when eating is associated with increased food intake (main effect of plate-clearing tendency). We predicted that plate-clearing tendencies would moderate the influence of portion size on food intake; portion size would significantly influence food intake among participants with a tendency to plate-clear when eating, but this effect would be smaller (or non-existent) among participants without a tendency to plate-clear when eating.

We also predicted that both portion size and a tendency to plate-clear would be independently associated with increased food intake.

2.3 Method

Participant recruitment and eligibility

We aimed for a minimum sample size of 80 participants ($n \geq 20$ per group) for analytical purposes. We recruited slightly above this number ($N = 91$) in case of having to exclude participant data. As our primary interest was in whether plate-clearing tendencies moderated the portion size effect (and were unsure of the likely association between plate-clearing and energy intake), we opted for this sample size as it provided sufficient power to detect an overall effect of portion size on food intake that was moderate to large in statistical size ($d = .65$, 80% power, $p < .05$), which is in line with a review of portion size studies by Zlatevska et al. (2014). We opted to recruit females only, as gender has been shown to moderate the magnitude of the portion size effect on food intake (Rolls, Roe, Kral, et al., 2004; Rolls et al., 2006; Rolls, Roe, Meengs, et al., 2004).

Participants were recruited from staff and students at the University of Liverpool and the surrounding area. The majority of participants (73%) were reimbursed financially for their participation and a minority of participants were 1st year psychology students participating in exchange for course credit. Eligibility criteria were as follows: female, BMI (self-reported): 18.5-29.9, no history of food allergies, characterized as either a plate-clearer or a non-plate-clearer based on responses to an online screening questionnaire. Demographics questions (age, gender, height and weight), and questions unrelated to the study (i.e. lifestyle questions) were

included in the online screening questionnaire to disguise its purpose. Embedded in the questionnaire was an item used to measure plate-clearing tendencies, as used in Robinson et al. (2015). Participants responded to the question "I always tend to clear my plate when eating" using a 5-point Likert scale. Participants who answered 'agree' were deemed ineligible, as we reasoned that they may not have a particularly strong tendency to plate-clear. Participants who answered 'Strongly disagree', 'Disagree', or 'Neither agree nor disagree' were eligible to participate as non-plate-clearers; those who answered 'Strongly agree' were eligible to participate as plate-clearers. Therefore, our 2 groups of participants were those who identified strongly as being habitual plate-clearers ("plate-clearers") or did not identify as being habitual plate-clearers ("non-plate-clearers").

Design

The current study used a between-subjects design. The independent variables were plate-clearing tendency (plate-clearer or non-plate-clearer) and portion size condition (normal or large). Participants were randomly assigned to a portion size condition using an online random number generator (https://www.random.org/lists/).

Demand characteristics

To disguise the aims of the study it was described to participants as being about 'Hunger and Cognitive Performance'. During the study participants completed a word search task before and after being served a lunchtime meal of pasta in tomato sauce. Feedback questionnaires about the word search tasks were also included to corroborate the cover story, and at the end of the study participants were also asked about their

beliefs regarding the study purpose (see procedure), in order to account for findings being explained by demand characteristics.

Test food

Participants were served pasta in tomato sauce at a 1:1 ratio (Tesco Conchiglie pasta, Dolmio Bolognese 'Smooth Tomato' sauce) in either a 500g or 1000g portion on a standard white dinner plate, with a 500ml glass of water. The 'normal' and 'large' portion sizes used were chosen from the results of a pilot study in which participants reported on the size of pasta meals that would be normal and large in size. These portions were selected to be larger than what people would typically eat in order to reduce the possibility of there being an insufficient amount of food that would have produced an artificial ceiling effect on how much participants ate. In line with other portion size studies (e.g. Rolls et al. (2002, 2006)), the large portion size in the present study was 100% larger than the normal portion size. Pasta dishes have been used as a test food in other portion size studies (e.g. Diliberti et al. (2004) and Rolls et al. (2002)) and pilot testing indicated that participants found the meal to be palatable, which was also confirmed by satisfaction ratings in the current study.

Main measures

Appetite: A mood and appetite measures questionnaire was used, including 3 appetite items: hunger, fullness, and desire-to-eat. These were presented as paper-based 99mm visual analogue scale questions (e.g. "How FULL do you feel right now?") with the anchors of 'Not at all' to 'Extremely'. The accuracy of measurement was confirmed by double entry.

Plate-clearing tendencies: To measure plate-clearing tendencies during the laboratory visit participants completed a self-report measure of plate-clearing, as used in Robinson et al. (2015). The measure consists of 5 questions ("I always tend to clear my plate when eating."; "I normally finish eating when my plate is empty."; "Before I start eating, I normally plan to finish the serving I am about to eat."; "I rarely leave food on my plate."; "It is normal for me to have very little food left or an empty plate at the end of a meal."), with a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Scores were summed, with a higher score indicating stronger plate-clearing tendencies (α =.89, (Robinson, Aveyard, et al., 2015)).

The Dutch Eating Behaviour Questionnaire (DEBQ): The DEBQ (Van Strien, Frijters, Bergers, & Defares, 1986) was used to measure external eating, emotional eating and restraint (e.g. "Do you have the desire to eat when you are irritated?" 'Never' to 'Very often').

Perceptions of portion size: Participants were asked to indicate their opinion regarding the size of the portion they were served for lunch ("In my opinion, the portion I was given in this study was…") with a 7-point Likert scale response format ('Too small' = 1, to 'Too large' = 7).

Awareness of study hypotheses: Participants completed a final questionnaire which included a free-text response question regarding what the participants believed the aim of the study to be ("What do you think the aim of the study was?").

Other measures

Participants also completed other measures relating to their eating habits and their experience during the study that we included for future research purposes, and

therefore did not plan to analyse in the present study. For a full description of these additional measures and missing questionnaire data see Appendix 1 (pages 195-7).

Procedure

The study was approved by the University of Liverpool Ethics Committee. Participants attended a single weekday lunchtime session. To standardize appetite participants were asked not to eat in the 2 hours prior to the study, or drink in the hour prior to the study. On arrival the experimenter obtained informed consent and verbally confirmed that the participant had no known food allergies and had not eaten in the 2 hours prior to the study session. Participants then completed the word search task, in which they were given 3 minutes to find as many words as possible from a list provided in the grid of letters. This was followed by a cognitive task feedback questionnaire, which included filler questions about the difficulty of the task and any distractions they experienced whilst completing the task, and a bogus personality questionnaire consisting of 10 questions. Participants then completed the mood and appetite questionnaire. After completing a short questionnaire to confirm an absence of food allergies, participants were served the lunchtime meal. Participants were told that they could eat and drink as much as they desired and to press a buzzer located in the cubicle to alert the experimenter when they had finished. Upon completion, the experimenter removed the lunchtime meal. Participants were then given a second word search task to complete, after which they answered another cognitive task feedback questionnaire and the mood and appetite measures questionnaire for a second time. Participants then completed the plate-clearing measure, some additional questions that included the perceptions of portion size item, the DEBQ, and a final questionnaire that included the awareness of

study hypotheses measure, before having their height and weight measured. Finally, the experimenter debriefed the participant and reimbursed them for their time. The experimental session lasted for approximately 50 minutes.

Main Analysis Strategy

A 2 x 2 ANOVA, with the between-subjects factors of plate-clearing (plate-clearer/non-plate-clearer) and portion size (normal/large), was used to test whether participant characteristics (age, BMI, external eating, restraint and emotional eating) differed between conditions. We examined differences in appetite (desire-to-eat, hunger, fullness) using mixed ANOVAs, with time (before meal/after meal) as the within-subjects factor, and portion size (normal/large) and plate-clearing tendency (plate-clearer/non-plate-clearer) as the between-subjects factors.

To test our main hypotheses we planned to conduct a 2 x 2 ANOVA with factors of portion size (normal/large) and plate-clearing tendency (plate-clearer/non-plate-clearer). The dependent variable was the weight of food eaten (in grams), which was calculated by weighing the plate of food before and after consumption. We also planned to run a hierarchical regression analysis to examine whether controlling for potential confounding variables had any effect on the results observed, with the following predictors: plate-clearing*portion size interaction, portion size (normal/large), plate-clearing tendency (plate-clearer/non-plate-clearer), BMI, emotional eating score, restraint score and external eating score. Results were considered significant at a $p < .05$.

Sensitivity Analyses

We also planned to examine whether the pattern of results seen in our main analysis was observed when total plate-clearing score was treated as a continuous variable using a moderation analysis, which was run using PROCESS (Hayes, 2013). Portion size (normal/large) was the independent variable (X), weight of food eaten in grams the outcome variable (Y) and plate-clearing tendency (continuous score derived from total scale score) was the moderator (M).

Finally, we also planned to examine the effect of removing participants that were aware of the study aims or those who finished the portion they were served on our main planned analysis. Participants were characterised as being aware of the study aims if in their written response to the question "What do you think the aim of the study was?" they mentioned the influence of portion size. Two researchers independently coded participant responses to this question, and agreed that 11 participants appeared to show some awareness of the study aims. Participants were identified as having finished the portion if they left less than 10% of the weight of the portion uneaten. Under this criterion, 7 participants (6 plate-clearers, 1 non-plate-clearer) were identified as finishing the normal portion size and no participants were identified as finishing the large portion size.

2.4 Results

Sample characteristics

A total of 91 participants were recruited (48 plate-clearers and 43 non-plate-clearers). Two participants were excluded from analyses due to researcher error in the weight of food served. This resulted in 89 participants being retained for use in our main

analysis; 48 plate-clearers and 41 non-plate-clearers, with a mean age of 25.43 (±10.22) years and a mean BMI of 22.42 (±2.63) kg/m^2. See Table 2.1 for participant characteristics, meal satisfaction, average plate-clearing scores for each condition, and full ANOVA results. The average plate-clearing scores were 4.23 (±0.63) for the plate-clearing group and 2.75 (±0.80) for the non-plate-clearing group. There were no significant main effects or interactions for age, BMI, external eating or emotional eating, with the exception of a significant main effect of plate-clearing on restraint scores (p =.001), whereby plate-clearers reported significantly higher dietary restraint scores than non-plate-clearers. The meal received reasonable satisfaction ratings across the conditions and there were no significant differences between the conditions, with the exception of a significant main effect of portion size on satisfaction scores (p =.016), with participants served the large portion size reporting lower meal satisfaction than those served the normal portion size. There were no significant differences between the conditions on average plate-clearing score, with the exception of a significant main effect of plate-clearing group on average plate-clearing score (p <.001), with plate-clearers scoring significantly higher on the plate-clearing scale than non-plate-clearers.

Table 2.1. Participant characteristics, meal satisfaction and average plate-clearing score (values are mean (±SD) and ANOVA results)

	Plate-clearers (n = 48)		Non-plate-clearers (n = 41)		Main effect of Portion Size condition	Main effect of Plate-clearing group	Portion Size by Plate-clearing interaction effect
Portion size condition	Normal (n = 25)	Large (n = 23)	Normal (n = 21)	Large (n = 20)			
Age (years) [b]	25.54 (±8.41)	28.09 (±12.16)	25.05 (±11.96)	22.65 (±7.34)	p >.99, η_p^2 <.01	p =.178, η_p^2 =.02	p =.261, η_p^2 = .02
BMI (kg/m²) [b]	21.50 (±2.18)	22.85 (±2.43)	23.18 (±3.60)	22.39 (±2.00)	p =.619, η_p^2 <.01	p =.282, η_p^2 =.01	p =.058, η_p^2 =.04
Emotional eating [a]	2.66 (±0.84)	2.80 (±1.00)	2.31 (±0.79)	2.50 (±0.55)	p =.341, η_p^2 =.01	p =.066, η_p^2 =.04	p =.883, η_p^2 <.01
Restraint [a b]	2.85 (±0.54)	2.95 (±0.71)	2.25 (±0.65)	2.60 (±0.78)	p =.127, η_p^2 =.03	p =.001***, η_p^2 =.12	p =.378, η_p^2 =.01
External eating [a b]	3.59 (±0.65)	3.56 (±0.66)	3.30 (±0.54)	3.51 (±0.49)	p =.472, η_p^2 =.01	p =.173, η_p^2 =.02	p =.354, η_p^2 =.01
Satisfaction	4.04 (±0.79)	3.65 (±0.98)	4.19 (±0.75)	3.75 (±0.55)	p =.016*, η_p^2 =.07	p =.463, η_p^2 =.01	p =.876, η_p^2 <.01
Plate-clearing score [c]	4.30 (±0.65)	4.15 (±0.61)	2.79 (±0.88)	2.71 (±0.73)	p =.457, η_p^2 =.01	p <.001***, η_p^2 =.52	p =.825, η_p^2 <.01

Table 2.1 displays the differences between plate-clearers and non-plate-clearers with regards to participant characteristics (age, BMI, emotional eating, restraint, external eating), meal satisfaction and plate-clearing score, and the results of ANOVAs investigating significant differences between plate-clearers and non-plate-clearers and individuals in each portion size condition. All ANOVA results were non-significant, with the exception of a main effect of portion size condition on satisfaction, whereby meal satisfaction was rated as significantly lower in the large compared to the normal portion size condition; a main effect of plate-clearing on restraint, whereby plate-clearers scored significantly higher in restraint than non-plate-clearers; and a main effect of plate-clearing on average plate-clearing score, whereby plate-clearers scored significantly higher on the plate-clearing scale than non-plate-clearers.*p < .05; **p < .01, ***p < .001

[a] DEBQ subscales are scored from 1-5 with higher values denoting greater emotional eating, restraint and external eating. [b] These variables contain data from <89 participants, as they are missing data (see Appendix 1, pages 196-7). [c] The highest possible average plate-clearing score is 5.

Table 2.2. Appetite ratings (100-mm VAS) pre-and post-lunch (values are mean (±SD) and ANOVA results)

		Plate-clearers (n = 48)		Non-plate-clearers (n = 41)		Main effect of Time	Main effect of Portion Size	Main effect of Plate-clearing	Portion Size by Plate-clearing interaction effect
	Portion size condition	Normal (n = 25)	Large (n = 23)	Normal (n = 21)	Large (n = 20)				
Pre-lunch	Desire-to-eat [a]	62.33 (±28.69)	67.90 (±16.35)	60.47 (±27.08)	64.15 (±22.46)	p <.001***, η_p^2 =.85	p =.360, η_p^2 =.01	p =.594, η_p^2 <.01	p =.869, η_p^2 <.01
	Hunger [a]	63.83 (±30.23)	69.73 (±19.60)	64.86 (±24.38)	65.91 (±23.41)	p <.001***, η_p^2 =.86	p =.260, η_p^2 =.02	p =.691, η_p^2 <.01	p =.429, η_p^2 =.01
	Fullness [a]	18.35 (±16.81)	18.42 (±16.30)	16.69 (±21.19)	19.38 (±13.54)	p <.001***, η_p^2 =.92	p =.625, η_p^2 <.01	p =.889, η_p^2 <.01	p =.441, η_p^2 =.01
Post-lunch	Desire-to-eat [a]	8.28 (±10.03)	7.85 (±8.38)	8.47 (±9.48)	7.97 (±12.99)				
	Hunger [a]	7.98 (±9.42)	3.00 (±2.28)	6.78 (±11.93)	5.91 (±12.38)				
	Fullness [a]	85.52 (±10.77)	87.30 (±9.80)	87.77 (±11.18)	85.68 (±14.16)				

Values are Mean(±SD) for pre-lunch and post-lunch appetite measures, and results of a mixed ANOVA with time (before meal/after meal) as the within-subjects factor, and portion size (normal/large) and plate-clearing tendency (plate-clearer/non-plate-clearer) as the between-subjects factors.

Participants felt significantly less desire-to-eat, significantly less hungry, and significantly fuller post-lunch relative to pre-lunch. There was no significant portion size*plate-clearing tendency interaction, main effect of portion size condition or main effect of plate-clearing tendency on any of the 3 self-reported appetite measures.

***p <.001.

[a] These variables contain data from <89 participants, as there are missing data (see Appendix 1, pages 196-7)

Self-reported appetite

Mean appetite ratings are displayed in Table 2.2. As expected, participants felt significantly less desire-to-eat, significantly less hungry, and significantly fuller post-lunch relative to pre-lunch (i.e. main effect of time in each analysis). There was no significant portion size*plate-clearing tendency interaction, main effect of portion size condition or main effect of plate-clearing tendency on any of the 3 self-reported appetite measures (pre- and post-meal ratings).

Table 2.3. Mean weight of food eaten in grams (values are Mean (±SE))

	Plate-clearers	Non-plate-clearers	Plate-clearers and Non-plate-clearers combined
Normal Portion Size condition	353.01 (±20.44), *n* = 25	299.48 (±17.79), *n* = 21	***328.57 (±14.18), *n* = 46
Large Portion Size condition	468.97 (±31.56), *n* = 23	383.29 (±26.78), *n* = 20	***429.12 (±21.76), *n* = 43
Portion Size conditions combined	**408.58 (±20.15), *n* = 48	**340.36 (±17.96), *n* = 41	

Table 2.3 displays the mean weight of food eaten (in grams). The mean difference in food intake between the normal and large portion size conditions was 100.55g (p <.001). The mean difference in food intake between plate-clearers and non-plate-clearers was 68.21g (p =.006). **p .<01; ***p <.001. *n* indicates number of participants.

Perception of portion size

There was no portion size*plate-clearing tendency interaction effect, $F(1,85) = 0.05$, p =.823, η_p^2 <.01, or main effect of plate-clearing tendency, $F(1,85) = 0.06$, p =.814, η_p^2 <.01, on perceived normality of portion size, indicating that perceptions of the portion sizes served were similar among plate-clearers and non-plate-clearers. As

expected, there was a significant main effect of portion size on perceived normality of portion size served, $F(1,85) = 87.60$, $p < .001$, $\eta_p^2 = .51$; participants that were served the large portion size perceived it as being larger in size than participants served the normal sized portion.

Main outcomes

The mean weight of food eaten in each condition is displayed in Table 2.3. The 2 x 2 ANOVA indicated that there was no significant portion size*plate-clearing tendency interaction effect on food intake, $F(1,85) = 0.42$, $p = .519$, $\eta_p^2 = .01$. Thus, the magnitude of the portion size effect was similar in plate-clearers and non-plate-clearers. However, there was a significant main effect of portion size; significantly more food was consumed when participants were served a large vs. normal sized portion, $F(1, 85) = 16.15$, $p < .001$, $\eta_p^2 = .16$. There was also a significant main effect of plate-clearing tendency; plate-clearers consumed significantly more food than non-plate-clearers, $F(1, 85) = 7.84$, $p = .006$, $\eta_p^2 = .08$. Re-running this analysis with the 11 participants characterised as showing awareness of the study aims removed from the sample did not change the pattern of statistical significance observed. Re-running this analysis with the 7 participants identified as finishing the normal portion removed from the sample did not change the pattern of statistical significance observed. A hierarchical regression was used to examine whether controlling for participant BMI, emotional eating, restraint and external eating affected the results of the main analyses. The regression model predicted 21% of variance in weight of food eaten, $\Delta R^2 = .21$, $F(7, 81) = 4.38$, $p < .001$. As in the main analysis the portion size by plate-clearing interaction was non-significant ($\beta = .04$, $p = .675$), portion size was significantly

positively associated with weight of food eaten (β = .36, $t(81) = 3.69$, $p < .001$), and so was plate-clearing (β = .23, $t(81) = 2.22$, $p = .029$). Participant BMI (β = .11, $p = .251$), emotional eating (β = .22, $p = .078$), restraint (β = .04, $p = .683$), and external eating (β = -.06, $p = .627$) were not significant predictors of weight of food eaten.

Results of sensitivity analyses

When plate-clearing was treated as a continuous variable the same pattern of results was observed as in the main analysis. The regression model predicted approximately 36% of variance in weight of food eaten, $R^2 = .36$, $F(3, 85) = 15.57$, $p < .001$. Plate-clearing tendencies did not significantly moderate the effect of portion size on weight of food eaten ($b = 3.26$, se = 4.48, $p = .469$, 95% CIs [-5.64, 12.16]), however there was a significant effect of portion size on weight of food eaten ($b = 108.11$, se = 22.65, $p < .001$, 95% CIs [63.07, 153.15]), and a significant effect of plate-clearing tendency on weight of food eaten ($b = 11.56$, se = 2.23, $p < .001$, 95% CIs [7.13, 16.00]). Including meal satisfaction as a covariate in our main analysis strategy did not influence the pattern of statistical significance observed.

2.5 Discussion

The primary aim of the present study was to examine whether individual differences in plate-clearing tendencies moderate the influence that portion size has on meal food intake in a laboratory setting. We found that the influence that portion size had on food intake was similar in size irrespective of participant plate-clearing tendencies, which is consistent with previous research (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). Thus, there was no evidence that a tendency to clear

one's plate explains the effect that portion size has on food intake. In line with a number of other studies (Diliberti et al., 2004; Levitsky & Youn, 2004; Rolls et al., 2000, 2002, 2007; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004), we found that portion size had a significant effect on meal food intake, whereby participants consumed more food when served a larger portion. We also found that irrespective of the portion size served, participants with a self-reported tendency to clear their plate when eating consumed significantly more food than participants who did not self-report a tendency to clear their plate when eating.

As far as we are aware, the results of the present study are the first to link plate-clearing tendencies to increased food intake. Plate-clearing has been associated with increased BMI (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016) and because of this it has been suggested to be a potentially maladaptive behaviour in the current obesogenic environment (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016). We found that irrespective of the portion size served participants with a tendency to clear their plate when eating consumed significantly more food than non-plate-clearers. However, because the portion sizes provided in the present study were deliberately selected to be large, very few participants actually cleared their plate. Thus, based on the present study it seems likely that individuals with a tendency to clear their plate when eating may have a desire to do so and this may increase the amount of food they consume at a meal even if it does not result in all available food being consumed. This finding was robust to controlling for other dietary habits (such as dietary restraint) and BMI, which suggests that the association between a tendency to clear one's plate when eating and increased meal food intake is not explained by plate-clearers and non-plate-clearers differing on these other variables. The present findings therefore suggest that a tendency to clear one's plate when eating may

promote overeating. However, because we examined food intake at a single test meal, we do not know whether the increased food intake observed among plate-clearers would be compensated for at subsequent meals. Thus, examining whether plate-clearing tendencies promote excessive consumption in the long-term would now be informative.

As in many other portion size studies (Zlatevska et al., 2014) we found evidence for the portion size effect, and our results further highlight the robust nature of the portion size effect, as even a group of participants who explicitly reported not being motivated to plate-clear when eating were susceptible to the influence of portion size. This indicates that the portion size effect is not limited to individuals who have a tendency to clear their plate when eating. However, we also found that participant with plate-clearing tendencies consumed more (irrespective of portion size) than participants without such tendencies, which has behavioural implications. In the current obesogenic environment, individuals with plate-clearing tendencies are likely to be at higher risk of passive overconsumption, and thus likely to be at higher risk of weight gain.

The failure to find evidence in support of plate-clearing tendencies moderating the influence of portion size on meal food intake may indicate that factors other than plate-clearing tendencies are better placed to explain why portion size has a reliable effect on food intake. However, the present study has limitations that warrant consideration. Because the study was conducted in a laboratory setting, demand characteristics may in part explain why the influence of portion size on food intake was similar in size across plate-clearers and non-plate-clearers. For example, even if participants without plate-clearing tendencies did not wish to consume a considerable amount of food from the portion sizes provided they may have felt it would be ill

mannered to waste a very large amount of food. Likewise, although we conducted pilot work to select portion sizes served that would be 'normal' and 'large' in size, on average participants perceived the normal sized portion to be larger than normal. It is likely that the relationship between increasing portion sizes and food intake is curvilinear (Zlatevska et al., 2014); if the portion sizes served in the present study had been smaller in size it is plausible that participants without plate-clearing tendencies may have continued to waste a substantial amount of food. However, participants with plate-clearing tendencies may have come close to finishing the amount of food served in both portion size conditions and this would likely lead to a larger effect of portion size on food intake in plate-clearers vs. non-plate-clearers. It is possible that the size of the portions and the large difference between the portion sizes led to a ceiling effect, "washing out" the effects of plate-clearing tendencies and thus limiting the ability to detect an interaction between portion size and plate-clearing. In future, a wider range of portion sizes should be used to allow greater sensitivity to the potential influence of plate-clearing on the portion size effect, especially given that the portion size effect has been found to be curvilinear (Zlatevska et al., 2014). It should also be noted that we found a main effect of portion size on meal satisfaction, with those in the large portion size condition reporting lower meal satisfaction. This finding is consistent with research which suggests that consumers habituate to large portions of food and find them less enjoyable by meal end (Garbinsky, Morewedge, & Shiv, 2014).

Further limitations of the present research were that our sample was not representative of the general population and that plate-clearing tendencies were self-reported. We presume that participants are likely to be able to report with some accuracy on whether they tend to clear their plate when eating, but self-report measures can introduce bias and objective measurement of plate-clearing tendencies would be

preferential. There is now evidence that self-reported plate-clearing tendencies predict elevated food intake (the present study) and BMI (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016), and objectively measured plate-clearing is more common among individuals with overweight and obesity than those of normal weight (Dodd et al., 1976; Krassner et al., 1979; Le Bow et al., 1985). Work that makes use of objective measurement of plate-clearing tendencies to clarify the extent to which plate-clearing is a behavioural risk factor for excess consumption and weight gain would therefore be valuable. Addressing these potential limitations of the present research in future studies will clarify the relationship between plate-clearing tendencies and the influence of portion size on food intake.

2.6 Chapter conclusion

In this laboratory study of female participants, the tendency to clear one's plate when eating was associated with increased food intake during a lunchtime meal. Experimentally manipulating the portion size of the lunchtime meal also affected food intake, although the tendency for a larger portion size to increase food intake was observed irrespective of participant plate-clearing tendencies. The findings of the present study suggest that those who habitually plate-clear may be at risk of overeating.

