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Portion sizes and preschool children: an exploration of caregiver food portioning practices and downsizing solutions

By *Sophie Louise Reale*

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Contents

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List of Abbreviations

BMI- Body Mass Index

CFQ- Child Feeding Questionnaire

CEBQ- Child Eating Behaviour Questionnaire

CFNS- Child Food Neophobia Scale

CFPQ- Comprehensive Feeding Practise Questionnaire

CI- Confidence Interval

CONSORT- Consolidated Standards of Reporting Trials

ECBQ- The Early Childhood Eating Behaviour Questionnaire

FFQ- Food Frequency Questionnaire

FNS- Food Neophobia Scale

FV- Fruit and Vegetables

HED- High Energy Dense

LED- Low Energy Dense

MESH- Medical Subjective Headings

NDNS- National Diet and Nutrition Survey

NHS- National Health Service

NIHR- National Institute for Health Research

PHE- Public Health England

PRISMA- Preferred Reporting for Systematic Reviews and Meta-analyses

PROSPERO- International Prospective Register of Systematic Reviews

PSE- Portion Size Effect

RE- Random Effects

SACN- Scientific Advisory Committee on Nutrition

SMD- Standardised Mean Difference

TDEI- Total Daily Energy Intake

WHO- World Health Organisation

Dissemination

Publications

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Abstract

Preschool children are being served large portion sizes of energy dense snacks contributing to overconsumption of sugar and saturated fat. An obvious action would be for caregivers to remove energy dense foods from children's habitual diets. However, snacks are highly liked and pervasive in the food environment therefore it seems neither feasible nor appropriate to remove these items. Instead portion control methods may be more suitable. However, surprisingly little is known about UK caregivers portioning practices, especially with regards to snack foods. The overall aim of this thesis was to explore caregiver snack portioning practices and to investigate downsizing solutions for preschool children.

Caregivers of preschool aged children (2- 4 years) were recruited from 38 toddler groups in Sheffield, and nationally using online advertisements. Studies 1-3 were exploratory and included a systematic review and meta-analysis. The meta-analysis results informed aspects of a home-based intervention, with feasibility and acceptability parameters (study 4). The qualitative components included semi-structured interviews and a think-aloud task which were analysed thematically. Quantitative data, including food diaries, questionnaires and anthropometric measurements were analysed in SPSS and STATA using multiple inferential tests.

This thesis revealed four key findings: 1) Caregiver's portion size decisions are dynamic, complex and multifaceted; 2) caregivers report that they lack confidence in identifying snack portion size recommendations for preschool children; 3) some caregivers are relatively good at downsizing snacks for preschool children and 4) snack reduction and replacement are feasible methods of portion control in the home environment.

This thesis makes an original contribution to the existing knowledge on caregiver food portioning practices and lends support by identifying two feasible and acceptable portion control methods. Furthermore, the findings from this work may support the development of downsizing interventions and methods of communicating portion size recommendations for preschool children.

1. Overview and background

The overall aim of this thesis was to explore caregiver snack portioning practices and to investigate downsizing solutions for preschool children. This thesis makes an original contribution to knowledge by revealing the complex, dynamic and multifaceted decisions caregivers make in regard to preschool children's snack portion sizes. Furthermore, this thesis lends support by identifying two feasible and acceptable portion control methods in the home environment which adhere to portion size recommendations for preschool children.

Children aged 2-4 years were included since dietary patterns established during childhood often persist into later life e.g. adolescence and adulthood (Birch et al., 1998). It is evident that young children are characterised by their preference for sweet tasting foods and will often reject foods with a more sour or bitter taste (Reese & Lipsitt, 1979). In the modern obesogenic environment, these predispositions can promote preference and consumption of palatable, energy dense foods, which if consumed in large quantities may result in sustained increases in total energy intake (Smethers, 2019). Fortunately, taste preferences are malleable and begin to develop through early sensory learning and repeated flavour exposures, such that repeated exposures have been found to have long lasting effects on solid food preferences through at least 10 years of age (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008; Birch et al., 1998; Farrow & Blissett, 2012; Sausenthaler et al., 2010) highlighting the importance of developing healthy eating behaviours early in life.

Currently, preschool children in the UK have a less than nutritionally optimal diet; exceeding saturated fat and sugar recommendations and not meeting the recommended 40g of fruits and vegetables per serving (NDNS, 2019). Contributing to this, is the portion size of meals and snacks routinely offered to children, often exceeding recommended amounts (Infant and Toddler Forum, 2014). More specifically, 61% of preschool children are frequently being offered too many sweets, with 24% of parents offering a whole packet of jelly sweets which equates to three times the weekly recommended amount. Snack foods are thought to contribute towards a healthy balanced diet for young children (USDA, 2010) when consumed in line with nutritional recommendations. However, in today's society snack foods are often energy dense and described as offering ‘empty calories’ rather than key nutrients needed for healthy growth and development (Maillot, Drewnowski, Vieux, & Darmon, 2011). Furthermore, snack foods contribute to at least 21% of children’s total daily energy intake (TDEI) (Macdiarmid et al., 2009), which if consumed frequently and in large portion sizes may result in poor diet quality and an increased risk of excessive weight gain and associated disease e.g. type 2 diabetes (Evans, Jacques, Dallal, Sacheck, & Must, 2015; Larson & Story, 2013). This therefore highlights the need to explore feasible and acceptable methods of downsizing snacks for preschool children, in line with recommended amounts.

Caregiver characteristics and food related behaviours were explored and contributed to the development of an intervention, since children mirror the eating behaviours demonstrated by their caregivers. For example, caregiver’s food preferences influence the type and quantity of food caregiver’s purchase and thus make available within the eating environment for their child (Anzman et al., 2010). Moreover, associations between mother and child portion size have been identified in the USA at an evening meal, with mothers who habitually eat large food portion sizes serving their children large food portion sizes (Johnson et al., 2014). Mothers have unique perspectives and experiences feeding their young children however, surprisingly little is known about the factors that influence caregivers snack portioning practices, particularly in the UK.

Structure of the thesis

This thesis forms a coherent body of work comprising traditional thesis chapters (i.e. literature review, rapid review, general methodology, discussion and conclusion) alongside a chapter (see Chapter 6) containing studies that have been written for publication. Chapter 6 comprises of 4 research studies (manuscripts), each with its own research questions and objectives. The manuscripts are outcomes of the original research undertaken by the student, who is the primary author, and has undertaken the work since registration of doctoral study at the University of Sheffield. A written statement of the author’s specific contribution to each co-authored manuscript and its current status in regards to publication is provided in the relevant chapter’s introduction as well as in Appendix 1. Confirmation that permission has been obtained to include published materials in the thesis are presented in Appendix 2.

2. Literature Review

In this chapter a comprehensive overview of the literature relevant to childhood obesity and its contributing factors will be considered in accordance to two themes on the Foresight map (Figure 1) since obesity is a multi-dimensional concept that relates to a whole systems approach. However, the Foresight map was not created with a specific focus on childhood obesity, as such only the thematic clusters related specifically to children and their caregivers will be discussed; social psychology and food consumption.

2.1 Childhood obesity

The prevalence of childhood obesity has been increasing over the past three decades such that it is recognised as one of the largest global public health challenges of the 21st century ("WHO | Facts and figures on childhood obesity," 2017). As such, childhood obesity is widely discussed within scientific communities, the media and the public domain. Reports utilise a variety of terminology when discussing obesity, therefore it is necessary to define obesity at this early stage (Reilly, 2005).

Obesity is most commonly known as an excessive accumulation of body fat which increases the likelihood of developing associated diseases, such as type 2 diabetes, and has been linked to a shorter life expectancy (Reilly, 2005). Children are classified as obese in relation to measurements of their height and weight which are taken to compute body mass index (BMI). This is then compared to growth patterns and the average BMI for children of a particular age, also known as the child growth reference (Himes, 2009). For consistency with clinical screening, children's BMI are reported as Z-scores based on the child's age and sex (i.e. the number of standard deviations away from the mean BMI) and compared to population norms. According to the British 1990 growth reference charts, children classified as overweight fall between the 85th and 95th percentile whereas children who meet or exceed the 95th percentile of BMI are defined as obese (Wright et al., 2002).

Globally, 38 million young children (< 5 years) are classified as overweight or obese, with the highest levels experienced in developed countries ("WHO | Facts and figures on childhood obesity," 2017). It is projected that by 2025, 70 million young children (< 5 years) around the world will be defined as overweight or obese ("WHO | Facts and figures on childhood obesity," 2017) which can lead to many complex consequences relating to children's physical health (Pulgarón, 2013) and psychological wellbeing (Schwimmer, Burwinkle, & Varni, 2003). For example, childhood obesity has been shown to affect almost every organ in the body, thus increasing the likelihood of serious medical conditions (Daniels, Jacobson, McCrindle, Eckel, & Sanner, 2009) including hypertension, sleep apnoea, dyslipidaemia, type 2 diabetes, nutritional deficiencies and fatty liver disease (Pulgarón, 2013).

The UK significantly contributes to global levels of childhood obesity. The Health Survey for England (NHS digital, 2017) revealed that in the year 2016-2017, 20% of preschool aged children (2-4 years) were classified as overweight or obese with little difference between sexes (girls = 18%, boys = 21%). Furthermore, the highest levels of childhood obesity have been observed in areas of deprivation, low income and Black/ Black British and Asian ethnicities ("Statistics on Obesity, Physical Activity and Diet," 2018). Children who are overweight or obese during childhood are more likely to remain overweight or obese throughout adolescence and into their adult years (Simmonds et al., 2015), highlighting a need for intervention during the preschool years. Furthermore, during the preschool years eating habits and preferences are formed which are likely to influence current and future health and weight status. As such, this thesis will explore key contributing factors related to obesity in preschool age children (aged 2-4 years). This will be introduced in the next section.

2.2 Contributing factors of obesity

The current levels of childhood obesity and its associated outcomes has triggered interest in explaining contributing factors in order to identify where intervention is needed. The multi-dimensional concept of this problem relates to a whole systems approach to obesity, which can be demonstrated in the Foresight map (Butland et al. 2007) (Figure 1). The Foresight map was created in 2007 to understand the relationship and relative importance of the main factors contributing towards obesity. The map comprises of seven thematic clusters (social psychology, individual psychology, food production, food consumption, physiology, physical activity environment and individual physical activity), demonstrating the complex interplay between a wide variety of factors, that each individually and collectively contribute to obesity at both an individual and group level.

The Foresight map was not created with a specific focus on childhood obesity, as such only the thematic clusters related to children and their caregivers will be discussed in this section, as other clusters are beyond the scope of this thesis. Firstly, food consumption will be discussed in relation to children's dietary intake, more specifically their snack intake. Next, social psychology will be discussed in relation to parental control and feeding practices. Mothers are often the gatekeepers of their child's nutritional intake and engage in daily interactions with food (Powell, Farrow, Meyer, & Haycraft, 2018). These interactions influence taste preference development and thus energy intake. Finally, factors related to food consumption such as energy density and palatability will be presented, however the main focus will be on food portion sizes since research has continually demonstrated that food portion size influences the total amount (in grams) and total energy intake (in kcal) consumed by children at meal or snack occasions e.g. (Fisher et al., 2007b).

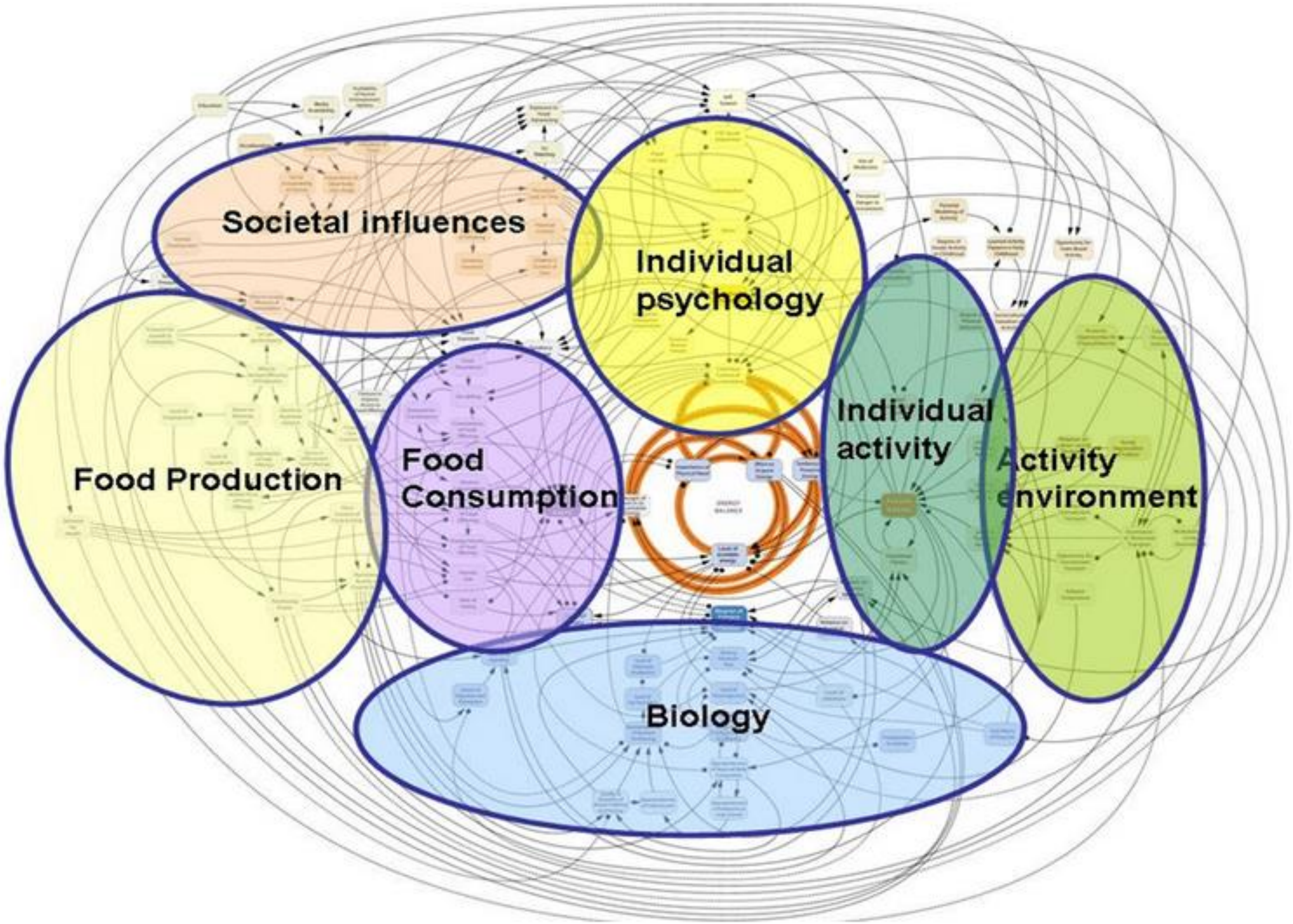

Figure 1: The Foresight map (Butland et al., 2007)

2.2.1 Children's habitual diet

The nutritional intake and energy density of food features in the food consumption cluster of the Foresight map and thus contributes to obesity in young children (Figure 1).

Data on current UK children's nutritional intake were derived from the National Diet and Nutrition Survey (NDNS) to explore children's habitual dietary intake. The NDNS provides information on the nutritional intake and nutritional status of a representative sample of UK households using four-day food diary data, interviews and blood or urine samples. Based on the most recent published findings (rolling programmes 2008/2009 – 2016/17) it has been identified that preschool children are currently not meeting recommendations for dietary fibre or fruits and vegetables (FV) and are exceeding recommendations for saturated fat and free sugar (NDNS, 2019).

In 2015, the Scientific Advisory Committee on Nutrition (SACN) reduced the free sugar recommendation for preschool children from 10 to 5% of total daily energy intake (TDEI). However, 87% of children aged 1-3 years are exceeding this recommendation (NDNS, 2019). Contributing to this, is the portion size of meals and snacks routinely offered to children, often exceeding recommended amounts (Infant and Toddler Forum, 2014). More specifically, the main sources of free sugar are high energy dense (HED; > 2.5kcal/ g) (Albar et al., 2014), confectionary snacks which contribute to at least 21% of children's TDEI (Macdiarmid et al., 2009). Sixty-one percent of preschool children are frequently being offered too many sweets and 24% of parents are offering a whole packet of jelly sweets which equates to three times the weekly recommended amount of sugar (Infant and Toddler Forum, 2014). Furthermore, results from a national survey in Scotland demonstrated that children typically receive at least one snack food per day, and the likelihood of this increases in relation to socioeconomic position; children from the most deprived backgrounds are more likely to be offered HED snack foods as opposed to children residing in the least deprived neighbourhoods (Campbell and Wolfson, 2017), which may contribute towards inequalities in health.

Snack foods, defined as 'all food items consumed between meals' (Gregori, Foltran, Ghidina, & Berchialla, 2011), are thought to contribute towards a healthy balanced diet for young children when consumed in line with nutritional recommendations

(USDA, 2010). However, in today's society snack foods are often energy dense and described as offering 'empty calories' rather than key nutrients needed for healthy growth and development (Maillot, Drewnowski, Vieux, & Darmon, 2011). Furthermore, snack foods are typically packaged in portion sizes 2.5 times larger than appropriate for young children (Sothern, 2004) which if consumed frequently may result in poor diet quality and an increased risk of excessive weight gain and associated disease e.g. type 2 diabetes (Evans, Jacques, Dallal, Sacheck, & Must, 2015; Larson & Story, 2013). For example, TDEI is directly linked to the number of snacks children are served (Anderson, 1995; Garcia, Kaiser, & Dewey, 1990a, 1990b; Mrdjenovic & Levitsky, 2005), and those who snack more frequently have poorer diet quality and are at greater risk of excessive weight gain and associated disease (Evans et al., 2015; Larson & Story, 2013). Furthermore, preschool children have been found to consume up to 70% less at a meal preceding a HED snack compared to a low energy dense (LED; < 2.5 kcal/ g) (Albar et al., 2014) snack (Johnson, 2000), minimising their opportunity to consume nutrient rich foods.

Children have an inherent liking for sweet tastes making HED snack foods more appealing to the child consumer such that snack foods chosen by children are often nutrient poor and HED (Piernas and Popkin, 2010). Snack foods are also convenient and in some cases used as a method to control or reward children's behaviour (Infant and Toddler Forum, 2014). Furthermore, frequent consumption of snack foods has been found to have negative outcomes such as poor dental hygiene and unhealthy consumption at mealtimes. For example, consumption of sweet foods and drinks between meals (i.e. snacks) is a high risk factor for dental caries in children.

Adequate vegetable consumption forms part of a healthy lifestyle with many benefits to health; including the prevention of disease e.g. type 2 diabetes (Harding et al., 2008). However, one in five children are not eating fruits, and three in five are not consuming leafy green vegetables, as part of their habitual diet (Public Health England, 2014). A national school FV scheme was launched in 2000 which provides young children (age 4-6) with one free FV unit per day at school (NHS, 2015). Furthermore, example menus and recipes have been developed to help early year providers plan healthy, tasty meals for preschool children (PHE, 2017). However, neither of these campaigns provide support to caregivers within the home environment where preschool children consume approximately two-thirds of their total daily energy intake (Knowlden and Sharma, 2012), and fruit, vegetable and fibre intake remains low. A more in depth understanding of the approaches caregivers adopt when feeding their children snacks may highlight important areas to tailor interventions to encourage healthy feeding practices in line with recommendations for children aged 2-4 years.

2.2.2 Caregiver influences

Parental control and feeding practices feature in the social psychology cluster of the Foresight map and thus contribute to obesity in young children (Figure 1). Multiple parental feeding practices exist as demonstrated in the Comprehensive Feeding Practices Questionnaire (CFPQ) (Musher-Eizenman and Holub, 2007) but it is beyond the scope of the thesis to discuss them all in turn. Instead, this section of the thesis will focus on six feeding practices that evidently influence children's eating behaviours, energy intake and weight status e.g. (Blissett and Haycraft, 2011) (Table 1).

2.2.2.1 Caregiver feeding practices

Caregiver's play a significant role in shaping their young children's dietary intake from early sensory learning and repeated flavour exposures, during foetal development, to interactions with food during and beyond the weaning process (Powell et al., 2018). Young children learn through imitation and mimic eating behaviours by their second year of life (Anzman et al., 2010; Hart et al., 2010), such that children tend to sample readily available foods if they observe their caregivers consuming the same item (Harper & Sanders, 1975). Mothers are often considered to be the gatekeepers of their child's nutritional intake however other caregivers such as fathers, grandparents, friends and babysitters may play a significant role in shaping eating behaviours due to the expanding female workforce and cost of nursery/ day care centres worldwide (Bell, Perry, and Prichard, 2018). In particular, grandparents are an important source of support in the UK, with over a quarter of children < 5 years of age receiving care from grandparents (Rutter, 2016).

Caregiver feeding practices translate into parent-child interactions which influence children's eating habits, preferences (Blissett, 2011) and weight status (Moens, Braet,

& Soetens, 2007). For example, parental feeding styles are related to children's food acceptance, food liking and the amount of fruits, vegetables (O'Connor et al., 2010), sugar (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2012) and dairy (Patrick, Nicklas, Hughes, & Morales, 2005) consumed by children. In order to promote a healthy diet, literature suggests that caregivers must strike a balance between restricting less healthful foods, making healthy foods available and offering structured eating occasions to support a child's unique appetite regulation and food preferences (Dovey, Staples, Gibson, & Halford, 2008; Kiefner-Burmeister, Hoffmann, Meers, Koball, & Musher-Eizenman, 2014).

Caregivers often use deliberate feeding strategies and practices to shape children's eating patterns and influence their food intake (Yee, Lwin, & Ho, 2017). Some feeding practices are successful in promoting healthy consumption (e.g. modelling) (Cullen et al., 2001) whereas others (e.g. pressure to eat) can reduce desire and consumption of a target food (Vereecken, Rovner, & Maes, 2010). Feeding practices fall into two main themes: controlling (e.g. restriction or pressure to eat) or non-controlling (e.g. provide child autonomy) (Haycraft, Karasouli, & Meyer, 2017) and are often an adaptive response to children's eating behaviours, food fussiness and specific food problems (Holley, Haycraft, & Farrow, 2018).

The associations between caregiver feeding practices and children's eating behaviours pertain largely from literature focussing on mothers practices rather than other caregivers (Lipowska, Lipowski, Jurek, Jankowska, & Pawlicka, 2018). Undoubtedly, father's and grandparents attitudes and feeding practices are likely to influence children's nutritional intake and it is acknowledged that there are potential differences in the the feeding practices adopted by mothers, fathers and grandparents . For example, Vollmer et al., (2015) found no association between fathers feeding practices and children's diet quality or weight status whereas mothers feeding practices have been related to child BMI (Farrow, Haycraft & Blissett, 2018). To date there is limited research exploring the influence of paternal or grandparent feeding practices upon child eating behaviours, thus suggesting that the inclusion of fathers and grandparents in future work may significantly contribute to the body of knowledge related to caregiver feeding practices (Vollmer et al., 2015). As such, the supported literature presented in this section will be related to maternal feeding practices, who will be referred to as caregivers, unless stated.

2.2.2.2.1 Controlling feeding practices: Overt versus Covert

Controlling practices can be executed using two distinct constructs: covert or overt control (Ogden, Reynolds, & Smith, 2006) (Table 1). Children are often aware of overt control including food restriction, monitoring and pressure to eat (Ogden et al., 2006). In contrast, covert control is not so easily detected by children as it is related to the micro-management of a food environment (Norman, Nyberg, Elinder, & Berlin, 2018). Controlling feeding practices often occur when caregivers have their own personal weight/ health concerns (Blissett & Haycraft, 2011; Blissett, Meyer, and Haycraft 2006), believe their child is overweight or obese (Costanzo & Woody, 1985) or want to change their child's unhealthy food preferences (Russell, Worsley, & Campbell, 2015). Research has demonstrated that controlling practices are linked to less healthful child eating behaviours (Bergmeier et al., 2015; Birch & Fisher, 2000; Galloway et al., 2006), more frequent consumption of healthy snack foods (Brown & Ogden, 2004) or produced no significant relationship with children's dietary intake (Costanzo & Woody, 1985). These conflicting findings may be attributable to variations in the sample studied, the questionnaire used ((e.g. the Child Feeding Questionnaire) (Birch et al., 2001) or the Parental Feeding Styles Questionnaire (Wardle et al., 2002)) or how feeding practices were measured e.g. self-report versus observations (Powell et al., 2018).