Chapter 3: Associations between food waste concerns, plate-clearing tendencies, food intake and BMI

3.1 Chapter Introduction

Chapter 3 introduces the second overarching focus of this thesis: food waste concerns. Food waste concerns may lead to desires and attempts to avoid food waste. In this way food waste concerns may encourage people to consume more food at an eating occasion, to reduce the amount of food that is wasted. Food waste concerns may also encourage desires to clear the plate when eating. A 5-item scale was created to measure food waste concerns in these studies. The aim of this chapter was to investigate the reliability and validity of the food waste concerns scale, and the relationship between food waste concerns, plate-clearing tendencies, body weight and overconsumption from larger portions. Chapter 3 details 3 studies investigating associations between food waste concerns, plate-clearing tendencies, food intake and BMI.

The studies reported in Chapter 3 have been submitted to the journal Appetite as:
Sheen, F., Hardman, C. A., & Robinson, E. (Under Review). Food waste concerns, eating behaviour and body weight, *Appetite*.

3.2 Introduction

In the last thirty years, there have been striking increases in population-level body weight across most developed countries (Ng et al., 2014; OECD/EU, 2017), including the U.K. (House of Commons, 2019). Changes to the food environment have been identified as a likely cause of the 'obesity crisis' (Swinburn et al., 2011). For example, larger portion sizes of energy dense food products are now more common (Matthiessen, Fagt, Biltoft-Jensen, Beck, & Ovesen, 2003; Piernas & Popkin, 2011; Steenhuis, Leeuwis, & Vermeer, 2010; Young & Nestle, 2003, 2007, 2012). Likewise, food prepared outside of the home often has a high energy content (Robinson, Jones, et al., 2018). Alongside increases in obesity, in recent times there has also been a growing awareness of the problem of food waste (FAO, 2014; Food and Agriculture Organization of the United Nations., 2013; Quested, Ingle, & Parry, 2013).

In higher income countries, a large proportion of food is wasted per capita at the retail and household level (Gustavsson et al., 2011). Because of this, there are attempts to raise public awareness about food waste, such as the 'Love Food Hate Waste' campaign that was initiated by The Waste and Resources Action Programme in 2007 (Quested et al., 2013). However, despite a 15% reduction of household food and drink waste in the U.K. in the 5 years following the campaign's launch, there are approximately 7 million tonnes of food and drink still wasted per annum, 60% of which is considered avoidable (Quested et al., 2013). Consumers also report being concerned about wasting food. For example, Setti, Falasconi, Segrè, Cusano, and Vittuari (2016) found that the majority of their sample of 1,403 Italian consumers reported concerns about food waste from an ethical standpoint (86%) and because of the environmental consequences of throwing food away (82%). Also, Gaiani et al. (2017) found that the majority of their respondents, also an Italian sample of 3,087 participants, considered food waste a serious issue. In addition, studies have shown

that people will often report feelings of guilt around wasting food (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015).

Although research has demonstrated that consumers now identify food waste as a significant issue, the extent to which food waste concerns may influence eating behaviour has received far less attention. Fay et al. (2011) investigated the prevalence of plate-clearing, pre-meal planning, and their influence on meal size. In an online questionnaire study, participants were asked about the last meal they had consumed. One question asked participants if they had "eaten all of the food on [their] plate, even though [they] could have stopped before that point". Of the individuals who answered yes, 77% reported that this was because they did not want to waste food. In other words, these individuals had cleared the plate past the point of fullness because they wanted to avoid food waste. Also, Robinson and Hardman (2016) found that a single item measure of disliking wasting food was predictive of self-reported plate-clearing tendencies in a sample of University students, and plate-clearing tendencies were associated with having a higher BMI.

Given that many people now live in an 'obesogenic environment', concerns about wasting food may be a contributor to excess energy intake. Indeed, Hall, Guo, Dore, and Chow (2009) propose a link between surplus food, food waste and overeating. Hall et al. (2009) argue that the obesity epidemic has been the result of the "push effect" of increased food availability and marketing, with individuals being unable to match their food intake with the increased supply of cheap, easily available food. Thus, the aim of the present research was to examine the relationships between food waste concerns, eating behaviour and body weight. Because concerns about food waste may promote excess energy consumption through encouraging the behaviour of plate-clearing, we made a number of predictions. We predicted that greater concerns

about wasting food would be associated with greater intentions to behave in ways that minimize food waste, such as eating leftovers (Study 1), greater plate-clearing tendencies and heavier body weight (Study 2) and objectively measured energy intake when served a large portion of food (Study 3).

3.3 Study 1

As we were aware of no scale directly measuring concerns about wasting food when eating, we designed a 5-item scale. In Study 1, we collected data online and tested internal consistency, test-retest reliability, convergent and divergent validity of the scale. Participants completed the same battery of questionnaires 2 weeks apart. To examine convergent validity, we hypothesised that the scale should predict intentions to reduce food waste and emotions experienced in response to the thought of wasting food. Given that our interest was in the potential influence of food waste concerns on eating behaviour and body weight, we tested the scale's divergent validity by examining whether it was distinct to existing trait measures of appetite and over-eating.

3.3.1 Method

Participant recruitment and eligibility

We aimed to recruit 300 participants, which is considered appropriate for scale development by Comrey, Lee, and Lee (2013). In total, 300 U.K. participants (207 females, 93 males) were recruited through the online recruitment platform Prolific Researcher. Eligibility criteria were as follows: aged 18 or over, no history of or current food allergies, no history of or current eating disorder(s) and fluent in English.

Of these 300, 276 (191 females, 85 males) completed the questionnaire a second time 2 weeks later. Participants were provided with monetary reimbursement for their time.

Measures

Food waste concerns scale: Participants completed a self-report measure of concerns about wasting food. The scale consisted of 5 items (7-point Likert-scales, 'Strongly disagree' to 'Strongly agree') designed to address concerns about wasting food ("It is morally wrong to waste food", "I cannot stand throwing food away", "Even if I felt full, I would rather finish what is on my plate than see it go to waste", "It is fine for food to go to waste sometimes", "It can be acceptable to waste food"). Scores on the latter 2 items were reverse-scored. Scores were summed, with a higher score indicating stronger concerns regarding food waste.

Intentions to reduce food waste: A 4-item self-report measure was taken from Aktas et al. (2018) (e.g. "I intend to eat leftover food") with a 7-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Scores were summed, with a higher score indicating stronger intentions to reduce food waste (α =.80) (Aktas et al., 2018).

Emotions towards wasting food: A single-item measure was taken from Russell, Young, Unsworth, and Robinson (2017). Participants were asked "Which of the following words best describe how you feel about wasting food in your home?" and provided with a list of emotions. Participant selected all the emotions that applied to them. These were then dummy coded as 1 = emotion present (i.e. selected) and 0 = emotion absent (i.e. not selected). From these, a negative emotion score (total score of responses to the 3 negative emotions: frustrated, anxious, guilty) and a positive emotion score (total score of responses to the 4 positive emotions: optimistic, proud,

content, relaxed) were computed, with higher scores indicating higher negative or positive emotions (Russell et al., 2017).

Overeating: The disinhibition subscale of the original Three Factor Eating Questionnaire (TFEQ) was used to measure trait overeating (Stunkard & Messick, 1985). Scores were summed, with a higher score indicating higher tendency towards overeating (α =.91) (Stunkard & Messick, 1985).

Hunger: The hunger subscale of the original TFEQ was used to measure trait appetite (Stunkard & Messick, 1985). Scores were summed, with a higher score indicating higher tendency towards hunger (α =.85) (Stunkard & Messick, 1985).

Attention check: We included an attention check question, "This is an attention check. Please leave blank", at 2 points in the study to ensure that participants were attending to the questions.

Procedure

After accessing the online study site, participants reported their gender, age, weight, height and answered questions relating to the inclusion criteria. In a randomized order, participants then completed the food waste concerns items, food waste intentions, food waste emotions, the trait disinhibition scale and trait appetite scale. Participants were invited to complete the same questionnaires 14 days later. Participants were reimbursed for their participation and the study took approximately 20 minutes to complete. A full copy of the questionnaire participants received can be found at https://osf.io/aef75/.

Analysis Strategy

To assess the internal consistency of the food waste concerns scale, we conducted a factor analysis on the first wave of data collected (time 1) using an oblique rotation and calculated Cronbach's alpha (a Cronbach's alpha of >.70 is considered acceptable for a sample size of n <300 (Cicchetti, 1994; Kline, 2013; Nunnally & Bernstein, 1994; Ponterotto & Ruckdeschel, 2007)).

To assess test-retest reliability, we examined the intra-class correlation (ICC) between the total food waste concerns score obtained at the initial time of testing (time 1) and following the 2-week interval (time 2). An average measures ICC and 95% confident intervals were calculated based on the mean of time 1 and time 2 ($k = 2$), with absolute-agreement and a 2-way mixed-effects model. Scores of 0.60 or more indicate good test–retest reliability (Cicchetti, 1994).

To assess convergent validity, we used linear regression to examine whether the food waste concerns scale predicted food waste intentions and food waste emotions, controlling for age, gender, BMI, trait hunger and trait overeating. Finally, to examine divergent validity, we used Pearson's correlation analysis to examine the correlation between the food waste concerns scale and the measures of overeating and hunger. We expected that that the food waste concerns scale would not be strongly correlated with overeating or hunger (i.e. r <.5). Results were considered significant at a p <.05. All analyses were conducted in IBM SPSS Statistics 24.

3.3.2 Results

Two hundred and seventy-six participants (191 females and 85 males) completed both online questionnaires and had a mean age of 37.43 (±12.66) years and a mean BMI

(self-reported with data missing from 2 participants) of 26.41 (±5.99) kg/m^2. The sample had a mean food waste concerns score of 4.74 (±1.23) at time 1 and 4.79 (±1.16) at time 2, equating to responses of 'Neither agree nor disagree' to 'Somewhat agree' with being concerned about food waste (7-point scale).

Exploratory factor analysis, internal consistency and test-rest reliability

An exploratory factor analysis was conducted on the 5 items with oblique rotation (direct oblimin). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, (KMO = 0.78), and Bartlett's Test of Sphericity demonstrated that correlations between items were large enough for factor analysis, $\chi^2(10) = 517.17$, $p < .001$. A single factor was identified with an eigenvalue over Kaiser's criterion of 1 (Eigenvalue = 2.94) and explained 58.8% of the total variance of the observed variables. The scale had good internal consistency, with all 5 items loading onto a single factor (α =.82). See Appendix 2 (page 199) for factor loadings and correlations between individual scale items. The food waste concerns scale had excellent test-retest reliability. The ICC was .90 (95% CIs = .87-.92, F(275,275) = 10.00, p<.001).

Convergent and divergent validity

As expected, food waste concerns scores were significantly positively correlated with intentions to reduce food waste ($r(274) = .58$, $p < .001$) and negative emotions towards wasting food ($r(274) = .34$, $p < .001$). Food waste concerns scores were significantly negatively correlated with positive emotions towards wasting food ($r(274) = -.29$, $p < .001$). These associations remained significant in regression analyses controlling for age, gender, BMI, trait appetite and overeating (see Appendix 2, pages 200-1). As

predicted, food waste concerns were not strongly correlated (r <.5) with trait overeating ($r(274) = .09$, $p = .128$) or trait appetite ($r(274) = .16$, $p = .009$), indicating that the scale is psychometrically distinct from measures of motivation to eat.

3.4 Study 2

In Study 1, we found that the 5 items from the food waste concerns scale all loaded onto a single factor, which we operationalise as a measure of individual differences in concerns about wasting food. The scale demonstrated good internal consistency and excellent test-retest reliability. We also found evidence in support of the scale's convergent validity (predictive of emotional response to food waste and intentions to avoid wasting food) and divergent validity (only weakly associated with measures of trait overeating and appetite). Our aim in Study 2 was to examine whether food waste concerns are predictive of a behaviour that may promote excess energy consumption in the current food environment (the tendency to clear one's plate when eating) and body weight. We also conducted a confirmatory factor analysis of the food waste concerns scale in Study 2.

3.4.1 Method

We included the 5-item food waste concerns scale at the end of a series of laboratory studies conducted at the University of Liverpool during 2016-2018. Studies were approved by the University of Liverpool research ethics board and participants were drawn from University students and the local community. Studies typically involved participants consuming a lunchtime meal or snack, in addition to completing standard psychological and eating behaviour questionnaires. See Appendix 2 (page 203) for

detailed information on the included studies. For Study 2, we made use of data from 14 studies, all of which had a researcher taken measurement of weight and height and included the food waste concerns scale. In 4 of these 14 studies, self-reported plate-clearing tendencies were also collected. As used in previous research, the plate-clearing measure consisted of 5 questions ("I always tend to clear my plate when eating."; "I normally finish eating when my plate is empty."; "Before I start eating, I normally plan to finish the serving I am about to eat."; "I rarely leave food on my plate."; "It is normal for me to have very little food left or an empty plate at the end of a meal.") with a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Scores were summed, with a higher score indicating stronger plate-clearing tendencies (α = .89) (Robinson, Aveyard, et al., 2015).

Analysis strategy

Using SPSS AMOS 24, a confirmatory factor analysis was performed on the single-factor solution observed in Study 1. For full information on the analysis strategy for the confirmatory factor analysis see Appendix 2 (page 202). A linear regression was used to test whether food waste concerns scores predicted plate-clearing tendencies scores while controlling for age, BMI and gender. We used linear regression analysis to also test whether food waste concerns scores were positively associated with BMI (kg/m^2), while controlling for age and gender. Finally, a logistic regression was conducted to investigate whether food waste concerns score predicted the likelihood of having overweight (BMI <25.0 vs. BMI ≥ 25.0). Results were considered significant at a p <.05.

3.4.2 Results

We included 996 participants in our main analyses (739 females and 227 males), with a mean age of 25.39 (±10.96) years, and a mean BMI of 24.78 (±5.30) kg/m^2. The sample had a mean food waste concerns score of 4.45 (±1.26). Of these 966 participants, 212 also completed the plate-clearing scale.

Confirmatory factor analysis

The Cronbach's alpha of the 5-item food waste concerns scale was acceptable (α = .80). The confirmatory factor analysis confirmed the single-factor structure yielded by the exploratory factor analysis in Study 1. Following the addition of covariance pathways based on modification indices, the single-factor model provided a good fit to the data (normed $\chi 2$ ($\chi 2$/df) = 3.52, CFI =.995, TLI =.984, RMSEA (90% CI) =.051 (.02-.09), SRMR =.02). See Appendix 2 (pages 205-6) for an explanation and schematic of this model.

Food waste concerns, plate-clearing tendencies and body weight

Food waste concerns score were positively associated with self-reported plate-clearing tendencies in the linear regression controlling for gender, age and BMI, whereby greater concerns about wasting food were predictive of greater plate-clearing tendencies (β = .37, p <.001). See Appendix 2 (pages 206-7) for full regression model results. Food waste concerns (β = -.04, p =.174) did not significantly predict BMI (continuous variable). Likewise, food waste concerns did not predict whether a participant was more likely to have overweight than be classed as healthy weight, B <.01 (SE =.01), Wald <.01, p =.984; OR =1.00, 95% CIs =0.86-1.17. See Appendix 2 (page 207) for full results.

3.5 Study 3

In Study 2, we found that although concerns about food waste were associated with an increased likelihood of self-reported plate-clearing, there was no significant association between food waste concerns and body weight. In Study 3, we aimed to explore the relationship between food waste concerns and energy intake when served a large portion of food. We tested whether food waste concerns are associated with increased energy intake when served a large portion of food because concerns about waste increase a person's likelihood of wanting to clear their plate when eating, which in turn has been shown to be predictive of increased energy intake (Sheen, Hardman, & Robinson, 2018) (i.e. an indirect effect of food waste concerns on energy intake via plate-clearing tendencies).

3.5.1 Method

Participant recruitment and eligibility

Based on Fritz and MacKinnon (2010), we aimed to recruit a minimum sample size of at least 126 participants in order to detect a mediation effect that was moderate to small in size. In total, 128 participants (85 females, 43 males) were recruited from staff/students at the University of Liverpool and the surrounding area. Most participants took part in exchange for course credit (1st year psychology students, 68.8%) whilst other participants were reimbursed financially for their participation. Eligibility criteria were: aged 18 or over, no history of food allergies, and had not participated in any recent similar studies (i.e. laboratory studies of food intake).

Overview

Participants completed questions on their plate-clearing tendencies and food waste concerns in an online pre-session questionnaire at least 1 day before the study session. To disguise the aims of the study, participants were informed in advance that the study was about 'Eating and Memory'. Participants completed word memory tasks before and after consuming *ad libitum* from a large lunch time meal in the laboratory.

Test food

Participants were served pasta in tomato sauce at a 1:1 ratio (Tesco Conchiglie pasta and Dolmio Bolognese 'Smooth Tomato' sauce, see Table 3.1 for nutritional information) in a 500g portion on a standard white dinner plate, with a 500ml glass of water. This portion size was chosen as participants in a recent laboratory study identified this portion as being 'larger than normal' and only a minority of participants (15%) consumed it in its entirety (Sheen et al., 2018). Pilot testing indicated that participants found the meal to be palatable, which was confirmed by an item measuring liking of the meal in the current study.

Table 3.1. Nutritional information for lunchtime meal (Tesco Conchiglie pasta and Dolmio 'Smooth Tomato' pasta sauce)

Typical Values	Per portion (500g)
Energy	2199kJ / 519kcal
Fat	3.54g
Saturates	0.6g
Carbohydrate	100.3g
Sugars	19.9g
Fibre	7.4g
Protein	17.5g
Salt	2.1g

Table 3.1 displays the nutritional information for 500g of cooked pasta in tomato sauce, approximately calculated from the nutritional information for the uncooked ingredients per 100g, as available. 500g of cooked pasta and tomato sauce at a 1:1 ratio (250g of cooked pasta and 250g of cooked sauce) equates to approximately 360g of uncooked ingredients (110g of uncooked Tesco Conchiglie Pasta (dry weight) and 250g of uncooked Dolmio "Smooth Tomato" pasta sauce).

Measures

Participants completed the food waste concerns scale (α = .80) described in Study 1, and the plate-clearing scale (α = .89) (Robinson, Aveyard, et al., 2015) described in Study 2.

Appetite: A mood and appetite measures questionnaire was administered, including 3 appetite items: hunger, fullness, and desire-to-eat. These were presented as 99mm visual analogue scale questions (e.g. "How FULL do you feel right now?") with the anchors of 'Not at all' to 'Extremely'.

Perceptions of portion size: Participants completed the question ("In my opinion, the portion I was given in this study was…") with a 7-point Likert scale response format ('Too small' to 'Too large').

Liking: Participants completed a question on liking of the lunchtime meal ("Overall, I liked the taste of the meal that was served to me") on a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Three Factor Eating Questionnaire (TFEQ): The TFEQ (Stunkard & Messick, 1985) was used to measure uncontrolled eating (e.g. "When I have eaten my quota of calories, I am usually good about not eating any more."), disinhibition (e.g. "I usually eat too much at social occasions, like parties and picnics."), and restraint (e.g. "I am usually so hungry that I eat more than three times a day.").

Awareness of study aims: Participants completed a free-text response question regarding what they believed the aim of the study to be ("What do you think the aim of the study was?"), in addition to another question (see Appendix 2, page 208).

Procedure

Before attending a single weekday lunchtime session, participants completed an online pre-session questionnaire that included the food waste concerns and plate-clearing scales. To standardize appetite, participants were asked not to eat in the 2 hours prior to the study or drink in the hour prior. On arrival the experimenter obtained informed consent, verbally confirmed that the participant had no known food allergies and had not eaten in the 2 hours prior to the study session, and asked participants to complete a short medical history questionnaire in compliance with laboratory health and safety procedures. Participants then completed a word memory task (included as part of the

cover story). Participants were presented with 25 words on a laptop. Each word was shown for 5 seconds and participants then were asked to write down as many words as they could remember. This was followed by a mock feedback questionnaire, which included filler questions about the difficulty of the task and any distractions they experienced whilst completing the task. Participants then completed the mood and appetite questionnaire, before being served the lunchtime meal. Participants were told that they could eat and drink (500ml water) as much as they desired and to press a buzzer located in the cubicle to alert the experimenter when they had finished. Upon completion, the experimenter removed the lunchtime meal. Participants then completed the mood and appetite measures questionnaire for a second time, and were given a similar word memory task and mock feedback questionnaire. Participants then completed the questions on portion size, lunchtime meal liking, the TFEQ, and questions regarding awareness of the study aims, before having their height and weight measured. Finally, the experimenter debriefed the participant and reimbursed them for their time. Each experimental session took approximately 50 minutes.

Analysis strategy

We planned to examine the indirect effect of food waste concerns on food intake via plate-clearing tendencies using a mediation analysis, which was run using PROCESS version 3 (Hayes, 2017). Food waste concerns (continuous score derived from total scale score) was the independent variable (X), food intake (measured as weight of food eaten in grams) was the outcome variable (Y) and plate-clearing tendency (continuous score derived from total scale score) was the mediator (M). All variables for the

mediation analysis were log-transformed. Results were considered significant at a $p < .05$.

Sensitivity analyses

We conducted Pearson's correlations between plate-clearing tendency score, food waste concerns score, food intake and the following variables: gender, age, BMI, appetite ratings (desire-to-eat, hunger, fullness), meal enjoyment, restraint, disinhibition and hunger (measured using the TFEQ). If any of these variables were significantly correlated with plate-clearing tendency score, food waste concerns score and/or food intake we included them as covariates in an additional mediation analysis. All variables for the mediation analysis were log-transformed (except for gender). We also planned to examine the effect of removing participants that were aware of the study aims on our main planned analysis. Participants were characterised as being aware of the study aims if they mentioned the influence of plate-clearing tendencies, food waste concerns or eating from large portions. Two researchers independently coded participant responses to this question and identified 8 participants with some awareness of the study aims. One participant requested and consumed a second serving of food, and therefore was served a total of 1000g of pasta in tomato sauce (2 portions), and 2 participants completed the screening questionnaire retrospectively (i.e. after the study session). We examined the effect of removing these participants in a sensitivity analysis and the results remained the same (see Appendix 2, pages 209-10).

3.5.2 Results

Table 3.2. Participant characteristics, meal liking, perception of portion size of meal, average food waste concerns score and average plate-clearing score

	Mean (±SD)
Time between screening questionnaire and study session (days) [a]	10.70 (±9.34)
Age (years) [b]	22.69 (±9.12)
BMI (kg/m^2)	23.85 (±4.45)
Food waste concerns score [c]	4.25 (±1.19)
Plate-clearing score [d]	3.94 (±0.65)
Weight of food eaten (grams)	399.20 (±109.86)
Liking [e]	4.05 (±0.75)
Perception of portion size [f]	4.84 (±0.85)

Table 3.2 displays averages for the number of days between completing the screening questionnaire and attending the study session, participants characteristics (age, BMI), food waste concerns score, plate-clearing tendency score, weight of food eaten (g), liking and perception of portion size.

[a] Two participants did not complete the screening questionnaire before the study session due to error, and instead completed the measures shortly after the laboratory session.

[b] Age (years) contains data from 127 participants, as there are missing data.

[c] Food waste concerns score is on a 1 to 7 scale, with higher values denoting greater food waste concerns.

[d] Plate-clearing score is on a 1 to 5 scale, with higher values denoting greater plate-clearing tendencies.

[e] Liking is on a 1 to 5 scale, with higher values denoting greater liking.

[f] Perception of portion size is on a 1 to 5 scale, with higher values denoting that the participant perceived the lunchtime meal to be larger in size.

Main analyses

One hundred and twenty-eight participants (85 females, 43 males) were included in our sample. See Table 3.2 for sample characteristics, and see Appendix 2 (page 209) for correlations between food waste concerns, plate-clearing tendencies, food intake and other study variables. In the mediation analysis there was no direct effect of food waste concerns on food intake, B =.12, SE =.12, 95% CIs = -0.13-0.36, *p* =.340. Food waste concerns were positively associated with plate-clearing tendencies, B =.16, SE =.06, 95% CIs =0.05-0.28, *p* =.005 and greater plate-clearing tendencies were associated with greater food intake, but not significantly so, B =.29, SE =.18, 95% CIs = -0.08-0.65, *p* =.124. Contrary to predictions, there was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies (*b*(*SE*) =.05(.06), 95% CI = -0.01, 0.22) (see Figure 3.1).

Figure 3.1. Model displaying the indirect effect of food waste concerns on food intake via plate-clearing tendencies

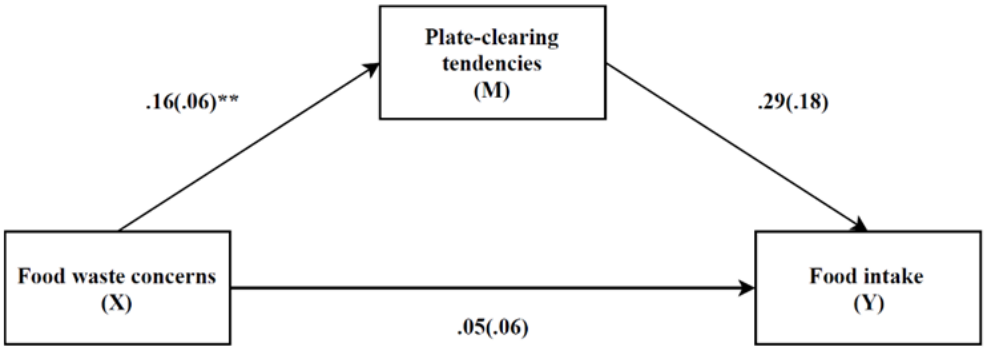


Figure 3.1 shows a conceptual model of our expected mediation model, with food waste concerns (X) on food intake (Y) mediated by plate-clearing tendencies (M). Contrary to predictions, there was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies. Values are B(SE). **p<.01

Sensitivity analyses

For the sensitivity analysis, 6 variables were correlated with either food waste concerns, plate-clearing tendencies and/or food intake and were therefore included in the mediation analysis as covariates: gender, desire-to-eat pre-lunch, hunger pre-lunch, fullness pre-lunch, meal enjoyment (liking) and hunger (measured by the TFEQ). The results of the model with covariates included were the same as in the unadjusted model. Food waste concerns significantly predicted plate-clearing tendencies, but were not directly or indirectly associated with food intake (see Appendix 2, pages 209-10, for full results).

3.6 Discussion

The aim of the present research was to examine the relationships between food waste concerns, eating behaviour and body weight. We developed and validated a short scale to measure concerns about wasting food when eating. In Study 1, the scale was shown to have a single factor structure, in addition to good internal consistency, excellent test-retest reliability, as well as both convergent (i.e. predictive of emotional responses to food waste) and divergent validity (i.e. only weakly associated with measures of trait overeating and appetite). In Study 2, the single factor structure of the scale was confirmed. Because concerns about food waste may promote excess energy consumption through encouraging the behaviour of plate-clearing, we made a number of predictions. We predicted that greater concerns about wasting food would be associated with greater intentions to behave in ways that minimize food waste, such as eating leftovers (Study 1), greater self-reported plate-clearing tendencies and/or heavier body weight (Study 2) and objectively measured energy intake when served a large portion of food (Study 3). Although we found that greater food waste concerns

were associated with self-reported intentions to minimize food waste and plate-clearing tendencies, we did not find evidence that food waste concerns were associated with body weight or laboratory-measured energy intake when served a large meal.

A strength of this research is the development and validation of a short scale to measure food waste concerns when eating. Although there are some scales created to measure attitudes towards food waste, these tend not to focus on eating behaviour (Aktas et al., 2018; Graham-Rowe et al., 2015; Russell et al., 2017). Why we observed no evidence linking food waste concerns to increased energy intake warrants consideration. Previous research highlights a disconnect between attitudes, intentions and behaviours, often referred to as the attitude-behaviour gap (Ajzen, 2001; Sheeran, 2002). For instance, Vermeir and Verbeke (2006) found that sustainable food purchasing intentions were not wholly consistent with attitudes towards a sustainable brand. Alternatively, previous research has suggested that guilt regarding wasting food can stem from a variety of sources. For example, personal responsibility, ethical, moral, environmental, financial concerns (Benson, 2009; Schanes, Dobernig, & Gözet, 2018; Setti et al., 2016), or perceived value of food itself (Ganglbauer et al., 2013). It may therefore be important to consider the origin of a person's concerns about wasting food in order to understand the effect these concerns may have on eating behaviour. For example, participants were provided with a free meal in Study 3 in a laboratory context. However, in a restaurant setting in which a person has had to pay for a meal and/or perceives the meal as being more valuable, food waste concerns may be more influential and promote overconsumption. Likewise, in Study 3 food was prepared by a researcher and participants may not have felt personally responsible for any wasted food and therefore not acted on their concerns about wasting food in this context. We also found no evidence linking food waste concerns to heavier body weight. This may

be because food waste concerns do not cause overeating or it may be because there are other factors associated with food waste concerns that mitigate any association with overeating. Alternatively, people concerned about food waste may primarily avoid wasting food though other ways than consumption (e.g. adjusting their purchasing and cooking behaviour).

We did find that food waste concerns were predictive of self-reported plate-clearing tendencies (Study 2 and 3). This is consistent with a previous finding that disliking wasting food was associated with plate-clearing tendencies (Robinson & Hardman, 2016), and that avoiding food waste was a common reason for plate-clearing beyond the point of fullness (Fay et al., 2011). Food waste concerns may therefore be a determinant of plate-clearing tendencies. However, plate-clearing tendencies were self-reported in the present studies. These data were also cross-sectional and given that the food waste concerns scale was found to have excellent test-retest reliability, it would now be useful to investigate how food waste concerns impact on eating behaviour or weight gain over time.

There are a number of factors that limit the generalisability of the present research. As we sampled U.K. participants and relied on predominantly white educated participants (university samples used in Study 2 and 3), examining food waste concerns in samples that are more diverse may yield different results. As discussed, we measured energy intake in a laboratory context and it may be the case that food waste concerns are more likely to impact on energy intake under different circumstances, such as when food is perceived as being more valuable and/or when personal responsibility, moral or environment concerns for wasted food are more salient. In this vein, our short scale also does not consider the potential causes of

concerns about wasting food when eating and future research may benefit from addressing the causes of food waste concerns.

3.7 Chapter Conclusion

Across 3 studies, we provide evidence that concerns about food waste are related to self-reported intentions to minimize food waste and plate-clearing tendencies, but no evidence that food waste concerns are related to objectively measured energy intake in the laboratory or body weight.

Chapter 4: The influence of manipulating beliefs about wasting leftover food on overeating from larger portions

4.1 Chapter Introduction

In Chapter 3, the studies reported found that food waste concerns were positively predictive of plate-clearing tendencies, but there were no associations found between food waste concerns, BMI and food intake. However, in these studies general concerns about wasting food were self-reported and associations between these, BMI and food intake were examined cross-sectionally. It may be that concerns about food being wasted are more likely to influence intake in a specific context in which food waste is highlighted, such as when leftover food is expected to go to waste. Chapter 4 consists of 2 laboratory-based studies investigating how food intake is affected by being explicitly told that leftover food will be wasted.

4.2 Introduction

An obesogenic eating environment is characterised by a surplus of food, which also translates into a significant amount of food going to waste (Gustavsson et al., 2011). Food waste is a complex, global issue (FAO, 2014; Food and Agriculture Organization of the United Nations., 2013; Quested, Ingle, & Parry, 2013), and despite attempts to reduce household food waste, there is still approximately 7 million tonnes of food and drink wasted in U.K. households alone (Quested et al., 2013). Individuals report being aware that food waste is a problem (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015), with many reporting being concerned about wasting food (Gaiani et al., 2017; Setti et al., 2016) and citing food waste as a social problem with individual responsibility (Parizeau et al., 2015).

People are typically averse to food waste (Bolton & Alba, 2012; Gjerris & Gaiani, 2013) and report feelings of guilt and concern around wasting food (Abdelradi, 2018; Abeliotis et al., 2014; Gaiani et al., 2017; Parizeau et al., 2015). Wasting food is cited as the most guilt-inducing household waste practice (Parizeau et al., 2015), whereas engaging in behaviours to reduce food waste is seen as good, beneficial, pleasant and satisfying (Russell et al., 2017). Thus, there appears to be a widely held belief that wasting food should be avoided.

One obvious action an individual can take to waste less food is to eat more, or all, of the food that is served to them. Recently, there has research examining how food waste concerns influence the amount of food wasted and intentions to perform behaviours to mitigate food waste (Aktas et al., 2018; Graham-Rowe et al., 2015; Parizeau et al., 2015; Russell et al., 2017), but the influence of beliefs about food going to waste on food intake is yet to be investigated. Concerns over food going to waste may encourage individuals to eat more than they otherwise would be motivated to.

This may be particularly true when faced with larger portions; individuals may be encouraged to overconsume as there is more food that could go to waste. Zuraikat et al. (2019) argue that reducing food waste represents another way value from a meal can be enhanced and that individuals may overconsume in order to reduce waste and increase value from larger portions. In support, Roe, Apolzan, Qi, Allen, and Martin (2018) found that although individuals wasted more food from larger portions, they still overconsumed from these larger portions.

These is also some indirect evidence indicating that whether or not people believe food will go to waste affects food intake. Bates and Shanks (2015) found that participants provided with a take-away container at the start of a lunchtime meal consumed an average of 90kcal less of the meal than those not given a container. Zuraikat, Roe, Smethers and Rolls (2018) followed a similar paradigm over 4 laboratory sessions with 4 portion sizes (100%, 125%, 150% and 175% of baseline) but instead told participants that leftover food would be packaged to take away after the meal. Participants given this information consumed less than those in a control condition without a take-away option. It could be argued that the availability of a take-away container may reduce how much people eat in that sitting by reducing concerns about food waste. However, this is speculative, as this mediator was not explicitly tested in either study. Thus, we propose it is plausible that knowing whether food leftover from an eating occasion would be saved or wasted may influence food intake.

In Chapter 3, food waste concerns were positively associated with plate-clearing tendencies, but there were no associations with BMI or food intake. However, in these studies general (i.e. non-specific) food waste concerns were self-reported and only cross-sectional associations with food intake were examined. It may be that beliefs concerning food going to waste are most likely to influence food intake, in

specific situations where leftover food is expected to go to waste. Therefore, the aim of the 2 studies in this chapter is to examine the influence of experimentally manipulating whether or not people believe food will go to waste on food intake.

The first study in this chapter examined whether manipulating food waste beliefs affects food intake of a snack food, specifically investigating whether individuals will consume more if they believe leftover food will be wasted. Participants were randomized to receive 1 of 4 versions of a bogus study information sheet to manipulate beliefs about what would happen to any leftover food served in the study. The second study aimed to replicate the findings of the first study.

4.3 Study 1

4.3.1 Method

Participant recruitment and eligibility

We aimed for a sample size of 120 participants (30 per condition). We did not conduct an *a-priori* power analysis, as this was an exploratory study, however our sample size met the recommendations for minimum sample sizes (Simmons, Nelson, & Simonsohn, 2011). We recruited slightly above this number (N = 121) in the case of having to exclude 1 participant's data. Participants were recruited from staff and students at the University of Liverpool and the surrounding area. Most participants were reimbursed financially for their participation (64.5%) whilst others took part in exchange for course credit (1st year psychology students). Eligibility criteria were as follows: aged 18 or over, no history of food allergies, and had not participated in any recent similar studies. One participant was removed from the sample for analysis due

to a missing value for weight of food left after intake (human error). Therefore, data from 120 participants was analyzed (80 females, 40 males).

Cover story

To disguise the aims of the study, it was described to participants as being about 'TV, personality, mood, and character identification'. To further corroborate this cover story, attention was drawn to the lounge laboratory in which the study took place (a laboratory decorated like a living room/lounge). The experimenter told the participants that this was a deliberate choice to make the study more realistic, providing a relaxing environment in which you would typically watch television. Participants completed mood measures before and after watching a television episode, and questionnaires on personality, enjoyment of the television episode, and identification with the episode's characters.

Design

The current study used a between-subjects design. Participants were randomized to 1 of 4 conditions: control, food will be saved, food will be available to take home, or food will be wasted. We included the 2 conditions in which participants were led to believe that no food would be wasted in order to explore whether this may decrease food intake compared to the control condition. We reasoned that participants may reduce their food intake even more if they believed they would personally benefit from the food not going to waste (the 'take home' condition) as compared to if it was not clear what would happen to the leftover food that was saved ('food is saved' condition). Participants were assigned to each condition using RANDOM.ORG.

Experimental manipulation

Four different versions of the study information sheet were created, identical except for the final sentence that provided a message about what would happen to the leftover food from the study. This message corresponded to one of the 4 conditions: control ("All food is ordered from local supermarkets"), 'food is saved' ("Any food leftover from the study session is saved; no leftover food will go to waste"),'take home' ("Leftover food during a session is available to be taken home by that volunteer"), and 'food is wasted' ("For health and safety reasons, all leftover food has to be thrown away").

Test food

Participants were served a large bag of Butterkist 'Sweet Cinema Style' popcorn (approximately 100g and 503kcal) with a 500ml glass of water. Popcorn was identified as a realistic snack to consume whilst watching television. As in Rolls, Roe, Kral, Meengs and Wall (2004) participants ate directly from the bag of popcorn as opposed to a bowl, so that they had fewer visual cues to guide or monitor their consumption.

Main measures

Appetite: A mood and appetite measures questionnaire was administered, which included 3 appetite items: hunger, fullness, and desire-to-eat. These were presented as 99mm visual analogue scale questions (e.g. "How FULL do you feel right now?") with the anchors of 'Not at all' to 'Extremely'.

Awareness of research questions: Participants completed a free-text response question regarding what they believed the aim of the study to be ("What do you think the aim of the study was?").

Extent of belief that leftover food will be wasted: Participants were asked, "To what extent did you believe that left over food in this study would be thrown away/wasted?" which was scored on a 99mm VAS scale with anchors of 'Did not believe it would be wasted' to 'Believed the food would be wasted'.

Belief regarding leftover food: Participants were asked, "What do you believe will happen to the food leftover from this study?" and had the following responses to choose from: 'It will be wasted', 'It will not be wasted', 'It will be taken home by me', and 'Other'. The first, second and third responses corresponded to the information provided in the 'food is saved', 'take home' and 'food is wasted' conditions respectively.

Perceptions of portion size: Participants completed a question regarding what they thought of the portion size served ("In my opinion, the portion I was given in this study was…") with a 7-point Likert scale response format ('Too small' to 'Too large'). The higher the score, the larger the participant perceived the portion to be.

Other measures

Participants also completed other measures during the study that we included for future research purposes, and therefore did not plan to analyse in the present study (see Appendix 3 (pages 212-3) for a full description of all measures administered).

Procedure

Participants attended a single weekday session between 11am and 5pm. To standardize appetite, participants were asked not to eat for 2 hours prior to the study, or drink for 1 hour prior to the study. On arrival, the experimenter verbally confirmed that the participant had no known food allergies and had not eaten in the 2 hours prior to the study session. Participants were then given a short information sheet regarding general laboratory practice, which contained the experimental manipulation (see earlier section 'Experimental manipulation'), and were left for 2 minutes to read it. Upon their return, the experimenter read out aloud each point on the sheet to ensure the participant had read and understand the information. Participants then completed the mood and appetite questionnaire and were provided with the bag of popcorn and a glass of water. They were then told that they would be watching an episode from the comedy series 'Friends', and to help themselves to the refreshments provided if they wished. The episode ("*The one with all the jealousy*") contained no focus on food or characters eating in the episode. The television clip lasted for 22 minutes and 44 seconds, and participants informed the researcher when the clip was over. Once the clip was over, participants answered the mood and appetite measures for a second time, a questionnaire about the television clip, and a personality questionnaire to corroborate the cover story. Participants next completed the study aims question, before being given questionnaires about the portion they were served, what they believed would happen to leftover food, plate-clearing scale, and the food waste concerns scale. Once completed, participants had their height and weight measured, and were then debriefed and reimbursed for their time. The experimental session lasted for approximately 40 minutes.

Main analyses

We ran a univariate ANOVA with condition as the between-subjects factor and the extent to which participant believed that food would go to waste as the dependent variable. We also ran a univariate ANOVA to examine the influence of condition on food intake. The dependent variable was food intake, measured as the weight of food eaten (in grams), which was calculated by weighing the bag of popcorn before and after consumption. Planned comparisons were examined using Bonferroni corrections (adjusted significance level is $p<.008$). We also planned to run a correlation to investigate the relationship between food intake, measured as the weight of food eaten in grams, and the extent to which people believed that leftover food would go to waste. Results were considered significant at a $p < .05$.

Sensitivity analyses

We planned to examine the effect of removing participants for whom the manipulation had not worked on our main planned analysis. Responses to the question "What do you believe will happen to the food leftover from this study?" included "it will be wasted", "it will not be wasted", "it will be taken home by me", and "other". The first, second and third responses corresponded to 'food is saved', 'take home' and 'food is wasted' conditions respectively. There was no specified response for control, and these participants were kept in the analysis. In total, 28 people did not select the response that corresponded to their study condition (15, 6 and 7 participants from the 'food is saved', 'take home' and 'food is wasted' conditions respectively).

We also planned to examine the effect of removing participants that were aware of the study aims on our main planned analysis. Participants were characterised as

being aware of the study aims if in their written response to the question "What do you think the aim of the study was?" they mentioned the influence of food waste concerns or beliefs about what would happen to leftover food. Two researchers independently coded participant responses to this question and agreed that no participants showed awareness of the study aims.

Exploratory analysis

As the study manipulation did not seem to be understood in the 'food is saved' and 'take home' conditions (see Results section), we removed these conditions and compared the control condition and the food is wasted condition separately using an independent-samples t-test. We also planned to conduct a 2 x 2 ANOVA to examine the gender by condition interaction on food intake in these 2 conditions, in order to examine whether gender may moderate the effect of believing food would be wasted.

4.3.2 Results

*Sample Characteristic*s

A total of 121 participants were recruited (81 females, 40 males). One participant was excluded from analyses due to researcher error in recording the weight of food eaten. This resulted in 120 participants (80 females, 40 males; 30 per condition) being retained for use in our main analysis, with a mean age of 23.30 (±8.03) years and a mean BMI of 23.78 (±4.18) kg/m². On average, participants reported that they believed the portion size served to be 'very large' (2.28 (±0.95)).

Table 4.1. Effect of condition on the extent of belief that leftovers will be wasted and the weight of food eaten (values are mean (±SD) and ANOVA results)

Condition	Control (n = 30)	'Food is saved' (n = 30)	'Take home' (n = 30)	'Food is wasted' (n = 30)	Main effect of Condition
The extent of belief that leftovers will be wasted [a]	47.68 (±35.04)	28.85 (±30.56)	41.58 (±35.72)	78.63 (±26.21)	p <.001, η_p^2 =.25
Weight of food eaten (g)	25.74 (±20.91)	32.76 (±27.46)	30.84 (±23.25)	39.48 (±28.59)	p =.213, η_p^2 =.04

Table 4.1 displays the results of univariate ANOVAs to investigate whether they were significant differences in the extent to which participants believed that leftover food would be wasted or in the weight of food eaten (g) in each condition. There was a significant main effect of condition on the extent to which the participant believed that food would be wasted. See Figure 4.1 for comparisons.

[a] This was scored on a 99mm VAS scale with anchors of "did not believe it would be wasted" to "believed the food would be wasted".

Main Analysis

See Table 4.1 and Figure 4.1 for full ANOVA results. There was a significant main effect of condition on the extent to which participants believed that food would be wasted. The extent to which participants believed that food would be wasted was significantly higher in the 'food is wasted' condition than in the control, 'food is saved', and 'take home' conditions. However, the extent of belief in the 'control' condition was not significantly different from the 'food is saved' or 'take home' conditions, which did not significantly differ from each other. Food intake was also significantly positively correlated with the extent to which participants believed that food would be wasted (r(118) = .19, p =.038). However, a univariate ANOVA

indicated no significant difference between the weight of food eaten (in grams) in the 4 conditions.

Figure 4.1. The extent of belief that leftovers will be wasted split by condition (Confidence Intervals are Bonferroni adjusted)

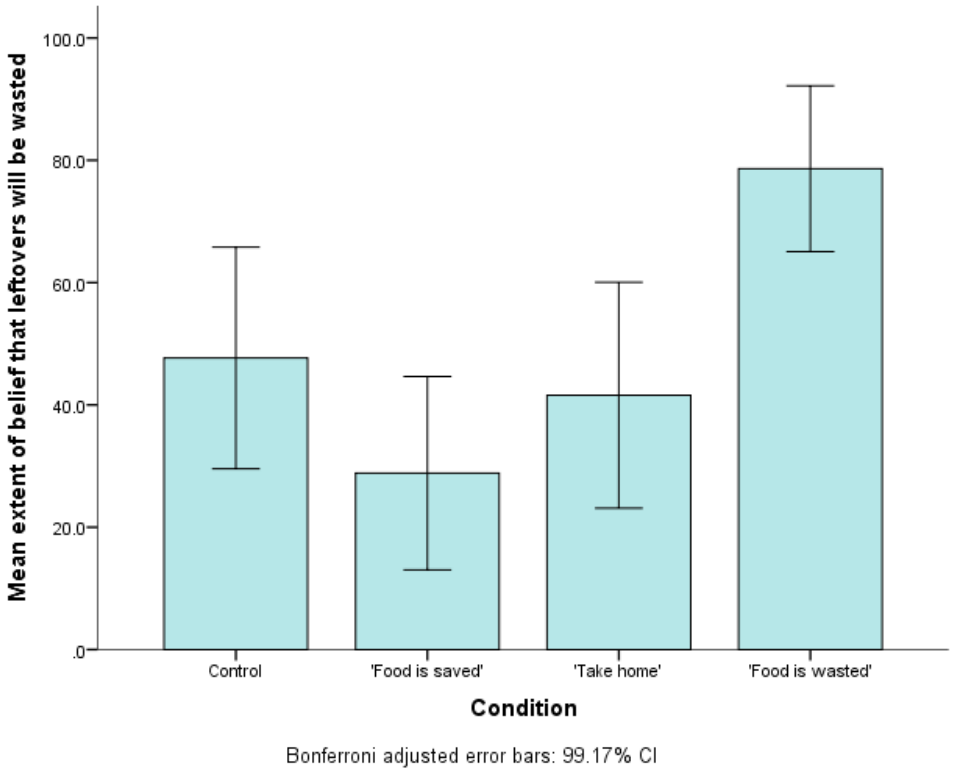


Figure 4.1 shows the effect of condition on the extent to which the participants believed that food would be wasted. Extent of belief was significantly higher in the 'food is wasted' condition than in the control (p =.002), 'food is saved' (p <.001), and 'take home' (p <.001) conditions. However, the extent of belief in the 'control' condition was not significantly different from the 'food is saved' (p =.150) or the 'take home' (p>.999) conditions, which did not significantly differ from each other (p =.764).

Sensitivity analyses

In total, 28 people did not select the response that corresponded to their study condition. Re-running the main analyses with these 28 participants removed did not change the patterns of statistical significance observed.

Exploratory analysis

Table 4.2. Mean weight of food eaten (g) by condition (control or food is wasted) and gender

Condition	Male (n = 20)	Female (n = 40)	Total (N = 60)
Control (n = 30)	21.12 (±13.18)	28.05 (±23.84)	25.74 (±20.91)
Food is wasted (n = 30)	54.00 (±30.08)	32.22 (±25.54)	39.48 (±28.59)

Table 4.2 shows the mean weight of food eaten (in grams) split by condition (control or food is wasted) and gender. Values are Mean (±SD).

Table 4.2 displays the mean weight of food eaten (in grams) split by condition and gender. An independent-samples t-test demonstrated that significantly more food was eaten by those who were told that leftover food would be wasted compared to the control group, $t(53.12) = -2.13$, $p = .038$, $d = .55$. A 2 x 2 ANOVA showed a significant gender by condition interaction effect on weight of food eaten, $F(1,56) = 4.68$, $p = .035$, $\eta_p^2 = .08$. Males ate significantly more food when they were told that the food would be wasted compared to receiving control information, $t(18) = -3.17$, $p = .005$, $d = 1.42$. However, intake in the 'control' and 'food is wasted' conditions did not significantly differ in females, $t(38) = -0.53$, $p = .596$, $d = .17$.

4.3.3 Conclusion

The aim of the present study was to examine whether experimentally manipulating beliefs about whether food served in the study would go to waste affects food intake from a large portion of snack food. There was no significant main effect of belief condition on food intake. However, the extent to which the participant believed that food would be wasted was significantly positively correlated with food intake. Also, in exploratory analyses we found that participants consumed significantly more food when they were led to believe that leftover food would be wasted, as opposed to being told nothing. This effect was observed among males, but not females. We found that our experimental manipulations to lead participants to believe that the food would not be wasted did not work as intended; these conditions did not significantly differ from the control condition in the extent to which participants believed the food would be wasted/saved. Likewise, when explicitly asked what would happen to the food in these conditions, a number of participants did not answer correctly (either they did not remember or did not believe our manipulation). However, our experimental manipulation designed to lead participants to believe that food would be wasted was effective. Given that our findings of significance were exploratory and driven by a small number of males (n <20 per condition). Study 2 aimed to replicate these findings with a larger sample size.

Unexpectedly, we found that males consumed significantly more when they were told that leftover food would be wasted compared to receiving control information, whereas there was no significant difference in intake between the 'control' and 'food is wasted' condition in females. The reason for this gender difference is unclear, but we speculate that it could be related to competing eating goals, particularly in females. One study has found that females report being more

concerned about eating, body weight, and physical appearance, lower appearance self-esteem and give weight control greater importance than males (Pliner, Chaiken, & Flett, 1990). It may be that females are considering eating-related goals, such as body weight and health, which may mean that they consume less in response to food waste information than males. However, this is speculative. In the second study, we recruited an equal number of male and females to be sufficiently powered to examine and replicate the potential influence of gender.

The second study sought to replicate the findings of the previous study with a refined study design and larger sample size. Following on from exploratory findings of the first study, it was hypothesized that participants would consume more food if they were told that leftover food would be wasted as opposed to receiving no information (control). Likewise, we tested whether we would replicate the finding that males would consume significantly more food in the 'food is wasted' condition than the control condition, whereas there would be no significant difference in the food intake of females in the condition and 'food is wasted' conditions. A secondary aim was to try to investigate whether the basis of any gender difference in response to the food waste belief manipulation would be due to differences in dietary restraint between males and females.

4.4 Study 2

4.4.1 Method

Participant recruitment and eligibility

We aimed to recruit a sample size of 160 participants (80 females, 80 males) which would provide more than adequate statistical power to detect a medium-sized

interaction effect (80% power, $p < 0.05$, G*Power 3.1.3), in order to detect the between group difference in the previous study and examine the moderation by gender (40 males and females in each condition). Participants were recruited from staff and students at the University of Liverpool and the surrounding area. Approximately half of the participants took part in exchange for course credit (1st year psychology students, 50.9%), whereas the other half were reimbursed financially for their participation (49.1%). Eligibility criteria were as follows: aged 18 or over, no history of food allergies, and had not participated in any recent similar studies. We recruited 165 participants, however 4 participants were excluded from analyses due to human errors in weighing food ($n = 2$), stating that they did not eat any popcorn because they did not like it ($n = 1$), and personally knowing the researcher ($n = 1$). Therefore, data from 161 participants was analyzed (81 females, 80 males).

Design

The current study used a between-subjects design. Participants were randomized to 1 of 2 conditions: control or food will be wasted. Participants were assigned to each condition using RANDOM.ORG.