Table 1: Examples of controlling and non-controlling feeding practices

Controlling (directive) feeding practices		**Non-controlling (non-directive) feeding practices**
Overt	*Covert*	
Food restriction	Food environment	Child autonomy
Pressure to eat	Modelling behaviours	-
Food as reward	-	-

Overt

Restriction

Restriction includes the application of food limits and stringent food related rules. For example, caregivers may attempt to limit food consumption by restricting intake of unhealthy foods possibly due to caregiver concerns related to their child’s weight status (Boots et al., 2015; Harrison et al., 2018). This is known as overt restriction which can be actioned verbally and physically. In an observational study, mothers of children aged 3-5 years used verbal restriction more often than physical restriction (Farrow, Haycraft, & Blissett, 2018). Yet, children rejected verbal and physical restriction 33 and 30% of the time respectively; suggesting that restriction may not always influence children’s eating behaviours.

High levels of food restriction may have adverse effects on children’s food consumption including an increased desire and consumption of a restricted versus non-restricted food once it becomes freely available, especially in the absence of their caregiver (Fisher & Birch, 1999). For example, when children aged 3-6 years were presented with palatable snack foods in four unrestricted sessions, followed by four restricted sessions, children demonstrated obsessive interests for the forbidden food (Fisher & Birch, 1999). Children requested the forbidden snack food frequently, attempted to consume it and made multiple comments referring to their liking of the forbidden item. Thus, demonstrating that restricting snack foods enhances desired consumption for that food item, which may lead to overconsumption of nutrients. In a similar study, children aged 5-6 years were restricted access to chocolate and crisps (Jansen, Mulkens, & Jansen, 2007). However, once the restriction was removed children consumed larger quantities of the prohibited snack compared to children in the control condition suggesting an association between highly restrictive feeding practices and children’s desire and consumption of a target food on removal of the restriction. However, it is important to note that children who were familiar with moderate food restrictions in the home environment were less affected by restriction than those who received it very rarely or frequently (Jansen, Mulkens, & Jansen, 2007). This suggests that caregivers need to consider how frequently they restrict food items since children become more eager to consume those foods, and indeed will when given access, which may be difficult to avoid in some cases i.e. when children attend parties, preschool or are in the care of others. However, determining what is classified as a moderate or large amount of restriction is unclear. Furthermore, it is unknown how restricting LED foods impact children's desires and consumption on FV. If the same holds true, restricting FV may have a positive outcome and encourage the consumption of FV in line with daily recommended amounts, however further investigation is required.

Similarly, restriction has been related to other adverse eating outcomes including a higher BMI (Clark et al., 2007; Farrow, Haycraft & Blissett, 2018; Fisher & Birch, 2002), emotional eating (Farrow, Blissett & Haycraft, 2011), increased energy intake (Blissett 2011; Shloim et al., 2015), interference with self-regulation of appetite (Hughes and Frazier-Wood, 2016; Jansen, Mulkens, and Jansen 2007) and eating in the absence of hunger (Birch, Fisher & Davison 2003; Corsini et al., 2018). However, the relationship between food restriction and children eating in the absence of hunger has produced mixed findings (Farrow, Haycraft & Blissett, 2018). For example, maternal restriction has been related to lower subsequent BMI z scores in infancy (Farrow & Blissett, 2008) and lower reports of eating in the absence of hunger in preschool aged children (mean = 27 months) (Bauer et al., 2017).

These discrepancies in outcomes (Birch, Fisher & Davison, 2003; Corsini et al., 2018; Farrow, Haycraft & Blissett, 2018) may be attributable to difference in study design or variations in the sample's characteristics. Alternatively, they may reflect differences in children's responses to caregiver restriction dependent on age. For example, findings from a systematic review exploring context specific parental feeding practices on child food consumption highlighted mixed effects of food restriction on intake (Yee, Lwin & Ho, 2017). A total of 8 studies suggested restriction was positively associated with unhealthy consumption however 14 studies demonstrated a null effect thus highlighting the large amount of heterogeneity between restrictive behaviours and unhealthy food consumption (Yee, Lwin & Ho, 2017). However, the meta-analysis revealed that restriction was negatively associated with unhealthy consumption. Interestingly, when stratified by age this effect was no longer apparent suggesting that restrictive feeding practices may be less effective, or not effective at all, in children 12 years and above such that older children may have more personal control over their nutritional intake and be able to override their caregivers attempt to restrict food items (Farrow, Haycraft & Blissett, 2018).

Pressure to eat

Pressure to eat refers to a common parental feeding practice whereby caregivers utilise verbal communication to encourage children to eat more food, to encourage sufficient nutrient intake, reduce food waste, or encourage their children to eat certain types of food, such as FV (Moore, Tapper & Murphy, 2007). One of the factors underlying parental pressure is related to caregivers concern that their child is underweight or not eating enough (Harrison et al., 2018). Interestingly, pressure to eat is less often cited in relation to snack food intake as parents may be less likely to encourage or pressure consumption of 'unhealthy' foods (Blaine et al., 2017; Davison et al., 2015; Vollmer & Mobley, 2013).

Pressure to eat may be counterintuitive and have detrimental effects on long-term FV consumption. For example, adverse eating outcomes such as reduced intake of a target food (Holley, Farrow & Haycraft, 2017), unhealthy food consumption (Yee, Lwin & Ho, 2017), low FV intake (Galloway et al., 2005; Fisher et al., 2002) and dietary restraint (Carper, Fisher & Birch, 2000) have been observed following pressure to eat. For example, children have been reported to consume more soup and make less negative food related comments when pressure to eat was not present (Galloway et al., 2006). In a systematic review, exploring context-specific parental feeding practices, pressure to eat produced mixed effects on nutritional intake. Out of 22 studies, 8 demonstrated a positive relationship and 13 produced no relationship between pressure to eat and unhealthy consumption (Yee, Lwin & Ho, 2017). Results of the meta-analysis revealed a positive association between pressure to eat and unhealthy consumption ($r = 0.04$, $p < 0.05$) however effects appear to be limited to younger children, with studies that included older children demonstrating non-significant effects. Furthermore, pressure to eat has been found to have paradoxical effects. For example, pressure to eat has been found to reduce energy intake and BMI (Carnell & Wardle, 2007; Keller et al., 2006; Powers et al., 2006). Pressure to eat has also been found to increase energy intake and BMI (Loth, 2016; Rodgers et al., 2013; Taylor, Wernimont, Northstone, & Emmett, 2015). These disparities may be due to the frequency in which pressure to eat is administered, possibly in relation to caregiver's beliefs about their child's food fussiness (Gregory, Paxton, & Brozovic, 2011) or consumption goals e.g. to eat vegetables in the present meal.

Food as Reward

In the current obesogenic environment, many caregivers struggle to get their children to eat a healthy balanced diet (Cooke et al., 2011). In the UK, at least 55% of caregivers have reported using incentives to encourage or reward healthy eating behaviours (Moore, Tapper & Murphy, 2007). Rewards include other food items or contingent, non-food rewards such as stickers, toys or verbal praise. When rewards are offered as a mode of encouragement this can be referred to as instrumental feeding whereby children are told 'if you eat X, you can have Y' (Cooke et al., 2011). Many caregivers believe instrumental feeding is restrictive but have concerns as to what point it becomes 'bribery' (Cooke et al., 2011).

Research exploring the role of reward on food acceptance and consumption began in the 1980's with a series of studies by Birch and colleagues (Birch et al., 1982) that demonstrated children's initial liking for a target food/ drink is reduced when rewards are offered. For example, when children were rewarded for tasting a novel drink, in subsequent taste tests they reported to like the target item less than children who did not receive any form of reward (Birch et al., 1982), and reward type did not influence the magnitude of the reduction in liking (Birch, Marlin & Rotter, 1984). To explore this phenomenon further, Mikula (1989) mimicked the family eating environment and offered children dessert to encourage consumption of a main meal, of which both items were moderately liked by the children. Two studies provided no evidence for a change in food liking of the meal items however liking for the reward item (dessert) significantly increased. In a third study, liking of fruit was reduced when instrumental feeding was introduced, regardless of fruit familiarity (Mikula, 1989). Collectively, these studies provide mixed or null effects of reward with none identifying a positive outcome. Children tend to develop a stronger preference for the already liked food item (the reward) (Mikula, 1989), which in most cases is high in energy density, and a reduced desire to consume the target food (Birch et al., 1982). For example, more recent work in the form of a meta-analysis has revealed a significant and positive relationship between food as a reward and unhealthy consumption in children ($r = 0.14$, $p < 0.05$) (Yee, Lwin & Ho, 2017), with most reward items being sweet snacks. However, there is limited evidence to support the use of healthy food rewards to influence children's eating behaviours (Yee, Lwin & Ho 2017).

Using food to reward (Añez, Remington, Wardle, & Cooke, 2013) or regulate (Wardle et al., 2002) a child's behaviour can also have long term negative implications on weight status (Rodgers et al., 2013; Wardle & Carnell, 2007), eating behaviours (e.g. eating in the absence of hunger) (Rodgers et al., 2013) and may encourage children to deliberately focus on external cues e.g. food portion size rather than internal self-regulatory cues of hunger and fullness (Croker, Sweetman, & Cooke, 2009). The long-term implications of this suggest that children may learn to eat in the presence of food cues rather than internal hunger cues which may hinder their ability to self-regulate their appetite (Fisher & Birch, 1999). According to the self-determination theory (Deci & Ryan 1985, 2000), offering extrinsic rewards for a given behaviour can reduce motivation to perform that desired behaviour. As such, rewarding children for consuming an already liked food item may reduce intrinsic motivation to consume that item and produce a net decline in motivation when the reward is subsequently removed (Cooke et al., 2011). Furthermore, children may devalue the food item consumed to receive the reward and may subsequently develop negative associations with that food item. This notion was supported in a meta-analysis that revealed a decrease in a desired behaviour or enjoyment of that behaviour when rewards were removed (Cameron & Pierce, 1994) which may be attributable to compromising feelings of competence and autonomy.

Other forms of reward, including praise, hugs and stickers have been linked to children selecting healthy versus unhealthy alternatives (Baer, Blount, Detrich, & Stokes, 1987; Stark, Collins, Osnes, & Stokes, 1986), increased consumption of a main meal (Orrell-Valente et al., 2007) and vegetables (Wardle et al., 2003), suggesting that tangible food rewards and praise are distinct methods with differing outcomes (Yee, Lwin & Ho, 2017). Tangible food rewards are often promised before the desired behaviour is achieved whereas praise will be delivered unexpectedly, either immediately or sometime after the desired behaviour (Carton, 1996). A child's awareness of reward can be detrimental (Deci, 1985) whereas non-food rewards may be advantageous in encouraging FV consumption (Yee, Lwin & Ho, 2017). Praise is different to materialistic rewards in that it fulfils and fosters intrinsic needs of relatedness, competence and autonomy whereas materialistic rewards are associated with extrinsic motivation (Orrell-Valente et al., 2007).

Non-food rewards have been found to successfully increase consumption of healthy snack foods in children aged 3-6 years (Stark et al., 1986) as well as encourage consumption of a previously disliked or novel vegetable in both the home (Corsini et al., 2013; Holley, Haycraft & Farrow, 2015) and school setting (Añez et al., 2013). Non-food rewards have been combined with peer modelling as part of a national school-based intervention 'Food Dudes' (Horne et al., 1995) to successfully increase short term vegetable consumption in school aged children (Horne et al., 1995; Lowe et al., 2004). However, due to the methodological design of the study it was difficult to distinguish whether children's increased vegetable consumption was due to the food reward or peer modelling, two similar constructs that are difficult to untangle (Horne et al., 2004; Lowe et al., 2004). Furthermore, programmes such as 'Food Dudes' run on governmental funding. As such, home-based interventions may be an alternative setting for interventions. For example, home based interventions have demonstrated an increase in preschool children's consumption of a previously disliked vegetable when children were offered a non-food reward (i.e. sticker) combined with repeated exposure and peer modelling over a 14-day period (Holley, Haycraft & Farrow, 2015). Interestingly, no differences between consumption in the repeated exposure, modelling or control condition were found suggesting the importance of including a reward to encourage consumption.

Covert

Food environment

Caregivers control the availability of a particular food in a particular environment in which a child is present (Yee, Lwin & Ho, 2017) and may do so to influence their child's dietary behaviour. Children develop food preferences through repeated exposure (Birch, 1999; Birch et al., 1990) therefore the availability of food within the immediate eating environment is crucial in determining what flavours/ foods children sample and accept (Yee, Lwin & Ho, 2017). For example, the availability of unhealthy food is significantly and positively related to unhealthy consumption as demonstrated in a meta-analysis ($r = 0.34$, $p < 0.001$) (Yee, Lwin & Ho, 2017), and therefore food availability may relate to weight status. Furthermore, limiting access to HED foods, by not purchasing these or having them within the home reduces unhealthy snacking (Ogden et al., 2006).

There may be an interaction between food availability (exposure) and child food fussiness. For example, it has been reported that caregivers who perceive their children to be fussy eaters may be less likely to purchase healthy foods compared to caregivers who do not see their children as fussy eaters (Tan & Holub, 2012), which could limit exposure and food acceptance. However, two studies (Holley, Farrow & Haycraft, 2017; Holley, Farrow & Haycraft, 2018) found no association between children's food fussiness and re-offering of vegetables by caregivers to their preschool child. Reasons for these differences may be associated with the child's response (e.g. tantrum) or the caregiver's concern of food waste which may have a greater influence on caregiver's reoffering of disliked foods compared to food fussiness of the child (Holley, Farrow & Haycraft, 2018).

Modelling

Modelling involves caregivers purposely choosing and eating health foods to encourage their children to conform to similar behaviours (Vaughn et al., 2016). Modelling is effective at increasing children's intake of healthy foods (Campbell, Crawford & Ball 2006; Fisher et al., 2002) through observational learning. For example, acceptance of novel fruits (Blissett et al., 2012) and previously disliked vegetables (Wardle et al., 2003). Furthermore, modelling of healthy eating is inversely associated with intake of energy dense, high fat snacks (Eisenberg et al., 2012).

Similar associations are observed when caregivers model unhealthy eating behaviours; children also have unhealthy food preferences (Yee, Lwin & Ho, 2017) thus suggesting that modelling may drive eating behaviours through social learning and self-efficacy beliefs (Bandura, 1998; Yee, Lwin & Ho, 2017). According to the social cognitive theory, individuals learn through observations and will adopt the behaviours they observe from an influential role model (e.g. the mother) (Bandura, 1998, 2001). More specifically, children learn through imitation and mimic eating behaviours by their second year of life (Anzman, Rollins, & Birch, 2010; Hart, Raynor, Jelalian, & Drotar, 2010), such that children tend to sample readily available foods if they observe their parents consuming the same item (Harper & Sanders, 1975). Similarly, peer modelling can influence the types of foods chosen by children (Birch, 1980) and their acceptance of novel foods (Hendy, 2002).

Modelling behaviours observed during family meals (Hammons & Fiese, 2011; Neumark-Sztainer, Wall, Story, & Fulkerson, 2004) and out-the-home (e.g. the supermarket) (Lively et al., 2017) have been found to encourage consumption of both healthy and unhealthy foods (Yee, Lwin & Ho, 2017). Regardless of location, positive modelling has been associated with reduced food fussiness, higher intake of FV (Heim et al., 2011; van der Horst, 2012; Powell, Farrow & Meyer 2011) and increased enjoyment of food (Palfreyman, Haycraft, & Meyer, 2015). Positive correlations have also been observed between mother and child food preferences and intake of most nutrients (Oliveria et al., 1992) such as FV (Beydoun &Wang, 2009; Busick et al., 2008; Cooke et al., 2004; Palfreyman, Haycraft & Meyer, 2014; Wroten et al., 2012), sweets (Beydoun & Wang, 2009; Wroten et al., 2012) and snack foods (Wroten et al., 2012) which may be a result of modelling behaviours. Therefore, it is possible that mothers could encourage children to consume healthy foods by consuming them themselves.

2.2.2.2.2 Non-Controlling feeding practices

Non-controlling feeding practices provide children with partial or full autonomy related to food decisions and preparation e.g. when, what and how much to eat (Russell et al., 2015) which are related to healthy eating behaviours in children and a good relationship with food (Haycraft, Karasouli & Meyer, 2017).

Child autonomy

Some caregivers choose to adopt less controlling feeding practices and allow their child to decide when, what and how much food they would like at meal and snack occasions. Increasing child autonomy has been found to reduce food fussiness and enhance diet variety (Morris, Neustadter, & Zidenberg-Cherr, 2001) which may encourage children to regulate their intake using internal cues of satiety. For example, including children in growing, choosing and preparing vegetables (Morris et al., 2001) or providing them with autonomy to choose from a selection of healthy foods (Patrick et al., 2005) increases a child’s willingness to try vegetables and enhances their autonomy development. However, it is important to note that by providing young children with too much control in an environment abundant with energy dense foods may result in poor dietary choices and food preferences (Haycraft, Karasouli & Meyer, 2017).

Having few rules or limits on snack foods, also known as permissive parenting (Hubbs-Tait et al., 2008), is associated with excessive energy intake and an elevated BMI in children (Hughes et al., 2005) which is concerning given that snacks are typically packaged in portion sizes larger than appropriate for young children (Sothern, 2004). Furthermore, research has compared parental feeding styles with maternal weight status to reveal that caregivers who were classified as obese were less likely to control their child's food intake (Haycraft, Karasouli & Meyer, 2017; Wardle et al., 2002), encourage less food variety and have a less healthful food environment compared to caregivers of a healthy weight (Haycraft, Karasouli & Meyer, 2017). However, this research needs replicating in a more diverse sociodemographic sample since most caregivers were white British and highly educated, and both socioeconomic status and ethnicity can influence parental feeding practices (Cardel et al., 2012).

Furthermore, caregivers of children who dislike vegetables sometimes find it easier to provide liked as opposed to disliked foods (Cooke, 2007). This may limit children's exposure to flavours and therefore restrict variety within their diet since foods need to be tasted a large number of times before they are accepted and liked (Caton et al., 2013, 2014).

Summary

Caregivers demonstrate a variety of parental feeding practices that influence children's food preferences, nutritional intake and weight status and are often an adapted response to their children's eating behaviours or personal feeding goals/ concerns. Observational studies and self-report methodologies have demonstrated a diverse range of outcomes associated with each parental feeding construct that may or may not adhere to the outcome expected by the caregiver. Caregivers need to be informed regarding which parental feeding methods are successful at encouraging long term healthy snacking behaviours such as modelling FV consumption or ensuring healthy snacks are available and easily accessible within a child's immediate eating environment. Secondly, caregivers need to be made aware of which parental feeding strategies to minimise, especially in an environment whereby large, energy dense portion sizes are abundant and easily accessible since many feeding practices (e.g. pressure to eat) have adverse effects such as eating in the absence of hunger.

2.3.3 Food portion sizes

Food portion sizes feature in the food consumption cluster (and to some extent on the food production cluster, however this is beyond the scope of the thesis) of the Foresight map and thus contribute to obesity in young children (Figure 1).

A food portion size can be defined as the amount of food served by one's self, a restaurant or food producer to be consumed at one occasion (Benton, 2015). Food portion size guidelines for adults in the UK are easily accessible on food packaging, and interactive guides have been created for commonly consumed food items e.g. (British Nutrition Foundation, 2019). Portion size recommendations for children are also available e.g. (British Nutrition Foundation, 2018a; More & Emmett, 2015; NHS, 2018; Nutrition, 2016; Scotland. Scottish Executive., 2006; Thomas & Bishop, 2007) however they are less clear, more difficult to access and tend to focus on meals as opposed to snack foods. For example, practical recommendations for children aged 1-5 years have been developed by the Children's Food Trust. Furthermore, the Eatwell guide (NHS, 2016) recommends that foods containing large quantities of sugar, fat and salt should be consumed less frequently and in small portion sizes.

More specifically for snack foods, Public Health England (2018) have recommended that caregivers limit the calorie content and frequency of snack's offered to children; 100 kcal snacks, twice daily. Furthermore, the Infant and Toddler Forum have produced a table containing snack portion sizes, advising caregivers to limit HED snacks to once per day based on research conducted by More and Emmett (2015). More and Emmett (2015) produced evidence based portion size ranges for 164 foods for children aged 1-4 years. The guide was developed to aid caregivers towards the provision of adequate nutrition and to address common parental anxiety that their child is not consuming enough (Savage, Fisher, & Birch, 2007). Adequate nutrition was defined as providing portion sizes that meet, and do not exceed, reference nutrient intakes (RNI) in the UK and recommended daily allowances (RDA) in the USA. However, mothers have reported feeling overwhelmed at the abundance of guidance and advice currently available on parenting (Croker et al., 2009).

2.3.3.1 The portion size effect

Manipulations to the amount of food on offer leads to a change in food intake (Herman, Polivy, Pliner, & Vartanian, 2015) such that large portion sizes often result in greater energy intake at a meal or snack occasion e.g. (Fisher et al., 2007b). This phenomenon can be referred to as the portion size effect (PSE). The PSE has been described as one of the most influential factors of food intake (Rozin, Kabnick, Pete, Fischler, & Shields, 2003) and has been subject to a meta-analysis (Zlatevska, Dubelaar, & Holden, 2014), systematic review (Hollands et al., 2015) and narrative reviews e.g. (Zuraikat et al., 2019). A combined increase in portion size and energy density has been found to have larger effects on energy intake (Kral, Roe, and Rolls 2004). Whereas, reducing food portion sizes or energy density produces a reduction in energy intake (Rolls, Roe, and Meengs 2006).

The PSE has been observed in men, women (Rolls, Roe, and Meengs 2007), and children (Fisher, 2007). Furthermore, the PSE has been demonstrated at single meals in laboratory (e.g. Rolls, Morris and Roe, 2002; Kral, Roe and Rolls, 2004; Rolls et al., 2004) or naturalistic settings (Diliberti et al., 2004), for unit (Geier, Rozin, & Doros, 2006), amorphous (Rolls, Morris, and Roe 2002), HED (Rolls et al., 2004) and LED foods (Spill, Birch, Roe, & Rolls, 2011). The PSE has been sustained for 2 (Barbara J. Rolls et al., 2006) and 11 days (Rolls, Roe, and Meengs 2007) without compensatory behaviour in adults, and over a 5 day period in children (Smethers et al., 2019).

Most of the original research in this field involved adult participants, however in more recent years children have become a focus of attention such that numerous studies in adults and children have been designed in parallel to facilitate comparisons, or studies have included mother-child dyads (Fisher et al., 2007b). Where available, supporting literature including both adult and child participants will be presented, to contextualise and focus this thesis exploring parental influences on children's portion sizes. Furthermore, understanding adult portion size selection and consumption is important since adult portion sizes have been demonstrated to influence child portion size (Johnson et al., 2014).

The PSE in Adults

Rolls et al., (2006) served adults main meals and snacks under controlled laboratory conditions for 2 days, and the portion sizes were 100-, 150- or 200% of the baseline amount. Energy intake increased for all meal and snack items by 16% in the 150% portion size condition and 26% in the 200% condition, relative to baseline. However, all meals were consumed in private cubicles, such that the effect may have been maximised due to the nature of the meal. Furthermore, consumers are more likely to compensate when provided with freedom of choice regarding when, and what to eat (Benton, 2015). Next, the same research group aimed to explore the impact of enlarged portion sizes over an 11-day period (Rolls, Roe & Meengs, 2007). All food items were provided for two 11-day periods and a 100- and 150% portion were compared. Participants demonstrated an increase in daily energy intake of 423kcal and this was not compensated by consuming less at a subsequent meal occasion. However, the provision of meals reduces the opportunity for physiological mechanisms to be observed, should they exist, especially when instructed to consume 3 meals per day (Benton, 2015), therefore, potentially inflating the PSE. These findings have been demonstrated elsewhere in the literature whereby sustained increases to TDEI have been observed following enhanced consumption of a large versus small breakfast (De Castro, 1996).

The PSE in children

Similarly, the PSE has been evaluated beyond a single meal in preschool children (Fisher et al. 2007a) and their Hispanic African American mothers. The portion size of three meals and an afternoon snack were doubled in size over a 24-hour period, as part of a within-subject study design. Both children and adults alike consumed 12 and 9% more when the food portion sizes were doubled over a 24 hours period, without compensatory reductions to other foods. More recent work (Smethers et al., 2019), has demonstrated a sustained increase in energy intake over 5 days in children aged 3 – 5 years, resultant of a 50% increase in all food and milk served. This finding challenges the notion that young children may be able to regulate their appetite and instead demonstrates that portion size may contribute towards the development of overweight and obesity where sustained increases in energy are observed over a prolonged period of time.