Experimental manipulation

Two different versions of the study information sheet were used, these were identical to those used in the 'control' and 'food is wasted' conditions for Study 1. This message corresponded to 1 of the 2 conditions: control ("All food is ordered from local supermarkets"), or 'food is wasted' ("For health and safety reasons, all leftover food has to be thrown away").

Test food, measures and procedure

The method was the same as the first study, with the following changes:

1. Although we used the same brand and flavour of popcorn, the company had rebranded this product as 'Cinema Sweet' popcorn, and slightly changed the kilocalorie content (526kcal per 100g bag).
2. In order to address our secondary aim to investigate whether the basis of any gender difference in response to the food waste belief manipulation would be due to differences in dietary restraint between males and females, the original TFEQ (Stunkard & Messick, 1985) was added. This provides measures of uncontrolled eating (e.g. "When I have eaten my quota of calories, I am usually good about not eating any more."), disinhibition (e.g. "I usually eat too much at social occasions, like parties and picnics.") and restraint (e.g. "I am usually so hungry that I eat more than three times a day.").
3. To avoid testing over lunchtimes, sessions ran between the hours of 10-12 midday and 2-5pm.

Main analyses

A t-test was conducted with condition (control/food is wasted) as the between-subjects factor and the extent to which participant believed that food would be wasted as the dependent variable (i.e. responses to the question "To what extent did you believe that left over food in this study would be thrown away/wasted?").

A 2 x 2 ANOVA was conducted, with condition (control/food is wasted) and gender (male/female) as between-subject factors. The dependent variable was food intake, measured as the weight of food eaten (in grams) which was calculated by

weighing the bag of popcorn before and after consumption. We also planned to run a correlation to investigate the relationship between food intake and the extent to which people believed that leftover food would go to waste (i.e. “To what extent did you believe that left over food in this study would be thrown away/wasted?”). Results were considered significant at a $p < .05$.

Sensitivity analyses

We planned to examine the effect of removing participants for whom the manipulation had not worked on our main planned analysis, i.e. those who did not appear to believe that leftover food would go to waste. Responses to the question “What do you believe will happen to the food leftover from this study?” were compared to condition, and any mismatches were identified. In total, 23 people from the ‘food is wasted’ condition did not select the response “it will be wasted”. We also planned to examine the effect of removing participants that were aware of the study aims on our main planned analysis. Participants were characterised as being aware of the study aims if in their written response to the question “What do you think the aim of the study was?” they mentioned the influence of food waste concerns or beliefs about what would happen to leftover food. Two researchers independently coded participant responses to this question and agreed that no participants showed awareness of the study aims.

Exploratory analyses

One potential explanation for gender differences in intake when led to believe that leftover food will go to waste is that females may be eating instead in response to dieting attempts. Therefore, we controlled for restraint (measured using the TFEQ) in

all primary analyses that involved gender to investigate whether any gender interactions were removed when restraint was accounted for.

4.4.2 Results

*Sample Characteristic*s

After exclusions (see *Participant recruitment and eligibility*), 161 participants (81 females, 80 males) were retained for use in our main analysis, with a mean age of 25.79 (±11.49) years and a mean BMI of 24.23 (±3.79) kg/m².

Main Analysis

The extent to which the participants believed that food would be wasted was significantly higher in the 'food is wasted' than in the control condition, $t(120.14) = -5.54$, $p < .001$, $d = .87$.

Table 4.3 displays the mean weight of food eaten (in grams) split by condition and gender. A 2 x 2 ANOVA showed that there was no significant main effect of condition, $F(1,157) = 0.25$, $p = .620$, $\eta_p^2 < .01$, or gender, $F(1,157) = 1.13$, $p = .290$, $\eta_p^2 = .01$, on the weight of food eaten. There was a significant gender by condition interaction effect on weight of food eaten, $F(1,157) = 5.01$, $p = .027$, $\eta_p^2 = .03$. Intake in the 'control' and 'food is wasted' conditions did not significantly differ in males, $t(78) = 1.81$, $p = .074$, $d = .40$, or females, $t(79) = -1.33$, $p = .189$, $d = .29$. Thus, this interaction effect appears to be driven by a tendency (non-significant) for males to eat less when told food would be wasted vs. control (the opposite direction of results to Study 1).

Table 4.3. Mean weight of food eaten (g) by condition (control or food is wasted) and gender (values are mean(±SD))

Condition	Male (*n*=80)	Female (*n*=81)	Total (*N*=161)
Control (*n* = 81)	44.14 (±27.73)	30.42 (±24.78)	37.19 (±27.01)
Food is wasted (*n* = 80)	32.76 (±28.44)	37.66 (±24.35)	35.21 (±26.42)

A Pearson's correlation showed that food intake was not significantly correlated with the extent to which the participant believed that food would be wasted in the overall sample ($r(159) = .05$, $p = .535$).

Sensitivity analyses

In total, 22 of the 'food is wasted' participants did not select the response "it will be wasted". When the main analyses were re-run with these 22 participants removed, the gender by condition interaction effect on weight of food eaten became non-significant, $F(1,135) = 2.63$, $p = .107$, $\eta_p^2 = .02$. There were no other changes to the patterns of statistical significance observed in the main analyses.

Exploratory analyses

Controlling for restraint (measured using the TFEQ) in a 2 x 2 ANCOVA with condition (control/food is wasted) and gender (male/female) as between-subject factors did not change the patterns of significance observed in the main analysis.

4.4.3 Conclusion

The aim of the present study was to replicate the findings of the first study. We did not replicate the findings of Study 1. There was no overall difference in food intake between participants led to believe that the food they were eating would be thrown away and participants who received no information. Although there was a significant interaction between gender and condition (p =.027) as in Study 1, when the interaction was broken down the pattern of results was not the same as in Study 1. The interaction appeared to be driven by a trend (p =.074) for males to consume more in the control condition than the food is wasted condition, which is the opposite finding to Study 1. There was no evidence that females consumed significantly more or less food dependent on their experimental condition. We also failed to replicate the positive significant association between the extent to which participants believed that the test food would go to waste and food intake observed in Study 1.

4.5 Discussion

The aim of this chapter was to investigate whether experimentally manipulating beliefs about whether food would go to waste or not influences food intake. In Study 1, we find no supporting evidence for this effect in our main planned analyses. However, exploratory analyses showed that participants consumed significantly more food when they were told that leftover food would be wasted, as opposed to being told nothing, and the more certain people were that food would be wasted, the more they consumed. This effect was driven by a small number of male participants, as males (but not females) ate significantly more food when they were told that the food would be wasted compared to control. However, a replication with a more rigorous study design

did not replicate these findings. In Study 2, we recruited a larger sample size overall and an appropriate number of male participants. However, there was no significant main effect of belief condition on the weight of food eaten, and although there was a significant gender by condition interaction effect on weight of food eaten, this was driven by a tendency (non-significant) for males to eat less when told food would be wasted vs. control (the opposite direction of results to Study 1). In Study 2, we also failed to replicate the significant correlation observed between beliefs about food going to waste and food intake observed in Study 1.

The reason for conflicting findings in these 2 studies is not clear. It is possible that the samples in the first and second study differed, however inspection of the data indicates that these participant groups were similar on variables such as age and BMI. We only measured dietary restraint in the second study, so whether the samples differed on more specific eating behavior traits is not known, although our exploratory analyses in the latter study indicated that these did not affect the influence of food waste concerns on food intake. Also, it is possible that the different times of day of the study sessions between the studies could have influenced how hungry, full, and the desire to eat that participants felt. However, exploratory testing we performed found no evidence in support of this (see Appendix 3, pages 213-4).

A more simple explanation is that the findings of our exploratory analyses in Study 1 were erroneous and a 'false positive' finding. The overall effect of believing that food would be wasted vs. control on food intake was driven by male participants and there were only a small number of male participants in each condition. Because we used a between-subjects design it is therefore plausible that random sampling resulted in a higher proportion of male participants eating a lot of popcorn being allocated to the food is wasted condition than the control condition. 'False positive'

findings are thought to be most likely under conditions of small sample sizes in between-subject designs because such conditions increase the likelihood of random differences between experimental groups occurring (Simmons et al., 2011).

The lack of convincing evidence on the effect of manipulating beliefs about food going to waste across the main analyses of our 2 studies may have been caused by the methods that we used. Participants were provided with a snack food that they did not have to pay for, which may not reflect real life situations, where the inherent value and the cost of a food would be considered. This could provide an explanation as to why individuals did not act on their food waste concerns by consuming more food. It is possible that people attribute more value to certain foods (such as meat or fish) which are more expensive and substantial, and would be less likely to waste such foods in a similar paradigm. In addition, the fact that this was an extra snacking occasion and not a set meal that participants prepared themselves could have meant that other factors as well as food waste concerns influenced their intake. Replication of this study in the context of a meal, or more valuable food, would now be of interest.

The 2 studies utilised a similar study paradigm. It must be considered that our method of experimentally manipulating food waste beliefs, by highlighting that leftover food would go to waste, may not have worked as effectively as we expected. The majority of participants in the 'food is wasted' condition reported that the leftover food would be wasted when they were asked 'What do you believe will happen to the food leftover from this study?', and the extent to which participants believed that the leftover food would go to waste was significantly higher in this group than in the 'control' group. However, it is difficult to discern whether these beliefs actually impact on how concerned participants were about the food going to waste. We presume that food waste concerns may have been heightened as a result of being led to believe the

food would be wasted, but did not measure this. In future, it may be beneficial to measure food waste concerns in response to the experimental manipulation. Also, we have no way of controlling what individuals in the 'control' condition, who were not given any message regarding leftover food, believed would happen to the leftover food. The responses of these participants when asked to report what they believed would happen to the leftover food were varied, but some did indicate that they believed leftover food would go to waste. This is likely because it was a laboratory study, so participants may have believed that saving or taking food home in these studies is unlikely. Furthermore, these participants may have taken part in other studies in which they were informed that food would be thrown away. Therefore, some individuals in the control condition may have been eating in response to concerns about food waste, despite our intention to provide no message about what would happen to leftover food.

Another potential limitation relates to our cover story. Participants were told that these studies were about 'TV, mood, personality and character identification', and it was highlighted to the participants that the study took place in the lounge laboratory to create a more natural, cosy environment in which they would watch TV, to corroborate this cover story. The popcorn and glass of water were provided as refreshments to consume whilst watching the comedy episode, with the reasoning that this would not seem suspicious as it is typical to consume a snack food whilst watching TV in the home. However, responses to the questions regarding the aims of the study indicate that participants often made a connection between watching TV and consuming more food through being distracted.

Finally, many of these individuals were students and staff from the University of Liverpool who would have a higher than average level of education, and so may approach food waste differently. The food used in our study, sweet popcorn, was an

unhealthy snack food. Whether or not those with differing education attainments, or differences in socioeconomic status, diverge in their approaches to wasting food has not been investigated, so it is unclear whether this would have an impact.

4.6 Chapter Conclusion

Chapter 4 detailed 2 studies examining the influence of manipulating beliefs about food waste on food intake. Specifically, investigating whether being explicitly told that leftover food will be wasted influenced intake of that food. In our main planned analyses of both studies we found no evidence to suggest that being led to believe that food would be wasted increased consumption of that food. In exploratory analyses of Study 1 that were limited in sample size we found some supportive evidence. However, Study 2 did not replicate these results. The present studies do not provide evidence that believing food will be wasted affects food intake. However, a number of methodological and sampling limitations of these studies should be addressed to comprehensively test this hypothesis in future.

Chapter 5: The influence of portion size, plate-clearing tendencies and food waste concerns on intended consumption

5.1 Chapter Introduction

Chapters 2, 3 and 4 outlined studies investigating the influence of plate-clearing tendencies and food waste concerns on food intake. In Chapter 2, participants with higher plate-clearing tendencies consumed significantly more than those who self-report lower plate-clearing tendencies, although plate-clearing tendencies did not moderate the influence of portion size on food intake. In Chapter 3, food waste concerns were positively associated with plate-clearing tendencies. However, food waste concerns were not significantly associated with the likelihood of having overweight, BMI or food intake. In Chapter 4, experimentally manipulating beliefs about what would happen to leftover food did not influence food intake. The final experimental chapter of this thesis outlines an online study that investigated the potential interacting influence of plate-clearing tendencies and food waste concerns on intended consumption of a range of different portion sizes.

5.2 Introduction

Most of the research into the portion size effect investigates actual intake in a laboratory or restaurant setting (e.g. Diliberti, Bordi, Conklin, Roe, and Rolls (2004) and Rolls, Roe, Meengs, and Wall (2004)). However, there is evidence that portion size influences intended food intake (Best & Papies, 2019; Cahayadi, Geng, Mirosa, & Peng, 2019; Robinson, te Raa, et al., 2015). Given that how much people intend to eat tends to maps onto how much they subsequently eat (Cahayadi et al., 2019; Robinson, te Raa, et al., 2015), intended consumption may be important in understanding the influence of portion size. Therefore, further investigation into what individuals intend to do when faced with larger portions may offer some insights into why we eat more, and typically overconsume when faced with larger portions. Several studies demonstrate that individuals plan the amount of food that they are going to eat before a meal begins (Fay et al., 2011; Hinton et al., 2013; Le Bow et al., 1985), and typically follow through with their intentions regarding a meal (Fay et al., 2011). Furthermore, recent research indicates that pre-meal planning may outweigh within-meal influences such as the onset of fullness (Brunstrom, 2011; 2014; Fay et al., 2011). For example, Fay et al. (2011) found that pre-meal planning was the strongest predictor of intake whereas within-meal influences, such as internal signals of satiety, were weaker predictors.

Three studies have investigated the effect of portion size on intended consumption. Robinson, te Raa, et al. (2015) examined the effect of manipulating portion size on intended consumption of 2 lunchtime meals and 1 dessert across 3 studies. Participants were shown an image of either a standard or a large portion of the meal, and asked to indicate how much they would intend to consume at a hypothetical evening meal in a restaurant. Participants reported the percentage of the meal they

would intend to consume. In the last study, participants were served a portion of ice cream, reported how much they intended to consume, and subsequently consumed as much ice cream as they wished from that portion. The first 2 studies found evidence for a pre-consumption portion size effect; participants intended to consume the majority of the meal in both cases, and thus intended to consume more calories when served a larger as opposed to smaller portion. The last study also found evidence for a pre-consumption portion size effect, which translated to a portion size effect on actual consumption in males. In contrast, females intended to consume less from the larger portion, and a portion size effect on actual intake was not observed.

Best and Papies (2019) utilised a similar paradigm online, showing participants portion sizes of a number of healthy and unhealthy snack foods. They found that participants intended to consume more from larger than smaller portions. Interestingly, they also found a larger portion size effect for unhealthy than healthy snacks, and that individuals with lower socioeconomic status intended to consume significantly more from larger portions than from smaller portions of unhealthy snack foods, relative to individuals with a higher socioeconomic status. Cahayadi, Geng, Mirosa, and Peng (2019) also compared the portion size effect on intended and actual consumption. Participants rated 'expected intake' (which is synonymous with 'intended consumption') for a pasta dish at 3 different portion sizes (400g, 600g and 800g) and then consumed each of these portions in *ad libitum* meal sessions over 7 weeks. Although expected intake increased as portion sizes became larger, following a near linear relationship, actual intake had a smaller increment with very large portion sizes (i.e. 600g-800g). Such that the pre-meal portion size effect was comparable to the actual portion size effect with moderate portion sizes (400-600g) but significantly stronger than the actual effect with larger portion sizes (600g-800g). This supports the

idea that portion size has a stronger influence on pre-meal planning than on energy intake, but only when the portion size is particularly large. This is in line with research showing that the portion size effect on food intake is curvilinear and so is diminished with very large portions (Vandenbroele et al., 2019; Zlatevska et al., 2014).

Plate-clearing is a common eating behaviour (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016). Specifically, Robinson and Hardman (2016) studied self-reported plate-clearing tendencies and found that the majority (77.9%) of participants agreed that they 'always tend to clear [their] plate when eating'. Two restaurant studies report plate-clearing occurring in 83% (Hinton et al., 2013) and 72% (Lorenz et al., 2017) of meals, with many participants reporting they 'generally try to return an empty plate' in the cafeteria (Lorenz et al., 2017). A tendency to clear one's plate when eating out of habit could put individuals at risk of regular passive overconsumption, and consequently at higher risk of excess weight gain. Previous research has found plate-clearing to be most common among participants with obesity (Dodd et al., 1976; Krassner et al., 1979; Le Bow et al., 1985), and more recently 2 studies (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016) have shown that self-reported plate-clearing tendencies are positively associated with BMI, suggesting that a tendency to plate-clear is a risk factor for obesity.

A tendency to plate-clear may represent an important pre-meal intention or decision. If plate-clearers are more influenced by the amount served to them - having a tendency to clear the plate out of habit - they may be less reliant on internal signals of satiety that arise during a meal, and thus may typically stick to their pre-meal decision to clear the plate. Fay et al. (2011) investigated the prevalence of pre-meal planning and plate-clearing behaviour by asking participants questions about the last meal they consumed. Ninety-one percent of individuals reported consuming all of their

last meal, or clearing the plate at their last meal, and in 92% of these cases this was pre-planned. Importantly, 28% followed through with this plan to consume all of the meal, and cleared their plate, despite feeling full before the end of the meal. Therefore, this indicates that individuals who engage in habitual plate-clearing will intend to consume most or all of a portion of food they are served.

Given that Fay et al. (2011) did not manipulate or measure the size of the participants' last consumed meal (as it was retrospective), conclusions cannot be drawn about how plate-clearers respond to differing portion sizes. In Chapter 2 of this thesis, it was found that plate-clearers consumed significantly more of a laboratory meal than non-plate-clearers, however there was no plate-clearing by portion size interaction effect on laboratory measured food intake. In other words, participants with plate-clearing tendencies exhibited a portion size effect of similar magnitude to that of non-plate-clearers. However, there are a few reasons to investigate a potential plate-clearing by portion size interaction effect on intended consumption. First, the study in Chapter 2 utilised only 2 portion sizes, which were 500g and 1000g respectively, and participants most commonly cited these portions as 'larger than normal' and 'too large' respectively. A meta-analysis by Zlatevska, Dubelaar, and Holden (2014) concludes that the portion size effect is curvilinear, and so is diminished for very large portions, which is also supported by more recent work (Vandenbroele et al., 2019). Given that the portion size we used as the 'large' portion was deemed 'too large', participants may have exhibited a diminished response to the portion size effect in this condition. The current study presented participants with 11 different portion sizes ranging from the recommended portion (280g) to 300% of the recommended portion (840g). Using a wide range of portion sizes should allow a more thorough investigation of the potential interplay between portion size and plate-clearing on intended consumption.

A small number of portion size studies have examined the portion size by plate-clearing interaction effect on food intake in secondary analyses, and have found no evidence that plate-clearing tendencies interact with portion size to influence food intake (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). However, the interaction effect was not the primary focus of these studies, resulting in a limited sample size for moderation analysis and limited information regarding how plate-clearing tendencies were measured and whether the sample included a substantial number of participants with and without plate-clearing tendencies. Thus, further investigation is warranted. Finally, as mentioned previously, intended consumption has been found to be closely related to actual consumption (Cahayadi et al., 2019; Robinson, te Raa, et al., 2015). Therefore, investigating a portion size by plate-clearing interaction effect on intended consumption will provide insight into how people may intend to consume and respond to differing portion sizes in the food environment.

Individuals report being aware that food waste is a problem (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015), with most consumers citing it as a serious issue (Parizeau et al., 2015). People are typically averse to food waste (Bolton & Alba, 2012; Gjerris & Gaiani, 2013) and report feelings of guilt and concern around wasting food (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015). For example, across studies investigating opinions regarding food waste, 37-90% of adults agree that food waste is a problem (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015; Setti et al., 2016), specifically an environmental, economic, ethical, and social problem (Parizeau et al., 2015; Setti et al., 2016). Respondents typically see individuals as responsible for reducing food waste (Parizeau et al., 2015) and report being concerned about wasting food (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015) and

the associated consequences (Setti et al., 2016). Thus, there appears to be a widely held belief that wasting food is problematic and should be avoided.

Although food waste concerns have not been investigated in the context of food intake before, Bates and Shanks (2015) found that participants provided with a take-away container at the start of a lunchtime meal consumed an average of 90kcal less of the meal than participants who were not given a container. In a similar vein, Zuraikat, Roe, Smethers and Rolls (2018) found that participants told that leftover food would be packaged to take away after the meal consumed less than those in a control condition without a take-away option. It could be argued that in these 2 studies the availability of a take-away container reduces how much people eat in that sitting by reducing concerns about food waste. This indicates that individuals may eat less, or at the very least not overeat, at an eating occasion where food waste becomes less of a concern.

Hall, Guo, Dore, and Chow (2009) propose that surplus food, food waste and overeating are paradoxically linked, which is illustrated in a recent study by Roe, Apolzan, Qi, Allen, and Martin (2018). Although plate waste was significantly associated with number of grams of food selected in this study, with individuals wasting more food from larger portions, participants still consumed more from larger portions. This indicates that larger portions paradoxically contribute to both overconsumption and wasting of food (Hall et al., 2009). Fay et al. (2011) also found that when participants were asked if they had "eaten all of the food on [their] plate, even though [they] could have stopped before that point", of the individuals who answered yes, 77% reported that this was because they did not want to waste food. In previous chapters we have found a positive association between food waste concerns and plate-clearing tendencies, and Benson (2009) found that many participants

reported feeling guilty if they leave food on their plates, as they had been encouraged from an early age to clear their plate.

From these findings, it is proposed that part of the reason why people plate-clear is to avoid wasting food, and in some cases, this may lead people to overconsume. Individuals may be inclined to eat more or attempt to clear their plates in order to avoid wasting food. Thus, food waste concerns may contribute to decision-making processes regarding how much to eat (by increasing plate-clearing tendencies) and thus increase risk of overconsumption in an environment characterised by large portions.

Given that food waste concerns and plate-clearing may encourage people to eat more, we suggest that those who report high plate-clearing tendencies and high food waste concerns will plan to eat more food, especially when faced with larger portions. Thus, the current study aimed to examine the influence of portion size, plate-clearing tendencies and food waste concerns on intended consumption in an online study. More specifically, the portion size effect on intended consumption with a range of portion sizes was examined, and whether those who self-report higher plate-clearing tendencies and/or food waste concerns are more prone to the influence of portion size on intended food intake was examined. Participants were presented with 11 different portion sizes of pasta in tomato sauce in a random order and asked how much of each portion they would intend to consume at a hypothetical meal.

It was hypothesised that there would be a main effect of portion size on intended consumption, such that people would plan to consume more from larger than smaller portions. We predicted a portion size by plate-clearing interaction effect on intended consumption, such that participants who have higher plate-clearing tendencies would plan to consume more food from large portions than those with lower

plate-clearing tendencies. We also predicted that there would be a portion size by food waste concerns interaction effect on intended consumption, such that participants who have higher food waste concerns would plan to consume more from larger portions than those with lower food waste concerns.

In addition, as an exploratory hypothesis, we predicted a 3-way interaction effect on food intake. Specifically, it was predicted that food waste concerns would moderate the relationship between plate-clearing and portion size on intended consumption. We made this hypothesis on the basis that food waste concerns may be more likely to influence food intake from larger portions when a person already has an intention to plate-clear, whereby concerns about food waste result in a person following through on their plan to attempt to eat the majority of the food provided.

5.3 Method

Participant recruitment and eligibility

As this was an exploratory study we did not conduct a formal power analysis and aimed to recruit a minimum sample size of 200 participants. This sample size however would provide us with sufficient power to detect a medium-small sized effect of portion size and interactions (at 80% power). Participants were recruited via social media (Facebook adverts, Twitter posts), posters across the University of Liverpool campus, and email announcements on the University of Liverpool staff and student intranet. Participants were considered eligible to take part if they were aged 18 years or over and had not taken part in either of our previous laboratory or questionnaire studies which focused on plate-clearing tendencies, food waste concerns, and overeating from larger portions.

A total of 640 participants started the study. Of these, 221 were incomplete responses that were deemed unusable. A response was deemed unusable if the participant had not completed as a minimum the questions relevant to our hypotheses, specifically all intended consumption, plate-clearing tendency, and food waste concerns questions. Two participants failed the comprehension check and 8 failed the attention check. Thus, the final analytic sample of participants was 409.

Design

The current study used a mixed design. The independent variables were portion size image (within-subjects), with 11 levels ranging from 100-300% of the recommended portion size of pasta, plate-clearing tendency score and food waste concerns score (between-subjects factors). Participants were shown all 11 portion size images in a randomized order and rated their intended consumption for each. The dependent variable was intended consumption (kcals).

Portion size images

We selected 11 portion size images of penne pasta in tomato sauce, ranging from 100% to 300% of a recommended portion (280g), with the portion size shown increasing by 20% of the recommended portion size with each subsequent photo. Pasta dishes have been used as a test food in other portion size studies (e.g. Diliberti et al 2004; Rolls, Morris & Roe, 2002), with pasta in tomato sauce being a typical meal that we reasoned most of our participants would be familiar with and consume relatively regularly.

Main measures

Dieting: Participants were asked, "Are you currently dieting?" with a coded response of 1 = 'Yes', 2 = 'No'.

Hunger: Participants reported their current level of hunger ("Please rate your current level of hunger") on a 7-point Likert scale response format (1 = 'Not at all hungry' to 7 = 'Extremely hungry').

Intended consumption: Intended consumption was measured using a single item: "Imagine you are served the displayed portion for an evening meal. How much of the portion would you plan to eat? Please answer as a percentage from 0-100". This percentage was then used to calculate intended consumption in kilocalories based on manufacturer-reported calorie content of the meal components (for weight and kilocalories for each portion size see Appendix 4, page 216).

Liking: Participants reported how much they liked pasta in tomato sauce on a 7-point Likert scale (1 = 'Not at all' to 7 = 'I like pasta a lot').

Frequency of consumption: Participants reported how regularly they consumed pasta in tomato sauce, ranging from 'Daily' to 'Less frequently than once a year'.

Familiarity: Participants reported how familiar they were with pasta in tomato sauce on a 7-point Likert scale (1 = 'Not familiar at all' to 7 = 'Extremely familiar').

Plate-clearing tendencies: Participants completed a self-report measure of plate-clearing (as used in Robinson et al. (2015)). The measure consists of 5 questions (e.g. "I always tend to clear my plate when eating.") with a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Scores were summed, with a higher score indicating stronger plate-clearing tendencies (α = .89) (Robinson et al., 2015).

Food waste concerns: Participants completed a self-report measure of individual food waste concerns. The measure consists of 5 questions (e.g. "It is fine for food to go to waste sometimes.") with a 7-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Scores were summed, with a higher score indicating stronger concerns regarding food waste (α = .80).

Attention check: We also included an attention check question "This is an attention check. Please leave blank." among the plate-clearing questions to ensure that participants were attending to the questions. Participants who did not correctly respond to the attention check were excluded from the analysis.

Comprehension of percentages: We included a comprehension question to ensure participants understood percentages. Participants were presented with an image of a circle that was coloured half white and half blue and asked, "Which percentage of the circle shown above is blue?" with the choice of '25%', '50%', '75%', or '100%'. Participants who did not select '50%' were excluded from the analysis.

Other Measures

Participants also completed other measures during the study that we included as part of a student project (see Appendix 4, page 216, for a full description of additional measures administered).

Procedure

This study was approved by the University of Liverpool ethics committee. Participants first completed questions on demographics, current dieting and hunger level.

Participants then viewed the 11 portion size images in a randomized order and reported their intended consumption for each. Next, participants completed food-related measures (liking, consumption frequency, and familiarity), comprehension and attention checks, the plate-clearing scale, the food waste concerns scale and the other included measures. Finally, participants were asked to indicate how they had heard about the study, were taken to the debriefing page and thanked for their participation. The study took approximately 15 minutes to complete.

Main analysis strategy

All statistical analyses were ran using IBM SPSS Statistics 24. To first investigate whether there was a portion size effect on intended consumption, we planned to conduct a within-subjects ANOVA, with portion size (11 levels) as a within-subjects factor and intended consumption (in kcal) as the dependent variable. Planned contrasts were used to investigate whether there was a significant increase in the calories consumed with each subsequent portion size.

An 11 x 2 ANOVA, with portion size (11 levels) as a within-subjects factor, plate-clearing score as a between-subjects factor (plate-clearers/non-plate-clearers), and intended consumption (in kcal) as a dependent variable, was conducted to investigate the influence of plate-clearing tendencies on intended consumption, and to assess the portion size*plate-clearing interaction effect on intended consumption. Individuals were defined as 'plate-clearers' if they score 18 or higher, and as 'non-plate-clearers' if they score 17 or lower on the plate-clearing scale. This was informed by our previous study, where the average plate-clearing score of a sample of self-identified plate-clearers and non-plate-clearers was 17.76. An 11 x 2 ANOVA, with

portion size (11 levels) as a within-subjects factor, food waste concerns score as a between-subjects factor (low/high) and intended consumption (in kcal) as a dependent variable was conducted to investigate the influence of food waste concerns on intended consumption, and to assess the portion size*food waste concerns interaction effect on intended consumption. Individuals were defined as having 'high' food waste concerns if they scored 21 or higher, and as having 'low' food waste concerns if they score 20 or lower on the food waste concerns scale. This was informed by the midpoint of the possible scale scores (with a lowest possible score (7) and the highest possible score (35) on this scale).

Finally, as it may be expected that those who are dieting may be more motivated to eat less, we planned to run the main analyses with those who reported that they were currently dieting removed from the sample. Results were considered significant at a $p < .05$.

Sensitivity analyses

We also planned to examine whether the pattern of results seen in our main analysis was observed when portion size, total plate-clearing score and total food waste concerns score were treated as continuous variables using multilevel modelling. We used multilevel modelling to account for the fact that 11 responses were given by each individual (within-subjects variable of portion size). Thus, our data was organised in 2 levels, with portion size trials (11 images; level 1) nested within participants (level 2). Plate-clearing and food waste concerns were level 2 predictors. The models included random intercepts.

Model 1 included portion size (11 images; level 1) to investigate the effect of portion size on intended consumption. Model 2 and Model 3 were compared to Model 1 to examine the additional variance explained by adding plate-clearing tendencies and food waste concerns as predictors. Model 2 included portion size trial (11 images; level 1), plate-clearing tendencies (level 2) and their interaction to investigate the portion size by plate-clearing interaction on intended consumption. Model 3 included portion size trial (11 images; level 1), food waste concerns (level 2) and their interaction to investigate the portion size by food waste concerns interaction on intended consumption. Models included random intercepts.

Exploratory analyses

To investigate the 3-way interaction (portion size by plate-clearing tendencies by food waste concerns) on intended consumption, Model 4 included portion size (11 images; level 1), individual participant (level 2), plate-clearing tendencies (level 2) and food waste concerns (level 2). This model was also compared to Model 2 to investigate the additional variance explained when we include food waste concerns in the interaction term. A significant portion size by plate-clearing by food waste concerns interaction effect on intended consumption would indicate moderated moderation. See Figure 5.1 for a conceptual diagram.

Figure 5.1. Proposed moderated moderation model of plate-clearing and food waste concerns, portion size and intended consumption

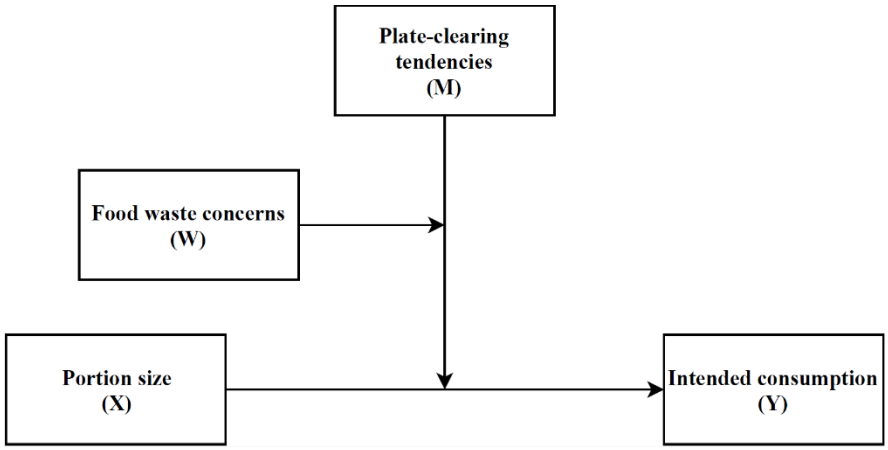


Figure 5.1 shows a conceptual model of our expected 3-way interaction, or moderated moderation model. It is predicted that the strength of the effect of portion size (X) on intended consumption (Y) would be moderated by plate-clearing tendency scores (W), which in turns would be moderated by food waste concerns scores (Z).

5.4 Results

Sample characteristics

The analytic sample (N = 409) consisted of 93 males and 316 females, with a mean age of 26.15 (±12.55) years. Seventy-six participants reported that they were currently dieting. The mean intended consumption in kilocalories at each portion size, split by plate-clearing tendency score and food waste concerns score is displayed in Table 5.1

Table 5.1. Intended consumption (in kcal) for each portion size (in kcal) split by plate-clearing tendency type and food waste concerns score

Portion size	Portion size			Food waste concerns		
(% of recommended)	(in kcal)	Non-plate-clearers (*n* = 118)	Plate-clearers (*n* = 291)	Low (*n* = 226)	High (*n* = 183)	Total (*N* = 409)
100%	299.00	267.86 (±44.44)	280.72 (±42.04)	273.98 (±42.70)	280.75 (±43.40)	277.01 (±43.09)
120%	328.90	272.02 (±84.00)	320.05 (±60.82)	300.50 (±68.39)	313.21 (±74.98)	306.19 (±71.60)
140%	418.60	280.53 (±83.37)	344.98 (±84.24)	315.73 (±84.87)	339.55 (±92.04)	326.39 (±88.83)
160%	478.40	286.47 (±92.20)	366.64 (±100.63)	331.79 (±100.27)	357.99 (±108.42)	343.51 (±104.68)
180%	538.20	313.21 (±103.38)	410.36 (±116.50)	368.10 (±117.50)	399.92 (±123.37)	382.33 (±121.05)
200%	598.00	326.92 (±120.38)	442.81 (±139.32)	388.51 (±138.81)	435.13 (±146.33)	409.37 (±143.93)
220%	657.80	322.21 (±119.55)	447.48 (±159.89)	390.98 (±151.40)	436.48 (±166.35)	411.34 (±159.68)
240%	717.60	326.20 (±134.04)	468.61 (±171.40)	405.95 (±168.10)	454.17 (±177.45)	427.52 (±173.80)
260%	777.40	361.29 (±157.81)	508.46 (±186.89)	443.39 (±186.94)	493.93 (±192.44)	466.00 (±190.85)
280%	837.20	343.39 (±158.81)	525.45 (±206.45)	440.27 (±202.03)	513.25 (±214.48)	472.93 (±210.59)
300%	897.00	380.84 (±166.43)	559.53 (±217.98)	475.21 (±213.27)	548.44 (±221.44)	507.98 (±219.74)

Table 5.1 displays the intended consumption in kilocalories for each portion size image presented split by plate-clearing tendency type (plate-clearers/non-plate-clearers) and food waste concerns score ('low' and 'high'). 'Plate-clearers' were individuals who scored 18 or higher and 'non-plate-clearers' were individuals who scored 17 or lower, on the plate-clearing scale. 'Low' food waste concerns were defined as scoring 20 or lower, and 'high' food waste concerns as scoring 21 or higher on the food waste concerns scale. Values are Mean (±SD).

Main outcomes

There was a significant main effect of portion size on intended consumption, $F(2.99, 1221.23) = 278.70$, $p < .001$, $\eta_p^2 = .41$, with participants intending to consume significantly more from larger portions. There was a significant increase in intended consumption with every increase in portion size (*ps* <.01), except for 200-220% ($p = .666$) and 260-280% ($p = .285$) of the recommended portion size (see Table 5.2 for effect sizes for each comparison).

Table 5.2. Pairwise comparisons for intended consumption (kcal) for each portion size

Portion sizes (being compared)	Change in intended consumption	Cohen's d
280g - 336g	29.18	.56***
336g - 392g	20.19	.36***
392g – 448g	17.13	.29***
448g – 504g	38.82	.53***
504g – 560g	27.04	.35***
560g – 616g	1.97	.02
616g – 672g	16.18	.19***
672g – 728g	38.48	.39***
728g – 784g	6.92	.05
784g – 840g	35.05	.28***

Table 5.2 shows the change in intended consumption (mean difference) and effect sizes (Cohen's d) for each pairwise comparison. ***p <.001

There was a significant main effect of portion size, $F(3.30, 1343.61) = 177.77$, $p < .001$, $\eta_p^2 = .31$, and a significant main effect of plate-clearing type, $F(1, 407) = 78.11$, $p < .001$, $\eta_p^2 = .16$, on intended consumption, with plate-clearers intending to consume significantly more than non-plate-clearers. There was a significant portion size*plate-clearing type interaction effect on intended consumption, $F(3.30, 1343.61) = 32.67$, p

<.001, η_p^2 =.07. Portion size effects on intended consumption tended to be statistically larger in plate-clearers than non-plate-clearers (see Table 5.3 for effect sizes for each comparison).

Table 5.3. Pairwise comparisons for intended consumption (in kcal) for each portion size (kcal) split by plate-clearing tendency type

Portion sizes (being compared)	Non-plate-clearers (*n* = 118)		Plate-clearers (*n* = 291)	
	Change in intended consumption	Cohen's d	Change in intended consumption	Cohen's d
280g - 336g	4.16	.06	39.33	.96***
336g - 392g	8.51	.15	24.93	.45***
392g – 448g	5.94	.11	21.66	.37***
448g – 504g	26.73	.41**	43.72	.58***
504g – 560g	13.72	.19	32.44	.42***
560g – 616g	-4.71	.05	4.68	.05
616g – 672g	3.99	.05	21.13	.25**
672g – 728g	35.09	.37**	39.85	.40***
728g – 784g	-17.90	.18	16.99	.12
784g – 840g	37.45	.38	34.08	.26***

Table 5.3 shows the change in intended consumption (mean difference) for each pairwise comparison made, and the effect sizes (Cohen's d) for plate-clearers and non-plate-clearers. **p <.01, ***p <.001

There was a significant main effect of portion size, F(3.05, 1240.37) = 287.62, p <.001, η_p^2 =.41, and a significant main effect of food waste concerns, F(1, 407) = 10.92, p =.001, η_p^2 =.03, on intended consumption, with those reporting high food waste concerns intending to consume significantly more than those reporting low food waste concerns. There was a significant portion size*food waste concerns interaction effect on intended consumption, F(3.05, 1240.37) = 6.14, p <.001, η_p^2 =.02. Portion size effects on intended consumption tended to be statistically larger in those who self-

reported high food waste concerns than those who self-reported low food waste concerns (see Table 5.4 for effect sizes for each comparison).

Removing participants that reported they were currently dieting did not change the overall pattern of statistical significance observed in the main analyses (see Appendix 4, page 217 for the main analyses with dieters removed).

Table 5.4. Pairwise comparisons for intended consumption (in kcal) for each portion size (in kcal) split by food waste concerns score type

Portion sizes (being compared)	Low (*n* = 226)		High (*n* = 183)	
	Change in intended consumption	Cohen's d	Change in intended consumption	Cohen's d
280g - 336g	26.52	.56	32.47	.57***
336g - 392g	15.23	.28	26.33	.47 ***
392g – 448g	16.06	.27	18.44	.31***
448g – 504g	36.31	.50**	41.93	.56***
504g – 560g	20.42	.27	35.22	.46***
560g – 616g	2.47	.03	1.35	.01
616g – 672g	14.97	.18	17.68	.21**
672g – 728g	37.44	.36**	39.76	.43***
728g – 784g	-3.12	.03	19.33	.14
784g – 840g	34.94	.36	35.19	.23***

Table 5.4 shows the change in intended consumption (Mean(±SD)) for each pairwise comparison made, and the effect sizes (Cohen's d) for those who self-report low and high food waste concerns. ***p* <.01, ****p* <.001

Results of sensitivity analyses

All results remained the same when plate-clearing tendencies and food waste concerns were treated as continuous variables. Full regression models for all reported models

are presented in Table 5.5. Model 1 revealed a significant effect of portion size on intended consumption, with participants intending to consume significantly more from larger than smaller portions (b =22.16, SE =0.42, p <.001).

A chi-squared test showed that Model 2 was a significantly better fit than Model 1 ($\chi^2(2) = 630.62$, p <.001). Model 2 revealed a significant portion size by plate-clearing tendencies interaction effect on intended consumption. Portion size had a stronger effect on intended consumption for those who self-reported higher plate-clearing tendencies compared to those who self-reported lower plate-clearing tendencies (b =2.14, SE =0.09, p <.001) (see Figure 5.2).

A chi-squared test showed that Model 3 was a significantly better fit than Model 1 ($\chi^2(2) = 109.36$, p <.001). Model 3 revealed a significant portion size by food waste concerns interaction effect on intended consumption. Portion size had a stronger effect on intended consumption for those who self-reported higher food waste concerns compared to those who self-reported lower food waste concerns (b =0.65, SE =0.07, p <.001) (see Figure 5.3).

Results of exploratory analyses

A chi-squared test showed that Model 4 was a significantly better fit than Model 2 (which investigated the portion size by plate-clearing interaction) ($\chi^2(4) = 28.79$, p <.001). Model 4 demonstrated a significant 3-way interaction on intended consumption (b =0.07, SE =0.01, p <.001 (see Figure 5.4). The interaction between self-reported plate-clearing tendencies and portion size became larger as self-reported food waste concerns increased. Thus, the tendency for plate-clearing tendencies to moderate the impact of portion size on food intake was more pronounced among those

who reported higher food waste concerns than those who reported lower food waste concerns.

Figure 5.2. A visual representation of the moderation of the effect of portion size on intended consumption by changing plate-clearing tendency score

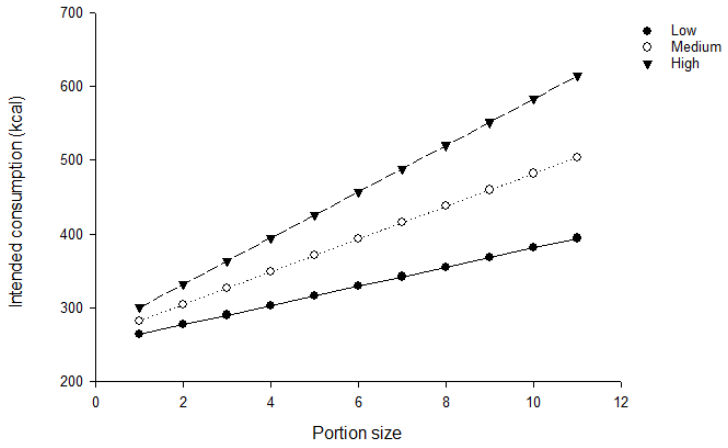


Figure 5.2 displays the intended consumption (in kcal) at select levels of portion size (1-11) and plate-clearing tendency scores. 'Low' 'Medium' and 'High' plate-clearing tendency scores are Mean-1SD, Mean, and Mean+1SD respectively.

Figure 5.3. A visual representation of the moderation of the effect of portion size on intended consumption by changing food waste concerns score

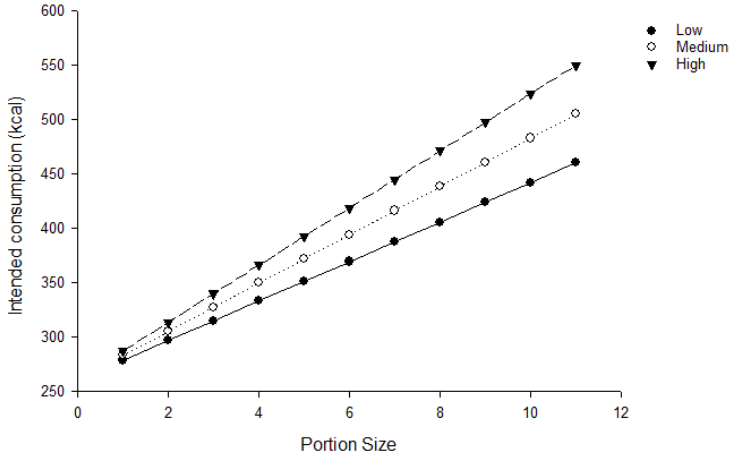


Figure 5.3 displays the intended consumption (in kcal) at select levels of portion size (1-11) and food waste concerns scores. 'Low' 'Medium' and 'High' food waste concerns scores are Mean-1SD, Mean, and Mean+1SD respectively.

Table 5.5. Multilevel regression models for all Mixed Models

	Model 1		**Model 2**		**Model 3**		**Model 4**	
	B	**SE**	**B**	SE	**B**	**SE**	**B**	**SE**
Intercept	260.73***	6.57	220.86***	25.97	259.86***	21.49	208.33**	80.03
Portion Size (continuous)	22.16***	0.42	-18.76***	1.82	9.27***	1.40	4.87	5.61
PCT	-	-	2.08	1.32	-	-	3.32	4.18
PCT x portion size	-	-	2.14***	0.09	-	-	0.78**	0.29
FWC	-	-	-	-	0.04	1.03	0.42	4.24
FWC x portion size	-	-	-	-	0.65***	0.07	-1.24***	0.30
PCT x FWC	-	-	-	-	-	-	-0.05	0.21
FWC x PCT x portion size	-	-	-	-	-	-	0.07***	0.01
Residual variance level 2	14289.07***	1050.70	10263.09***	763.28	13700.52***	1008.40	10169.06***	756.42
Residual variance level 1	8080.42***	178.68	7150.80***	158.13	7899.63***	174.69	7107.06***	157.16
Model fit (-2 log likelihood)	54480.40		53849.79		54371.04		53821.00	

Table 5.5 displays the multilevel regression model for Model 4. Portion size was a level 1 predictor. Plate-clearing tendencies (PCT) and food waste concerns (FWC) were level 2 (individual level) predictors. All predictors were included as individual main effects, in all possible 2-way interactions, and in a 3-way interaction. Values are B(SE). ***p* <.01, ****p* <.001

Figure 5.4. A visual representation of the moderating effect of plate-clearing tendency on the effect of portion size on intended consumption by changing food waste concerns score (low, medium and high)

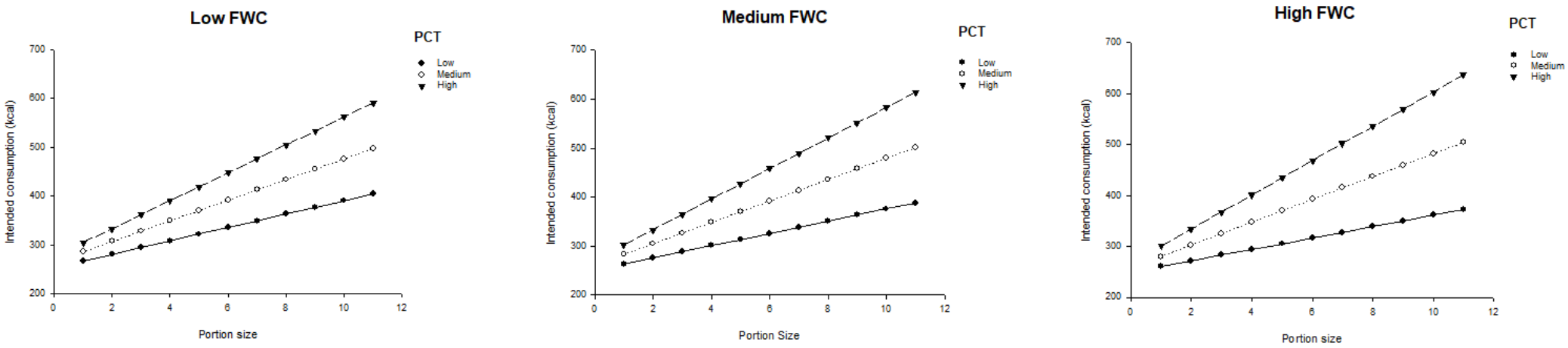


Figure 5.4 displays the intended consumption (in kcal) at select levels of portion size (1-11) and plate-clearing tendency (PCT) scores, which are then split by 'low', 'medium' and 'high' food waste concerns (FWC). Low', 'medium', and 'high' plate-clearing tendency scores are Mean-1SD, Mean, and Mean+1SD respectively. 'Low', 'medium', and 'high' food waste concerns scores are Mean-1SD, Mean, and Mean+1SD respectively.

5.5 Discussion

The aim of the present study was to examine whether plate-clearing tendencies and food waste concerns moderate the influence portion size has on intended consumption of a hypothetical lunchtime meal. As expected, we found a significant portion size effect on intended consumption, with individuals intending to consume significantly more from larger portions relative to smaller portions. We found that individuals who self-reported higher plate-clearing tendencies intended to consume significantly more from larger portions relative to smaller portions than those who self-reported lower plate-clearing tendencies. Participants who self-reported higher food waste concerns also intended to consume significantly more from larger portions relative to smaller portions than those who self-reported lower food waste concerns. Finally, exploratory findings showed a significant 3-way interaction of portion size by plate-clearing tendencies by food waste concerns on intended consumption. This demonstrated that the interaction between self-reported plate-clearing tendencies and portion size becomes larger as self-reported food waste concerns increase.

The portion size effect on food intake is a robust finding (Hollands et al., 2015; Steenhuis & Vermeer, 2009; Zlatevska et al., 2014), but research into the portion size effect on intended consumption is limited. The current findings demonstrate that intended consumption increased as portion sizes became larger, supporting the findings of Cahayadi et al. (2019) and Robinson, te Raa, et al. (2015). Cahayadi et al. (2019) found a near linear relationship between portion size and intended consumption, and Robinson, te Raa, et al. (2015) found that intended consumption led to males overconsuming, showing a pre-consumption portion size effect.

The current findings also support a portion size by plate-clearing interaction effect on intended consumption. Given that individuals typically stick to their pre-meal intentions, even over within-meal influences such as the onset of fullness (Brunstrom, 2014; Brunstrom, 2011; Fay et al., 2011), pre-meal intentions to plate-clear could potentially be maladaptive in the current eating environment characterised by large portions. However, the first study of this thesis found no significant portion size by plate-clearing interaction effect on actual food intake. There are some potential explanations that may reconcile these different findings. First, this online study improves upon the laboratory intake study (Study 1 of Chapter 2) by utilising 11 portion size images, as opposed to serving 2 portion sizes only. In addition, the 2 portion sizes served in the laboratory study were large, and it is possible that the size of the portions and the large difference between them led to a ceiling effect, "washing out" the effects of plate-clearing tendencies and thus limiting the ability to detect an interaction between portion size and plate-clearing. An immediate next step would be to replicate the laboratory intake study using more portion sizes. This would allow greater sensitivity to the potential influence of plate-clearing on the portion size effect, especially given that the portion size effect has been found to be curvilinear and diminishes with larger portion sizes (Vandenbroele et al., 2019; Zlatevska et al., 2014).

Second, although intended consumption has been shown to be an accurate measure of what an individual will subsequently consume, there are still within-meal influences that act on actual food intake. Cahayadi et al. (2019) report that the intended portion size effect is similar to that for actual consumption at moderate portion sizes, but not at very large portion sizes, which is attributed to internal signals that occur during a meal but not during the pre-meal planning process (Morton et al., 2006; Rolls et al., 1981; Rolls, 1986; Yeomans, 2000). Finally, the artificial environment of the

laboratory where Study 1 of Chapter 2 took place may have also created an extra influence of social desirability, for instance not wishing to appear greedy. Therefore, replicating the study in a restaurant-based or more naturalistic setting would now be of interest.