The PSE in adults and children

Increasing food portion sizes by 100% (i.e. a double portion size) results in adults and children consuming on average an additional 35%, and this trend is curvilinear (producing a medium-sized effect, d = .45) (Zlatevska et al., 2014). Zlatevska et al., (2014) examined 8 articles each offering three or more different portion sizes (in grams). Similar trends in portion size were identified in a Cochrane review by Hollands et al., (2015). A random-effects meta-analysis including 92 independent comparisons, 6711 adult and child participants and 61 eligible studies revealed that increasing food portion, package or unit size increased the amount of food consumed by both children (SMD = 0.21, 95% CI = 0.10 – 0.31) and adults (SMD = 0.46, 95% CI = 0.40 – 0.52). A small to medium effect size (d = 0.37) was produced demonstrating that continuous consumption of large food portion sizes could lead to a sustained increase in TDEI in UK children and adults.

2.3.3.2. Potential moderators of the PSE

Potential moderators of the PSE have been offered to develop an understanding of the factors that influence the quantity people consume and to support the development of interventions/ strategies to counter the PSE e.g. (Zuraikat et al., 2019). Each moderator's contribution to the PSE differs in relation to the individual and the eating context. Eight potential moderators of the PSE will be discussed in this section of the thesis (Figure 2) and where available, the moderators of the PSE will be supported by literature from research involving adult and child participants, since there is a strong correlation between adult and child food portion sizes (Johnson et al., 2014).

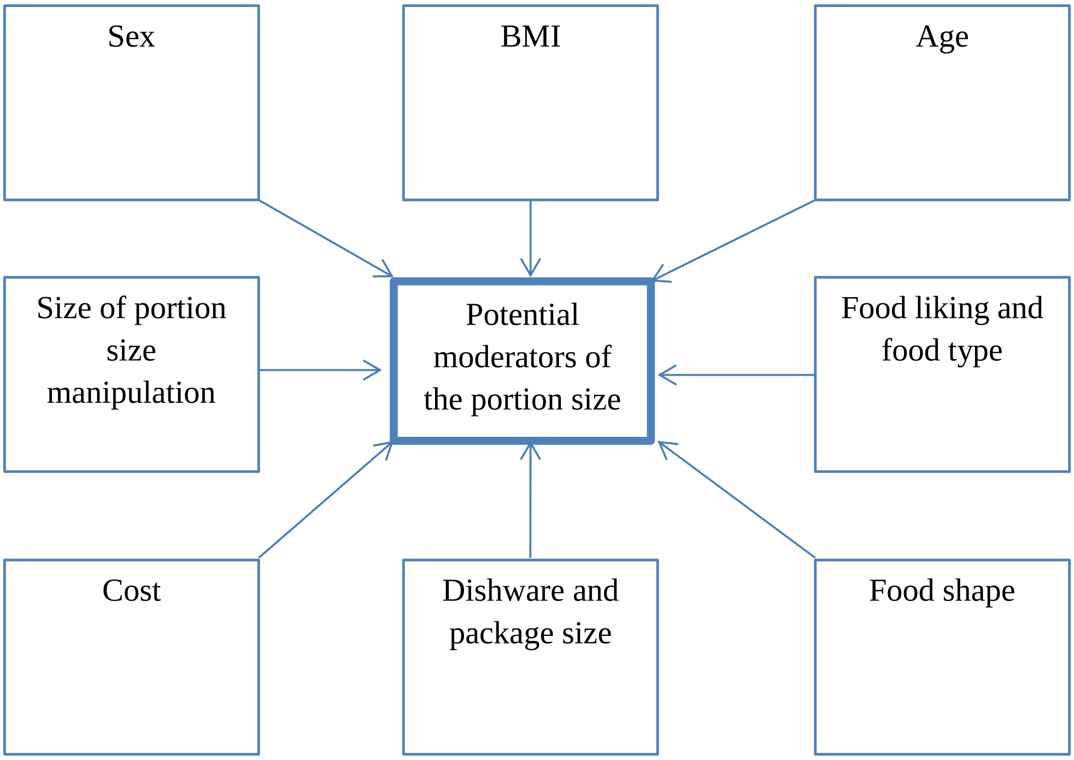

Figure 2: Potential moderators of the portion size effect

2.3.3.2.1 Sex differences

Sex differences in adults

Research has reported mixed findings regarding individual characteristics as moderators of the PSE. For example, the PSE has been found to operate in both male and female participants (Rolls, Roe & Meengs, 2007) yet studies have also reported sex differences in portion size estimation (Lewis et al., 2015) and the magnitude of the PSE (Robinson, te Raa & Hardman, 2015). In one study (Rolls, Morris & Roe, 2002), male and female participants were served two portion sizes of macaroni and cheese and consumed 30% more energy when served the large (1000g) versus regular (500g) portion size. Similarly, with each increase in sandwich portion size, participants consumed more (6, 8, 10, or 12 inches), however sex differences were revealed in this study, with men consuming 56% more compared to females who consumed 31% more (Rolls et al., 2004). Furthermore, in a study carried out by Robinson and colleagues (Robinson, te Raa & Hardman, 2015) only males demonstrated the PSE. Participants were presented with either a standard or large ice cream in a laboratory-based study and were requested to report their intended consumption, before subsequently eating the ice cream. Both male and female participants in the large portion size condition reported an intention to consume larger amounts than those in the small portion size condition. However, for females, there were no differences between the amount consumed in the small and large portion size condition. This may be attributable to females having a higher reported level of dietary restraint, lower plate clearing tendency or lower BMI (Robinson, te Raa & Hardman, 2015).

Sex differences have also been reported when self-selecting portion size (Burger, Kern, & Coleman, 2007; Lewis et al., 2015). For example, when presented with HED foods (e.g. chocolate pudding), high fat foods and high carbohydrate foods, men self-selected significantly larger portion sizes than females (Burger et al., 2007). However, there were no differences in portion size selections between male and female participants for LED foods (e.g. cereal). The diet food industry tends to target females therefore it is possible that unhealthy foods, associated with high energy intake, may be better regulated by females than males (Burger et al., 2007) therefore the PSE may be attenuated in females (Rolls, Roe & Meengs, 2006; Rolls et al., 2004).

Similarly, Lewis et al., (2015) explored differences between personal and social norms of portion sizes based on sex; personal norms were related to individual's perception of an appropriate amount of food for themselves whilst a social norm was defined as participant's perception of the amount of food that other individuals consider to be normal. Male participants were found to have significantly larger personal norms compared to female participants and significantly larger personal norms than social norms, a trend not identified for females. This finding demonstrates that men may meet their greater energy needs by consuming larger food portion sizes. Using multiple linear regression models, response slopes were produced and revealed that the curve was shallower for men than women indicating that men were less certain about their portion size selections compared to women. Interestingly, sex influenced social norms which may represent the participant's perception of suitable portion sizes for the opposite sex.

Due to inconsistencies in the literature, sex was input into a random coefficient model, as a potential moderator of the PSE (Zlatevska et al., 2014). The analysis revealed that men were more susceptible to the PSE and demonstrated a 52% increase in consumption when presented with a double portion size compared to a 27% increase in consumption for female adult participants. Alternatively, differences in consumption may be related to bite size. Men tend to take larger bite sizes than females which could explain differences in consumption (Zlatevska et al., 2014) (more information on bite size as a mechanism is provided in section 2.4.3.2.6). However, results of Zlatevska meta-analysis highlight the need for further research regarding sex as a moderator of the PSE due to inconsistencies in findings. For example, a second review examined the relationship between dishware size and the amount of food consumed to reveal no significant differences in sex in a subgroup analysis (Robinson et al., 2014).

Sex differences in children

Studies in children have also demonstrated inconsistent results when exploring sex as a moderator of the PSE. Most, have found no relationship between sex and the amount of food consumed when portion sizes are enlarged (Fisher, Rolls & Birch, 2003; Leahy et al., 2008; Rolls, Engell & Birch, 2000; Savage et al., 2012). Yet, other studies have identified boys as being more susceptible to the PSE than girls (Mccrickerd, Leong & Forde, 2017), or vice versa (Fisher, 2007). Both studies included children of a similar age (age 3-7 years versus age 2-9 years) and served an amorphous main meal. However, one study was conducted within a naturalistic environment with children eating amongst their peers (Mccrickerd, Leong & Forde, 2017) whilst the other study was conducted under strict laboratory conditions (Fisher, 2007). Presumably differences in eating location would influence male and female participants similarly but it is possible that differences between studies may be attributable to consumption measures. McCrickerd et al., (2017) reported children's consumption from the large portion relative to the small portion, such that females consumed less in the small condition than males. Therefore, the PSE may be inflated in female participants due to similar consumption responses to large food portion sizes but a smaller initial amount consumed, demonstrating a larger difference.

2.3.3.2.2 BMI

The PSE has consistently been demonstrated regardless of participant BMI (Rolls et al., 2004; Rolls, Morris & Roe, 2002). However, there is evidence to suggest that BMI may moderate the PSE; influencing both portion size estimation and consumption (Burger, Kern & Coleman, 2007; Smethers et al., 2019). For example, a positive correlation has been identified between children's body weight and portion size in American children (Huang, Howarth, Lin, Roberts, & McCrory, 2004). Likewise, Dutch adults classified as obese have been found to consume larger portions of HED foods compared to participants classified as normal weight, of whom were matched for age (Westerterp-Plantenga, Pasman, Yedema, & Wijckmans-Duijsens, 1996). However, correlation does not infer causation.

Adult BMI

In 1968, Nisbett directly compared consumption between normal and overweight adults when offered 1 or 3 sandwiches (Nisbett, 1968). The study revealed an effect of BMI such that individuals classified as overweight ate larger amounts when offered a large food portion whereas participants classified as normal weight demonstrated negligible changes in intake between conditions. These findings may be related to the social desirability effect. For example, people who are overweight have a stronger desire to avoid inappropriate behaviour than those with a normal body weight such that participants who were classified as overweight ate what the experimenter offered them, and no more or less, to comply with instructions.

However, contradicting evidence has suggested no difference in the PSE based on weight status (Diliberti et al., 2004; Fisher et al., 2007a; Rolls, Morris & Roe, 2002). For example, there was no association between BMI and portion size selection of foods displayed in an online survey exploring estimates of everyday portion sizes (Brunstrom, Shakeshaft, & Scott-Samuel, 2008). It is possible that this was related to the self-report measure whereby consumers may knowingly or unknowingly misreport their usual intake (Barrett-Connor, 1991). For example, underreporting may have influenced the outcome of Brunstrom et al., (2008) study, however more research is required to conclude this. Alternatively, participants may have recently begun dieting which may explain some of the variance in portion size estimations. It is also possible that portion sizes were similar between BMI classifications such that differences in energy intake may be attributable to frequency of consumption (Ma et al., 2003) or the type of food offered e.g. snacks vs. non-snack foods (Zlatevska et al., 2014).

Robinson et al., (2014) examined the effect of BMI in a subgroup analysis examining the effects of dishware size on consumption. Studies that specifically recruited participants who were classified as overweight or obese were compared to studies recruiting participants classed as a healthy weight, or those that had no recruitment criteria for BMI. The analysis produced a smaller effect size for the two comparisons that specifically recruited participants classified as overweight or obese compared to those who were identified as having a healthy body weight. This finding suggests a negative relationship between BMI and susceptibility to the PSE. However, caution should be taken when interpreting the findings since only a small number of studies qualified for inclusion into the overweight and obese group. Furthermore, despite the studies that had no recruitment criteria for BMI reporting a mean sample BMI within the healthy range (BMI = 18.5 – 24.9 $kg{\cdot}m^2$) it is unjust to assume that none of the sample were overweight or obese, thus the subgroup analysis does not accurately reflect healthy versus overweight.

To examine whether individuals classified as overweight or obese are more susceptible to the PSE, BMI was used as a potential moderator variable in a random coefficient model and studies were coded into two groups: BMI > 25 $kg{\cdot}m^2$ versus BMI < 25 $kg{\cdot}m^2$ (Zlatevska et al., 2014). The results revealed that adults with a BMI > 25 $kg{\cdot}m^2$ were less responsive to increases in portion size than adults with a BMI <

25 kg·m^2. Adults in the lower BMI category consumed 34% more when food portion sizes were doubled compared to 18% more for adults in the higher BMI group (Zlatevska et al., 2014). This finding suggests that downsizing may not effectively reduce intake in adults with a BMI above 25, since they appear to be less responsive to manipulations to portion size. However, findings should be considered with caution for two reasons. Firstly, a simple linear model was used and secondly the quantification of the PSE may be underestimated as a result of studies including small portion sizes to enhance the likelihood of producing a PSE.

Regarding self-selected portion sizes, differences between personal and social norms have been identified based on body weight classification (Lewis et al., 2015). Study participants classified as obese had a significantly larger personal norm compared to those who were classified as lean. Furthermore, participants classified as obese were found to have larger personal norms than social norms but this difference was not identified in participants classified as lean. Using multiple linear regression models, response slopes were produced and revealed that the curve was shallower for individuals classified as obese compared to adults classified as non-obese, indicating that adults with obesity were less certain about their portion size selections compared to individuals classified as non-obese.

Child BMI

Similarly, to adults there is inconclusive evidence to suggest that the PSE is moderated by child BMI (Fisher, Rolls & Birch, 2003; Fisher, 2007; Rolls, Engell & Birch, 2000). One of the first studies exploring the PSE in preschool children (aged 3- 5 years) adopted a within subject crossover design study in which children were served 4 macaroni and cheese meals (2 normal and 2 large) separated by 2 weeks (Fisher, Rolls & Birch, 2003). In this study, increases in children's food intake were not related to BMI, however heavier children were found to be taking larger bites. Similarly, Fisher (2007) designed a study to primarily examine the effects of age on the PSE. Within this study, the effects of portion size on intake were explored based on weight status. The study revealed that child BMI, maternal BMI and maternal disinhibited eating were not associated with changes in consumption ($p > 0.05$) consistent with previous laboratory-based studies that were unable to identify a link between the PSE and child BMI (DiSantis et al., 2013; Fisher, Rolls & Birch, 2003; Kral, Roe & Rolls, 2004; Rolls, Engell & Birch, 2000; Rolls, Morris & Roe, 2002).

Collectively, the evidence suggests that the tendency to consume greater amounts when served larger food portion sizes may not be related to child or adult BMI.

2.3.3.2.3 Age

This section presents literature from studies with children and adults independently, however the main focus is on children. Research suggests age may be the only characteristic to reduce the PSE as early work has demonstrated that infants may be able to self-regulate their appetite in laboratory-based studies (Birch et al., 1987; Fisher, Rolls & Birch, 2003; Fisher, 2007; Rolls, Engell & Birch, 2000).

Zlatevska et al., (2014) examined age as a potential moderator variable, in a random coefficient model. Studies were coded into two age categories (< 15 years and > 15 years) to reveal that adults consume 39% and children consume 20% more in the presence of a double food portion size respectively. The PSE may be attenuated in children compared to adults suggesting that learning or adaption to the external environment may moderate the PSE (Birch et al., 1987). However, the meta-analysis categorised children into one group, independent of age, and therefore was limited to examining the PSE between children and adults only. As such, the results of a meta-analysis exploring child age as a potential moderators of the PSE is presented in chapter 6.3.

Age of children

The first published study to explore the PSE in children provided macaroni and cheese to preschool aged children in small, medium and large portion sizes at three separate lunch occasions (Rolls, Engell & Birch, 2000). The older children (aged 4-6 years) consumed more food as the portion size was enlarged, however intake among the younger children (aged 2-3 years) did not differ significantly across conditions. This study provided initial evidence of portion size stimulating children's intake. In subsequent research (Fisher, Rolls & Birch, 2003), preschool children (aged 3- 5 years) were recruited to a within subject crossover design study in which they were served 4 macaroni and cheese meals (2 normal and 2 large) separated by 2 weeks. Intake significantly increased by 25% due to increases in the portion sizes served ($p < 0.001$), however when age was input as a categorical variable, no associations between age and intake were revealed ($p = 0.20$). Yet, when age was analysed as a continuous variable, age significantly influenced the total amount children consumed ($p < 0.05$), with older children consuming more than younger children.

The aim of Rolls et al., (2000) study was not primarily related to exploring the effects of age in response to enlarged food portion sizes, with differences in age being only a year or less. With this in mind, Fisher (2007) designed a study to primarily examine children's age as a moderator of the PSE. Children aged 2 to 9 years (age 2-3 years; age 5-6 years; age 8-9 years) were provided three portion sizes of macaroni and cheese for an evening meal in the laboratory, on three separate occasions. All children consumed larger amounts when served the large portion size ($p < 0.001$) with no significant differences in consumption between age groups ($p = 0.40$) demonstrating that very young children (aged 2 years) are susceptible to the PSE. However, the effect of portion size on consumption in children younger than two years old remains to be investigated.

Outcome differences between Rolls et al., (2000) and Fisher (2007) may be attributable to methodological differences such as time of day (evening versus lunch), location (laboratory versus natural environment) and number of accompanying foods, however these were held constant across conditions and are unlikely to have influenced intake (Fisher, 2007). Instead, differences in study outcomes may be related to the methods of analysis. Fisher (2007) expressed intake as the relative change between the large and reference condition to account for differing portion sizes in each age group such that each child acted as their own control. Alternatively, Rolls et al., (2000) compared the amount consumed (in grams) in each condition.

2.3.3.2.4 Food liking and food type

Adult literature

Evidence suggests that the PSE is moderated by the type of food on offer such that two meta-analyses have revealed that the PSE is attenuated for main meals compared to more energy dense snack foods (Robinson et al., 2014; Zlatevska et al., 2014). In adults, food liking and food portion size selections were explored in two online surveys (Brunstrom & Shakeshaft, 2009; Lewis et al., 2015). In one study, foods which were highly liked were selected in larger portion sizes than less liked food items however in a second study food liking did not influence portion size selections (Brunstrom & Shakeshaft, 2009).

Child literature

Food liking and acceptance is linked to the type of food on offer therefore there is reason to believe that food liking may moderate the PSE. When evaluating the PSE beyond a single meal in preschool children (Fisher et al., 2007b), children consumed 22% more of the food items that were doubled in size without compensatory reductions of other foods. However, this result was driven by the increased consumption of just two out of the five foods enlarged in portion size (chicken nuggets and cereal). In contrast to previous work e.g. (Fisher, Rolls & Birch, 2003), the PSE was not demonstrated for macaroni and cheese thus demonstrating inconsistencies in the PSE based on food type. It is possible that these discrepancies were caused by participants having a stronger preference for some food items compared to the others items served, however this was not reported in the manuscript (Fisher et al., 2007b).

Other studies have examined the PSE of multiple foods (Kral, Kabay, Roe, & Rolls, 2010) by manipulating both the energy density and portion size (Kling, Roe, Keller, & Rolls, 2016). One study (Leahy et al., 2008) provided children aged 3-5 years with a macaroni and cheese lunch in a 2 (1.6kcal/g vs 1.2kcal/g) x2 (400g vs 300g) design. In contrast to Kling et al. (2016), portion size did not significantly influence energy intake, however the foods energy density did with children consuming more of the HED food items relative to the LED food items. One possible explanation is the size of the portion size manipulation being too small to detect significant differences in consumption.

Kral et al., (2010), explored the PSE when foods of varying preferences were served. A fixed portion of pasta was served to children aged 5-6 years alongside applesauce or vegetables (carrot or broccoli). Applesauce was described as sweet and palatable whereas the vegetables were less liked. Children consumed 43% more apple sauce when the portion size was doubled, however children consumed a similar amount in each portion size condition when vegetables were served. At first inspection this study appears to demonstrate that the PSE is only apparent with some types of food, and not others. However, more recent work has identified that when less palatable foods (i.e. vegetables) are doubled in portion size in isolation of other foods; the PSE is observed (Spill, Birch, Roe, & Rolls, 2010; Spill et al., 2011). This finding demonstrates that competing foods may moderate the PSE of less palatable/ liked foods. For example, children aged 3-5 years were served carrot at the beginning of a meal, which was doubled and tripled in size (Spill et al., 2010). Children consumed 47% and 54% more when doubled and tripled respectively, however vegetable intake during the meal was unaffected therefore demonstrating a total increase in vegetable consumption across the meal. The results of Spill et al., (2010) study suggest that the provision of contrasting vegetables as a starter may increase total vegetable intake due to variations in sensory properties reducing sensory specific satiety and therefore enhancing intake. For example, Carstairs et al., (2018) provided children aged 3-5 years with a single or variety of vegetables (carrot, cherry tomato, cucumber) to primarily identify whether offering a variety of vegetables promotes total vegetable intake. Indeed, children consumed more vegetables when offered a variety compared to a single vegetable suggesting the types of food on offer, including competing foods, may moderate the PSE.

2.3.3.2.5 Food shape

Food shape may moderate the PSE since both children (Weber et al., 1999) and adults (Bolland, Yuhas, & Bolland, 1988) alike have great difficulty estimating the portion size of amorphous food items compared to unit foods, and links between portion size estimation, selection and consumption have been reported (Disantis et al., 2013). Amorphous foods change in shape when transferred between plates and bowls however unit foods have a clear outline producing a more distinctive shape (Weber et al., 1999).

Adult literature

Throughout the literature food consumption has increased due to increases in food portion size independent of food shape e.g. (Diliberti et al., 2004; Rolls et al., 2004). However, findings may be skewed since most studies exploring the PSE in adults have adopted similar study designs and provided an amorphous meal, often consisting of a macaroni and cheese dish e.g. (Rolls, Engell & Birch, 2000).

Child Literature

Food shape has been demonstrated to influence the portion size that children select for themselves and thus how much they consume (DiSantis et al., 2013). For example, children served themselves an additional 239 kcal when unit foods were on offer compared to amorphous items ($p = 0.001$) and for every additional calorie served children consumed an additional 0.43 kilocalories ($p < 0.01$). This finding suggests that food shape might moderate the PSE. However, very few studies were designed to explore food shape as a moderator of the PSE despite the evidence being available. Therefore, a meta-analysis including food shape as a potential moderator of the PSE was conducted and the results are presented in Chapter 6.3.

2.3.3.2.6 Dishware and package size

Food portion sizes are often determined by package, unit or dishware size of which have been associated with portion size selection in adults (Raynor et al., 2007) and consumption in children (Disantis et al., 2013).

Adult literature

Raynor et al., (2007) compared intake in response to providing cereals in small pre-packaged portion sizes compared to self-selection from a larger portion size containing multiple servings. Adults consumed 16% less cereal, peaches and applesauce from a smaller predefined portion as opposed to a self-served portion from a larger packet size. This result may emphasise consumer unawareness of suitable portion sizes or may simply reflect the PSE where more is consumed when more is available. Many consumers believe a packaged food contains one serving and fail to realise that a packet may contain multiple servings (Pelletier, Chang, Delzell, & McCall, 2004). Increases in packet size has been demonstrated to increase consumption and increase portion size estimates known as the 'pack size effect' e.g. (Zlatevska et al., 2014).

Similar findings have been observed when adults were provided with a small and large scoop to serve themselves M&M's at a reception desk; adults self-served more with the large compared to the small serving scoop (Marchiori, Corneille, & Klein, 2012). However, the quantity consumed in each condition was not measured.

Manipulating plate size has no relation to energy intake in adults (Rolls et al., 2007; Shah et al., 2011). For example, Rolls, Roe, Halverton and Meengs, (2007) had 45 participants self-serve a main meal once a week, for three weeks, each time using a different sized plate (17, 22, 26cm). However, plate size did not influence total energy intake. Within the same study, 44 participants self-served from a buffet containing five foods that were each matched for energy density, once a week for three weeks, again using three different plate sizes. Participants using the smallest plates made significantly more trips to the buffet however plate size was not significantly related to total energy intake at a meal.

Child literature

Dishware size has been found to influence the amount of food children self-serve for lunch at elementary school (Disantis et al., 2013). Children served themselves an additional 90 kcal when serving onto an adult (large) plate compared to a child (small) plate. For every additional calorie served children consumed an additional 0.43 kcal ($p < 0.01$). It is possible that a larger dishware size inflates consumption norms or alters children's visual perception. However, findings may not be accurate since children within this study were unfamiliar with the self-serving methodologies utilised as their normal lunch procedures involve children self-selecting from pre-portioned servings rather than serving themselves.

Adult and child literature

Consistent with these findings a systematic review and meta-analysis revealed that total energy intake is marginally affected by dishware size however the effect is small (SMD = 0.18) and there is substantial heterogeneity (Robinson et al., 2014). Nine studies were included in the review and the meta-analysis included 8 experiments from 7 publications of which contributed 15 comparisons. The subgroup analysis revealed that manipulations to bowl size ($n = 3$) produced a larger effect size (SMD = 0.61, $p < 0.001$) than manipulations to plate size ($n = 11$) (SMD = 0.06, $p = 0.46$) thus demonstrating that serving food in small bowls may reduce total energy intake and reduce food waste, however results are inconsistent and the effect is small. Furthermore, the analysis contained a small number of comparisons.