The current study found that those who reported higher food waste concerns planned to eat more food, especially when faced with larger portions. Food waste concerns may encourage people to eat more than they otherwise would be motivated to. Research has indicated that individuals may consume less when food waste concerns are reduced (Bates & Shanks, 2015; Zuraikat, Roe, Smethers, & Rolls, 2018), and others have proposed a link between surplus food, food waste and overeating (Hall et al., 2009; Roe et al., 2018). However, as with plate-clearing tendencies, the studies detailed in Chapters 3 and 4 did not find an effect of food waste concerns on food intake, even when experimentally manipulated, so it is unclear how food waste concerns influence actual consumption. Given that this is the first study to investigate a portion size by food waste concerns interaction effect, replication is now needed.

We explored whether food waste concerns would moderate the relationship between plate-clearing and portion size on intended consumption. A significant portion size by plate-clearing tendencies by food waste concerns interaction effect on intended consumption was found. Specifically, the interaction between self-reported plate-clearing tendencies and portion size became larger as self-reported food waste concerns increased. This finding supports our earlier preposition that food waste concerns may be more likely to influence intended consumption when a person already has an intention to plate-clear, whereby concerns about food waste result in a person following through on their plan to attempt to eat the majority of the food provided.

Following on from these exploratory findings, it would now be of interest to investigate whether this moderated moderation model holds for actual food intake.

A limitation of the current study was its online nature. Portion sizes were presented as images, and it could be argued that individuals may have not gained a realistic perspective of the size of the portion from a screen. An improvement would be to use a paradigm that allows individuals to be directly faced with the portion they are judging, or to use 3D-modelling (as in Cahayadi et al. (2019)). Further limitations of the present research were that our sample was not representative of the general population and that plate-clearing tendencies and food waste concerns were self-reported. We presume that participants are likely to be able to report with some accuracy on whether they tend to clear their plate when eating and how concerned they are about wasting food, but self-report measures can introduce bias and objective measurement of each would be preferential. Also, the plate-clearing tendencies and food waste concerns questions were measured after the intended consumption questions were completed. Some participants may have answered in a way that was consistent with their answers to the intended consumption questions, i.e. reporting being high in plate-clearing tendencies and food waste concerns to justify their intentions to consume most or all of the food in the 11 different portion sizes.

Addressing the above limitations in future studies will clarify the relationship between plate-clearing tendencies, food waste concerns and the influence of portion size on both intended and actual consumption. The immediate next step would be to replicate the current findings with actual consumption as an outcome measure. Previous work indicates that measures of intended consumption are likely to map well onto actual consumption (Robinson, te Raa, et al., 2015; Wilkinson et al., 2012). Also, the meta-analysis by Zlatevska et al. (2014) highlights a larger effect of portion size

on actual consumption (*d* =.45) than on intended consumption (*d* =.18), which suggests that the influence of plate-clearing and food waste concerns on actual intake from larger portions may be underestimated by intended consumption results.

The current study did not investigate gender differences, and given that Robinson et al. (2015) only used 2 portion sizes in their study, replicating the current study with equal numbers of males and females to enable thorough investigation of interactions with gender would be useful. Previous research has highlighted that males typically report stronger plate-clearing tendencies than females (Fay et al., 2011), a finding that we have replicated (see Study 2 of Chapter 3). Therefore, investigating how gender influences the associations found in the current study would be of interest.

Finally, Best and Papies (2019) recently found a larger intended portion size effect for unhealthy than healthy snacks. If people intend to consume more from unhealthy foods, this may present a further issue regarding overconsumption of energy, and potentially contribute to excess weight gain. Furthermore, they found that individuals with lower socioeconomic status intended to consume significantly more from larger portions of unhealthy snack foods. This indicates that portion size may influence those with lower socioeconomic status differently. Therefore, looking at how plate-clearing tendencies, food waste concerns and socioeconomic status combine to influence the portion size effect may now be informative, as plate-clearing and concerns about food waste may differ according to socioeconomic status.

5.6 Chapter Conclusion

The findings of the present study demonstrated that plate-clearing tendencies and food waste concerns moderate the influence portion size has on intended consumption of a hypothetical lunchtime meal. Exploratory findings showed a significant 3-way

interaction of portion size by plate-clearing tendencies by food waste concerns on intended consumption, suggesting that the tendency for people with plate-clearing tendencies to be more responsive to portion size becomes larger if they are particularly concerned about food waste. Overall, these results indicate those who are concerned about wasting food and habitually clear their plate may be at risk of overeating, especially when faced with larger portions.

Chapter 6: General Discussion

6.1 Overview of Findings

The overarching aim of this thesis was to investigate how plate-clearing tendencies and food waste concerns may contribute to overconsumption from larger portions. Chapter 2 outlines a lunchtime laboratory study with an all-female sample. Participants were categorised as either plate-clearers or non-plate-clearers, and randomised to receive either a normal or a large portion of pasta in tomato sauce. I found evidence for the portion size effect; participants consumed significantly more food from larger relative to smaller portions of the lunchtime meal provided. This highlights the robust nature of the portion size effect, as even a group of participants who explicitly reported not being motivated to clear their plate when eating were susceptible to the effect of portion size, therefore indicating that the phenomenon is not limited to those who self-report a tendency to clear their plate.

Also, irrespective of the portion size served, those who self-reported a tendency to plate-clear consumed significantly more of the lunchtime meal they were served than those who reported low plate-clearing tendencies. Coupled with research demonstrating that plate-clearing behaviours are associated with increased BMI (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016), this suggests that plate-clearing is a potentially maladaptive eating behaviour, particularly in an eating environment characterised by larger portions. Furthermore, there was no portion size by plate-clearing interaction effect on food intake; the effect that portion size had on intake was similar in size regardless of participants' reported plate-clearing tendencies.

Therefore, there was no evidence that a tendency to clear one's plate when eating explains the portion size effect.

Chapter 3 examines the reliability and validity of a self-devised scale to measure food waste concerns in an eating context. The food waste concerns scale was found to have a single-factor structure. The scale demonstrated 'good' internal consistency (Kline, 2013; Nunnally & Bernstein, 1994; Ponterotto & Ruckdeschel, 2007) (Study 1 of Chapter 3) and 'excellent' test-retest reliability (Cicchetti, 1994) over a 2-week interval (Study 1 of Chapter 3). It also exhibited convergent validity, significantly predicting intentions to reduce food waste, negative and positive emotions towards wasting food, and divergent validity, appearing to be psychometrically distinct from overeating and hunger (Study 1 of Chapter 3). Thus, I successfully developed a reliable and valid novel tool to measure food waste concerns in the context of eating behaviour, and it is a valuable contribution of this thesis.

Scores on the food waste concerns scale positively predicted self-reported plate-clearing tendencies (Study 2 of Chapter 3). This supports research finding that 'avoiding food waste' was a common reason for clearing the plate despite feeling full earlier in the meal (Fay et al., 2011), and that a single item measure of dislike of wasting food was predictive of plate-clearing tendencies in a sample of University students (Robinson & Hardman, 2016). However, food waste concerns were not associated with BMI or the likelihood of having overweight. In addition, Study 3 of Chapter 3 investigated whether food waste concerns and plate-clearing tendencies are predictive of eating more from a larger portion of a lunchtime meal in a laboratory setting. Results showed that while self-reported food waste concerns were associated with self-reported plate-clearing tendencies, there was no indirect effect of food waste concerns on food intake from a large portion via plate-clearing tendencies or directly.

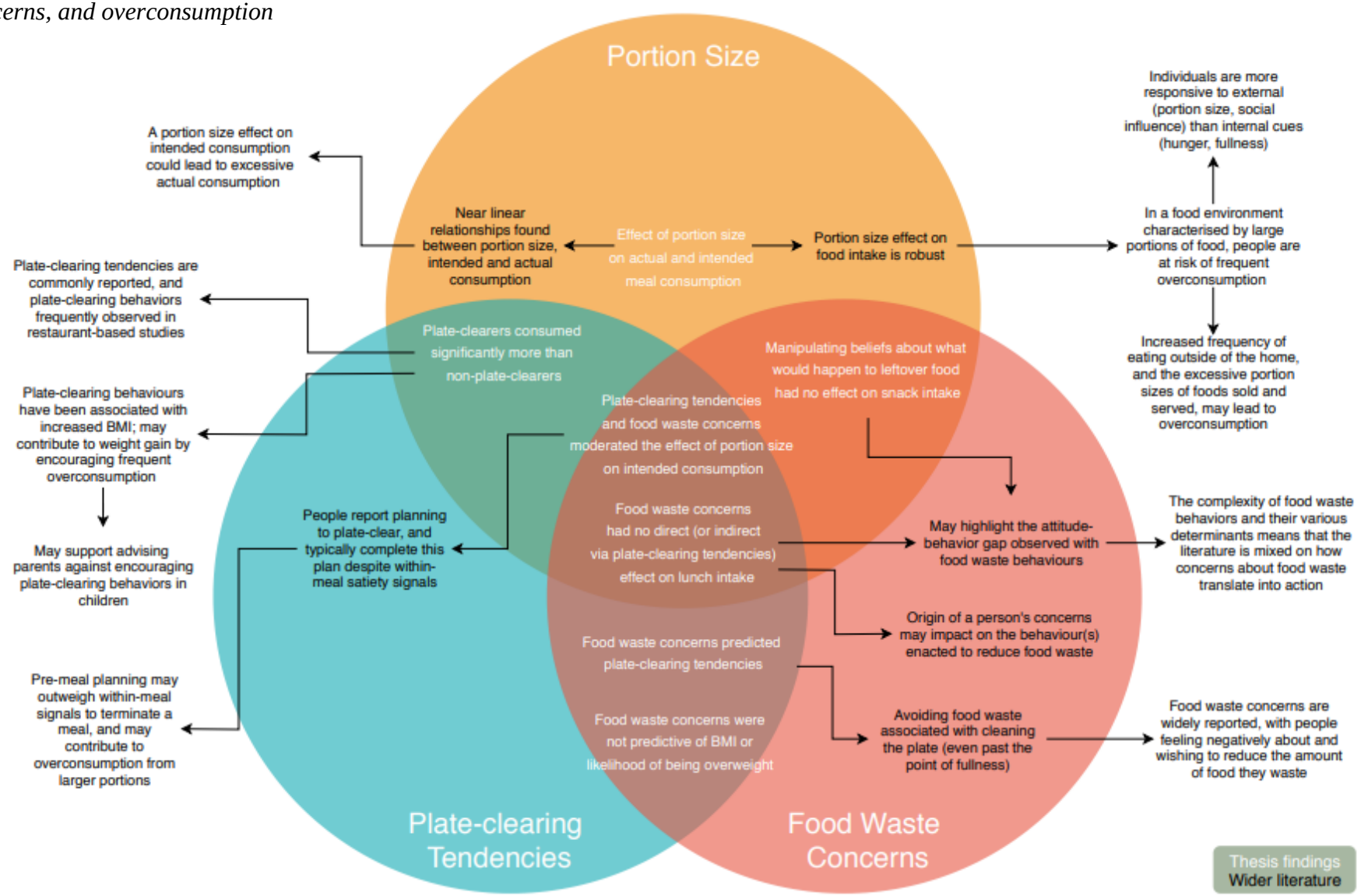
This suggests that being more concerned about food waste does not put individuals at higher risk of developing overweight and obesity, or of overconsuming from larger portions.

These results were corroborated by 2 studies that utilised a different paradigm, specifically investigating whether directly manipulating beliefs about what would happen to leftovers would influence intake from a large portion of a snack food (Study 1 and Study 2 of Chapter 4). In Study 1, an exploratory study, participants were told that the food would be saved, available to take home, wasted, or received a control sentence, and their intake of a snack was covertly measured. There was no significant effect of belief condition on food intake in the planned analyses. However, exploratory analyses that compared the control and 'food is wasted' conditions only found that participants consumed significantly more when they were led to believe that leftovers would be wasted, relative to being given no message regarding the leftover food. In addition, the more certain participants reported believing that leftovers would be wasted was associated with increased food intake. Also, males consumed significantly more when they were told that food would be wasted, relative to receiving no message, whereas intake between conditions did not differ in females. However, as these findings were exploratory and limited by a small sample size, I replicated the study with a more rigorous design and sufficient power in Study 2. Study 2 did not replicate these findings. There was no significant effect of belief condition on food intake, and although there was a significant gender by condition interaction effect on weight of food eaten, this was driven by a tendency (non-significant) for males to eat less when told food would be wasted vs. control (the opposite direction of results to Study 1). In Study 2, I also failed to replicate the significant correlation observed between beliefs about food going to waste and food intake observed in Study 1. Overall, across

Chapters 3 and 4 I did not find convincing evidence that food waste concerns influence objectively measured food intake.

The final study in this thesis (see Chapter 5) investigated the influence of plate-clearing tendencies and food waste concerns on intended consumption from larger vs. smaller portions. Study 1 in Chapter 5 tested whether plate-clearing tendencies and food waste concerns moderate the influence portion size has on intended consumption of a hypothetical lunchtime meal. In support of a small amount of research into the effect of portion size on intended consumption (Cahayadi et al., 2019; Robinson, te Raa, et al., 2015), participants intended to consume significantly more food from larger relative to smaller portions. I also found that plate-clearing tendencies and food waste concerns moderated the influence portion size has on intended consumption of a hypothetical meal. This suggests that both plate-clearing tendencies and food waste concerns may inform decisions regarding how much of a portion to consume. Given that intended consumption has been found to be predictive of actual consumption (Cahayadi et al., 2019), these results indicate that individuals who are concerned about wasting food and habitually clear their plate may be at risk of overeating, especially when faced with larger portions. However, why these effects were not found on actual intake is unclear. It may be that individuals with high plate-clearing tendencies or food waste concerns intend to consume more of a given portion, but are still subject to within-meal influences that limit intake, especially for very large portions. Alternatively, methodological considerations such as the smaller number of portion sizes I used to test these hypotheses in my studies measuring actual intake may have contributed.

Figure 6.1 Venn diagram showing how the research findings of this thesis relate to the wider literature on portion size, plate-clearing, food waste concerns, and overconsumption



6.2 Theoretical Implications

See Figure 6.1 for an infographic displaying how the research findings of this thesis relate to the wider literature on portion size, plate-clearing, food waste concerns, and overconsumption. First, my findings contribute to the wealth of literature on the portion size effect, finding that a female sample consumed significantly more food when provided with a large portion relative to a smaller portion of a lunchtime meal. This adds to existing literature showing that the portion size effect occurs with a variety of foods (Diliberti et al., 2004; Levitsky & Youn, 2004; Reinders et al., 2017; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, & Meengs, 2004), in artificial laboratory settings (Levitsky & Youn, 2004; Rolls, Roe, Meengs, et al., 2004), at a lunchtime meal (Diliberti et al., 2004; French et al., 2014) and in females (Rolls et al., 2002; Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004; Zuraikat, Roe, Smethers, & Rolls, 2018). Interestingly, the 'normal' and 'large' portions were more than double and quadruple the recommended portion size for that meal. Despite individuals labelling these as 'larger than normal' and 'too large' respectively, participants in the larger portion condition still consumed more. This highlights the risk of overconsumption from larger portions, as people overconsume even from portions deemed 'too large'.

Although the effect of portion size on actual intake is well documented, the influence of portion size on intended consumption has received much less attention. My finding that individuals intended to consume significantly more from larger portions, intending to consume significantly more with each subsequent portion size, indicates that portion size influences intended consumption and decision-making even before a given meal begins. This also supports Cahayadi et al. (2019) who found a near linear relationship between portion size and intended consumption. Likewise,

Robinson, te Raa, et al. (2015) found that intended consumption and actual consumption were similar in males and females when served different portion sizes of food. It would now be of interest to merge the paradigms utilised in Chapters 5 and 2. Specifically, participants could complete the online questionnaire utilised in Study 1 of Chapter 5, then be categorised as plate-clearers and non-plate-clearers (as in Study 1 of Chapter 2) and consume either a small, medium or large portion in the laboratory. This would allow investigation of both intended and actual consumption in conjunction. It would also enable further investigation of the pre-consumption portion size effect found by Robinson, te Raa, et al. (2015). Given that the portion size has been found to be curvilinear (Zlatevska et al., 2014), future research would benefit from using a range of portion sizes (time and funding permitting).

My research has implications for how plate-clearing tendencies are viewed in eating behaviour research. A small number of portion size studies have found no evidence that plate-clearing tendencies statistically moderated the influence of portion size on food intake (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, Meengs, et al., 2004). However, the extent to which plate-clearing tendencies could explain the influence that portion size had on food intake was not the primary focus of these studies. This resulted in a limited sample size for moderation analysis, along with little information regarding how plate-clearing tendencies were measured and whether the sample included a substantial number of participants with and without plate-clearing tendencies. Thus, my study is the first to principally examine whether plate-clearing tendencies are associated with increased *ad-libitum* food intake, and to investigate the interaction between portion size and plate-clearing tendencies with a sufficient sample size.

I refer to those who self-report high plate-clearing tendencies as 'plate-clearers'. This does not necessarily mean that, to qualify as a 'plate-clearer', one must eat all of a portion of food served to them. I propose that those who have a tendency to plate-clear will not clear every portion of food they consume, but have the desire and effort to clear their plate when eating. As such, these tendencies may lead them to overconsume, and occasionally consume all of the food they are served. This can be seen in my first study, whereby only 7 participants (6 'plate-clearers' and 1 'non-plate-clearer') finished the 'normal portion', with no participants finishing the large portion. These results suggest that individuals with a tendency to plate-clear may increase the amount of food they consume at a meal, even if this does not result in all the available food being consumed. Therefore, plate-clearing tendencies can still influence food consumption without people simply eating all of the food they are served. Overall, plate-clearers consumed significantly more relative to those who self-reported lower plate-clearing tendencies, highlighting how this tendency may encourage overconsumption.

In the first study of this thesis (see Chapter 2), I found that plate-clearers consumed significantly more than non-plate-clearers, irrespective of the size of the portion. This has potential behavioural implications. In both Robinson, Aveyard, et al (2015) and Robinson and Hardman (2016), it was suggested that individuals with a tendency to plate-clear may be at higher risk of passive overconsumption in the current obesogenic environment, and thus at higher risk of weight gain. This is consistent with previous research that has also indicated a relationship between plate-clearing and BMI; thus, plate-clearing may present a risk factor for excess weight gain. Furthermore, in the present research the effect of plate-clearing tendencies on intake was robust to controlling for other dietary habits (such as dietary restraint) and BMI.

This suggests that the association between a tendency to plate-clear when eating and increased meal intake is not explained by plate-clearers and non-plate-clearers differing on these variables. Investigation into the differences between self-identified 'plate-clearers' and 'non-plate-clearers' is now warranted. Some research indicates that plate-clearing tendencies stem from parental practises during childhood (e.g. Robinson and Hardman (2016)). However, this was not explored in the current study, and the biases involved with retrospective reporting make this explanation more difficult to investigate.

The final study in this thesis (Study 1 of Chapter 5) demonstrated a portion size by plate-clearing interaction effect on intended consumption, with the effect of portion size on intended consumption being larger in plate-clearers than non-plate-clearers. Previous research has also demonstrated that many individuals frequently plan to clear their plate and typically stick to this intention (Fay et al., 2011), even over within-meal influences such as the onset of fullness (Brunstrom, 2011, 2014). Together, these findings suggest that intentions to plate-clear may be maladaptive and contribute to overeating, particularly in an eating environment characterised by increasingly larger portions. However, Study 1 of Chapter 2 which investigated plate-clearing tendencies and food intake of an actual lunchtime meal found no portion size by plate-clearing interaction effect on actual food intake. Given that these 2 studies are the first to investigate the influence of plate-clearing tendencies on intended and actual consumption, further investigation is necessary to clarify this.

To my knowledge, this thesis represents the first examination of the impact of food waste concerns (and experimentally manipulating beliefs about what would happen to leftover food) on eating behaviours and food intake. In Study 2 of Chapter 3, I found that food waste concerns were positively predictive of self-reported plate-clearing

tendencies, in line with previous literature (Robinson & Hardman, 2016). Those who reported higher food waste concerns also reported significantly higher plate-clearing tendencies. Together, these findings suggest that food waste concerns may be a potential determinant for plate-clearing tendencies. As noted, I also found those who report higher plate-clearing tendencies consume significantly more food than those who report lower plate-clearing tendencies. I also propose that if individuals are highly concerned about wasting food, they will desire to waste less food, and therefore be more likely to want to clear their plate. In situations where this portion is large, and thus more food is liable to be wasted, this effect may be stronger. Over time, this increased intake resulting from plate-clearing tendencies, encouraged by concerns about food waste, may lead to excess weight gain.

However, in a laboratory study where actual food intake was covertly measured, food waste concerns did not predict food intake directly or via plate-clearing (Study 3 of Chapter 3). This was supported by a different method utilised in Chapter 4, whereby beliefs regarding what would happen to leftover food were experimentally manipulated. Manipulating beliefs about what would happen to leftover food did not influence intake of a large portion of a snack food. In addition, food waste concerns did not predict BMI nor the likelihood of having overweight. Given that weight gain is a complicated, multifaceted problem, food waste concerns in isolation may not have a substantial influence on BMI.

In addition, the reasons why individuals are concerned about food waste, and why others are less concerned, are likely to be complex. On top of this, why people ultimately act or do not act on these concerns is unclear. Previous research highlights the attitude-behaviour gap, or the disconnect between attitudes, intentions and behaviours (Ajzen, 2001; Sheeran, 2002; Vermeir & Verbeke, 2006). For instance,

Vermeir and Verbeke (2006) found that participants' sustainable food purchasing intentions were not wholly consistent with their attitudes. Also, greater intentions to reduce food waste have, paradoxically, been associated with wasting more food (Aktas et al., 2018; Russell et al., 2017) and reducing household food waste (Graham-Rowe et al., 2015), demonstrating that intentions do not always translate to expected behaviour. Specifically, the latter findings illustrate that one may hold strong food waste concerns, but still engage in behaviours that lead to food going to waste. Concerning the findings in Study 3 of Chapter 3, this may also partly explain why holding stronger food waste concerns was not associated with consuming more food at the lunchtime meal.

Although my studies and newly created scale measured concerns about food waste, they do not investigate the underpinning reasons for being concerned about wasting food or how these might differ amongst individuals. Previous research has suggested that guilt regarding wasting food can stem from a variety of sources including ethical, moral, environmental or financial concerns (Benson, 2009; Schanes et al., 2018; Setti et al., 2016), or perceived value of food itself (Ganglbauer et al., 2013). It is possible that the specific reasons for being concerned about food waste inform the behaviours enacted to attempt to reduce food waste. Therefore, it may be important to consider the origin of a person's concerns about wasting food in order to understand the effect these concerns might have on their eating behaviour. For example, Study 1 of Chapter 2 and Study 3 of Chapter 3 involved providing participants with a free meal in laboratory context. Food waste concerns may be more influential and promote overconsumption in a restaurant setting, where a person has had to pay for a meal and therefore may perceive the meal as being more valuable. Furthermore, in these studies a researcher prepared the food. Therefore, participants

may not have felt personally responsible for any wasted food, and therefore may not have felt compelled to act on their concerns about wasting food in this context. Expanding my current food waste concerns scale into one that is more comprehensive would allow us to discern individual reasons underlying food waste concerns, and investigate how these may impact differently on overconsumption of food and other behaviours in response to those concerns.

Our findings also support research that highlights gender differences in plate-clearing tendencies. As in previous work (Fay et al., 2011), I found that males reported stronger plate-clearing tendencies than females (Study 2 of Chapter 3). Previous research also indicates that males may exhibit a stronger portion size effect on food intake than females (Rolls, Roe, Kral, et al., 2004; Rolls, Roe, & Meengs, 2006a; Rolls, Roe, Meengs, et al., 2004), intending to consume more from a large portion and exhibiting a portion size effect where females did not when actual intake was measured (Robinson, te Raa, et al., 2015). This could be related to stronger plate-clearing tendencies in males than females, which may be related to societal constructs of masculinity. Previous research is mixed as to whether individuals consider it more masculine and less feminine to consume more food (Chaiken & Pliner, 1987; Pliner et al., 1990; Yantcheva & Brindal, 2013) and further investigation is required to discern whether males are more at risk of overconsumption, through societal pressures to finish portions, than females.

6.3 Applied Relevance

There is an abundance of research stating that large portions increase energy intake, and I have found that individuals both intended to consume more from larger portions

(even when portions were 300% of a recommended portion) (Study 1 of Chapter 5) and actually consume more when faced with larger relative to smaller portions (Study 1 of Chapter 2). Interventions that target the food environment, especially those that work to reduce the size, availability and appeal of large portions, could contribute to substantial reductions in the amount of food people select and consume (Hollands et al., 2015).

Changes to the food environment have the potential to reach a larger proportion of people than individual-level behavioural interventions, which may only reach a very small select audience (Adams, Mytton, White, & Monsivais, 2016). Furthermore, plate-clearing tendencies are common and habitual (Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016). Such behaviours may be hard to modify, and so tackling the food environment to ensure that plate-clearing no longer constitutes a maladaptive behaviour would be more effective. In this vein, Bray (2004) highlights that the typical treatments to tackle obesity, such as dieting, exercise and behaviour therapy, can be considered cognitive, taking continued effort at an individual level. Most importantly, there is evidence that population interventions that require recipients to use personal resources to benefit, such as responding to a message or making a behavioural change, can exacerbate health inequalities (Beauchamp, Backholer, Magliano, & Peeters, 2014; Lorenc, Petticrew, Welch, & Tugwell, 2013). An example is a recent U.K. government campaign 'Change4Life', which uses education, advice and guidance in an attempt to improve the populations' diet quality and activity behaviours. Individuals must hear the message, engage with it, and have the motivation and resources to change their behaviour in order to benefit from this intervention. Thus, population interventions that rely less on individual actions and more on changes to the external environment are likely to be most effective and equitable, and more likely to achieve

both public health aims of preventing disease and reducing inequalities (Adams et al., 2016; Beauchamp et al., 2014; Dobbs et al., 2014).

Thus, one recommendation of this thesis would be widespread downsizing of portion sizes in the food environment. In a recent economic analysis, reduced portion size was ranked as having the highest potential to reduce the population health burden of obesity (Dobbs et al., 2014). Unlike individual-level approaches or taxation, this would influence all individuals equally, and rely less on recipient's levels of literacy and cognitive control (Adams et al., 2016; Beauchamp et al., 2014; Hollands et al., 2015). The idea of downsizing is not new, having been discussed widely as a potential intervention for obesity (Hetherington & Blundell-Birtill, 2018; Hetherington et al., 2018). Individuals have been found to view a wide range of portions as normal (Haynes et al., 2019; Herman & Polivy, 2005), some of which deviate from public health recommendations (Almiron-Roig et al., 2013; Brogden & Almiron-Roig, 2011). The widespread downsizing of portion sizes would provide widespread exposure to smaller portions (Raynor, 2014), potentially reducing the size of portions that are considered 'normal' over time and leading to sustained reductions in intake. In support, Robinson and Kersbergen (2018) found that being served and consuming a smaller portion influenced perceptions of normality and led to the selection of smaller portions and reduced consumption at a subsequent eating occasion 24 hours later.

However, there is a question of how much portion sizes should be reduced. Some research indicates that there is typically a wide range of portion sizes that individuals recognises as 'normal', meaning that they would consume that portion in its entirety at a given eating occasion (Haynes et al., 2019; Herman & Polivy, 2005). Very small or very large portions are likely to be outside of this 'norm range', and so not seen as 'normal'. Thus, portion sizes no longer visually perceived to be normal in

size may inspire compensatory intake. In support, Haynes et al. (2019) found that participants reported that they would compensate for portions that they saw as 'smaller-than-normal'. In light of this finding, there could be a risk of going 'too small' and actually encouraging people to consume more, to compensate for what they perceive to be too small a portion. An alternative is to increase the available range of portion sizes, to give individuals the choice to select smaller portions. However, Zuraikat, Roe, Privitera, and Rolls (2016) found that, although presenting a range of portion sizes allowed the selection of smaller portions, the sizes offered were a critical determinant of energy intake. This suggests that increasing the range of portion sizes available would help to moderate intake if the portion sizes offered were within an appropriate range for energy needs. Thus, downsizing may still be necessary, given the dramatic sizes of portion sizes that have been noted (Condrasky et al., 2007; Piernas & Popkin, 2011; Smiciklas-Wright et al., 2003; Young & Nestle, 2002, 2003, 2007, 2012).

We still must exercise caution in implementing downsizing as an intervention to tackle obesity. There is currently little research into interventions to reduce portion size, and existing studies show mixed results (Steenhuis & Vermeer, 2009). In addition, a lot of existing evidence into the effect of reducing portion size comes from studies into very large portions. Therefore, we cannot be certain that reducing to smaller portions would be effective in reducing food consumption (Marteau, Hollands, Shemilt, & Jebb, 2015). The environmental impact of downsizing is also unclear. For instance, Fresán, Errendal, Craig, and Sabaté (2019) found that individual-serving containers produced more greenhouse gas emissions than multi-serving packages for a wide range of commonly consumed foods. However, they also noted that the environmental impact of food production were always greater than those associated

with the packaging of the product, suggesting that if downsizing occurred in such a way that food production was reduced, then this may have environmental benefits that outweigh the increased use of packaging.

One major criticism of downsizing is the potential lack of public acceptance, with findings from a focus group study suggesting that portion size reductions may not be publicly accepted (Vermeer et al., 2010). One issue for this is the cost-effectiveness of purchasing and consuming larger portions (Vermeer et al., 2010). Alternatively, participants felt more positive about increased availability of portion sizes and pricing strategies, followed by improvements to serving-size labels (Vermeer et al., 2010). My work contributes an interesting angle to this discussion. Dislike of waste, particularly food waste, and concerns about the global issue of food waste are well-documented (Abdelradi, 2018; Gaiani et al., 2017; Parizeau et al., 2015; Setti et al., 2016). Therefore, it may be that people would be more willing to accept downsizing as a solution not only to overconsumption, but also to reduce food waste. Further research into public opinion on downsizing as a solution to reduce food waste would be of interest. Since making substantial changes to the food environment could take many years, arming individuals with the awareness, knowledge and skills that contribute towards having a healthy, balanced diet may present a more timely approach to reduce the prevalence of overweight and obesity.

My findings on intended consumption are particularly relevant to eating outside of the home, where large portions of food are the norm and typically exceed daily energy intake recommendations (Robinson, Jones, et al., 2018). I found that individuals intended to consume significantly more from larger relative to smaller portions of a hypothetical main meal. Given that a recent survey by the Foods Standards Agency found that 11%, 29% and 27% of adults report eating breakfast,

lunch and dinner outside of the home at least once a week or more (Food Standards Agency, 2019), this may contribute to overconsumption in restaurants or cafes. I also found that plate-clearing tendencies and food waste concerns individually moderate the effect of portion size on intended consumption. Therefore, this may be a particularly problem for individuals with high plate-clearing tendencies, which are common (Fay et al., 2011; Hinton et al., 2013; Lorenz et al., 2017; Robinson, Aveyard, et al., 2015; Robinson & Hardman, 2016) or high food waste concerns, which are also common (Evans, 2011, 2012). Also, Best and Papies (2019) found a larger intended portion size effect for unhealthy than healthy snacks, which may present a further issue regarding overconsumption of energy. Furthermore, my finding that those with stronger plate-clearing tendencies consume more than those with lower plate-clearing tendencies represents a target for behaviour intervention. Making people aware of the ubiquitous nature of plate-clearing tendencies, and the ease at which we overconsume in today's food environment on a potentially daily basis, may encourage individuals to mitigate this behaviour. A solution specific to eateries outside of the home would be to utilise take-away boxes, which has been suggested to attenuate the portion size effect on consumption of a meal (Bates & Shanks, 2015; Zuraikat, Roe, Smethers, & Rolls, 2018). Saving leftovers for a subsequent eating occasion presents a practical solution to both overconsumption and reducing waste that could be encouraged by restaurants (i.e. advertising the provision of take-away boxes at the end of a meal).

Although this thesis represents one of the first lines of research into how food waste concerns influence food intake, a relationship between them has been alluded to previously by Hall, Guo, Dore, and Chow (2009). Hall et al. (2009) proposed a paradoxical relationship between an abundant food environment, wasted food and obesity, which is maintained by growing portion sizes. These authors suggest that if

you tackle one of these elements, you will actively aid in the improvement of the others. Some research into the effect of portion size reduction on food intake supports this. Berkowitz, Marquart, Mykerezi, Degeneffe, and Reicks (2016) examined consumption and plate waste for 5 weeks before and 7 weeks after introducing 5 reduced-size meals in a worksite cafeteria, and for 3 weeks before and 4 weeks after introducing these in a restaurant setting. Food waste and energy intake were significantly lower when both full and reduced-size meals were served compared to when only full size portions were available. This suggests that reducing portion sizes and providing a wider range of options could influence both intake and waste. Furthermore, the intervention was well received, with both eateries continuing to offer the reduced portion sizes after the intervention. However, what do we target? The food environment, food waste, or obesity? These 3 issues have proved thus far to be difficult to tackle, and my research does not clarify how exactly food waste concerns influence food intake beyond intended consumption. Thus, further research into how we could more effectively target any one of these issues would be valuable, and would hopefully have a positive impact on all 3 issues.

6.4 Strengths and Limitations

The research methods utilised in this study have several strengths. I strived to use validated measures and scales where possible to ensure that psychological processes and behaviours were sensitively recorded. I also validated my own scale to measure food waste concerns to ensure it would accurately measure food waste concerns in these studies. I utilised power calculations to ensure that these samples were large enough to provide sufficient power to detect likely effects. Attention checks were utilised in my online studies to increase my certainty that the data collected was from

participants who were attending and answering questions as honestly as possible. In my laboratory studies, food intake was always covertly measured. I also made use of cover stories that were believable and descriptive, and included specific tasks, to disguise the aims of each study. Recent research indicates that people may act differently if they are aware of the hypotheses of the study (Kersbergen, Whitelock, Haynes, Schroor, & Robinson, 2019) or if they are aware that their eating behaviour is being observed (Robinson, Hardman, Halford, & Jones, 2015). The use of cover stories in eating behaviour research is recommended (Best, Barsalou, & Papies, 2018; Robinson, Bevelander, Field, & Jones, 2018).

All my observational studies, where food intake was directly and covertly measured, took place in a laboratory setting. This makes drawing implications and conclusions about the behaviour of free-living participants in a real world setting difficult. First, eating behaviour is affected by a multitude of factors and there is a certain amount of etiquette involved when eating. The use of large portion sizes in all my laboratory studies may have encouraged those who may have usually eaten less to consume more, so as not to appear ill-mannered towards the experimenter who had cooked their food and would see the amount of food they leave. On the other hand, those who may have usually eaten more from a large portion may have been constrained by impression management, not wanting to appear greedy. For example, in the study outlined in Chapter 2, participants were presented with a hot lunchtime meal that has come from the research laboratory kitchen and been cooked by the researcher. Even if participants with lower plate-clearing tendencies did not wish to consume a considerable amount of food from the portion size provided, they may have felt it would be ill mannered to waste a very large amount of food that had been prepared for them. Alternatively, some of those who identified themselves as plate-

clearers may have consumed less to avoid appearing greedy. Indirect support to this proposition comes from a study by Robinson, Kersbergen, Brunstrom, and Field (2014), who found that participants ate significantly less when told that their consumption would be recorded.

The artificial eating situation created by a laboratory study, in which participants are provided with a set portion of a food or meal that they did not have to choose or pay for, neglects elements of eating occasions that are present in real-world settings. An exception to this is the studies reported in Chapter 4, which took place in a laboratory designed to look like a lounge. Utilising a laboratory that more closely matches the experience I want to investigate in participants would be more ecologically valid. Another solution would be to replicate my studies in a real-world setting, such as a restaurant or canteen, to discern whether the results from the laboratory mirror those found in the free-living environment. However, such naturalistic approaches bring different caveats to consider, such as lack of methodological control.

Across most of my studies individuals were recruited from student and staff populations from the University of Liverpool (the exceptions to this are Study 1 of Chapter 3, which utilised an online recruitment platform used by participants across the U.K., and the study reported in Chapter 5, which utilised social media posting to recruit more widely). The majority of participants were students, some of whom were seeking course credits and so would take part in many of these studies, or staff members, who again would be aware of these ongoing studies and take part in many studies in their lunch break for monetary reimbursement. Both of these populations are not representative of the general population. Furthermore, these individuals may be aware of the use of cover stories, deception and concealing of aims. Thus, they may

be more sceptical or recognise it as an artificial situation where behaviour is being measured. This could influence how participants behave in the study, regardless of whether or not they are aware of the study aims.

In terms of my research aims, we may expect university students and staff to have a higher than average level of education than the general population. Whether or not those with differing education attainments, or differences in socioeconomic status, diverge in their approaches to plate-clearing or practicing behaviours intended to reduce food waste has not been investigated. However, these have been found to be important to other aspects of eating behaviour. For example, Best and Papies (2019) found that those with lower socioeconomic status intended to consume more from larger portions.

A limitation across all studies is that plate-clearing tendencies and food waste concerns were self-reported. Although we would expect individuals to be able to report with some accuracy on their plate-clearing behaviour and food waste concerns, self-report measures can introduce bias. However, there was variability in these measures throughout my studies, which indicates that it was not the case that everyone felt compelled to report high plate-clearing tendencies and food waste concerns, Also, this is unavoidable when measuring food waste concerns, as concerns by their nature are self-reported. For plate-clearing tendencies, utilising objective measures of plate-clearing behaviour to corroborate self-reported measures is a possible solution. However, my studies would indicate that one can report strong plate-clearing tendencies without necessarily finishing every portion of food served to them. Although ‘plate-clearers’ may not always clear the plate every time without fail, the desire and effort to clear the plate is present when eating, which I argue encourages overconsumption, as was observed in Study 1 of Chapter 2.

Apart from Study 1 of Chapter 3, that explicitly aimed to investigate the consistency of food waste concerns over a 2-week period, all my studies were cross-sectional, with food intake being examined at a single test meal or measures completed at one time point. Therefore, I do not know if those with stronger food waste concerns and stronger plate-clearing tendencies would be more at risk of overconsumption or weight gain over time. For example, in the study outlined in Chapter 2, it was found that plate-clearers consumed significantly more than non-plate-clearers. However, I cannot discern whether individuals would have compensated for this increased intake at subsequent eating occasions, which would influence whether plate-clearing tendencies inspire overconsumption or weight gain over time. I have found that the food waste concerns scale has excellent test-retest reliability, but this has not been investigated with regards to the plate-clearing tendencies scale (Robinson, Aveyard, et al., 2015). It would now be useful to investigate how food waste concerns and plate-clearing tendencies impact weight gain and food intake over time.

Finally, the failed replication of Study 1 of Chapter 4 presents a lesson for the scientific study of eating behaviour in Psychology. Here, I attempted to replicate significant but exploratory findings. However, I believe the findings of my exploratory analyses in Study 1 were most likely erroneous and a 'false positive' finding, as the overall effect of believing that food would be wasted vs. control on food intake was driven by a small number of male participants in each condition. Because I used a between-subjects design it is plausible that random sampling resulted in a higher proportion of male participants eating a lot of popcorn being allocated to the food is wasted condition than the control condition. 'False positive' findings are thought to be most likely under conditions of small sample sizes in between-subject designs, because such conditions increase the likelihood of random differences between experimental

groups occurring (Simmons et al., 2011). There is guidance regarding creating robust studies to examined the psychology of eating behaviour (Best et al., 2018; Hetherington & Rolls, 2018; Robinson, Bevelander, et al., 2018) and replication of findings before publication may also improve the reliability of research findings.

6.5 Contributions and Future Directions

This thesis represents the first piece of extensive research to investigate the influence of plate-clearing tendencies and food waste concerns on overconsumption from larger portions. As such, replications of all these studies would be beneficial. A key contribution of this thesis is the development and validation of a novel tool to measure food waste concerns in the context of eating behaviour. Although there are some existing scales that measure attitudes towards food waste, these focus more specifically on engaging in food waste behaviours (Graham-Rowe et al., 2015; Russell et al., 2017) or do not include a food intake element (Aktas et al., 2018). My scale, which addresses food waste concerns in the context of food intake, could be used in future to investigate food waste concerns and how they impact both eating and food wastage.

Study 1 of Chapter 5 is the first to look at the influence of plate-clearing tendencies and food waste concerns on intended consumption, and one of only 3 studies to investigate the effect of portion size of intended consumption. As such, it contributes significantly to this currently sparse literature. An immediate follow-up would be to replicate this study design in conjunction with a paradigm that includes both intended and actual consumption as outcome measures, such as studies by Cahayadi et al. (2019) and Robinson, te Raa, et al. (2015). This would not only expand

upon the literature investigating how intended consumption corresponds to actual consumption, but would also improve upon some limitations in my studies. For example, only 1 or 2 portion sizes were used in the studies measuring food intake reported in this thesis. Since the portion size effect has been found to be curvilinear (Zlatevska et al., 2014), it would be of interest to investigate how plate-clearing tendencies and food waste concerns influence food intake from various portion sizes.

6.6 Summary

This thesis provides further evidence for a portion size effect on both intended and actual consumption, which has implications for policies and interventions aimed at reducing the size of portions available in our food environment. Also, this thesis provides the first thorough investigation into how plate-clearing tendencies and food waste concerns influence food intake. My finding that those who self-report stronger plate-clearing tendencies consume more than those who report lower plate-clearing tendencies indicates that targeting plate-clearing behaviours as an avenue for intervention, or working to create a food environment in which plate-clearing would no longer constitute a maladaptive behaviour, would benefit widespread reductions in food intake. I also provide evidence that food waste concerns are associated with plate-clearing tendencies. Further investigation into how food waste concerns influence plate-clearing tendencies and how this may influence eating behaviours is now warranted.

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Appendices

Appendix 1: Supplementary Materials for Chapter 2

Participants completed a number of other self-report measures that we collected in order to inform other research. For completeness, we describe them below.

Additional plate-clearing questions

Participants completed 5 additional items relating to their plate-clearing habits: parental encouragement ("My parents used to always encourage me to clear my plate when eating"), parental reward for plate-clearing ("As a child, I would be rewarded by my parents for clearing my plate"), dislike of food waste ("I don't like to see food go to waste"), tendency to plate-clear past the point of fullness ("Even when served a very large portion of food and I start to feel full, I feel that I have to clear my plate"), and habitual plate-clearing ("When eating, I clear my plate out of habit"). These items were presented in a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Questions related to food consumption

Participants were also asked why they stopped eating the portion ("I stopped eating this portion because…") for which they had a selection of responses to choose from: "I was no longer hungry", "I was bored", "I've had all that I am allowed", "the food was all gone", "the food stopped tasting good", and "for another reason (please specify)", where they could write their response by hand if they wished.

Participants were also asked why they finished the portion they consumed ("I finished this portion because…") for which they had a selection of responses to choose from: "I felt hungry", "The food was really addictive", "To relieve negative emotions (e.g. boredom, anxiety, etc.)", "I couldn't control myself", "I didn't want to turn down free food", "I was craving something savoury", "Because it was just there", "I wanted to fill myself up" and "for another reason (please specify)", where they could write their response by hand if they wished.

Participants were also asked "To what extent did the portion size influenced how much you ate?", for which they were given a 99mm visual analogue scale question with the anchors of 'Not at all' to 'Extremely'.

Awareness of measurement of consumption

Participants were asked about their experience of the study at the end of the study; included in this feedback questionnaire was the question "I felt as though the amount of food I was eating would be measured by the researcher". This was presented in a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Missing data

There was no missing data on the main outcome variables, but there was data missing from some of the secondary measures. List-wise deletion was used for any inferential statistics calculations with the affected variables. Missing data is as follows: 1 participant's age, 1 participant's BMI, 5 participants' baseline appetite measures before eating (fullness), 9 participants' appetite measures after eating (fullness), and 1

participant's appetite measures after eating (fullness). Two participants' did not complete the baseline appetite measures correctly. One participant had data missing for the external eating measure, and one participant had missing data for the restraint measure.

Appendix 2: Supplementary Materials for Chapter 3

Study 1

Figure 1. Scree plot for Exploratory Factor Analysis

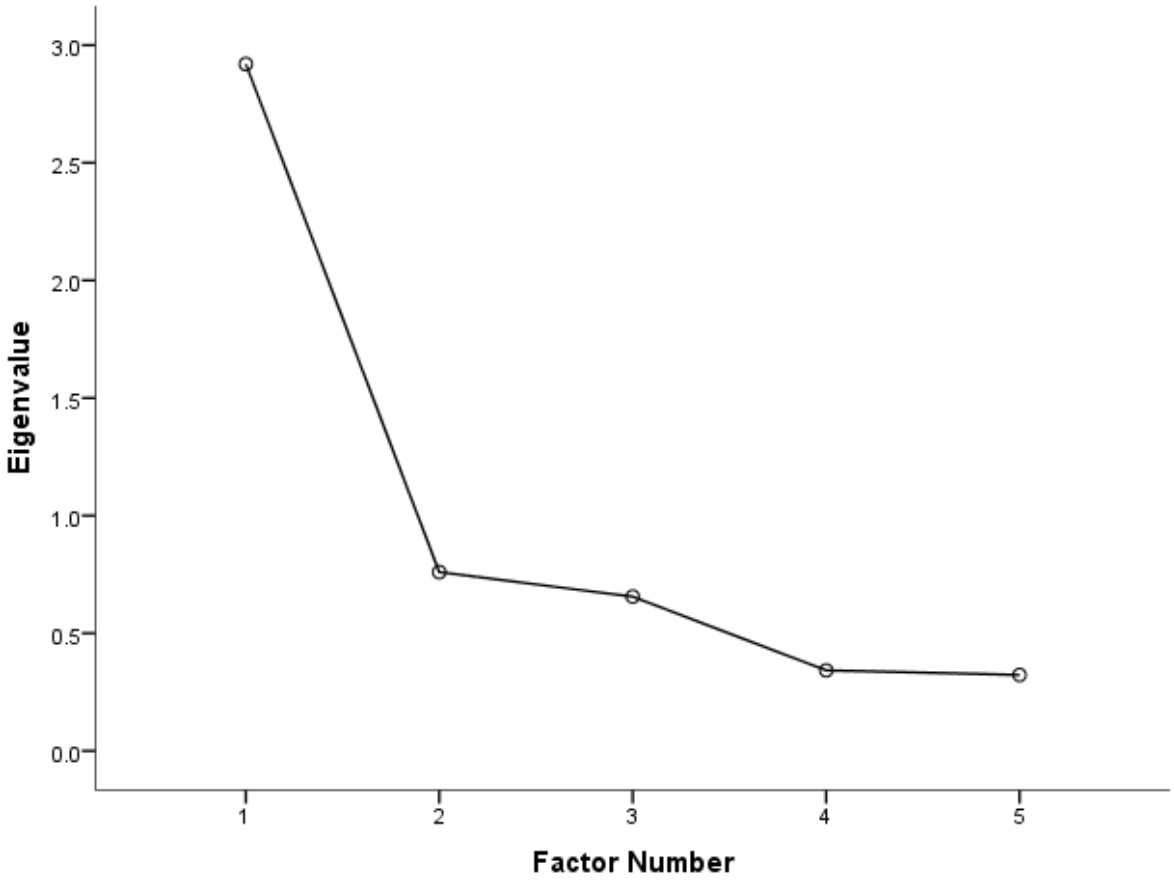

Figure 1 displays a scree plot showing the factors generated by the exploratory factor analysis. The inflection point, and the fact that Factor 1 is the only factor to have an Eigenvalue above Kaiser's criterion of 1.0 (Eigenvalue =2.94), indicates a single factor structure.

Table 1. Correlations, means and standard deviations for the 5 items of the food waste concerns scale (Time 1)

	Item 1 [a]	Item 2	Item 3	Item 4	Item 5 [a]
Item 1 [a]	1				
Item 2	.56	1			
Item 3	.54	.68	1		
Item 4	.32	.35	.34	1	
Item 5 [a]	.66	.49	.45	.38	1
Mean(±SD)	4.62 (±1.72)	5.07 (±1.59)	5.26 (±1.56)	4.39 (±1.74)	4.34 (±1.49)

Table 1 display the correlations, mean and standard deviations (Mean(±SD)) for the 5 food waste concerns items. Item 1 = "It is fine for food to go to waste sometimes"; Item 2 = ""It is morally wrong to waste food"; Item 3 = "I cannot stand throwing food away"; Item 4 = "Even if I felt full, I would rather finish what is on my plate than see it go to waste"; Item 5 = "It can be acceptable to waste food".

[a] Items were reversed-scored prior to calculating the food waste concerns score.

Table 2. Factor matrix

	Factor loadings
"It is fine for food to go to waste sometimes" [a]	.78
"It is morally wrong to waste food"	.77
"I cannot stand throwing food away"	.74
"Even if I felt full, I would rather finish what is on my plate than see it go to waste"	.72
"It can be acceptable to waste food." [a]	.46

Table 2 displays the factor loadings for each item. All of these are above .40, which indicates that they are significant factor loadings. Therefore, all 5 items loaded onto the same factor.

[a] Items were reversed-scored prior to calculating the food waste concerns score.

Convergent validity

Two participants presented unclear responses for either weight or height, and so they were removed from analyses involving BMI. No implausible height and weight values were reported. A regression analysis was conducted to examine whether food waste concerns were positively associated with intentions to reduce food waste, while controlling for age, gender, BMI, hunger and overeating. The full model predicted approximately 36% of variance in intentions to reduce food waste, R^2 =.36, F(6, 267) =25.16, p <.001. Food waste concerns scores were positively associated with intentions to reduce food waste (β =.59, p <.001). Age (β =.06, p =.254), gender (β =.01, p =.913), BMI (β = -.08, p =.160), trait overeating (β = -.13, p =.076) and trait hunger (β =.02, p =.801) did not significantly predict intentions to reduce food waste.

A regression analysis was conducted to examine whether food waste concerns were positively associated with negative emotions towards wasting food, while controlling for age, gender, BMI, hunger and overeating. The full model predicted approximately 15% of variance in negative emotions towards wasting food, R^2 =.15, F(6, 267) =7.73, p <.001. Food waste concerns scores were positively associated with negative emotions towards wasting food (β =.34, p <.001). Age was negatively associated with negative emotions towards food waste (β = -.13, p =.028). Gender (β =.04, p =.464), BMI (β = -.04, p =.523), overeating (β =.07, p =.397) and hunger (β =.03, p =.752) did not significantly predict negative emotions towards wasting food.

A regression analysis was conducted to examine whether food waste concerns were negatively associated with positive emotions towards wasting food, while controlling for age, gender, BMI, hunger and overeating. The full model predicted approximately 9% of variance in positive emotions towards wasting food, R^2 =.09,

$F(6, 267) = 4.50$, $p < .001$. Food waste concerns scores were negatively associated with positive emotions towards wasting food ($\beta = -.29$, $p < .001$). Age ($\beta = .03$, $p = .583$), gender ($\beta = -.07$, $p = .229$), BMI ($\beta < -.01$, $p = .956$), overeating ($\beta = -.04$, $p = .639$) and hunger ($\beta < .01$, $p = .995$) did not significantly predict positive emotions towards wasting food.

Study 2

We included the 5-item food waste concerns scale at the end of a series of laboratory studies conducted at the University of Liverpool during 2016-2018. After removal of duplicate participants and missing values from 14 studies, we had data from 966 participants with complete food waste concerns scale ratings and researcher measured weight and height. See Table 3 for the number of participants from each individual data set that were included in our main analyses.