2.3.3.2.7 Cost

In the current obesogenic environment, large food portion sizes are easily accessible and usually at a proportionally lower cost than standard sizes (Steenhuis & Poelman, 2017). Value for money influences food choices and provides an incentive for selecting larger food portion sizes (Steenhuis and Vermeer, 2009). For example, the PSE is enhanced when bottled, expensive water is offered in large portion sizes compared to free tap water; consumers will drink more water when bottled and costly, compared to tap water, which was interpreted to suggest that not the size but in fact the cost of the item influenced intake (Benton, 2015). Consumers enjoy value for money so often tend to consume the majority of the portion purchased, however the PSE has often been explored as part of a research study where food items are provided free of charge e.g. (Levitsky & Youn, 2004). It is possible that participants might consider consuming more food than usual when offered a large portion size, to save subsequent money due to being less hungry later in the day. If true, participants may maximise their opportunity to consume large quantities of food with no associated financial cost by consuming as much food as deemed manageable in all portion size conditions. However, participants tend to eat less when offered small versus larger portion sizes and plate clearing is not common (Benton, 2015).

Related to value for money is a desire to reduce or avoid food waste which likely contributes to an increased desire to plate clean and thus larger amounts of food consumed when offered larger food portion sizes (Sheen, Hardman, & Robinson, 2018). Therefore, reducing food waste may be a more influential moderator of the PSE than the direct cost of the food or beverage item (Zuraikat et al., 2019).

Evidence of the PSE in children, related to cost, is missing since young children are not responsible for purchasing food. However, since caregivers are the gatekeepers of their children's nutritional intake and associations between maternal and child portion size have been revealed (Johnson et al., 2014) it is possible that the maternal influence of cost may inadvertently influence the PSE in children.

2.3.3.2.8 Size of portion size manipulation

The PSE may be moderated by the magnitude of change in the portion size offered and the size of the initial portion size served (Zlatevska et al., 2014). For example, the larger the initial portion size the smaller the PSE, demonstrating a curvilinear relationship. Therefore, the design phase of a study is important, and study results should be considered with caution if the reference portion size is small (e.g. smaller than age appropriate) or if the magnitude of the portion size change is large. For example, offering a small portion size may inflate the PSE due to plate clearing tendencies producing a ceiling effect (e.g. Aerts et al., 2017). Alternatively, offering portion sizes much larger than age appropriate may attenuate or eliminate the PSE.

However, the point at which the PSE may be eliminated is unclear due to limited research. Further work containing multiple portion size manipulations is required, since most studies exploring the PSE have compared a reference portion to a double portion size e.g. (Fisher, Rolls & Birch, 2003). Also, the impact of reducing portion sizes on the amount consumed by children is an understudied area requiring further exploration. To explore this further, a meta-analysis including ‘initial portion size’ as a potential moderator of the PSE was conducted and the results are presented in chapter 6.3.

2.3.3.3 Mechanisms of the PSE

There is an abundance of literature that demonstrates the outcome and moderators of the PSE however to date there appears to be inconclusive evidence regarding the mechanisms of the PSE (Marchiori, Papies, & Klein, 2014). Six potential mechanisms have been offered and will be discussed in turn with supporting literature from studies including both child and adult participants since there is a strong correlation between parent-child dietary intake and susceptibility to the PSE (Zlatevska et al., 2014).

2.3.3.3.1 Portion distortion

Over the past 40 years portion sizes of food and drink items have been increasing and the availability of ‘super-sized’ or ‘family-sized’ portion sizes in supermarkets (Matthiessen, Fagt, Biltoft-Jensen, Beck, & Ovesen, 2003) and dining out establishments (Diliberti et al., 2004) have become abundant. Consequently, consumers struggle to select portion sizes in line with recommended amounts (Young & Nestle, 2002). As such, adults have often been found to select portion sizes much larger than recommended amounts (Burger et al., 2007; Schwartz & Byrd-Bredbenner, 2006). This is known as ‘portion distortion’ whereby consumers perceive a large food portion size to be an appropriate amount to consume at one meal or snack occasion (Schwartz & Byrd-Bredbenner, 2006).

Increases in portion sizes have been documented in the literature. An example of this includes the increase in the American muffin, increasing from 72-130g between 1993 and 2012 which changes consumption from 280 to 475 kcal per unit. This size is 333% larger than United States Department of Agriculture (USDA) recommendations (Benton, 2015). Furthermore, meals in popular cookbooks have increased in portion size over the past 100 years (Eidner, Qvistgaard Lund, Harboe, & Clemmensen, 2013) or now recommend fewer servings for the same amount of ingredients (Benton, 2015). Similarly, portion sizes of many premium products have increased in the UK, however the provision of a wider range of portion sizes available including smaller portion sizes, usually as part of multipacks has been documented (Church, 2008).

It is concerning that supersizing food portion sizes have normalised what is deemed to be an acceptable amount to eat. However, it is unclear if these changes are in response to consumer demand or whether the food industry are shaping food preferences and social norms of what is perceived to be an appropriate portion size. However, what is known is that young adults are now selecting larger food portion sizes compared to 20 years ago (Schwartz & Byrd-Bredbenner, 2006). Similarly, the average food portion consumed by the American child has increased as demonstrated by the results of the Continuing Survey for Food Intakes by Individuals (Nielsen & Popkin, 2003; Helen Smiciklas-Wright, Mitchell, Mickle, Goldman, & Cook, 2003). For example, children as young as 2 consumed larger portions of cookies, ready to eat cereals, pasta, sweetened soft drinks and fruit drinks between 1989 and 1996.

2.3.3.3.2 Social norms

Social norms provide information about the appropriateness and normality of behaviours in a given situation (Colman, 2015) and therefore in the context of eating, an inflated portion size norm may provide information regarding large portions as an appropriate amount to consume (Herman & Polivy, 2005), similarly to 'portion distortion'. If true, it suggests that consumers are not principally influenced by hunger and satiety (Herman & Polivy, 2005) and instead believe that the portion sizes offered in restaurants or available in supermarkets are an authoritative indication related to an appropriate amount to consume (Benton, 2015).

In many developed countries (e.g. the UK) it is not uncommon for consumers to eat all that is offered to them on their plate (Fay et al., 2011), such that the more they are served the more they will consume. This is defined as plate clearing which became a common parenting expectation adopted during the war when foods were rationed, and has continued to be influential despite changes to food availability and affordability (Burger, Fisher, & Johnson, 2011). However, interestingly plate cleaning is not encouraged in all cultures, especially when dining out or as a guest within the home environment (e.g. Asia) (McCrickerd & Forde, 2016). Yet, the PSE is still present in these countries (Smith, Conroy, Wen, Rui, & Humphries, 2013). Instead some consumers choose to eat a fixed percentage of the portion size that they are served. A possible explanation of this is related to visual cues which is discussed in the next section.

2.3.3.3.3 Visual cues and volume illusions

Subtle visual cues related to food portion size may contribute to energy intake in children and adults alike. Volume illusions alter portion size estimation, selection and consumption. For example, people often use the vertical as opposed to the horizontal length of an object to estimate size (Raghubir & Krishna, 1999). As such, children and adults have greater difficulty estimating the correct portion size of an amorphous item due to its unclear outer shape, compared to a unit item (Bolland et al., 1988; Harnack, Steffen, Arnett, Gao, & Luepker, 2004; Weber et al., 1999).

Some consumers will always leave a set proportion (e.g. 10%, 50%) of food on their plate due to politeness or personal health goals, thus still consuming more in the presence of large food portion sizes despite not cleaning their plate. This is referred to as the 'fractional version' of the appropriateness mechanism where people eat a fraction of what they are served (Kerameas, Vartanian, Herman, & Polivy, 2015). Within this model, the degree of plate emptiness acts as a cue for meal termination (Burger et al., 2011) with the result that more is consumed when more is served (Herman et al., 2015). Alternatively, this can be referred to as anchoring. This refers to a food's portion size providing the consumer with information regarding what constitutes a normal portion size in which they make a decision regarding the quantity to consume (Marchiori et al., 2014). The initial portion size served acts as an anchor which can be adjusted in relation to the consumers momentary hunger and perception of palatability (Marchiori & Papies, 2014).

2.3.3.3.4 Unit bias

The 'unit bias' is related to consumers tendencies to consume one portion of food regardless of its size (e.g. one sandwich) (Geier et al., 2006). For example, when small or large portion sizes of Tootsie Rolls were available in an office environment, and the total weight remained stable (i.e. different unit sizes), participants selected items as units and thus selected more in the large as opposed to the small unit condition (Geier et al., 2006). Conversely, unit size has been found to have no effect on consumption (Kerameas et al., 2015; Raynor & Wing, 2007). When adults were offered cookies they were highly unlikely to eat precisely one unit and people consumed more in the large portion size condition (30 g versus 90g) irrespective of number of units served (1 vs 3) (Kerameas et al., 2015). Similar findings have been demonstrated in children aged 8 - 13 years when offered the same quantity of cucumber in two unit sizes (small versus large) (van Kleef et al., 2015). Children consumed more cucumber in the small unit condition however, the results were not significant. This finding may be attributable to eating difficulty. The large units were considered more difficult to eat than the smaller units. Furthermore, offering smaller portion sizes may result in unintended outcomes such as justifying the need to consume multiple units or additional items (Benton, 2015), especially if the food is highly palatable.

2.3.3.3.5 Consumption regulation

A possible mechanism that differs from the normative influences on consumption is related to an individual's conscious decisions before consumption occurs; pre-meal planning (Benton, 2015). For example, one study explored consumer's cognitive expectations about satiety and satiation which revealed a significant influence on portion size selection (Brunstrom et al., 2012). One hundred volunteers were exposed to a 300ml or 500ml bowl of soup and then were provided with a 300 or 500ml bowl of soup to consume. The quantity of soup was manipulated covertly using a peristaltic pump. Hunger and fullness measures were taken immediately before and after consumption and then a further three times, at hourly intervals. Participants hunger scores increased with time, however to a lesser extent for those who had observed the 500ml of soup compared to those who saw the 300ml bowl suggesting that external cues (i.e. portion size) may influence self-reported hunger more so than internal satiety cues. Furthermore, participants memory of the portion size they were served was assessed by providing participants with a litre jug and requesting they fill the bowl to represent the portion size that they had consumed. Those who saw the small portion but were offered the larger portion to consume recalled consuming a much smaller portion size compared to participants who initially were exposed to the large portion size but were offered the small portion for consumption. These findings demonstrate the influential effect of memory on satiety (Higgs, 2002) which in turn is shaped by familiarity and experiential learning and inversely related to subsequent intake (Pliner & Zec, 2007).

Related to expected satiation is pre-meal intended consumption. In a questionnaire-based study, pre-meal intentions were significantly associated with amount consumed with very few participants deviating away from their plans (Fay et al., 2011). Similarly, 124 male participants were recruited to take part in an online survey to identify if there was a pre-meal portion size intention effect. Participants were provided with images of two meals (1. curry and rice, 2. spaghetti Bolognese) in two portion sizes (standard versus large), and were asked how much they intended to consume of the meal (Robinson, te Raa & Hardman, 2015). Males wanted to consume almost all of both the small and large portion sizes, thus demonstrating a pre-meal intention PSE. In part two of the study, participants completed a laboratory-based study. Pre-meal consumption intentions of ice cream were recorded and compared to subsequent (actual) intake. Male participants intended to consume the entire ice cream portion and consumed more in the large versus small portion size condition suggesting that food properties (i.e. portion size), may influence both intended consumption and actual amount consumed.

2.3.3.3.6 Bite Size

In the presence of larger food portion sizes both adults (Almiron-Roig et al., 2015; Burger et al., 2011) and children (Fisher, Rolls & Birch, 2003) have been identified to alter their microstructure of eating; an increased bite size. Larger bites increase the speed of eating and reduce oral processing time, both of which are known to influence food intake (Krop et al., 2018). For example, adult men consumed larger quantities per bite size with increases to food portion size offered (Spiegel, 2000) totalling an increase of 0.22g per bite size for each increase in food portion size of 100g (Almiron-Roig et al., 2015). This pattern has also been observed when fluids are offered; adults increased the amount consumed by 15% when presented with 150-, 300- and 600-mL of water (Lawless, Bender, Oman, & Pelletier, 2003).

Similar findings have been identified in children (Fisher, Rolls & Birch, 2003). For example, when offered a reference and large portion size of pasta and cheese, preschool children consumed more as the portion size increased and took significantly larger bites compared to being offered a small food portion size ($p <$

0.05) (Fisher et al., 2003). Furthermore, children aged 2-9 years consumed 29% more when a portion of pasta was doubled in size which reflected an increased amount per bite, yet bite frequency was unaffected (Fisher, 2007). It is not possible to determine whether variations in bite size and the PSE were attributable to individual differences in children's self-regulatory abilities nor are the mechanisms behind this effect clear. However, increased bite size seems to be a general response to large portion sizes irrespective of child age (Benton, 2015).Yet, the specific visual cues that influence this behaviour are not well understood. One possible suggestion is related to reductions in sensory-specific satiety. Increased chewing often results in food spending a longer duration of time in the mouth, therefore larger bites may result in food being consumed more quickly thus reducing sensory specific satiety (Herman et al., 2015).

Summary

Variations in portion size correspond with a change in food intake such that larger food portion sizes encourage children to consume larger quantities of food which has been found to have a sustained increase on TDEI, without compensatory behaviour over a 5day period. This can be referred to as the PSE. Evidence suggests that the PSE is moderated by a minimum of eight potential factors including age, food type and food liking. For example, children are more susceptible to the PSE when palatable foods, which tend to be energy dense, are on offer compared to less liked, lower energy dense foods. Less is known about the mechanisms behind the PSE however it is thought that large food portion sizes or unit sizes are setting the 'norm' as to what constitutes an appropriate amount to consume. Alternatively, children may consume more in the presence of larger food portion as visual cues related to plate size and content act as a prompt for how much to consume.

3. Rapid Review

This chapter provides results of a rapid review that was undertaken to identify the factors that influence UK caregivers when making portion size decisions for their child. To date, it is well documented that caregivers are the gatekeepers of their child's nutritional intake and thus responsible for the type and quantity of food children consume. Furthermore, children consume larger amounts of food when served larger food portion sizes resulting in sustained increases in energy intake over five days, which may be attributable to portion distortion or changes in the microstructure of eating. However, it is unclear how caregivers determine what constitutes a suitable portion size to serve to their child especially in a UK cohort. Therefore, a rapid review was undertaken to identify and synthesise the current literature available.

3.1 Introduction

It is well documented that children consume larger quantities of food in the presence of larger food portion sizes, which may be attributable to social norms, visual cues or changes in the microstructure of eating (see Chapter 2 for more information). Therefore, as the gatekeepers of child nutrition, caregiver’s may inadvertently contribute to their child’s overconsumption by providing them with portion sizes larger than age appropriate (Johnson et al., 2014). Large portion sizes of energy dense foods are becoming more easily accessible and available in our obesogenic environment such that manufacturers are typically packaging snacks in portion sizes up to and beyond 2.5 times larger than necessary for young children (Sothern, 2004). Furthermore, portion sizes of food consumed within the home are also increasing (Nielsen & Popkin, 2003; Smiciklas-Wright et al., 2003; Young & Nestle, 2002). The impact of these ongoing changes to children’s dietary intake have been recorded (Campbell & Wolfson, 2017; Infant and Toddler Forum, 2014) and demonstrate that children aged 1-4 years are being offered HED snacks up to three times the recommended weekly amount at one eating occasion. Mothers have unique views and experiences of feeding their children however it is unclear how caregivers determine what constitutes a suitable snack portion size to serve to their child.

Early research from the USA suggests that there is a degree of variation in the influences and strategies used to portion control food items served to young children (Johnson et al., 2015). Very few parents consider the portion size that they provide to their children and thus do not report using measurements or expert recommendations. Instead they are influenced by perceived or reported child hunger and food liking, or choose to provide portion sizes based on past feeding experiences (Sherry et al., 2004; Herman et al., 2012; Johnson et al., 2015). Some parents place restrictions on the portion sizes that they offer to their children based on the perceived healthiness of the food item or the proximity to the last/ next eating occasion (Blake et al., 2015; Johnson et al., 2015). For example, in a qualitative study of low income mothers from the USA, Blake et al., (2015) revealed that some parents allow their children to consume ad libitum quantities of foods that they perceive to be healthy (e.g. LED snacks) whereas items they perceive to be unhealthy (e.g. HED snacks) are more likely to be restricted.

One strategy caregivers in the USA employ to limit portion sizes is to subdivide larger portions using containers or hand measurements (Blake et al., 2015). However, using an adults hand as a measuring tool for a child may result in children receiving portion sizes that are too large, and more appropriate for adult consumption. Associations between maternal and child portion size have been observed at an evening meal, such that child portion size was positively related to maternal portion size (Johnson et al., 2014). This could be resultant of parental hunger, food liking or confusion regarding what constitutes a child friendly portion size e.g. (Stromberg & Janicke, 2016)

These findings provide a broad understanding of the factors that influence portioning practices in the USA and may be applicable to a UK population since both countries are developed with high levels of paediatric obesity ("Statistics on Obesity, Physical Activity and Diet," 2018; Yanovski, 2017). However, due to the dominance of qualitative methodologies employed within the literature findings from the USA are not generalisable to other populations e.g. (Blake et al., 2015). Furthermore, to the author's knowledge, no previous work has mapped out the literature that exists from a UK population to determine the need for further review and/ or primary research. Moreover, to develop tailored interventions an understanding of a specific populations needs, current behaviours and associated motivations are warranted

(Lippke & Ziegelmann, 2008). Therefore, a rapid review was conducted to identify and synthesise literature on a UK cohort of caregivers, as little is known about UK caregiver's unique perspectives on portioning practices and what influences their portion size decisions given the dominance of literature from the USA (Kairey et al., 2018). Rapid reviews have emerged as a streamlined method to synthesise evidence and inform emergent decisions related to study design (Khangura, Konnyu, Cushman, Grimshaw, & Moher, 2012) and ensure reviews are conducted in a succinct yet well-timed manner. The aim of the present rapid review was to synthesise the literature that exists on UK caregiver feeding practices to explore caregiver's motivations, goals and decisional processes when determining preschool children's food portion sizes to guide the development of tailored interventions that seek to enhance children's dietary intake. The specific research question was 'What factors influence parental portioning practices of UK caregivers when providing food to children aged 2-12 years?' Children aged 2-12 years were included due to a priori indication that limited data exists specifically in a UK cohort. Therefore, the inclusion criteria was expanded to include older children to provide a good indication of what factors influence parental portioning practices in the UK.

3.2 Methods

The principles of a systematic literature review process were adopted including the generation of a search strategy and inclusion and exclusion criteria to assess the relevance of articles independently. However, the current rapid review differs from a traditional systematic review as stricter limitations are applied and only published full length articles are examined for inclusion. This approach was selected for its fast but rigorous methods to identify gaps within the literature to inform future study design.

Search Strategy

Firstly, MEDLINE was used to conduct a scoping search to explore the literature that exists on factors that influence caregiver decisions regarding food portion sizes to serve to their children and the portion size strategies employed. The purpose of this was also to establish whether any previous review had explored the factors that influence portioning practices, with a focus specifically on UK families. To do this the search was split into three concepts (population, exposure, comparison), and multiple search terms for each concept were formed. Keywords identified from relevant papers were included in the MESH search terms. The revised search was conducted in August 2018 and included 3 databases: MEDLINE, PsycInfo and Web of Science. Search terms were combined as follows: (child* OR infant* OR preschool* OR toddler*) AND (strateg* or consider* or aspiration* or view* OR perspective* OR perception* OR attitude* OR opinion* OR thought*) AND (portion* OR amount* or quantit*) AND (food* OR meal* OR snack* OR eat* OR consum* OR feed*) AND (mother* OR caregiver* OR mum* OR dad* OR father* OR parent* OR carer* OR gran* OR nan*). The search terms were approved by Mark Clowes, information specialist, ScHARR library. Reference lists of the included studies were scanned to identify potential articles not found during the main search.

Study selection criteria

Articles that met all of the inclusion and none of the exclusion criteria were included in the review. Titles, abstracts and full texts were screened by the primary author to determine inclusion into the review (See Table 2) and 10% were cross checked by an independent second reviewer. This process was guided by the preferred reporting for systematic reviews and meta-analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2010). Articles were included if they explored caregiver feeding practices in relation to portion sizes and/ or portion control strategies. If articles included multiple dependent measures that were not of interest, only the measures that related to the review and met the inclusion criteria were included. Articles that did not meet the inclusion criteria were excluded.

Table 2: Inclusion and exclusion criteria for review of articles

	Inclusion	**Exclusion**
Population	UK primary caregivers responsible for feeding their child, aged 2-12 years and below e.g. mother, father, grandmother. No restrictions on ethnicity, socioeconomic class or gender.	Not primarily responsible for feeding a child (e.g. school, community worker) or the child is over 12 years of age. Not a UK resident.
Intervention/ Exposure	Meal or snack time	Beverages
Outcome	Factors that influence portion size offerings to children or portion control strategies used (snacks and meals).	Factors that influence portion size offerings of beverages to children.
Study Type	Qualitative (interviews, focus groups, observations), quantitative or mixed methods, primary data, published in English in a peer review journal. Full length text. No restriction on publication date or sample size.	Systematic reviews, meta-analyses and abstracts from conferences. Post-test data from experimental studies.

Data extraction

The lead author developed a data extraction tool specific to the review question (Appendix 3) and extracted data from all included studies of which 10% were cross checked by a second independent reviewer. Information was extracted in relation to the primary outcome measures (portioning practices and factors that influence portion size offerings). The following information was extracted: study design, recruitment method, study location and time, participants (age, sex, ethnicity, socioeconomic status) type of food served, influential factors of portion size (quotes and themes), feeding goals, portion control strategies, amount of food served (if available), and study limitations.

Synthesis of findings

Quantitative studies were summarised narratively. Similarities and differences between studies were investigated in accordance to guidance on conducting and reporting a narrative synthesis (Popay et al., 2006). However, this method was restricted due to the small number of quantitative articles that qualified for inclusion in the review.

Qualitative data were synthesised thematically and presented narratively in accordance to guidelines produced by Thomas and Harden (2008). Qualitative data were defined as all text labelled as 'results' or 'findings' and were imported verbatim into NVivo. During stage 1, an inductive approach was taken to form initial codes for each article, by reading them line-by-line. During stage 2, initial codes were refined and collated to create descriptive hierarchical themes that remained 'close' to the primary papers. During stage 3, analytical themes were constructed in line with the rapid review research question.

3.3 Results

Figure 3 presents a PRISMA flow chart of the research results and illustrates how the included articles were selected. The search returned 2481 articles, and after duplicates were removed (n=212) 2269 articles were screened against inclusion and exclusion criteria. Follow up searches of the reference lists identified 18 potential articles. The articles were screened against the inclusion and exclusion criteria of which 2 articles qualified for inclusion in the rapid review. A total of 42 full text articles were screened, 35 articles were excluded as the article did not focus on portion size or were not conducted in the UK. Overall, 6 articles met the eligibility criteria and were included in the rapid review (Carnell, Cooke, Cheng, Robbins, & Wardle, 2011; Croker et al., 2009; Curtis, Atkins, & Brown, 2017; Douglas, Clark, Craig, Campbell, & McNeill, 2014; Ohly et al., 2013a; Potter et al., 2018).

Article characteristics

The characteristics of the articles included are presented in table 3. Overall, a total of 587 caregivers were included in the 6 articles. Of these, 349 were described as mothers, 21 as fathers and 217 as parents. One article included caregivers from diverse socioeconomic backgrounds (Douglas et al., 2014) whereas another included caregivers with a variety of educational attainments (Carnell et al., 2011). Caregiver's children were male and female between the ages of 3 - 11 years.

All studies were conducted in the UK. Of those that reported the research setting (n = 5), one collected data in the home environment (Carnell et al., 2011), three collected data in a university or community setting (Curtis et al., 2017; Douglas et al., 2014; Ohly et al., 2013a) and one collected data in the home and a community setting (Potter et al., 2018).

Three studies were qualitative in nature (Carnell et al., 2011; Curtis, Atkins & Brown, 2017; Douglas et al., 2014), two were quantitative (Ohly et al., 2013a; Potter et al., 2018) and one included a mixed methods design (Croker et al., 2009). Of those adopting qualitative methods (Carnell et al., 2011; Croker, Sweetman & Cooke, 2009; Curtis, Atkins & Brown, 2017; Douglas et al., 2014), one study used individual interviews (Carnell et al., 2011) and three studies used focus groups (Croker et al., 2009; Curtis et al., 2017; Douglas et al., 2014). Data were analysed using grounded theory (Douglas et al., 2014), framework analysis (Carnell et al., 2011) or thematic analysis (Croker et al., 2009; Curtis et al., 2017).

The main outcomes were meal and snack parental portioning practices (Carnell et al., 2011; Curtis, Atkins & Brown, 2017; Douglas et al., 2014; Potter et al., 2018) and factors that influence meal and snack portion size decisions (Croker, Sweetman &

Cooke, 2009) and portion size advice (Ohly et al., 2013a). No studies focussed or asked specific questions in relation to snack foods.

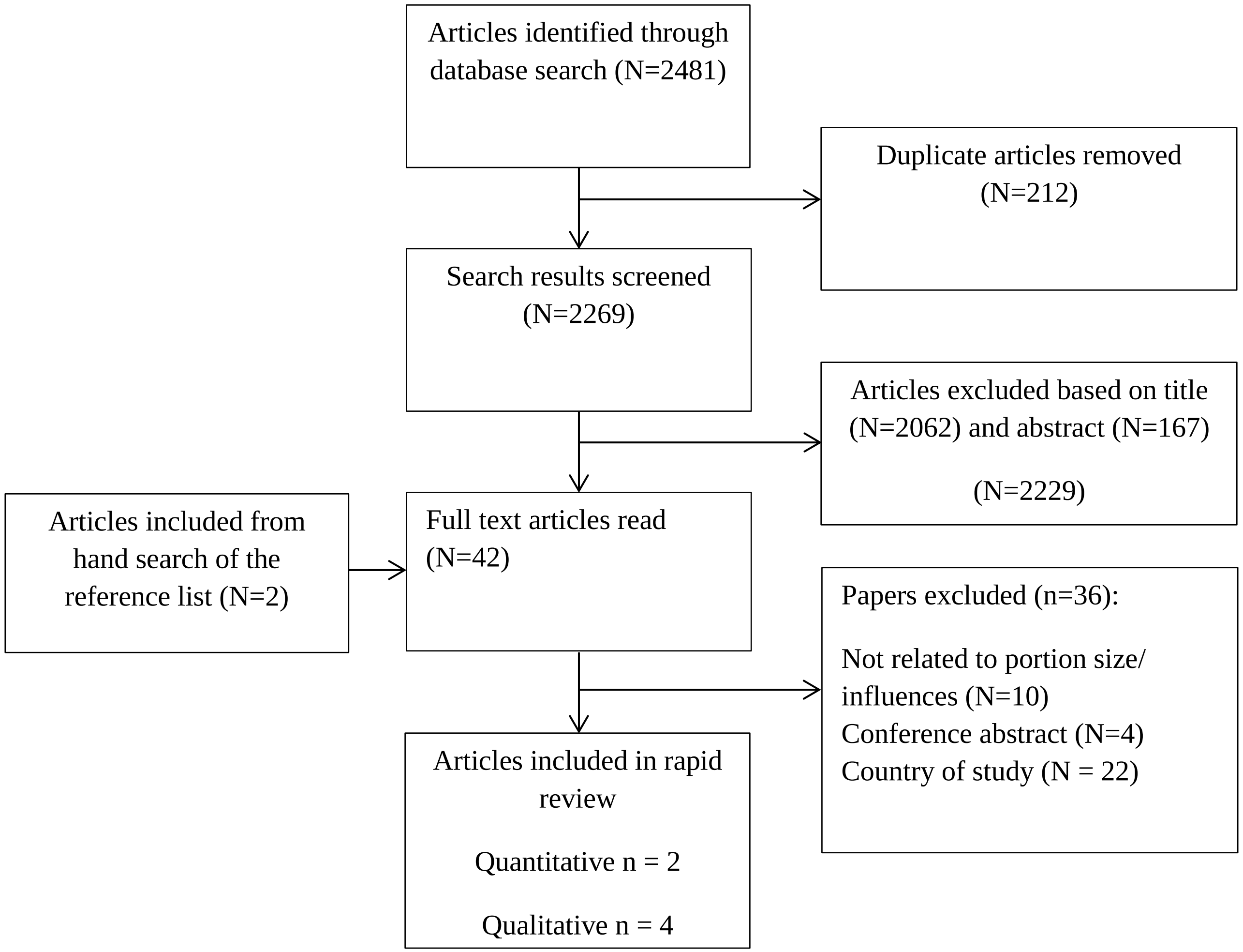

Figure 3: PRISMA flow diagram of search results, screening and included studies

Table 3: Summary of included articles in the rapid review

Author (year)	Research aim(s)	Participants		Setting	Study Design	Outcomes	Data Analysis
		N	Characteristics				
Carnell 2011	To identify parents views and motivations for parental feeding practices	14 caregivers of children aged 3-5 years	Most (86%) were white with varied educational attainment. 25% were educated to high school level, 31% up to college, and 31% up to university level. Age 31-40 years.	Home environment, UK.	Telephone interviews at 5pm, lasting 30-60 mins	Parental motivations when feeding their child	Thematic framework analysis.
Croker 2009	To explore factors that influence portion size decisions and possible parental concerns	14 mothers of children aged 6-7 and 10-11 years	Twelve mothers with mixed ethnicity. Five with university level education, six with A levels	UK *No further information provided	A mixed methods study consisting of a weighing task and 4 focus groups	Parents views on portion size. Food portion sizes served to children	Thematic analysis. Issues were raised in group meetings. Consensus was achieved.

Author (year)	**Research aim(s)**	**Participants**		**Setting**	**Study Design**	**Outcomes**	**Data Analysis**
			or vocational qualifications and three with high school education				
Curtis 2017	To identify factors that influence parents' portion control behaviours using theories of behaviour change	22 primary caregivers (and care workers, but data not presented) of children under 5 years old.	18 female and 4 male caregivers	University of Warwick, UK and local community settings	Six focus groups	Factors influencing childhood weight management mapped onto the behaviour change wheel	Thematic analysis following Braun and Clarke framework. One trained qualitative researcher familiar with the behaviour change wheel and framework analysis. An additional 10% cross checked.
Douglas 2014	To explore mothers perspectives' about the nature and causes of childhood obesity and how they manage their child's weight status	34 mothers of children aged 3-4 years	Caregivers with varying socioeconomic positions. Mean age of 37 years (range 23-42 years).	North-East Scotland, community based locations	9 focus groups lasting 1-2 hours	Mothers views about paediatric obesity prevalence, perception of child weight status, factors responsible for overweight and obesity	Grounded theory using thematic analysis.

Author (year)	Research aim(s)	Participants		Setting	Study Design	Outcomes	Data Analysis
						and parent's role in weight management.	
Ohly 2013a	To identify factors that influence parental food choices for preschool children and to assess parent's views on healthy eating support	261 parents of children aged 2-5 years	Most caregivers were female (94%), married (78%), white British (75%), not working or unemployed (57%) with medium level of education (37%)	Child centres in Cornwall and Islington, UK	Quantitative study with questionnaire methodology	Factors that influence food choice and parental desire for support with their children's nutritional intake	Descriptive statistics and correlational analysis were conducted in SPSS
Potter 2018	To explore parent's beliefs about the ideal and maximum tolerated portion size for their child as a predictor of child BMI percentile. The secondary aim	217 caregiver child dyads aged 5 – 11 years	A majority of caregivers were overweight (n = 122), married or living with a partner (n = 159) and employed full or part-time (n	Science centre and home environment, Bristol, UK	Observational cross-sectional quantitative study displaying portion sizes on a laptop screen	Caregivers perception of their child's ideal and maximum tolerated portion size	A linear regression model was conducted including the following predictors: children's self-selected ideal and maximum portion size, caregiver ideal portion size, caregiver estimate of

Author (year)	Research aim(s)	Participants		Setting	Study Design	Outcomes	Data Analysis
	was to examine the correlation between child portion preferences and that of their parents.		= 163). Half of the children were lean (n = 110) and half were overweight (n = 101)				child ideal and maximum portion size and caregiver BMI

Narrative synthesis of quantitative studies

Caregiver estimates of child food portion size

In one study (Potter et al., 2018), parents and children (age 5 – 11 years) selected their ideal and maximum portion size of seven meals: (i) chicken, chips and baked beans; (ii) chicken curry with rice; (iii) spaghetti Bolognese; (iv) lasagne and peas parents; (v) macaroni and cheese (vi) sausage, mashed potatoes and peas and (vii) pizza and chips. The results demonstrated that caregiver's perception of their child's ideal portion size was not related to their own ideal portion size. Moreover, children's self-selected ideal portion sizes were not related to their parent's ideal portion sizes (Potter et al., 2018).

Potter et al., (2018) also revealed no relationship between children's self-selected portion sizes and their BMI. However, a relationship between caregiver selection of their child's portion sizes and their child BMI was revealed with caregivers of children classified as overweight or obese selecting larger portion sizes for their child. Furthermore, caregivers of children classified as a normal weight tended to underestimate their child's portion size selections (106 kcal difference).

Portion size recommendations

A cross-sectional questionnaire based study revealed that 99 caregivers of preschool children would like advice to improve their children's dietary intake (Ohly et al. 2013a). Caregivers were presented with multiple suggestions related to improving children's dietary intake including recipe ideas, how to introduce new foods and guidance on appropriate portion sizes for children. When caregivers were asked what type of support they wanted, 50% selected guidance on appropriate food portion sizes. Caregivers were grouped by education level (low, medium and high) to reveal that guidance on portion size was considered significantly more useful to caregivers with fewer or lower educational attainments.

Thematic synthesis of qualitative studies

The portioning practices caregivers adopt when serving their children meals appears to be dependent on multiple influential factors. These were categorised into 4 themes: 1) caregiver-related factors, 2) child-related factors, 3) external-related factors and 4) portion size recommendations

Theme 1. Caregiver-related factors

Mothers in two studies considered themselves primarily responsible for managing their child's food intake (Douglas et al., 2014) and in some cases consider their own food portion size when determining how much food to offer their child (Curtis et al., 2017). For example, mothers in one study stated that they give children and adults the same food portion size ("*For me, I find it particularly difficult dishing out the correct portion size for children and for adults, I suppose. I just tend to give everybody the same amount*") (Curtis et al., 2017).

Theme 2. Child-related factors

2.1 Child body size and weight status

Mothers in two studies (Carnell et al., 2011; Douglas et al., 2014) were largely influenced by their child's weight status, body weight and growth development when deciding on a suitable food portion size to serve. In most instances mothers restricted their child's intake if they felt their child was overweight (*"I've always been strict with my older daughter because she was bigger"* (Carnell et al., 2011) whereas they encouraged consumption in children they described as 'slim' (*"I'm happy for her to eat anything she can eat to make her put on some weight"* (Carnell et al., 2011). Moreover, caregivers reported to receive pressure from friends and family regarding their portioning practices in relation to their child's weight status (*"I had a lot of pressure with my eldest cause he was so very skinny, people were like 'you must feed him'. I realised I was giving him all these things to try and fatten him up* but actually *I thought I've got to get away from that"*) (Douglas et al., 2014).

2.2 Child hunger and food liking

Mothers in one study expressed their desire for a happy child (Carnell et al., 2011). They thought hunger was associated with unhappiness and pain, and therefore when feeding their child they considered an appropriate portion size to be the quantity that will prevent child hunger (*"I offered…more pasta as I didn't want her to say she was hungry later at bedtime"* (Carnell et al., 2011). Moreover, mothers indicated that children were unique with regard to their food preferences and expressed being responsive to their individuality (Croker et al., 2009). For example, items that children liked were served in larger, unrestricted portion sizes compared to less liked food items (*"She likes fruit a lot so obviously there are no boundaries on fruit. And yoghurts. In fact, she does eat a lot of yoghurt before a meal"* (Croker et al., 2009). An explanation for this was to reduce food waste ("*I don't like to throw it in the bin so it goes on the plate"*) (Curtis et al., 2017).

Mothers were generally confident that their child would not over consume, as they were able to self-regulate their appetite (*"I think (whatever I) give them they will only have what they want to eat. Then portion size doesn't really come into it, does it?"*) (Croker et al., 2009) and thus were provided autonomy in determining their own food portion size (*"I think it's [portions] quite driven by the children. With pasta she would sometimes say: oh don't give me too much of that or I don't want loads or I can't eat all of that"*) (Croker et al., 2009). However, mothers made reference to certain food items in which their child would eat to excess unless restrictions were enforced (*"It's only a packet [of crisps] a day because if I did let him he will have three or four packets a day"*) (Carnell et al. 2011).

2.3 Child age

Mothers in one study (Douglas et al., 2014) discussed their child's age when discussing portioning practices however it appears that mothers do not adjust food portion sizes based on the age of their child,

P10: "she gets the same portions now she did when she was two, I think, oh, actually, did I overfeed her at two or am I underfeeding her now?"

P11: "My two get the same size, three and six, you know"

P08: "So do mine"

Theme 3. External related factors

3.1 Plate size

Mothers in two studies (Curtis et al., 2017; Douglas et al., 2014) made reference to plate size when explaining their portion size practices. Mothers often used plate size as a cue for how much to serve (*"the plastic plates out of Asda or Tesco, that's her* *plate so we fill that plate or should it be less?"*) (Douglas et al., 2014) but made reference to everything *"being bigger nowadays"* which makes it difficult to judge an appropriate portion size. Mothers also associate larger plates with increased consumption ("*my daughter has gone to a larger plate as she got older. When it gets to a larger plate then that's when it gets it bit out of hand"*) (Curtis et al., 2017).

3.2 Food availability

Mothers in two studies (Curtis et al., 2017; Douglas et al., 2014) often determine portion sizes based on the amount of food available. For example, if mothers had cooked a large quantity of food, they were more likely to serve their child a large food portion size ("*So if you've over cooked, you will overfeed…"*) (Curtis et al., 2017). This method was adopted to prevent food waste. There was no mention of alternative solutions, such as food storage.

Theme 4. Portion size recommendations

Mothers in three studies (Croker et al., 2009; Curtis et al., 2017; Douglas et al., 2014) made reference to portion size recommendations when considering portion sizes for their children. There was a consensus that caregivers lack knowledge of appropriate food portion sizes for children (*"Until I came here, I didn't really know much about portion sizes at all"*) (Curtis et al., 2017) and therefore often rely on 'trial and error' or 'guesswork' when determining a suitable child portion size (*"you really don't know as a parent, do you? How much you should be giving the children. You kind of have a guess"*) (Croker et al., 2009). One mother made reference to observing portion size guidance on TV which prompted other mothers to think that they are likely providing their child with portion sizes larger than age appropriate.

P09: "There was a thing on telly and they showed you what a child should be eating and it was one slice of pizza and I thought 'oh my God'"

P10: "That's all they should have at a meal is one slice of pizza?"

P09: "I probably give them too much but then I'm not expecting them to eat it all" (Douglas et al., 2014)

In one study (Croker et al., 2009) mothers expressed their lack of concern regarding age appropriate portion sizes for children. Instead, providing a balanced diet was their primary feeding goal (*"It is about combinations for me, so portion size is not that much of an issue"*) (Croker et al., 2009).

3.4 Discussion and conclusion

The aim of the present rapid review was to synthesise the literature that exists on UK caregiver feeding practices to explore caregiver's motivations, goals and decisional processes when determining preschool children's food portion sizes to guide the development of tailored interventions that seek to enhance children's dietary intake. The review revealed a wide degree of variation among the factors that influence food portion size. The primary consideration appeared to be related to the child or caregiver such that portion sizes were dependent on children's hunger, weight status, food preferences or caregiver portion size. Caregivers were confused whether portion size information exists and instead rely on 'trial and error', guesswork, food availability or plate size to determine a suitable child portion size. None of the included studies focussed or asked questions related specifically to snack foods or portion control methods highlighting an area for future work.

Caregiver related factors

UK caregivers made reference to their own food portion size when deciding a suitable amount of food to serve their child at an evening meal, in line with observed feeding practices in the USA (Johnson et al., 2014). However, associations between caregiver and child portion size were not revealed in the online study conducted by Potter et al., (2018), possibly due to methodological differences or country of recruitment. For example, Potter et al., (2018) adopted a cross-sectional quantitative study displaying food portion sizes on a laptop screen. Children may lack the ability to use computerised programmes and may not usually make personal choices about portion sizes since caregivers are often responsible for the amount and type of food young children are offered and thus consume (Powell et al., 2018). As such, children's self-selected portion sizes were high. In comparison, Johnson et al., (2014) observed feeding behaviours in the home environment. Conducting research in familiar, real world environments enhances the likelihood that participants will respond habitually (Gray & Wandersman, 1980) and enhances ecological validity.

These findings highlight the need for further research adopting suitable research methods with children (i.e. observations in the home environment) to identify if this same relationship exists in the UK.

Child related factors

It is possible that parent's portion size selections are influenced by their child's weight status however evidence for causation is lacking and requires further investigation. In interviews and focus groups caregivers discussed adjusting meal portion size in accordance to their child's weight status. Generally, mothers stated that they are more restrictive with food portion sizes offered to children perceived to be overweight or obese (Carnell et al., 2011; Douglas et al., 2014). Yet, the quantitative study demonstrated that caregivers select larger ideal and maximum tolerated portion sizes for children with a higher BMI compared to children who are lean (Potter et al., 2018). These differences may be attributable to study design.

Interviews and focus groups are suitable for exploratory studies where the primary aim is to gain in depth responses (Silverman, 2013). However, these methods rely on memory and thus may not be appropriate for understanding passive processes such as portion control strategies. Johnson et al., (2015) used the think aloud method, and thus requested that mothers verbalised their actions, feelings and decisional processes whilst preparing an evening meal for their child. This method provided an insight into the cognitive processes employed during food preparation and has been found to stimulate thoughts, reduce bias and unveil feeding behaviours that mothers may struggle to verbalise.

External related factors

External factors, including bowl size, influence UK caregiver's portion size decisions. Over the past 40 years, the availability and portion size of commonly consumed food items, as well as dishware size, have increased (Marteau, Hollands, Shemilt, & Jebb, 2015). These changes have contributed to perceptions of what constitutes an appropriate amount to consume (Robinson et al., 2016). Therefore, by relying on external cues caregivers are more likely to provide children with food items in portion sizes larger than age appropriate due to portion distortion. Research in the USA (Blake et al., 2015), suggests that external cues relating to unit size and package size influence portioning practices and are used to portion control snack foods yet it is unclear if these same practices are adopted in the UK since no research to date has examined caregivers decisional processes when serving snack foods to children. Furthermore, it is unclear if caregivers are providing snacks foods in line with recommended amounts as research has yet to compare portion sizes served (in grams) to recommended amounts for children aged 2-4 years e.g. (More & Emmett, 2015).

Portion size recommendations

Results from the current review suggest that caregivers in the UK felt that they lacked knowledge regarding suitable portion sizes for children (Croker et al., 2009; Curtis et al., 2017) and think that they are probably providing portion sizes too large. Indeed, caregivers are providing energy dense snack foods in portion sizes larger than age appropriate (Infant and Toddler Forum, 2014) and at a frequency of at least once per day (Campbell &Wolfson, 2017). Previous US-based research indicates that this effect is additive, with children consuming more energy when served larger, energy dense food portion sizes e.g. (Fisher, Liu, Birch, & Rolls, 2007). Energy dense foods, such as snacks contribute approximately 21% of children's total energy intake. Snack foods are often considered a root cause of dietary imbalances (Piernas & Popkin, 2011) offering few nutrients beyond energy (Maillot et al., 2011). However, surprisingly not much is known about how caregivers determine a suitable portion size to offer to young children, particularly around snacking (Blake et al., 2015), and especially in the UK. Several articles did not qualify for inclusion in the present review due to the country in which the research took place. A large number of studies exploring portioning practices and influences during decisional processes have been conducted in the USA. However, environmental differences reduce the generalisability of findings, especially due to the qualitative nature of the work.

Strengths and limitations

Literature searches and data extraction were conducted by a single reviewer due to this being a student piece of academic work, which may introduce bias or increase the likelihood of excluding potentially qualified papers (Buscemi, Hartling, Vandermeer, Tjosvold, & Klassen, 2006). However, three large online databases were searched and a second independent reviewer crosschecked 10% of searches.

Search terms were approved by an informational specialist and PRISMA guidelines were followed thoroughly (Moher et al., 2010).

Strict limitations were applied to the search strategy and 'grey' literature was not explored therefore it is possible that findings presented in conference abstracts or as part of a thesis, that may have been relevant, were not included. Moreover, due to the inclusion of this work in a student thesis, quality of evidence was not assessed therefore there is uncertainty related to the strength of the evidence synthesised in the included studies. Furthermore, rather than summarising themes presented in primary studies, a thematic synthesis was conducted to derive novel interpretations of findings from diverse populations (Thomas & Harden, 2008).

Conclusion

This review identified that to date there is limited research in the UK exploring the factors that influence food portion size decisions, especially in relation to snack foods and portion control methods utilised in the home environment. Most studies were qualitative in nature; however it is likely that theoretical saturation has not yet been achieved in the UK due to the small number of studies conducted thus far. More research is needed to explore the factors that influence the portion size of snack foods offered to young children during a stage when eating practices and preferences are being developed. Furthermore, future research should consider less reliance on recall or singular methodology studies and seek to include the think aloud method in the home environment to stimulate habitual behaviour and observe behaviours caregivers may find difficult to verbalise.

4. Summary

Chapter 1, 2 and 3 highlight childhood obesity and poor diet quality as a significant public health concern in the UK and globally, with the health inequalities gap between the least and most deprived widening. The contributing factors are multidimensional and relate to a whole systems approach to obesity, however this thesis aims to focus on two out of the seven thematic clusters: food consumption and social psychology. Caregivers are the 'gatekeepers' of children's nutritional intake and influence the development of food preferences, consumption and general diet quality through the feeding practices they adopt and the portion sizes that they serve. Caregiver feeding practices influence children's eating behaviours and TDEI with eating behaviours adopted early in life tracking into adulthood, thus highlighting the need for adopting healthy eating behaviours early in life.

Currently, children's nutritional intake is less than optimal and UK caregivers are providing children with snack foods in portion sizes larger than age appropriate. Snack foods, defined as all food consumed between meals, contribute significantly towards children's TDEI however they tend to be highly energy dense and of low nutritional quality, thus contributing to excess sugar and energy intake. The food industry are continuously increasing food and beverage portion sizes, thus changing consumer perception related to what constitutes an acceptable amount to eat. Furthermore, snacks are typically packaged in portion sizes more appropriate for adult consumption. Children consume larger amounts of food when served large food portion sizes, and this effect is sustained for at least 5 days without compensatory behaviour, which may have long term negative implications on children's eating behaviours, weight status and risk of chronic disease. Therefore, strategies to moderate intake and address portion sizes served to children are warranted. However, firstly, an understanding of caregiver's unique perspectives on feeding their young children is needed to identify barriers and enablers of offering snack foods in line with portion size recommendations, in order to develop feasible interventions.

Early research from the USA suggests that meal time portioning practices are influenced by a variety of factors related to environmental and situational cues. However, findings cannot be generalised to a UK population. A rapid review of UK based studies revealed that no research to date has explored caregiver decisions related to the snack portion sizes that they serve to preschool children nor have they compared portion sizes served to recommended amounts. Furthermore, little is known about the portion control methods utilised in the UK home environment. Most research in this field has been qualitative in nature and thus theoretical saturation is unlikely due to the small number of studies conducted thus far, highlighting the need for further work. Furthermore, the methods adopted have tended to rely on memory. Instead, methods to stimulate thoughts and actions should be adopted, such as the think aloud method, which has been found to reveal feeding practices that may be difficult to verbalise.

4.1 Primary study aims and research questions

The development of the PhD research questions and aims were informed by evidence from the narrative and rapid literature review. In this section the aims and research questions of four primary studies conducted under this PhD are summarised. This is followed by a description of the general methodology adopted to address the PhD research questions/aims in chapter 5.

Study aims

Study 1

The primary aim was to investigate whether preschool children are served HED and LED snack food items in line with More and Emmett's portion size recommendations. The secondary aim was to examine factors that predict portion size selection of HED and LED snack foods for preschool children.

Study 2

The primary aim was to explore what factors influence mothers' decisions and judgements about a suitable snack portion size to serve preschool children and to further explore what portion control methods mothers adopt in the home environment, using the think aloud method. The secondary aim was to compare the snack portion sizes mothers served in the home environment to a) the portion size consumed by the child, b) to recommended amounts and c) to portion sizes selected in an online study. The third aim was to explore associations between maternal and child portion size.

Study 3

The primary aim was investigate the impact of offering unit or amorphous food on the portion size effect in children aged 2 to 12 years.

Study 4

The primary aim was to explore the feasibility and acceptability of two strategies of snack portion control: snack reduction and snack replacement. The secondary aim was to examine the preliminary efficacy of snack reduction and snack replacement on nutritional intake.

Research questions

Study 1

Are preschool children being served LED and HED snacks in line with recommended amounts?

What factors predict caregivers serving portion sizes of LED and HED snacks smaller or larger than recommended for preschool children?

Study 2

What factors influence snack-portioning practices in the home environment?

What portion control strategies do mothers adopt in the home environment?