Confirmatory factor analysis

Appropriateness of sample size

To determine the minimum sample size required for our confirmatory factor analysis, a minimum sample size for tests of fit was computed on the basis of the Root Mean Square Error of Approximation (RMSEA) fit index using R Statistics software (Kim, 2005; MacCallum, Browne, & Sugawara, 1996). Chosen null and alternative values of RMSEA, the *a* level, degrees of freedom, and desired level of power were entered, and the program computed the minimum necessary sample size to achieve the desired

power. Our calculation of power (at RMSEA H_0 =.10, RMSEA H_1 =.05, *a* =.05, df =5, and 80% power) found that a minimum of 569 respondents would be required.

Main analysis strategy

Using AMOS 22, a confirmatory factor analysis was performed on our one-factor solution. Model fit was assessed by examining the normed $\chi 2$ test, the Comparative Fit Index (CFI), the Tucker-Lewis index (TFI), the RMSEA and Standardized Root Mean Square Residual (SRMR). A normed $\chi 2$ test was used, as the $\chi 2$ test of exact fit is highly sensitive to large sample sizes, which inflate the $\chi 2$ value. A normed $\chi 2$ test value between 1 and 2 are indicative of a 'good' model fit, between 2 and 3 an 'acceptable' model fit (Carmines & McIver, 1981), although Lomax and Schumacker (2004) argue that up to 5 is 'acceptable'. CFI values of $\geq$ 0.95 are considered 'good', and $\geq$ 0.90 is 'acceptable'. TFI values of $\geq$.95 indicate 'good' fit and $\geq$.90 is considered 'acceptable' (Hu & Bentler, 1999). RMSEA values indicate either 'good fit' ($\leq$0.05), 'fair fit' ($\leq$0.08), or 'mediocre fit' ($\leq$0.10). SRMR values of <0.08 are considered 'good fit' (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006). Where appropriate, model fit was improved by adding covariance pathways between error terms. These were determined following inspection of the modification indices and consideration of theoretical explanations.

Table 3. Study 2 individual studies (N=966)

Study number	Study reference	Number of participants in present analysis
1	Using the norm range to predict the effect of portion size reduction on compensation (Haynes, 2019a) (Study 1, unpublished data, available at: https://osf.io/wzesx/)	39
2	Using the norm range to predict the effect of portion size reduction on compensation (Haynes, 2019a) (Study 2, unpublished data, available at: https://osf.io/wzesx/)	19
3	Visual perceptions of portion size normality and intended food consumption (Study 2 in (Haynes et al., 2019)	34
4	Laboratory study on body size and social anxiety (unpublished data)	41
5	Laboratory study on body size and conformity (unpublished data)	38
6	Laboratory study on beliefs about food intake and food wastage (unpublished data)	120
7	Portion size and later food intake (Study 3 in Robinson and Kersbergen (2018))	13
8	The psychosocial experience of feeling overweight and snack food consumption (Study 1 in (Oldham, Tomiyama, & Robinson, 2018))	72
9	The psychosocial experience of feeling overweight and snack food consumption (Study 2 in (Oldham et al., 2018))	111
10	Influence of attentive eating on later snack food intake (Study 2 in Whitelock, Higgs, Brunstrom, Halford, and Robinson (2018))	136
11	Influence of attentive eating on memory for meal satiety and later food intake in men (Whitelock, Gaglione, Davies-Owen, & Robinson, 2019)	33
12	Remembered Meal Satisfaction, Satiety, and Later Snack Food Intake (Whitelock & Robinson, 2018)	120
13	Smartphone-based attentive eating intervention for energy intake and weight loss (Whitelock, Kersbergen, et al., 2019)	62
14	Visual exposure and compensation for small portions (Haynes, 2019b) (unpublished data, available at: https://osf.io/xbpg3/)	128

Table 3 displays the titles of each study, the author(s), and links to the relevant publication or data set (if available online). The number of participants from each of the individual data sets used to create the final data set for this analysis (N = 966) is also shown.

Table 4. Correlations, means and standard deviations for the 5 items of the food waste concerns scale

	Item 1 [a]	Item 2	Item 3	Item 4	Item 5 [a]
Item 1 [a]	1				
Item 2	.42	1			
Item 3	.44	.54	1		
Item 4	.35	.38	.58	1	
Item 5 [a]	.61	.42	.43	.34	1
Mean(±SD)	4.41 (±1.70)	4.83 (±1.62)	4.77 (±1.70)	4.24 (±1.79)	4.00 (±1.60)

Item 1 = "It is fine for food to go to waste sometimes"; Item 2 = ""It is morally wrong to waste food"; Item 3 = "I cannot stand throwing food away"; Item 4 = "Even if I felt full, I would rather finish what is on my plate than see it go to waste"; Item 5 = "It can be acceptable to waste food.".

[a] Items were reversed-scored prior to calculating the food waste concerns score.

Table 5. Standardised and unstandardized coefficients for confirmatory factor analysis

Observed variable	β	*B*	*SE*	*p*
Item 1 [a]	.55	1.08	.06	<.001
Item 2	.71	1.33	.10	<.001
Item 3	.80	1.58	.10	<.001
Item 4	.71	1.48	.11	<.001
Item 5 [a]	.54	1.00 [b]		

In the context of a confirmatory factor analysis values represent standardised and unstandardized factor loadings. The unstandardized coefficients (*B*) indicate that all items significantly loaded onto the latent factor. [a] Items were reversed-scored prior to calculating the food waste concerns score and running this analysis. [b] This path ('Food Waste Concerns' to 'Item 5') is fixed at 1 (and thus has no SE and there is no significance test for this path) as this path is setting the measurement scale of the latent variable (Food Waste Concerns) in relation to the indicator variable (Item 5). See Figure 2.

Confirmatory factor analysis

Five items were free to load onto the latent factor (food waste concerns score). The initial iteration indicated an acceptable to poor fit model (normed $\chi 2$ ($\chi 2$/df) =40.06, CFI =.873, TLI =.746, RMSEA (90% CI) =.201 (.18-.23), SRMR =.07). The normed $\chi 2$ test value was above the cut-off of 5.00 for 'acceptable fit', both CFI and TLI values were below the cut-off of 0.90 for 'acceptable fit', and the RMSEA was above the cut-off of .10 for 'mediocre fit'. Only the SRMR value indicated a good model fit, being below the cut-off of .08 for 'good fit'. However, following the addition of covariance pathways based on modification indices, the single-factor model provided a good fit to the data (normed $\chi 2$ ($\chi 2$/df) =3.52, CFI =.995, TLI =.984, RMSEA (90% CI) =.051 (.02-.09), SRMR =.02). Here, the normed $\chi 2$ test value was below .5, indicating 'acceptable fit'; both CFI and TLI values were above .95, indicating 'good fit'; the RMSEA value was lower than .08, indicating 'fair fit'; and the SRMR value was lower than .08, indicating 'good fit'. Figure 2 shows the final model. Table 5 shows the standardised and unstandardized parameter estimates. Standardised factor loadings indicated that all items appropriately reflected their underlying latent variable (Figure 2).

Figure 2. Model generated by Confirmatory Factor Analysis

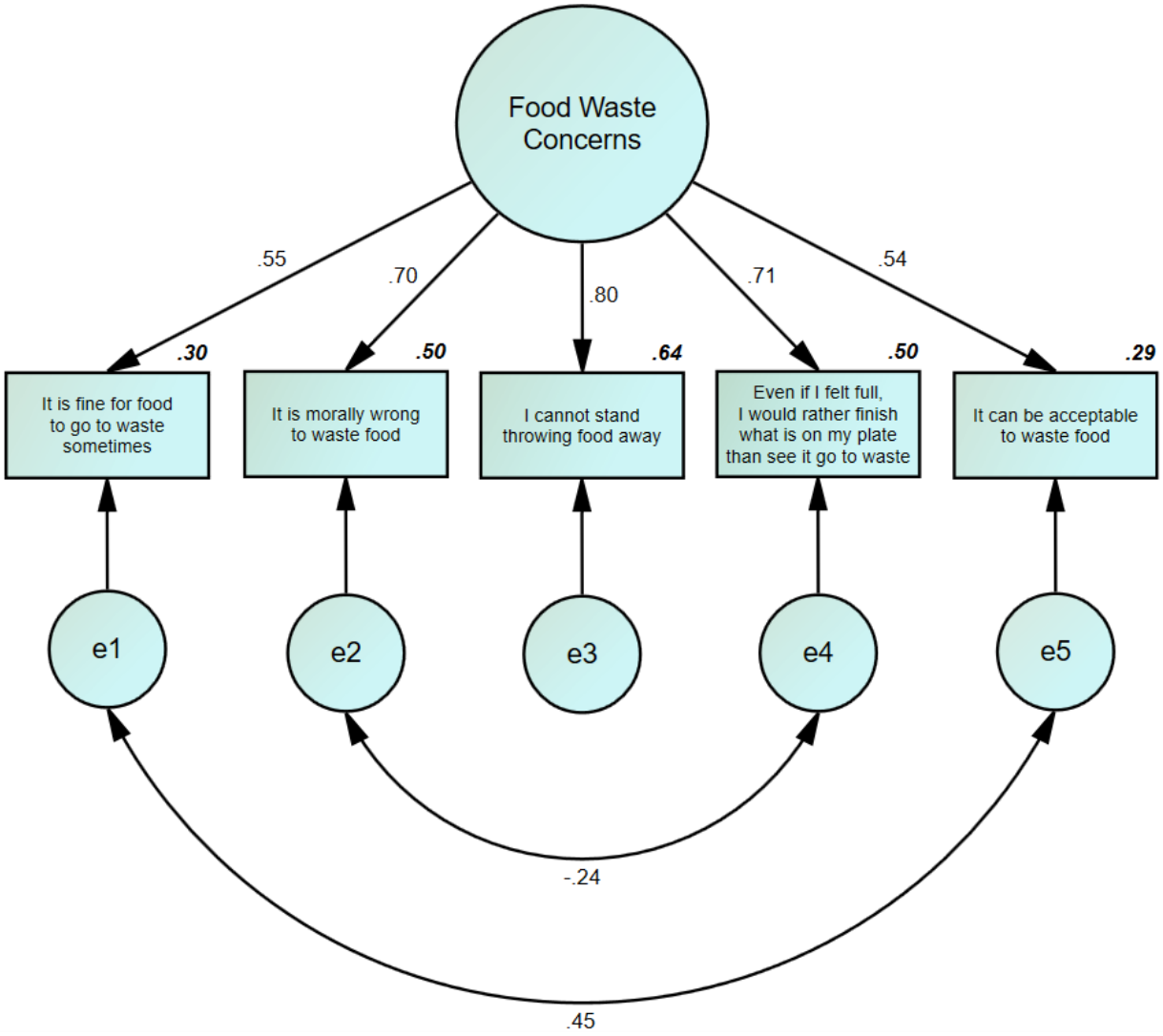

Figure 2 shows the model generated by the confirmatory factor analysis. Values are standardised coefficients. Values in bold italics are factor loadings for the respective item. 'e' denotes the error term for each item. The curved arrows represent covariances between error terms, which were added following inspection of the model indices

Food waste concerns and plate-clearing tendencies

A regression analysis was conducted to examine whether food waste concerns predicted plate-clearing tendencies score while controlling for gender, age, and BMI. The full model predicted approximately 22% of variance in plate-clearing tendencies

score, R^2 =.22, $F(4, 205)$ =14.06, p <.001. Gender was negatively associated with plate-clearing tendencies, with higher plate-clearing scores in males than females (β = -.23, p <.001). Food waste concerns score was positively associated with plate-clearing tendencies, with greater food was concerns being associated with greater plate-clearing tendencies (β =.37, p <.001). Age (β =.07, p =.294) and BMI (β = -.05, p =.491) did not significantly predict plate-clearing tendencies.

Food waste concerns and weight

A regression analysis was conducted to examine whether food waste concerns were associated with BMI, while controlling for age and gender. The full model predicted approximately 21% of variance in BMI, R^2 = .21, $F(3, 960)$ = 86.65, p <.001. Age was positively associated with BMI (β =.46, p <.001). However, gender (β = -.03, p =.242) and food waste concerns (β = -.04, p =.174) did not significantly predict BMI. A logistic regression analysis was conducted to investigate whether food waste concerns predicted likelihood of being overweight, while controlling for age and gender. The regression model significantly predicted BMI, correctly identifying 70.6% of cases, Cox & Snell R^2 =.13, Nagelkerke R^2 =.17, p <.001. Age was associated with an increased likelihood of being overweight, B =.07 (SE =.01), Wald =98.27, p <.001; OR =1.08, 95% CIs =1.06-1.09. Neither gender, B =.18 (SE =.17), Wald =1.14, p =.286); OR =1.19, 95% CIs =0.86-1.66, or food waste concerns, B <.01 (SE =.01), Wald <.01, p =.984; OR =1.00, 95% CIs =0.90-1.12, were associated with the likelihood of being overweight.

Study 3

Other measures

Awareness of measurement of consumption

Participants were asked about their experience of the study at the end of the study (including awareness of the study aims). Included in this questionnaire was the question “I felt as though the amount of food I was eating would be measured by the researcher”. This was presented in a 5-point Likert scale response format (‘Strongly disagree’ to ‘Strongly agree’). The data were not analysed in the context of the present study. See https://osf.io/aef75/ for study measures in full.

Table 6. Pearson's correlations between study variables

	FWC score	PCT score	Food intake (g)	Gender	Age (years)[a]	BMI (kg/m²)	Desire-to-eat pre-lunch	Hunger pre-lunch	Fullness pre-lunch	Meal enjoyment (liking)	Dietary restraint[b]	Disinhibition	Hunger
FWC score	-	.29**	.19*	-.01	.09	-.06	.17	.21*	-.08	.06	-.04	.17	.43***
PCT score	.29**	-	.20*	-.19*	-.07	.12	-.10	-.01	-.07	.17	-.09	.15	.04
Food intake (g)	.19*	.21*	-	-.36***	.14	-.02	.23*	.17	-.24**	.35***	-.01	.07	.25**

Table 6 displays the correlations between plate-clearing tendencies (PCT) score (M), food waste concerns (FWC) score (X), food intake (measured in grams) (Y) and the following potential covariates: gender, age, BMI, desire-to-eat pre-lunch, hunger pre-lunch, fullness pre-lunch, meal enjoyment (liking), restraint, disinhibition and hunger (measured via the TFEQ). Six variables were found to be correlated with one or more of our mediation variables, and therefore 6 variables were included as covariates in our mediation analysis.

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

[a] Age (years) contains data from 127 participants, as there are missing data.

[b] Dietary restraint contains data from 123 participants, as there are missing data.

Results of sensitivity analyses

Food waste concerns score was positively correlated with hunger pre-lunch ($r(126) = .21$, $p = .023$) and hunger (TFEQ) ($r(126) = .43$, $p < .001$). Plate-clearing tendencies were negatively correlated with gender ($r(126) = .-19$, $p = .035$). Weight of food eaten (g) was negatively correlated with gender ($r(126) = -.36$, $p < .001$) and fullness pre-lunch ($r(126) = -.24$, $p = .008$), and positively correlated with desire-to-eat pre-lunch ($r(126) = .23$, $p = .010$), meal enjoyment (liking) ($r(126) = .35$, $p < .001$) and hunger (TFEQ measure) ($r(126) = .25$, $p = .005$). All other correlations were found to be non-significant ($ps > .05$). Therefore, 6 covariates were included in the mediation analysis: gender, desire-to-eat pre-lunch, hunger pre-lunch, fullness pre-lunch, meal enjoyment (liking) and hunger (measured by the TFEQ). All variables were log-transformed (except for gender). Including these 6 covariates in the mediation model did not change the pattern of significance observed. Food waste concerns were positively associated with plate-clearing tendencies, B =.18, SE =.06, 95% CIs =0.06-0.30, $p = .003$. There was no direct effect of food waste concerns on food intake, B =.07, SE =.11, 95% CIs = -0.15-0.29, $p = .545$. Plate-clearing tendencies did not significantly predict food intake, B =.17, SE =.16, 95% CIs = -0.15-0.49, $p = .304$. There was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies, b(SE) =.03(.05), 95% CIs = -0.01, 0.17.

Two participants completed the screening questionnaire retrospectively (i.e. after the study session). Re-running the main analyses with these participants removed did not change the pattern of significance observed. Food waste concerns were positively associated with plate-clearing tendencies, B =.16, SE =.06, 95% CIs =0.05-0.28, $p = .006$. There was no direct effect of food waste concerns on food intake, B =.10, SE =.12, 95% CIs = -0.14-0.34, $p = .419$. Plate-clearing tendencies did not predict

food intake, B =.29, SE =.19, 95% CIs = -0.08-0.65, *p* =.125. There was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies, b(SE) =.03(.05), 95% CI = -0.01, 0.16. One participant requested and consumed a second serving of food, and therefore was served a total of 1000g of pasta in tomato sauce (2 portions). Re-running the main analyses with this participant removed did not change the pattern of significance observed. Food waste concerns were positively associated with plate-clearing tendencies, B =.16, SE =.06, 95% CIs =0.04-0.27, *p* =.008. There was no direct effect of food waste concerns on food intake, B =.11, SE =.12, 95% CIs = -0.13-0.35, *p* =.370. Plate-clearing tendencies did not predict food intake, B =.27, SE =.19, 95% CIs = -0.09-0.64, *p* =.145. There was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies, b(SE) =.04(.06), 95% CIs = -0.01, 0.20.

Eight participants reported some awareness of study aims. Re-running the main analyses with these participants removed did not change the pattern of significance observed. Food waste concerns were positively associated with plate-clearing tendencies, B =.16, SE =.06, 95% CIs =0.05-0.28, *p* =.007. There was no direct effect of food waste concerns on food intake, B =.12, SE =.13, 95% CI = -0.12-0.37, *p* =.327. Plate-clearing tendencies did not predict food intake, B =.27, SE =.19, 95% CIs = -0.11-0.64, *p* =.158. There was no significant indirect effect of food waste concerns on food intake via plate-clearing tendencies, b(SE) =.04(.06), 95% CIs = -0.01, 0.21.

Appendix 3: Supplementary Materials for Chapter 4

Study 1

Participants completed a number of other self-report measures that we collected in order to inform other research. For completeness, we describe them below.

Knowledge of what would happen to leftover food: Participants commented on whether "The knowledge of what would happen to leftover food affected how much [they] ate." This was presented in a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Questions on the snack food: Participants commented on the amount they ate in comparison to their typical consumption of this snack food ("In my opinion, compared to what I would normally eat of this snack, the amount I ate was…"). This was scored on a 5-point Likert scale response format ('A lot smaller than normal' to 'A lot larger than normal'). Participants also commented on their enjoyment of consuming the snack food ("Overall, I enjoyed the snack that was given to me"), whether it was a snack they consume regularly ("This is a snack I regularly consume") and how tasty they found the snack food ("I thought the snack was tasty"). These were presented in a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Influence of portion size: Participants reported whether the portion size influenced their intake ("Would you say that the portion size of food served influenced how much you ate?"). This was presented in a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Awareness of measurement of consumption: see Appendix 1, *Other measures*.

*Plate-clearing questions***:** see Study 1 of Chapter 2, *Measures*.

Socioeconomic status questions: Participants answered 3 questions about their childhood before the age of 12 in relative to the amount of money their family had ("My family had enough money for things growing up"), how wealthy their neighbourhood was ("I grew up in a relatively wealthy neighbourhood"), and how wealthy they felt ("I felt relatively wealthy compared to others of my age"). They also answered questions relating to the present and foreseeable future, regarding expendable income ("I have enough money to buy the things I want"), bills ("I don't worry too much about paying bills"), and money in the future ("I don't think I'll have to worry about money too much in the future"). All items were presented in a 7-point Likert scale response format ('Strongly disagree' to 'Strongly agree').

Additional analyses for Study 1 of Chapter 4

Influence of time of day

6 x 4 ANOVAs were conducted to confirm that time of day did not influence hunger or food intake overall or in each condition, with time of day (11:00/12:00/13:00/14:00/15:00/16:00) and condition (control/food is saved/take home/food is wasted) as the between-subjects factors. There was no significant main effect of time of day, $F(5, 96) = 2.28$, $p = .053$, $\eta_p^2 = .11$, or a significant time of day by condition interaction effect, $F(15, 96) = 0.76$, $p = .720$, $\eta_p^2 = .11$, on pre-consumption hunger. There was also no significant main effect of time of day, $F(5, 96) = 0.94$, $p = .461$, $\eta_p^2 = .05$, or a significant time of day by condition interaction effect, $F(15, 96) = 1.15$, $p = .325$, $\eta_p^2 = .15$, on weight of food eaten.

Study 2

Participants completed a number of other self-report measures that we collected in order to inform other research. For completeness, we describe them below.

Knowledge of what would happen to leftover food: see Appendix 3, Study 1.

Awareness of measurement of consumption: see Appendix 1, *Other measures*.

Questions on the snack food: Participants commented on their enjoyment of consuming the snack food ("Overall, I enjoyed the snack that was given to me"). This was scored on a 5-point Likert scale response format ('Strongly disagree' to 'Strongly agree'). Participants

Participants were also asked, "Regardless of how successful you were, *how hard did you try* to stop yourself from eating extra popcorn, or to limit the amount of popcorn you ate?" which was scored on a 99mm VAS scale with anchors of 'Not at all' to 'Extremely'.

*Plate-clearing questions***:** see Study 1 of Chapter 2, *Measures*.

Additional analyses for Study 2 of Chapter 4

Influence of time of day

6 x 2 ANOVAs were conducted to confirm that time of day did not influence pre-consumption hunger or food intake overall or in each condition, with time of day (10:00/10:50/14:00/14:50/15:40/16:30) and condition (control/food is wasted) as between-subjects factors. There was no significant main effect of time of day, $F(5,$

149) = 0.74, p =.592, η_p^2 =.02, or a significant time of day by condition interaction effect, F(5, 149) = 0.34, p =.889, η_p^2 =.01, on pre-consumption hunger. There was also no significant main effect of time of day, F(5, 149) = 0.24, p=.945, η_p^2 =.01, or a significant time of day by condition interaction effect, F(5,149) = 2.16, p =.061, η_p^2 =.07, on weight of food eaten.

Restraint

The covariate, restraint, was not related to food eaten, F(1, 152) = 1.33, p =.251, r = .10. There was no significant effect of condition (p=.584) or gender (p=.387), and there remained a significant gender by condition interaction effect on food eaten (p=.045), after controlling for restraint.

Appetite scores

Although we asked participants not to eat in the 2 hours prior to attending the study session, the differing times of day of the study sessions could have influenced how hungry, full, and the desire to eat that participants felt. Therefore, we computed a composite appetite score (the total of pre-lunch hunger, reverse-scored pre-lunch desire to eat, and reverse-scored pre-lunch fullness) and ran a Pearson's correlation to investigate whether this correlated with the weight of food eaten. A significant correlation would be followed up with a 2 x 2 ANCOVA, with condition (control/food is wasted), and gender (male/female) as between-subject factors, weight of food eaten as the dependent variable, and composite appetite score as a covariate. However, a Pearson's correlation demonstrated that there was no significant correlation between

composite appetite score and the weight of food eaten, $r(159) = .11$, $p = .149$. As these 2 variables were not significantly correlated, no further analyses with composite appetite score were ran.

Appendix 4: Supplementary Materials for Chapter 5

Table 1. Weight (g) and estimate kilocalories (kcal) for each portion size of pasta image

Portion size (% of recommended)	Portion Size (in g)	Portion Size (in kcal)
100%	280.00	299.00
120%	336.00	358.80
140%	392.00	418.60
160%	448.00	478.40
180%	504.00	538.20
200%	560.00	598.00
220%	616.00	657.80
240%	672.00	717.60
260%	728.00	777.40
280%	784.00	837.20
300%	840.00	897.00

Other measures

Participants completed a number of other self-report measures that we collected in order to inform other research. Participants completed 5 additional items relating to their plate-clearing habits (see Appendix 1), and were asked to give the first 3 letters of their postcode. This would allow us to use the Index of Multiple Deprivation as an estimation of socioeconomic status. Here, postcodes are ranked from 1 (most deprived area) to 32,844 (least deprived area).

Additional sensitivity analyses

We planned to run the main analyses with those who reported that they were currently dieting removed from the sample. Of the 409 participants, 76 participants reported that they were currently dieting.

When these participants were removed, the same patterns of significance were observed in our main analyses. There was a significant main effect of portion size on intended consumption, $F(3.01, 998.09) = 239.97$, $p < .001$, $\eta_p^2 = .42$, with participants intending to consume significantly more from larger portions. There was a significant increase in intended consumption with every subsequent increase in portion size (*p*s <.01), except for 200-220% ($p = .781$) and 260-280% ($p = .437$) of the recommended portion.

Also, there was a significant main effect of portion size, $F(3.31, 1095.96) = 162.24$, $p < .001$, $\eta_p^2 = .33$, and a significant main effect of plate-clearing type, $F(1, 331) = 66.41$, $p < .001$, $\eta_p^2 = .17$, on intended consumption, with plate-clearers intending to consume significantly more than non-plate-clearers. There was a significant portion size*plate-clearing type interaction effect on intended consumption, $F(3.31, 1095.96) = 26.21$ $p < .001$, $\eta_p^2 = .07$. Portion size effects on intended consumption tended to be statistically larger in plate-clearers than non-plate-clearers.

Finally, there was a significant main effect of portion size, $F(3.05, 1010.69) = 246.22$, $p < .001$, $\eta_p^2 = .43$, and a significant main effect of food waste concerns, $F(1, 331) = 8.75$, $p = .003$, $\eta_p^2 = .03$, on intended consumption, with those reporting high food waste concerns intending to consume significantly more than those reporting low food waste concerns. There was a significant portion size*food waste concerns

interaction effect on intended consumption, $F(3.05, 1010.69) = 4.73$, $p = .003$, $\eta_p^2 = .01$. Portion size effects on intended consumption tended to be statistically larger in those who self-report high food waste concerns than those who self-reported low food waste concerns.