What proportion of snacks served do children consume?

How do portion size selections in in the home environment compare to portion size recommendations?

How do portion size selections in in the home environment compare to portion sizes selected online?

Is there an association between maternal and child snack portion size?

Study 3

Does food type (unit vs amorphous) moderate the PSE?

Does child age moderate the PSE?

Does initial portion size served moderate the PSE?

Study 4

How feasible and acceptable are snack reduction and snack replacement as portion control methods in the home environment?

What impact does snack reduction and snack replacement have on children's nutritional intake?

5. General methodology

This chapter presents a general description of the methods that were adopted to address the PhD research questions. First, the epistemological underpinning of a mixed methods approach is described, followed by a description of the approach, and a justification for adopting this method. Specific methodological information for each study is presented in the respective chapters.

5.1 Research Paradigm

A research paradigm is regarded as a philosophical position relating to the nature of the social phenomena and structure. It often directs research efforts, determines the exclusion of other paradigms and reflects the researcher's epistemological standpoint (Feilzer, 2010). These beliefs aid the development of research questions and methodological design.

Traditionally there were two main paradigms used in research which stemmed from debates about singular or multiple realities and approaches to viewing the world: Positivism and Constructivism (also referred to as Interpretivism). Positivism was formed in response to the idea that metaphysical speculation could provide a foundation for obtaining 'true' knowledge of phenomena (Hasan, 2016). It refers to the notion that there is a singular reality waiting to be discovered through objective methodologies (Benton & Craib, 2010). In this paradigm, quantitative methodologies are employed using experimental and quasi-experimental designs to collect numerical data. Contrastingly, the qualitative paradigm studies social phenomena using anthropological methods. This is known as Constructivism. Constructivists immerse themselves into the cultures in which they are exploring by observations, interactions, interviews and analysis of existing documents to elicit an insider's view; believing that there are multiple realities to be explored (Harris & Graham, 1994).

To date, these two paradigms have dominated methodological and epistemological debates (Teddlie & Tashakkori, 2009); however, each methodology is not without limitation. As these paradigms are based on different yet complementary assumptions it is thought that their limitations can be compensated by the strength of the other, such that the sum of its parts are stronger than its individual components (Teddlie & Tashakkori, 2009). These paradigms combined are referred to as the alternative paradigm, pragmatism. Pragmatists believe that the measurable world relates more closely to an "existential reality" to ensure the main focus is on the research questions and consequences. They acknowledge that both singular and multiple realities exist in order to solve practical problems (Morgan, 2014). Pragmatists base their decision on each methodologies strengths and limitations to determine whether the research has answered the research questions. In terms of practicality, this paradigm extends others by testing the full spectrum of an intervention under investigation to determine whether it works in reality (Patsopoulos, 2011). In other words, pragmatists decide which methods to use based on its suitability to the research questions, thus granting themselves the option of using either a quantitative or qualitative design, or a combination of the two, known as mixed methods (Denscombe, 2008).

5.2 Mixed Method Research

In recent years, mixed methods research has become a distinctive methodology (Tashakkori & Teddlie, 2003). It positions itself between the two paradigm extremes and is recognised as the third methodological paradigm. Mixed methods research is a logical and practical synthesis of quantitative and qualitative research often implemented to produce a detailed understanding of a topic (Johnson, Onwuegbuzie, &Turner, 2007). It often provides the most informative, complete and balanced research outputs by drawing interpretations from the combined strengths of quantitative and qualitative sets of data for the purpose of breadth and depth of understanding (Johnson, Onwuegbuzie & Turner, 2007). This is called triangulation, a method used to cancel out bias inherent from the data, investigators and any particular method used, to construct superior explanations of the observed social phenomena (Olsen, 2004). The decision to take a mixed-methods approach was based on the researchers pragmatic standpoint and the recognition that combining these two methods minimises the weaknesses of adopting quantitative or qualitative research as a single approach (Hesse-Biber & Johnson, 2015). This methodology provides flexibility and integrity to address the range of complex research questions included (Powell et al., 2008), to provide a deeper understanding of participant's decisional processes and actions, and to ensure questions are answered in full rather than being only partially addressed.

Six mixed methods designs exist, each differing in their characteristics. All designs collect data either concurrently (Triangulation design, transformative design and concurrent embedded design) or sequentially (Explanatory design, exploratory design and sequential embedded), then analyse separately and integrate findings in the results or discussion section (Johnson & Onwuegbuzie, 2004). This thesis comprised of four quantitative and qualitative studies (table 4) and adopted the triangulation design to develop a more complete understanding of mother's decisional processes and actions when preparing an afternoon snack for their preschool child. Furthermore, the triangulation design was adopted to enhance understanding of the intervention outcomes and to explain any surprising results or outliers (Harrison & Reilly, 2011).

Collecting data concurrently in a mixed methods study has potential to introduce bias if the quantitative and qualitative data are collected from the same participants e.g. (Luzzo, 1995). One possible solution is to measure unobtrusive qualitative data or adopt a sequential design by postponing collection of the qualitative or quantitative component. Therefore, in study 4 interviews were conducting on completion of the intervention (postponed until completion of the quantitative data collection) to minimise bias.

Table 4: Summary of methods used throughout the thesis

Study	Methodology	Method	Questionnaires included
Study 1	Quantitative	Online Survey Questionnaires	CFQ CFPQ CFNS CEBQ
Study 2	Quantitative Qualitative	Think aloud task Semi-structured interview	
Study 3	Quantitative	Systematic Review Meta-analysis	
Study 4a	Quantitative	Questionnaire Pilot 'test' meal	Screening Questionnaire Feedback pro-forma
Study 4b	Quantitative Qualitative	Feasibility study Questionnaires Semi-structured interview	Maternal & child FFQ ECBQ CFPQ CEBQ CFNS FNS Acceptability Q Follow-up Q

5.3 Methodological procedures

Quantitative

Laboratory versus free living environment

Humans consume food at regular or intermittent intervals throughout the day in various eating locations. Therefore, when studying eating behaviour, researchers must decide whether to conduct research in laboratory or natural environments (Gibbons, Finlayson, Dalton, Caudwell, & Blundell, 2014). Eating behaviours and the effects of portion size have typically been studied by observing *ad libitum* food intake in laboratory settings (Fisher et al., 2007b; Kral et al., 2014; Mooreville et al., 2015) where intake can be studied in isolation, free from external influences. However, this acute examination is time consuming, costly and often renders only a single meal or snack occasion therefore subsequent eating behaviours, such as compensation, often go unrecorded e.g. (Buckland, Finlayson, Edge, & Hetherington, 2014). For example, Buckland et al. (2014) was unable to examine whether restrained dieters compensated for their restricted intake over the duration of a day due to an acute examination period in a human appetite research unit. Furthermore, laboratory studies create an artificial setting that provides information in an unnatural context when one is required to eat (Meiselman, 1992). It is therefore not clear if these findings replicate children's typical eating behaviours (Mooreville et al., 2015) nor if they inform the question of when individuals choose to eat. Moreover, inviting small children to the laboratory removes normal feeding interactions and role modelling between the mother and their child that may influence the amount of food consumed (Hendy & Raudenbush, 2000) and may change normal eating behaviours e.g. (Fisher et al., 2013).

To ensure the findings from this thesis replicate the free-living environment, and to enhance ecological validity, the decision was made to collect data in the home environment, where young children consume a majority of their TDEI (Poti & Popkin, 2011). However, research in natural environments poses the challenge of recording eating behaviours and intake data accurately between participants, given that a trained researcher is not always present.

Collecting habitual food intake data is challenging and can often lead to under-reporting, selection bias or reporting bias (Livingstone et al., 1990). Furthermore, very young children often lack the literacy skills, writing skills and memory to report on their own intake (Foster et al., 2008) and have difficulty estimating food portion sizes (Weber et al., 1999). However, evidence has shown that caregivers are reliable reporters of their children's intake in the home environment (Baranowski, Sprague, Baranowski, & Harrison, 1991); therefore, caregivers can record food intake as a proxy for their child.

Food intake measures

A review of the literature suggests that there are several subjective and objective methods that have been employed in previous eating behaviour studies (Vereecken et al., 2010). Subjective methods, such as dietary recall, are useful in population-based studies, however, these methods rely on memory and estimation thus may not reflect habitual intake or provide an accurate measurement of portion size (Karvetti & Knuts, 1985). Alternatively, caregivers can record their children's intake in a food diary. Food diaries are cheap and convenient however they rely on portion size estimations and household measures (Robinson et al., 1997). To enhance accuracy, tools such as food photographs and models have been provided to assist with recall and estimation. However, when portion size estimates from these methods have been compared to the foods actual weight, substantial differences have been observed regardless of participant age or duration since consumption (Frobisher & Maxwell, 2003).

The most accurate and frequently used method for measuring food intake and portion size is the weighed food diary which provides an objective measure of portion size served and consumed by subtracting food waste (grams) from the amount served (grams) (Jansen, Mulkens & Jansen, 2007; Ramsay et al., 2013). However, this method is not without limitation. Weighing and recording all foods served and leftover can be burdensome for the participant and may require motivated individuals, which minimises the generalisability of findings (Foster et al., 2008). Alternatively, the demands of weighed food diaries may result in participant withdrawal from the study. Therefore, limitations on the number of days recorded should be introduced. For example, research has suggested that 4 consecutive days is a suitable duration of food recording but anything above this threshold may result in unsatisfactory reporting which, due to respondent fatigue, normally decreases the depth of information gained (Gersovitz, Madden, & Smiciklas-Wright, 1978).

In addition to the home-based study, a screen-based measure was used to assess portion size selection of multiple foods at one occasion whilst maintaining consistency across participants and test sessions (Study 1). Screen based measures provide a flexible approach to data collection, including settings that do not have access to facilities required to prepare and serve food (Wilkinson et al., 2012). Responses are often derived from large samples, to enhance statistical power and encourage participation from individuals less likely to participate in research that requires commuting or direct contact with researchers (Brunstrom et al., 2008). Furthermore, this method has shown a clear relationship between ideal portion size selection and actual selection of physical foods, confirming similarities between software and actual feeding behaviours (Wilkinson et al., 2012). However, screen-based stimuli may not provide a true representation of nutritional intake in circumstances where there is a difference between the expected and actual food properties, such as taste, smell, composition and size e.g. (Buckland, Finlayson, & Hetherington, 2013). Therefore, a second study was conducted with a subsample of participants to explore actual portion size selections in the home environment (study 2). The two studies were conducted with a week washout period in between, such that participants were not able to recall and purposefully replicate their previous portioning practices (Wilkinson et al., 2012).

Qualitative

Caregivers have unique experiences and perspectives of feeding their young children (Johnson et al., 2015). The success of capturing in depth and accurate accounts of caregivers thought processes, experiences and portion control strategies employed within the home environment is therefore dependent on the methodology employed. Qualitative research is an interpretive, naturalistic approach to the world. It includes the exploration of people in their natural environments and attempts to develop an understanding and interpretation of phenomena in terms of the meaning people bring to them (Denzin & Lincoln, 2005). Typically, thought processes and factors that influence portioning practices have been explored in semi-structured interviews e.g.

(Blake et al., 2015; Johnson et al., 2015) or focus groups e.g. (Croker, Sweetman & Cooke, 2009; Curtis, Atkins & Brown, 2017), whereby caregivers are asked to recall their habitual portioning practices. Semi-structured interviews have been deemed appropriate to explore behavioural patterns, how views and judgements are made and the acceptability and practicality of interventions (Bowen, 2009). Furthermore, face-to-face semi-structured interviews resemble a naturally occurring conversation and are deemed more likely to produce detailed responses than structured interviews (Bryman, 2012; Silverman, 2013). Moreover, semi-structured interviews can be advantageous to focus groups whereby some group members may not feel comfortable sharing their opinions, especially if there are dominant participants in the group (Curtis et al., 2017). However, when exploring passive processes (i.e. portioning practices) interviews may be limited due to participant's reliance on memory and their ability to articulate their actions (Blake et al., 2015). Therefore, in study 2 mothers were asked to prepare snack foods for their child whilst concurrently verbalising their actions to stimulate thoughts and to allow for actions to be observed. This can be referred to as the think aloud method.

The think aloud method is a projective technique that offers an innovative solution to reduce biases and unveil important insights into a range of behaviours that people may often find hard to articulate or even be consciously aware of (Hussey & Duncombe, 1999). In combination with semi-structured interviews, the think aloud method has been used to stimulate thoughts and unveil feeding behaviours that had not been previously verbalised when preparing food at an evening meal (Johnson et al., 2015). Furthermore, portioning practices can be situational (Blake et al., 2015) therefore the think aloud method may produce more reliable data from participants than conducting qualitative interviews alone due to the reduced dependence on memory, often only highlighting habitual practices (Kuusela & Paul, 2000).

To maximise participant response during semi-structured interviews and the think aloud task, it was important that the researcher was able to facilitate the participant to reveal and disclose information (Punch, 2013). Based on the researchers (interviewer) past experience conducting focus groups and semi-structured interviews, multiple approaches to achieve this were implemented. Firstly, all qualitative data were collected at a date and time that was chosen by the participant as a method to reduce barriers of engagement. Secondly, the researcher always dressed appropriately for the context, in order to yield a professional yet relaxed atmosphere. Thirdly, the interviews were conducted after having met or spoken to the participant on multiple previous occasions where the researcher engaged in personal conversation, to develop a co-equal relationship based on trust and rapport (Pope, Ziebland, & Mays, 2006). Finally, qualitative data were collected in the family home to replicate the free-living environment, and to enhance ecological validity. Research in the home ensures participants are in a familiar environment to increase the likelihood of responding in a normal fashion. More specifically, qualitative research in natural settings (e.g. in the kitchen or living room to reflect a normal snack offering) has been reported to elicit people's underlying motivations, attitudes and beliefs (Johnson et al., 2015).

The next section will describe the study participants, recruitment strategy, data collection methods and analyses used. Specific methodological information for each study is presented in its relevant chapter.

5.4 Participants

Caregivers of children aged 2 to 4 years were recruited to take part in one of four primary studies. Currently children in the UK have a less than nutritionally optimal diet; exceeding saturated fat and sugar recommendations and not consuming fruits and vegetables in line with recommended amounts (NDNS, 2019). Dietary patterns established during the preschool years are likely to persist into adolescence and adulthood highlighting the importance of developing healthy eating behaviours early in life. Children's nutritional intake and eating behaviours are developed through direct experiences with food and observations of their caregivers (Birch, Savage, and Ventura, 2007). Caregivers act as a role model and influence the types and amounts of food consumed by their children through observational learning and parental feeding practices. As such, associations between maternal and child meal portion size have been identified in the USA (Johnson et al., 2014). However, it is unknown if this same relationship exists for snack foods.

5.5 Recruitment

Sampling techniques and sample size can influence outcomes of a mixed methods study due to the merging of quantitative and qualitative datasets (Tashakkori & Teddlie, 2003). Having unequal sample sizes of differing participants in the qualitative and quantitative components is a common problem as each data set is usually collected to answer a different research question (Bergman, 2008). It is therefore preferable to have the same individuals participate in both components since the data can then be compared (Tashakkori & Teddlie, 2003). In this thesis, the same participants completed both the qualitative and quantitative components of study 1 and 2 so data could be integrated and compared. However, only a subset of participants were interviewed in study 4 since theoretical saturation was achieved.

Participants were recruited in toddler groups, on social media pages (e.g. Facebook, Twitter) and university email lists via convenience sampling. Toddler groups were identified from internet searches which led to a snowball effect based on recommendations. Convenience sampling is a nonprobability and non-random sampling method that includes individuals from the target population that meet inclusion criteria and are willing to participate. It can be assumed that a convenience sample is homogenous and thus there are no differences in results compared to a random sample (Etikan, Abubakar Musa, & Sunusi Alkassim, 2016). However, this sample is not representative of the entire UK population.

Participants were provided with study specific participant information sheets and provided with a minimum of 24 hours to consider the information before providing informed consent. The participant information sheets detailed the study purpose, procedures, possible advantages/ disadvantages of participation, data storage methods, ethical review and contact information. Full disclosure of the study purposes and procedures were provided as opposed to a cover story in line with University of Sheffield ethics and the BPS code of conduct, ensuring integrity was honoured. Potential participants were informed that the study purpose was to find out more about eating habits in young children (See Appendix 4 for example).

5.6 Materials and measures

Presented below is a summary of the data collection tools used throughout this thesis. Questionnaires were used to examine participant eligibility, children’s eating behaviours and parental feeding practices. Existing measures validated in preschool age children were included alongside self-developed measures designed to screen for participant eligibility and test the acceptability and longer term impacts of a feasibility and acceptability intervention (study 4). A scoping review of the literature was conducted to explore the types and number of questions commonly used in a feasibility and acceptability questionnaire to inform the development of the screening questionnaires e.g. (Fulkerson et al., 2010). Information for each validated measure is provided in this section with a more detailed description of the data collection tools and methods used for each individual study presented in its relevant chapter.

The Child Feeding Questionnaire (CFQ) (Birch et al., 2001) is one of the most commonly used measures of caregivers feeding practices. It was designed and validated for use by caregivers of children aged 2 to 11 years of age based on the domain specific parenting theory developed by Costanzo and Woody (1985). The CFQ was based on the theoretical perspective that caregivers of who may be concerned about the health and growth trajectory of their child will be more likely to control children's nutritional intake via feeding practices. Birch et al., (2001) tested three versions of the questionnaire with the third version becoming the CFQ, with seven different dimensions. The first four dimensions focus on parental perceptions and control whereas the final three factors focus on parental control attitudes and practices (i) perceived parent weight, (ii) perceived child weight, (iii) parental concerns, (iv) parental responsibility, (v) parents use of restriction, (vi) parental pressure on their child to eat, (vii) parental monitoring.

The Comprehensive Feeding Practices Questionnaire (CFPQ) (Musher-Eizenman & Holub, 2007) is a validated instrument designed to examine feeding practices of caregivers with children aged 2-8 years. It comprises of 49-items with 12 subscales; child control; emotion regulation; encourage balance and variety; environment; food as a reward; involvement; modelling; monitoring; pressure; restriction for health; restriction for weight control; teaching about nutrition. Qualitative research from the USA, has suggested associations between portion sizes served to children and a) restriction for health, b) restriction for weight control and c) use of pressure to eat (Blake et al., 2015; Croker, Sweetman, and Cooke 2009) however this was not measured using the CFPQ. Furthermore, it is currently unknown if these findings are generalizable to the UK due to environmental and cultural differences.

The Children's Food Neophobia Scale (CFNS) (Pliner, 1994), adapted from the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992), is a 10-item parental report measure of child trait food neophobia. Food neophobia is a personality trait that becomes increasingly problematic between the ages of 2 and 5 (Cooke et al., 2003). It acts as a protective function thus affecting consumption of novel foods which can contribute to eating habits and preferences in adulthood. The full ten-item version of the questionnaire was originally validated with children aged 8 to 11 years and, as a result, four of the items were considered to lack relevance for preschool children. For the purpose of this research an adapted 6-item version for use in preschool children was included (Cooke et al., 2003).

The Children's Eating Behaviour Questionnaire (CEBQ) (Wardle et al., 2001) is one of the most commonly used questionnaires to explore children's eating styles and to investigate early precursors of eating disorders or obesity. It comprises of 35 items scored on a five point Likert scale from never to always. For the purpose of this research, two out of the eight scales were included to examine how children's eating behaviours influence caregiver's portioning practices: (i) food responsiveness and (ii) satiety responsiveness. Eating behaviours are shaped early in development due to flavour and texture exposures during the weaning phase (Stang, 2006).

The Early Childhood Behaviour Questionnaire (ECBQ) (Rothbart, Ahadi, Hershey, & Fisher, 2001) was designed to assess temperament in young children aged 18 to 36 months. The ECBQ assesses temperament across 18 dimensions: Activity level/Energy, Attentional Focusing, Attentional Shifting, Cuddliness, Discomfort, Fear, Frustration, High-intensity Pleasure, Impulsivity, Inhibitory Control, Low-intensity Pleasure, Motor Activation, Perceptual Sensitivity, Positive Anticipation, Sadness, Shyness, Sociability, Soothability. For the purpose of this research, items relating to impulsivity and inhibitory control were included as they have been associated with overweight and obesity (Guerrieri, Nederkoorn, & Jansen, 2008). The association between poor inhibitory control and BMI have been noted in children as young as age 2 (Graziano, Calkins, & Keane, 2010).

The FNS (Pliner & Hobden, 1992) was included to measure parental neophobia. Even though food neophobia is of most concern during the toddler years it is also problematic in adults and can have an adverse effect on children's food preferences due to modelling behaviours. It comprised of 10 items that participants rated from strongly disagree to strongly agree.

The Food Frequency questionnaire (FFQ) (Hammond, Nelson, Chinn, & Rona, 1993) collects data on the frequency of consumption of food and beverage items over a specified period. For each item participants are asked to select "Never", "once a month", "once a fortnight", "once a week", "6 days a week" or "every day". Within this thesis an amended version of the FFQ was included, which was limited to snack items relevant to the scope of the thesis e.g. sweet biscuits, cakes/ scones, crisps, green cooked vegetables, salad, fresh fruit.

To explore caregivers portioning practices and the feasibility and acceptability of snack reduction and replacement, semi-structured interviews and the think aloud method were employed. Two interview guides were developed and included questions, relevant to the research questions, aim and objectives (Appendix 5). The interview guides were designed to gather information regarding mother's decisional processes when serving their young children at an afternoon snack, and the acceptability and feasibility of snack reduction and snack replacement in the home environment. Questions were open-ended to assist participants in providing detailed responses. Prompt and follow-up questions were also included to elicit more detail where necessary. The interview guides were edited during pilot interviews in alignment with Bryman's development of a finalised interview guide (Bryman, 2012). In line with good research practices, the pilot interviews were included in the analysis to maximise the use of research time and data (Bryman, 2012).

5.7 Data Analysis

Separate analyses were performed on the quantitative and qualitative data and the findings were merged during the interpretation phase. A summary of analytical procedures are presented in this section however more detail on the analyses performed for each individual study can be found in its relevant chapter.

Quantitative

Data was imported into SPSS (SPSS Inc., USA, Version 22) and STATA (Release 15. TX: StataCorp LLC, version 15) for statistical analysis. In each chapter descriptive statistics were produced alongside inferential tests specific to the research questions e.g. independent and paired t-tests, repeated measure ANOVA and multinomial logistic regression. Data in each study tended to fulfil parametric assumptions of independence, normal distribution and homogeneity of variance. However, in cases where parametric assumptions were violated, the relevant non-parametric tests were run, and this was indicated. Where significant differences were detected ($p < 0.05$) post-hoc tests were run.

Qualitative

Due to the growth of qualitative research, an extensive range of analytical methods now exist (Silverman, 2013). Braun and Clarke (2006) claim that these methods can be split into two categories. The first is driven by a theoretical or epistemological standpoint with limited variability in how the method is applied, including grounded theory (Glaser & Strauss, 2017) and discourse analysis (Burman & Parker, 2016), whilst the second is independent of both theory and epistemology, such as thematic analysis. Currently there is no consensus to which method is deemed the best approach (Bradley et al., 2007). For this study two potential analytic methods were considered in regards to the research questions, study design and researcher experience (Grounded theory and thematic analysis). Grounded theory was considered as it takes an inductive approach to explore new topics and generates theory of phenomena grounded in a data set (Glaser & Strauss, 2017). However, it requires large data sets to gain the necessary depth for forming theory, and a detailed theoretical and technological knowledge. Furthermore, it does not acknowledge the influence of the researcher, reflexivity or accept the notion of multiple realities (Silverman, 2013).

Thematic analysis offers an accessible form of analysis which is particularly useful for early career researchers who can learn core skills of qualitative analysis which are transferable to other approaches (Braun & Clarke, 2006). Thematic analysis' theoretical freedom provides a flexible and useful research tool to produce an in depth, detailed account of the data set (Braun & Clarke, 2006). It does this by identifying, analysing and reporting patterns, also known as themes, from the data as opposed to the researcher's theoretical interest. This approach adheres to the researcher's pragmatic standpoint as it is the analytic method that 'works best' given the lack of a pre-existing theoretical framework. Furthermore, it is beneficial as the inductive approach allows participants to voice their perceptions and experiences. For these reasons, thematic analysis was employed.

Braun and Clarke's (2006) six phase process of thematic analysis was followed. Each phase was visited and re-visited as part of a recursive process as the analysis developed over time.

In phase 1, data familiarisation occurred. This commenced during the pilot interviews and continued throughout data collection and transcription (Riessman, 1993). The process of transcribing and repeated reading was somewhat time consuming however, it allowed the researcher to immerse in the data and begin to identify possible patterns. In phase 2, transcripts were imported into NVivo and initial codes were generated by identifying patterns of potential interest in the data and organising into meaningful groups accordingly (Miles & Huberman, 1994). Due to the exploratory nature of the research questions, and the researcher's limited qualitative experience, a high number of codes were generated to ensure no possible patterns had been missed (Braun & Clarke, 2006). In phase 3, generated codes were collated with related codes to form groups, also known as broader themes. An inductive approach e.g. (Frith & Gleeson, 2004) was taken ensuring that the themes were data driven and thus strongly related to the data itself (Patton, 1990). Sub-themes were also formed to provide structure and demonstrate hierarchy within themes. The relationship between themes and sub-themes were explored and updated in NVivo.

In phase 4, the themes were reviewed and refined on two levels. Firstly, all of the data extracts at the coded level were re-read to check they formed a coherent pattern and were supported by sufficient data. Next, the entire data set was re-read to check the validity of each theme in relation to the data set and whether the thematic map reflected the cohort's responses to interview questions. Furthermore, this step ensured that any data that had been missed in earlier coding stages could be coded. In phase 5, each theme was named and defined by writing a detailed account of the 'story' it was telling and how it related to the larger 'story' in terms of the studies research questions. Each theme was considered individually and in relation to the others. Refinement of themes and subthemes continued until the researcher was able to define each sub-theme and its contribution to each theme, and then each theme and its contribution to the thematic map. In the final phase, a rich thematic description of the entire data set was produced alongside the quantitative findings to provide a deeper understanding of participant's decisions and actions. Data extracts were chosen based on their relevance to the area of interest and were embedded within an analytical narrative to describe and support the outcome of the research questions. A sufficient number of extracts are provided in the relevant chapters and tables to demonstrate the prevalence of each theme.

Mixed methods integration

Conducting a mixed methods study requires integration of the qualitative and quantitative components within a single study (O'Cathain, Murphy, & Nicholl, 2007). Integration can take place from the point of formulating the research question, throughout the design phase, sampling, analysis, interpretation and write up of results (Brannen, 2017; Sandelowski, 2000). In this thesis, integration of methods occurred during the interpretation phase, after each component had been analysed separately. Findings from the two components were integrated and presented together in the results and discussion section using an adapted model of triangulation (see section 5.2).

5.8 Ethical Considerations

Throughout the entire research process ethical issues were considered and addressed to adhere to the values of honesty and scientific integrity as outlined by the British Psychological Society (Punch, 2013; Willig & Stainton Rogers, 2008). Ethical approval, and amendments where necessary, were approved by the School of Health and Related Research Ethics Committee before data collection began (reference number 011 913 and 007850). Two studies (study 2 and 4) involved vulnerable participants (children < 18 years old) who did not have the capacity to give consent. Therefore, written consent was sought from their primary caregiver who was the main participant in each of the studies. Direct contact with children was only required to take height and weight measurements and in all instances the primary caregiver was present. The researcher explained to each child what they were required to do and used a toy to demonstrate. The researcher did not continue without verbal consent from the child and written consent from their primary caregiver. No pressure was placed on the child to participate.

For confidentiality and anonymity, participants were informed that they would not be identified in any document or any third party who was involved in this research. Names were replaced with a unique identification code that was only accessible to researchers who were directly involved in the project. Electronic data was stored on an encrypted hard drive and hard copies were stored in a locked drawer in the primary researcher's office. Only the primary researcher had the key to the locked drawer, as well as the password to the encrypted computer containing the research data and the participants' information. All interviews were audio recorded with participants' permission. Participants were advised that participation was voluntary, and they could withdraw if they did not want to take part. Both verbal and written consent was gained, and participants were asked whether they were happy for their quotes to be linked to unidentifiable demographic information, e.g. relationship to child and age. For most interviews, the participant's child was present and could be heard on the audio recordings. This information was removed immediately and was not transcribed. The interviews were transcribed within 24 hours and then permanently deleted. The transcripts were stored on an encrypted hard drive.

Entering participant's houses alone put the primary researcher in a potential position of threat. Caution was taken in line with university policy, and a safety checker was put in place. The safety checker was made aware of the time and location the primary researcher would be entering a participant's house and was added to the researcher's speed dial in case of emergency (Safe Working Practices SOP, 22.06.2012; v1.0, The University of Sheffield). The primary researcher made sure contact had been sought with the participant before travelling to the participant's house. Furthermore, a travel plan was created, including bus routes and times. Once the researcher had arrived into the local area and house, caution was taken to identify possible escape routes. At no point during the study was the researcher left alone with the child. The safety checker was informed once the researcher had left the property and had returned safely back to the university campus.

5.9 Reflexivity

Qualitative research is subjective and accepts the active role that the researcher plays in collecting, analysing and interpreting the data (Silverman, 2013). It is important to understand how the researcher's background, beliefs and knowledge may influence this process. This can be achieved through reflexivity, a process by which one is transparent and self-aware of personal influences on data interpretation (Davies & Dodd, 2002). In this next section, personal information will be shared to provide a detailed account of how reflexive practise was used, therefore this section will be written in the first person.

I undertook this study as part of my doctoral thesis based on my interests in nutrition, obesity and behaviour change. My initial interests in these topics derived from past experiences in academia and employment. At the time of applying for a faculty scholarship I was employed as a health care assistant and exercise therapist in a weight management centre. Within this role I provided advice regarding weight management to children, adolescents and adults classified as overweight or obese. I gained experience working with families from lower socioeconomic backgrounds as well as experience working alongside health care professionals in a multidisciplinary team. Regarding academia, I have a BSc in Sport and Exercise Science and an MSc in Psychology. I gained extensive knowledge of the human body and the importance of a healthy balanced diet. I also took particular interest into behaviour change techniques.

Whilst my academic and professional experiences deemed me suitable for researching this topic, they could have potentially influenced my assumptions, perceptions and interpretation of the data (Finlay, 2002). For example, my opinion may have conflicted with that of the participant. Therefore, the need to withhold personal opinions to minimise bias and ensure that the key themes accurately represented the participants' responses was acknowledged. To do this, I firstly created and shared an interview guide with my supervision team before piloting it. I kept a log of any additional questions that were asked due to the natural flow of conversation and reflected on the phrasing used to ensure consistency was maintained throughout questioning. The hand written log was completed before and after each visit and the interview process with pre-conceptual thoughts, a description of the interview, challenges faced and problems solved. This was referred back to when analysing and interpreting the data. Next, I provided an exploratory account of the key themes found to a random sample of participants (n = 5) to check that the account provided a true reflection of what the participant had voiced. The participants agreed that their opinions had been accounted for, which confirmed that coding was complete and bias had been minimised. Furthermore, themes from the interviews were compared to the quantitative outputs using triangulation which improves confidence in research findings to overcome bias e.g. (Murray, 1999).

Another factor identified as potentially influencing responses gained during the interview process was the level of rapport built with participants (Bassey, 1999). In study 4, I had met each participant on at least 3 occasions prior to the interview, thus a level of rapport had been built. Rapport is a valued aspect of interpersonal relationships in research, known to elicit open responses that are honest and valued (Jorgenson, 1992). However, in study 2, interviews took place on first meeting the participant, therefore multiple follow up questions had been devised in case participants were not very responsive. To aid the development of a coherent relationship quickly, I spent the first 10-15 minutes of each visit conversing with participants about factors unrelated to the research, e.g. the weather, the local area, current affairs. I also took a colouring book for each child to help them feel comfortable and to keep them occupied during the interview process. However, in most scenarios this was not needed as the children were intrigued by the presence of a new person in their home and saw it as an opportunity for somebody new to play with. At the end of each visit field notes were written regarding how welcoming the participant had made me feel and how comfortable I thought they felt. This was referred back to during the analysis phase.

6. PhD Primary studies

This chapter of the thesis presents results from four individual studies that have been written in the style of published work; the first two studies explore caregiver portioning practices in an online survey and in the home environment, followed by a systematic review and meta-analysis that explores three potential moderators of the PSE; food type (unit versus amorphous), child age and size of the initial food portion served. Prior to results of a feasibility and acceptability intervention (study 4; chapter 6.5), the process and results of the intervention development are presented. The intervention development section has been written in a reflective style.

This chapter is presented in the format of a published paper that is in preparation for submission to a scientific journal.

6.1 Study 1: Snack portion sizes for preschool children are predicted by caregiver portion size, caregiver feeding practices and children's eating behaviours

6.1.1 Background

Caregivers are responsible for the type and quantity of food they make available within the household for their children (Brown & Ogden, 2004). They act as the 'gatekeepers' of paediatric nutrition, determining the amount of food to be offered, and developing social norms for the child (Hetherington & Blundell-Birtill, 2018). For example, the portion size mothers serve their children at an evening meal is strongly correlated to the portion size they serve themselves (Johnson et al., 2014). Similarly, data from the UK suggest that snack foods are also offered to children in adult or larger than recommended portion sizes. For example, a recent national survey involving 1000 UK parents identified that 61% of parents are offering their children large portion sizes of jelly sweets (candy), with 24% of parents allowing their children to consume portion sizes of sweets that were the equivalent to three times the recommended weekly amount within one serving (Infant and Toddler Forum, 2016). Similarly, 29% of parents in Scotland were identified to be offering their infants (aged 8 – 12 months) HED snack foods at least once per day, and the frequency of snack offerings increased with higher levels of deprivation (Campbell & Wolfson, 2017).

The obesogenic food environment which features as a cluster on the Foresight map (food production), has been reported to exacerbate food related health inequalities. For example, fast-food outlet exposure combined with lower educational attainment are related to an increased likelihood of developing obesity or an increased BMI in adults (Burgoine et al., 2016). A recent systematic review (Chung et al., 2016) reported that socioeconomic inequalities are continuing to widen in both adults and children. Best and Papies (Best & Papies, 2018) demonstrated that people with a low socioeconomic position are at an increased risk of overconsuming when offered large food portion sizes as opposed to individuals from more affluent backgrounds. This finding was attributed to differing views of what was classified as an appropriate portion size to consume, which may be related to greater exposure to large portion sizes of HED foods in these environments. Therefore, differences in social norms based on socioeconomic position may influence portioning practices.

In terms of energy intake, low income families consume approximately 24 additional kcal per single snack occasion compared to high income families, which is sufficient to elicit health disparities in children and adults classified with overweight (Department of Health, 2011). Consuming large portion sizes of HED foods frequently has been associated with a larger BMI (Kachurak, Davey, Bailey, & Fisher, 2018; Larson & Story, 2013; Piernas & Popkin, 2010). Snack foods are reported to contribute around 21% of children’s TDEI in the UK (Macdiarmid et al., 2009) and USA (Piernas & Popkin, 2010). Given that large food portion sizes often result in greater immediate energy intakes (Kling et al., 2016) and sustained intake over a 5day period without compensation in children aged 3- 5 years (Smethers et al., 2019); a more in depth understanding related to the factors that predict portion size selection may be useful for developing public health interventions aimed at improving children’s snack intake as part of a healthy balanced diet.

Snack portion size recommendations and daily eating plans have been proposed for children in the UK (Crawley, 1998; Scotland. Scottish Executive., 2006) and USA (US Department of Agriculture & US Department of Health and Human Services, 2010), to help guide caregivers towards offering their children a nutritionally balanced diet. More recently More and Emmett (2015) proposed evidence-based appropriate portion size ranges for a variety of foods, and a practical, balanced food plan for preschool children by combining published data from two national surveys (The British National Diet and Nutrition Survey (Friebe, 1996) and The Avon Longitudinal Study of Parents and Children (Cowin & Emmett, 2000; Emmett, Rogers, Symes, & Team, 2002)). Foods were allocated into five food groups (1. Bread, rice potatoes, 2. Fruit and vegetables, 3. Milk, yoghurt and cheese, 4. Meat, fish, eggs, nuts and pulses and 5. Foods high in fat and/ or sugar) and two food groups (group 2 and 5) were split further to provide flexibility in serving frequencies and to reflect snack foods. However, these recommendations are not easily accessible to the general public and manufacturers tend not to state portion sizes for children on their products (Sothern, 2004).

Children's snack consumption is influenced by environmental and behavioural variables related to snack food availability (Hearn et al., 1998), the maternal diet (Wroten, O'Neil, Stuff, Liu, & Nicklas, 2012), individual differences in eating traits (e.g. satiety responsiveness) (Kral & Hetherington, 2015) and parental feeding practices (e.g. pressure to eat) (Yee et al., 2017). Caregivers often use deliberate practices to influence their children's food intake in line with patterns that they deem appropriate (Birch et al., 2007; Yee et al., 2017). Feeding practices fall into two main themes: controlling (e.g. restriction or pressure to eat) or non-controlling (e.g. provide child autonomy) (Haycraft et al., 2017) and are often an adaptive response to children's eating behaviours, food fussiness and specific food problems (Holley, Haycraft, et al., 2018). Feeding practices also have differing outcomes on children's eating behaviours. For example, some feeding practices, such as modelling, are successful in promoting healthy consumption (Cullen et al., 2001) whereas others (e.g. pressure to eat) can reduce desire to eat, and actual consumption of a target food (Vereecken et al., 2010), and in some cases may lead to the development of dietary restraint and disinhibition (Carper et al., 2000).

A recent systematic review (Kairey et al., 2018) revealed that parental portioning practices at meals are influenced by caregiver portion size, perceived child hunger, body size and employment status. However, to date little is known about the associations between children's snack intake, portion sizes and established parental feeding practices in the UK since the review comprised only three studies from the

UK, of which none focussed primarily on snack foods (Croker, Sweetman & Cooke, 2009; Douglas et al., 2014; Curtis, Atkins & Brown, 2017). It is not yet clear what determines the amount caregivers serve to preschool children and whether they follow portion size recommendations for preschool children. Therefore, the primary aim was to investigate whether preschool children are served LED and HED snack food items in line with More and Emmett's portion size recommendations. The secondary aim was to examine potential factors that might predict caregivers serving LED and HED snacks smaller or larger than the recommended portion sizes for children.

6.1.2 Methods

Participants

Caregivers of children aged 2 to 4 years old were recruited from across the UK via university emailing lists, social media advertisements (e.g. Facebook, Twitter) and within toddler groups in Sheffield. To be eligible for participation, caregivers had to confirm on the online consent form that they were ≥ 18 years old, responsible for the food their child consumed in the home environment and neither themselves or their child had a food allergy. The study was reviewed and approved by the School of Health and Related Research Ethics committee at the University of Sheffield (#011913).

Procedure

Participants were invited to take part in an online survey hosted on Qualtrics (Version January 2018; Provo, Utah, USA). Caregivers were presented with images and measurements of the bowl and plate which featured throughout the survey (Williamson et al., 2003). Caregivers were then presented with a scenario to imagine; *"It is 2:30pm, your child/ you had a sandwich 2.5 hours ago for lunch and they/ you are now hungry. Please select which snack you would provide*" and in a randomised order, images of 10 individual snack foods were then presented on screen. There were two sets of images, one related to adult portion sizes and one related to children's portion sizes. Each snack food was presented in 6 portion sizes and caregivers were asked to choose which portion size they would usually serve to their child and themselves for an afternoon snack. The images for adults and children were presented to participants in a counterbalanced order to minimise possible order effects. The imaginary scenario was provided to maintain consistency across participants and to control situational factors that have been found to influence portion size selections, such as child hunger and proximity to last/next eating occasion (Blake et al., 2015). Caregivers completed measures of food liking and frequency of consumption for each snack food presented, for themselves and their child. Finally, caregivers provided demographic information and completed subscales from questionnaires related to parental feeding practices and children's eating traits. On completion, caregivers were able to enter into a prize draw and/or express an interest in completing a second study if they so wished (see chapter 6.2).

Materials and measures

Food items

For the online survey, two items from each food group, as defined by More and Emmett (More & Emmett, 2015), were selected to ensure inclusion of sweet and savoury, unit and amorphous and high and low energy dense snacks (Low < 2.5 kcal/g, High > 2.5kcal/g, (Albar, Alwan, Evans, & Cade, 2014)). The selected snack items (Table 5) were identified as being familiar and regularly consumed by children (Emmett et al., 2002; Infant and Toddler Forum, 2014; NDNS, 2018) and adults (Albar et al., 2014; NDNS, 2018).

Calculation of portion sizes

Adult and child recommended portion sizes were derived from WHO recommendations (WHO, 2019) for fresh fruit and vegetables for both children (40g) and adults (80g). For commercially available foods, recommended amounts for children were based on the portion sizes outlined by More and Emmett (More & Emmett, 2015). For adults, portion size information was taken from food packaging (Table 6).

The remaining five portion sizes, three above and two below the recommended portion size were calculated on a log scale, ensuring equal increments between each portion size, as research indicates that sensory systems respond in a logarithmic fashion to objects in the external world (Foster & Adamson, 2012) (Table 5 and 6). This is referred to as Weber's Law (Ekman, 1959) which suggests that as the size of a stimulus increases the just noticeable difference gets larger, usually in proportion to the stimulus magnitude. Similarly with previous research, portion sizes ranged between 40% and 400% of the recommended amount (Brunstrom et al., 2008).

Table 5. Weight and energy of each snack item presented in the online survey for children aged 2-4 years

Food Item	**Energy Density (kcal/ g)**	**Portion size 1 (energy in kcal)**	**Portion size 2 (energy in kcal)**	**Portion size 3* (energy in kcal)**	**Portion size 4 (energy in kcal)**	**Portion size 5 (energy in kcal)**	**Portion size 6 (energy in kcal)**
Cucumber[a]	0.16	16g (3)	25g (4)	40g (6)	64g (10)	101g (16)	160g (26)
Carrot[a]	0.42	16g (7)	25g (11)	40g (17)	64g (27)	101g (42)	160g (67)
Gala Apple[a]	0.53	16g (8)	25g (13)	40g (21)	64g (34)	101g (54)	160g (85)
White Grapes[a]	0.66	16g (11)	25g (17)	40g (26)	64g (42)	101g (67)	160g (106)
White Toast[b] (Hovis ©)[b]	2.56	11g (28)	17g (44)	27g (69)	43g (110)	68g (177)	108g (276)
Swiss Roll[b] (Strawberry & cream, Tesco)	3.64	9g (33)	14g (51)	23g (83)	36g (131)	57g (205)	90g (328)
Cereal[b] (Cornflakes, Kellogg's ™, ®, ©)	3.78	7g (26)	11g (42)	18g (68)	29g (110)	45g (170)	72g (272)
Chocolate biscuit[b] (Digestives, McVities ®)	4.95	6g (30)	9g (45)	15g (74)	24g (119)	38g (188)	60g (297)
Salted crisps [b](Walkers ©)	5.26	4g (21)	6g (32)	10g (53)	16g (84)	25g (132)	40g (210)
Mini milk chocolate buttons[b] (Mondelez ©)	5.35	3g (16)	5g (27)	8g (43)	13g (70)	20g (107)	32g (171)

[a] LED, [b]HED (Albar et al., 2014), * recommended amount (More and Emmett 2015; WHO | WHO calls on countries to reduce sugars intake among adults and children 2016)

Table 6. Weight and energy of each snack item presented in the online survey for adults

Food Item	**Energy Density (kcal/ g)**	**Portion size 1 (energy in kcal)**	**Portion size 2 (energy in kcal)**	**Portion size 3* (energy in kcal)**	**Portion size 4 (energy in kcal)**	**Portion size 5 (energy in kcal)**	**Portion size 6 (energy in kcal)**
Cucumber[a]	0.16	32g (5)	50g (8)	80g (13)	127g (20)	202g (32)	320g (51)
Carrot[a]	0.42	32g (13)	50g (21)	80g (34)	127g (53)	202g (85)	320g (134)
Gala Apple[a]	0.53	32g (17)	50g (27)	80g (42)	127g (67)	202g (107)	320g (170)
White Grapes[a]	0.66	32g (21)	50g (33)	80g (53)	127g (84)	202g (133)	320g (211)
White Toast[b] (Hovis ©)[b]	2.56	16g (41)	25g (64)	40g (102)	64g (164)	101g (259)	160g (410)
Swiss Roll[b] (Strawberry & cream, Tesco)	3.64	13g (47)	20g (73)	32g (116)	51g (186)	81g (295)	128g (466)
Cereal[b] (Cornflakes, Kellogg's ™, ®, ©)	3.78	12g (45)	19g (72)	30g (113)	48g (181)	76g (287)	120g (454)
Chocolate biscuit[b] (Digestives, McVities ®)	4.95	14g (69)	22g (109)	35g (173)	56g (277)	88g (436)	140g (693)
Salted crisps [b](Walkers ©)	5.26	10g (53)	16g (84)	25g (132)	40g (210)	63g (331)	100g (526)
Mini milk chocolate buttons[b] (Mondelez ©)	5.35	11g (59)	18g (96)	28g (150)	45g (241)	71g (380)	112g (599)

[a] LED, [b]HED (Albar et al., 2014), * recommended amount (WHO, 2016)

Display of food

Each snack food item was removed from its original packaging, pre-weighed to the nearest gram and photographed in the centre of a plain white plate (23cm diameter) or bowl (18.3cm diameter) (Foster, Hawkins, Simpson, & Adamson, 2014; Lewis et al., 2015) (Appendix 6). Each photograph was taken in a specialist media suite, under constant lighting using a digital camera. A knife and fork were placed next to the plate/ bowl to act as a size cue. The camera was mounted on a tripod at a 45-degree angle, 60cm above and 60cm horizontally away from the centre of the bowl or plate to improve consistency between stimuli (Lee et al., 2012). A paper template was created to specify where the bowl or plate should be placed and was fixed to the surface to ensure optimal visibility (Nicklas et al., 2012). The camera was positioned at the same angle and distance away from each food item to ensure the apparent sizes of all food items remained constant across the stimuli (Nicklas et al., 2013).

Each snack food was photographed in six portion sizes based on the log scale developed. The stimuli were presented in a vertical line from smallest to largest for all foods presented. This presentation was chosen as it is the most suitable display for survey completion on a mobile device, allowing participants to scroll through the stimuli in a normal fashion.

Caregiver portion size

Caregivers reported the size of each snack they would serve themselves by selecting the portion size image online that most closely resembled the usual amount they would serve themselves. Self-served caregiver portion size was then used as a predictor variable for the amount that the caregiver would serve their child.

Food Liking and hunger

Snack food liking and caregiver current hunger were assessed online using 100mm visual analogue scales, with left to right anchors indicating 'not at all' on the left and 'extremely' on the right (Brunstrom et al., 2008; Lewis et al., 2015). Caregivers reported snack food liking for themselves and their child e.g. *Please rate how much your child likes the following food items from 0 (not at all) to 10 (extremely)'*. For food liking, an additional response was provided for food items that had not been consumed before. Liking and hunger were included as predictors in the model since parents have been reported to respond to their children's food preferences and appetite (Herman et al., 2012).

Frequency of consumption

In the online survey, caregivers were required to indicate how often they and their child usually consume each snack item using the scale derived from a Food Frequency Questionnaire (FFQ) (Hammond et al., 1993). For each snack item, participants selected either "Never", "once a month", "once a fortnight", "once a week", "6 days a week" or "every day".

Parent and child characteristics

Several measures of children's eating traits and parental feeding practices were included in the online survey: one scale from the Child Feeding Questionnaire (CFQ) (Birch et al., 2001) (Parental responsibility); three scales from the Comprehensive Feeding Practices Questionnaire (CFPQ) (Musher-Eizenman & Holub, 2007) (restriction for health, restriction for weight control and use of pressure); two scales from the Child Eating Behaviour Questionnaire (CEBQ) (Wardle et al., 2001) (Food responsiveness and Satiety responsiveness) and the adapted 6-item Child Food Neophobia scale for use in preschool children (CFNS) (Pliner, 1994). Caregivers also reported time spent watching television or playing video games in hours per week, as a proxy for caregiver and child sedentariness (Santaliestra-Pasías et al., 2018). Demographic variables including, caregiver age (years); self-reported height (cm) and weight (kg) (converted to BMI kg/m^2); relationship to child; educational attainment; employment status; ethnicity; income; deprivation score (based on postcode, (Ministry of Housing, 2015)); child age (months) , sex (n= 131[1]) and parental reported child height (cm) and weight (kg) (BMI z-score were calculated using the WHO anthropometric calculator http://www.who.int/childgrowth/software/en/) were also included as potential predictors.

Data analysis

[1] Data on child sex was collected from 131 participants due to this variable being missing from the early data collection period

All quantitative analyses were carried out using STATA (StataIC 15 (64-bit)). Responses for the LED snacks were combined by calculating the mean of the four LED portion sizes selected. Similarly, responses for all HED snacks were combined by calculating the mean of the six HED portion sizes selected. Data are presented as mean (±SD), percentages, odds ratios and confidence intervals for LED and HED foods. Significance was established at $p < 0.05$.

Chi squared tests were run to identify if there was an association between portion size selection and snack energy density, for children and adults. To explore differences between the characteristics of caregivers who selected small versus large portion sizes, caregiver characteristics were compared using one-way ANOVA with three factors; smaller than recommended amounts, in line with recommended amounts and larger than recommended amounts. Caregiver characteristics included: caregiver food liking, caregiver frequency of consumption, caregiver BMI and caregiver food portioning practices (monitoring, food as reward and pressure to eat). Where significance was detected, post hocs tests were run using the Bonferroni correction. Pearson's chi square test were used to explore differences between characteristics of caregivers who selected small versus large portion sizes, whereby the characteristics were categorical: educational attainments and annual household income.

A multinomial logistic regression with robust standard errors (clustered at the participant level) was conducted to identify predictors of amounts caregivers selected for their child according to whether these were larger or smaller than recommended amounts. Next, subgroup analyses were conducted based on snack energy density (LED and HED). All variables were input into the model and removed individually using the backward step elimination method (Field, 2009). The final model contained only the variables that significantly increased the odds of selecting a small or large portion size compared to the recommended portion size. The recommended portion size (More & Emmett, 2015; WHO, 2019) was assigned as the comparative model; therefore results are presented as the odds of selecting larger or smaller portion sizes compared to the recommended portion size. Responses regarding snack items that had not previously been consumed were recorded as missing data and not included in the analysis (Fildes et al., 2014). Outliers, as identified using the *extremes* function, were also identified and checked for typographical error e.g. decimal point is misplaced. Typographical errors were corrected and values that were identified as substantially different from other observations were removed from the analysis to reduce the likelihood of distorting estimates of regression coefficients (Williams, 2016).

As part of a sensitivity analysis, missing (at random) (Bhaskaran & Smeeth, 2014) survey responses (<10%) from 11 demographic variables (child age, child BMI z-score, child screen time, adult age, adult BMI, adult screen time, hunger, education, employment, income and deprivation), were imputed (n = 50) using the multiple imputation method in STATA. The *mi impute chained* function was used with *regress*, *ologit* and *mlogit* for continuous, ordered categorical and unordered categorical variables respectively. Data was pooled using Rubin's rules (Rubio, 1987) and the parameter standard errors combined using the mi estimate command. This method was repeated for each subgroup analysis and the Wald statistic was used to identify which predictor to remove at each stage. The findings of the sensitivity analysis (data not shown) corresponded with the initial analysis therefore findings from the initial analysis are presented.

6.1.3 Results

Participant characteristics

A total of 930 caregivers consented to participate in the online survey, of which 232 (25%) dropped out part way through survey completion whilst 698 (75%) completed the online survey in its entireity. Seventeen participants (2%) were removed due to outliers and 22 participants (3%) were removed due to missing at random data resulting in a total of 659 caregivers. Participant were caregivers (611 mothers, 37 fathers, 4 aunts, 3 foster carers, 2 grandmothers and 2 undeclared) of preschool aged children with a mean age of 34.2±4.7 years. Most caregivers had completed high school education (95% ≥ A-level or equivalents), were employed (82%), white British (87%) from England (99%), and on average classified as overweight (M = 25.3±5.4 kg·m^2). Three participants were from Scotland and two were from Wales. According to the index of multiple deprivation, caregivers were from diverse socioeconomic backgrounds; 39% residing in one of the 50% most deprived areas in the UK (Ministry of Housing, 2015) with 26% of caregivers earning below the average household income for 2017 (ASHE, 2017). Children had a mean age of 35.9±9.2 months and on average were of a normal body weight (BMI centile 57.9±32.0, z score 0.3±1.3). Of those who reported child gender (n=131), 53% were female.

Portion size selection; smaller than, in line or larger than recommendations

Chi squared tests were run to identify if there were associations between portion size selection and the energy density of the snack on offer. A significant association between child portion size selection and snack energy density was revealed, with more caregivers selecting LED snacks in line with recommendations for preschool children compared to HED snacks ($x^2(2) = 621.79$, $p < 0.001$) (Table 7). Similarly, the results demonstrated a significant association between caregiver portion size selection and snack energy density, $x^2(2) = 31.67$, $p < 0.001$; in contrast to child portion size selection more caregivers selected HED snacks in line with recommendations for adults compared to LED snacks (Table 7).

Table 7: Percentages of caregivers who selected LED and HED snack portion sizes in line, smaller or larger than recommended amounts for preschool children and adult

	Child portion size	**Adult portion size**	**Child portion size**	**Adult portion size**
	LED (n=659)		HED (n=659)	
Smaller than recommended	105 (16%)	205 (31%)	303 (46%)	198 (30%)
In line with recommended	271 (41%)	237 (36%)	171 (26%)	277 (42%)
Larger than recommended	283 (43%)	217 (33%)	185 (28%)	184 (28%)

LED snacks

ANOVA revealed significant differences in portion size selection based on caregiver food liking ($F(2, 2633) = 13.00$, $p < 0.001$), and caregiver frequency of consumption ($F(2, 2633) = 5.30$, $p = 0.005$) (Table 8). Post hoc tests revealed that caregivers who selected a small LED snack for their children reported a significantly lower food liking score compared to caregivers who selected LED snacks in line or larger than portion size recommendations ($p < 0.001$). Caregivers who selected LED snacks in line with portion size recommendations reported significantly lower frequency of consumption ($p = 0.01$) compared to caregivers who selected LED snacks in portion sizes larger than recommended.

HED snacks

ANOVA revealed significant differences in portion size selection based on caregiver BMI ($F(2, 3357) = 11.46$, $p < 0.001$), monitoring ($F(2, 3951) = 30.56$, $p < 0.001$), food as a reward ($F(2, 3951) = 31.77$, $p < 0.001$), restriction for health ($F(2, 3951) = 5.02$, $p = 0.007$), pressure to eat ($F(2, 3951) = 18.74$, $p < 0.001$), caregiver food liking ($F(2, 3951) = 38.38$, $p < 0.001$), caregiver frequency of consumption ($F(2, 3951) = 24.47$, $p = 0.001$), educational qualifications ($x^2(10) = 70.48$, $p < 0.001$) and annual household income ($x^2(8) = 42.01$, $p < 0.001$) (Table 8).

Post hoc tests revealed that caregivers who selected small portion sizes of HED snacks for their children reported significantly lower food as reward ($p < 0.001$), pressure to eat ($p < 0.05$), caregiver BMI ($p < 0.01$) and caregiver food liking ($p < 0.001$) compared to caregivers who selected HED snack in line or larger than recommended amounts. In contrast, caregiver's who selected small portion sizes of HED snacks for their children reported significantly higher monitoring scores compared to caregivers who selected HED snacks in line ($p < 0.001$) or larger ($p < 0.001$) than recommended amounts. Furthermore, caregiver's who selected small portion sizes of HED snacks reported significantly lower frequency of consumption ($p < 0.001$) and significantly more educational qualifications ($p < 0.001$) and a higher annual household income ($p < 0.001$) in comparison to caregivers who selected HED snacks larger than recommended amounts.

Table 8: Characteristics of caregivers selecting portion sizes smaller, larger or in line with recommendations for preschool children

	Smaller than recommended	**In line with recommended**	**Larger than recommended**
LED			
Monitoring	4.08±0.73	4.03±0.78	3.99±0.79
Food as Reward	2.59±1.18	2.50±1.16	2.60±1.18
Pressure to eat	2.80±0.98	2.70±0.99	2.76±1.01
Adult BMI	25.14±5.24	25.46±5.64	25.21±5.22
Adult Liking	7.03±2.87*#	7.62±2.50	7.75±2.38
Adult frequency	2.94±4.21	2.98±2.92	3.42±3.77*
Education	83% ≥ A-levels	84% ≥ A-levels	82% ≥ A-levels
Household income	23% ≤ £30,000 per annum	27% ≤ £30,000 per annum	26% ≤ £30,000 per annum
Restriction for Health	3.66±0.85	3.65±0.88	3.70±0.87
HED			
Monitoring	4.12±0.73*#	4.00±0.79	3.89±0.83*
Food as Reward	2.40±1.15*#	2.64±1.18	2.73±1.17
Pressure to eat	2.65±1.00*#	2.75±0.98	2.88±1.00*
Adult BMI	24.83±5.19*#	25.59±5.70	25.81±5.38
Adult Liking	6.44±2.93*#	7.29±2.75	7.17±2.81
Adult FFQ	1.24±2.11#	1.18±1.74	1.73±2.32*
Education	87% ≥ A-levels#	84% ≥ A-levels	76% ≥ A-levels
Household income	22% ≤ £30,000 per annum#	26% ≤ £30,000 per annum	32% ≤ £30,000 per annum
Restriction for Health	3.64±0.87	3.66±0.88	3.74±0.87

*significantly different to recommended portion size

#significantly different to large portion size

Predictors of child portion size

Table 9 and 10 show the results of the multinomial logistic regression analyses for LED and HED snack foods respectively. Each row provides statistics associated with the variables that predict smaller than recommended portion size selection (LED = adult portion size, child liking and child satiety responsiveness; HED = adult portion size, child liking, child frequency of consumption and monitoring) and larger than recommended portion size selection for preschool children (LED = adult portion size, adult food liking, child food liking, child satiety responsiveness and pressure to eat; HED = adult portion size, child food liking, child frequency of consumption, child BMI z-score and pressure to eat).

LED snacks

Caregivers who selected LED snacks in line (OR = 2.60, 95% CI = 1.98 – 3.41, $p < 0.001$) or larger (OR = 13.45, 95% CI = 9.90 – 18.28, $p < 0.001$) than recommended portion sizes for themselves were 2.6 and 13.5 times more likely to select a large portion size for their child. Furthermore, the odds of caregivers serving large portion sizes of LED snacks were increased by 17% and 14% respectively, with increases in child food liking (OR = 1.17, 95% CI = 1.11 – 1.23, $p < 0.001$) and pressure to eat (OR = 1.14, 95% CI = 1.02 – 1.26, $p = 0.02$). In contrast, the odds of caregivers serving large portion sizes of LED snacks were reduced by 13% and 19% with increases in adult liking (OR = 0.87, 95% CI = 0.84 – 0.92, $p < 0.001$) and child satiety responsiveness (OR = 0.81, 95% CI = 0.68 – 0.95, $p = 0.01$).

HED Snacks

Caregivers who selected HED snacks in line (OR = 2.38, 95% CI = 1.80 – 3.15, $p < 0.001$) with recommended or larger (OR = 5.58, 95% CI = 4.12 – 7.53, $p < 0.001$) portion sizes for themselves were 2.4 and 5.6 times more likely to select a larger than recommended portion size for their child. The odds of caregivers serving larger than recommended portion sizes of HED snacks were increased by 22% with increases in child frequency of consumption (OR = 1.22, 95% CI = 1.16 – 1.28, $p < 0.001$), 3% with increased child BMI z-score (OR = 1.03, 95% CI = 1.00 – 1.06, $p = 0.02$) and 11% with increased pressure to eat (OR = 1.11, 95% CI = 1.01 – 1.21, $p = 0.03$). In contrast, the odds of caregivers serving smaller than recommended portion sizes of HED snacks were increased by 13%with increases in child frequency of consumption

(OR = 1.13, 95% CI = 1.08 – 1.18, $p < 0.001$). Increases in child food liking reduced the odds of selecting both smaller than recommended (OR = 0.86, CI = 0.83 – 0.90, $p < 0.001$) and larger than recommended portion sizes (OR = 0.95; CI = 0.91 – 0.99, $p < 0.05$).

Table 9. Variables that predict portion size selection of LED foods (n = 2620 [a])

Smaller than recommended		
	Odd Ratio	95% CI
Adult PS in line (vs small)	0.20	0.15 – 0.27
Adult PS above (vs small)	0.15	0.09 – 0.25
Child Liking[b]	0.83	0.79 – 0.88
Satiety Responsiveness	1.23	1.00 – 1.51
Larger than recommended		
Adult PS in line (vs small)	2.60	1.98 – 3.41
Adult PS above (vs small)	13.45	9.90 – 18.28
Adult Liking[b]	0.87	0.84 – 0.92
Child Liking[b]	1.17	1.11 – 1.23
Satiety Responsiveness	0.81	0.68 – 0.95
Pressure to eat	1.14	1.02 – 1.26

Reference category = recommended snack portion size

[a] Based on 659 participants and four individual LED food items

[b] Based on a visual analogue scale from 0 - 10

Table 10. Variables that predict portion size selection of HED foods (n =3399[a])

	Odds Ratio	95% CI
Smaller than recommended		
Adult PS in line (vs small)	0.51	0.42 – 0.63
Adult PS above (vs small)	0.31	0.24 – 0.39
Child Liking[b]	0.86	0.83 – 0.90
Child frequency of consumption[c]	1.13	1.08 – 1.18
Monitoring	1.22	1.10 – 1.38
Larger than recommended		
Adult PS in line (vs small)	2.38	1.80 -3.15
Adult PS above (vs small)	5.58	4.12 – 7.53
Child Liking[b]	0.95	0.91 – 0.99
Child frequency of consumption[c]	1.22	1.16 – 1.28
Child BMI	1.03	1.00 – 1.06
Pressure to eat	1.11	1.01 – 1.21

Reference category = recommended snack portion size

[a] Based on 659 participants and six individual HED food items

[b] Based on a visual analogue scale from 0 – 10

[c] Mean frequency of consumption per week based on the FFQ scale (Hammond et al., 1993)

6.1.4 Discussion

The primary aim was to investigate whether preschool children are served LED and HED snack food items in line with More and Emmett's portion size recommendations. The secondary aim was to examine potential factors that might predict caregivers serving LED and HED snacks smaller or larger than the recommended portion sizes for children. The results demonstrate that caregivers are more likely to serve portion sizes of LED snacks in line with and larger than the recommended amounts for children and themselves. Furthermore, caregivers were more likely to serve themselves and their child HED snacks in portion sizes in line with, or smaller than, the recommended amount. The results of the multinomial logistic regression demonstrate that caregiver portion size, reported child liking, pressure to eat, child satiety responsiveness, caregiver monitoring, child frequency of consumption and child BMI z-score were significant predictors of LED and HED child snack portion size selection.

Portion size selection

Overall, caregivers were reasonably accurate at selecting portion sizes in line with recommendations for adults and children (More & Emmett, 2015) thus demonstrating their ability to downsize portion sizes to match their preschool children's energy requirements. However, 31 and 16% of caregivers selected smaller than recommended portion sizes of LED snacks for themselves and their child respectively. Furthermore, almost a third of caregivers selected portion sizes of HED snacks up to four times the recommended amount in one serving, for themselves and their child. These findings are consistent with previous UK survey results (Infant and Toddler Forum, 2014) demonstrating that preschool children are being served packaged snacks, in their entirety, which is equivalent to three times the weekly recommended amount. Similarly, adults are typically consuming larger amounts than on pack portion size suggestions which might be due to "portion distortion" whereby increasing portion sizes are setting the norm for what is perceived to be an acceptable quantity of food to consume (Rippin, Hutchinson, Jewell, Breda, & Cade, 2019). Consumption of large portion sizes has demonstrated a sustained increase in energy intake over a 5 day period in children aged 3-5 years (Smethers et al., 2019) and over 11days in adults (Rolls, Roe, & Meengs, 2007) suggesting that exposure to large portion sizes might contribute towards a positive energy balance and thus weight gain.

Exploration of caregiver characteristics revealed that caregivers who selected large portion sizes of HED snacks compared to those who selected smaller than recommended portion sizes were characterised by their slightly higher BMI, a higher percentage (32 versus 22%) of participants with a household income below the national average (approximately £30,000) (Office for National Statistics, 2018) and were moderately educationally disadvantaged; 76% versus 87% had UK advanced-level educational attainments. Although these differences are small and none of these factors were significant predictors of portion size selection; it is possible that these factors were not significant predictors due to the relatively small number of participants of who were classified as having a low household income, and thus warrants further investigation. Furthermore, caregivers who selected larger than recommended HED snacks for their child reported higher overt, controlling feeding practices, such as restriction for health and pressure to eat compared to caregivers selecting smaller than recommended HED portion sizes. Economic deprivation and accessibility of healthy foods are related to health and weight status (Drewnowski, 2009). For families living in deprivation, meeting the UK government's nutritional recommendations would require families to spend 42% of their after-housing disposable income (Scott, Sutherland, & Taylor, 2018). Thus, low income families often opt for energy dense foods which can displace consumption of more expensive foods, such as FV that are rich in protective nutrients (Andrieu, Darmon, & Drewnowski, 2006). Furthermore, as highlighted in the present study, caregivers from low income households have a higher tendency to serve their preschool children LED snacks in portion sizes smaller than recommended. Differences in dietary intake between socioeconomic groups has been found to contribute towards exacerbating health inequalities during infancy (Marmot & Bell, 2012), thus highlighting the need to develop more effective and accessible interventions targeted towards reducing food-related health inequalities.

Predictor Variables

Caregiver portion size was positively associated with child snack portion size, demonstrating that for all snacks, parents tend to judge appropriate portion sizes for their child, using online images, related to their own self-selected portion size. This finding extends previous US-based research that identified a positive association between adult and child portion size at an evening meal (Johnson et al., 2014). Positive associations between child and adult portion size may be due to social norms (Robinson & Kersbergen, 2018), food availability (Hearn et al., 1998; Rasmussen et al., 2006), parental food liking (Johnson et al., 2014) or parental hunger (Stromberg & Janicke, 2016). For example, maternal feelings of hunger have been demonstrated to influence maternal perceptions of their child's hunger and thus the total amount of calories mothers served their children at a buffet style meal, regardless of their child's actual hunger levels (Stromberg & Janicke, 2016).

Reported food liking is thought to reflect an individual's motivation to consume a food (Mela & Rogers, 1998), however previous work has demonstrated no association between food liking and actual food consumption in adults (Stubbs & Whybrow, 2004; Wilkinson et al., 2012). In the present study, increased child food liking was related to reduced odds of both smaller and larger than recommended portion size selections meaning that caregivers are highly likely to serve their child snacks in line with recommended portion sizes. Qualitative research suggests that caregivers consider their child's food preferences and requests when preparing meals by responding to their child's individual differences (Croker et al., 2009; Herman et al., 2012; Johnson et al., 2015). Caregivers believe adjustments to portion size should be made according to nutritional content, such that HED foods should be limited (Croker et al., 2009). Therefore, one possible explanation as to why some caregivers are reluctant to offer large portion sizes of HED snacks, despite them being highly liked, is that caregivers choose to prioritize their child's health and nutritional intake over their child's food preferences.

Related to child liking is frequency of consumption, since foods that are well-liked by children are generally offered more frequently (Johnson et al., 2015). Frequency of consumption was not a significant predictor of LED snack portion size. However, increased frequency of consumption predicted increased odds of selecting both smaller and larger than recommended portion sizes of HED snack foods. For example, caregivers who report that their child frequently consumes HED snacks might offer this snack in smaller than recommended portions sizes, possibly in an attempt to monitor their child's snack intake. Conversely, other caregivers are demonstrating more permissive feeding practices and offering frequent and large portions of HED snacks, a method previously described to control preschool children's behaviour (Infant and Toddler Forum, 2014).

Child BMI z-score also predicted larger than recommended portion sizes of HED snacks, so the higher the child BMI z-score the more likely their caregiver was to select a larger than recommended portion size of HED snacks. These findings support previous literature demonstrating a positive association between portion size of HED snacks and BMI (Huang, Howarth, Lin, Roberts, & McCrory, 2004; Kachurak et al., 2018; Lioret, Volatier, Lafay, Touvier, & Maire, 2009; Piernas & Popkin, 2010). It is possible that caregivers serve children with a higher BMI z-score larger snack food portion sizes to meet their greater perceived energy needs; however this warrants further investigation as the direction of causality remains unknown.

Monitoring food intake was a significant predictor of smaller than recommended portion sizes of HED snacks. Parental monitoring has been associated with reduced purchases of HED foods (Hughner & Maher, 2006) and increased offerings of FV (Haszard, Skidmore, Williams, & Taylor, 2015). Monitoring intake might be a successful strategy to limit overconsumption of HED snacks. In contrast, pressure to eat was associated with increased odds of selecting large portion sizes of HED and LED snacks, suggesting that caregiver drive to promote consumption extends beyond meal times. Pressure to eat is often demonstrated in circumstances where caregivers want their child to eat a certain type of food (usually fruits and vegetables) or an increased portion size (Scaglioni, Salvioni, & Galimberti, 2008). However, the literature consistently demonstrates counterproductive effects of pressure to eat, normally in relation to reduced intake (Fisher & Birch, 2002; Galloway et al., 2005). Instead, combining modelling and repeated exposure with rewards appear to be more successful strategies to encourage consumption of F&V (Holley, Haycraft, & Farrow, 2018).

Satiety responsiveness, associated with feelings of fullness and good internal self-regulation (Benelam, 2009), was associated with increased odds of selecting smaller than recommended portion sizes of LED snacks, as well as reduced odds of selecting larger than recommended portion sizes of LED snacks. This suggests that children scoring high on satiety responsiveness have an increased likelihood of being served portion sizes smaller, or in line, with recommendations. Caregivers learn from past feeding experiences and respond to their child's appetite to provide portion sizes in line with the quantity they believe their child will accept and consume at meal times (Croker et al., 2009; Herman et al., 2012; Johnson et al., 2015; Sherry et al., 2004). For example, in a qualitative study exploring the goals and challenges of feeding preschool children, mothers stated that they determine mealtime portions by honouring and valuing their child's food preferences and trust their child to stop consuming a meal when full (Herman et al., 2012). Similar portioning practices may be apparent when LED snacks are on offer as caregivers may be conscious of food waste and the associated financial costs (Reale et al., 2018).

Strengths/ limitations

The present study primarily represents maternal portioning practices since respondents were predominantly female (94%) thus exemplifying the dominant role female caregivers play in determining preschool children's portion sizes (Brown & Ogden, 2004) or alternatively, the increased likelihood of female research participation. The chosen research design allowed for multiple snack foods to be assessed within a single test session, online. The ease of participation increased statistical power meaning the findings could be used to understand the variety of factors that influence snack portion size selection.

Despite the advantages, screen based measures may misinform actual portion size selection and consumption, when differences between perceived and actual food properties exist (Wilkinson et al., 2012). For example, snack food items were removed from their packaging and provided on a plate/ bowl, thus observed as 2D objects without exposure to sensory characteristics, which may influence snack food selection and consumption e.g. (Buckland et al., 2013; McCrickerd & Forde, 2016). Furthermore, an even number of snack food images were presented to reduce a central tendency effect, however images were displayed in order of size, from smallest to largest, which may have influenced portion size selection.

The present study examined the snack portion size that caregivers select for their young children without addressing possible second servings or snack variety. Research suggests that some mothers choose to offer a small portion size in the first instance, knowing that their child will ask, and thus receive, more (Croker et al., 2009). Therefore, it is possible that the portion sizes selected in this online study may not reflect the entire quantity children receive at one snack occasion. Furthermore, this study did not examine actual snack food liking or food intake thereby producing an unexpected result; a negative association between reported adult food liking and portion size selection. It is also important to note that portion sizes influence the quantity children consume (Disantis, Katherine I., Birch, Leann., Davey, Adam., Serrano, Elena., Zhang, Jun., Bruton, Yasmeen., and Fisher, 2013); however, simply serving a food item does not always guarantee its consumption (Holley, Haycraft, et al., 2018).

Data on child sex was only collected from 131 participants due to this variable being missing from the early data collection period. Of the sample, 53% of the participant population were female which is a good representation of the UK population, whereby 51% are female (Office for National Statistics, 2011). Moreover, a sensitivity analysis was carried out only on those data where sex data was available. Sex was not demonstrated to be a significant predictor in our study population.

6.1.5 Conclusion

Overall, in the current sample of UK-based caregivers, most selected portion sizes for HED and LED snacks close to recommendations. However, 16 and 31 % of the sample selected smaller than recommended portions sizes of LED snacks for their child and themselves respectively, and 28% selected larger than recommended portion sizes of HED snack foods for themselves and their children. Significant predictors of portion size include; factors associated with adult eating behaviour, primarily caregiver portion size selection; child characteristics including reported child liking, child satiety responsiveness, child BMI z-score, and parental feeding practices such as pressure to eat, caregiver monitoring and child frequency of consumption. These findings suggest that interventions could focus on increasing portion sizes of LED snack foods and reducing portion sizes of HED snack foods, especially in caregivers, since this will influence choices for children.

6.2 Study 2: Maternal decisions on portion size and portion control strategies for snacks in preschool children

Study 2 was conducted in a naturalistic environment to objectively measure consumption and observe caregiver response to children's request for additional or alternative snacks. Study 2 also addressed some of the limitations highlighted in study 1. Furthermore, the study replicated the imaginary scenario provided in the online survey so portion size selections online could be compared to portion sizes served in the home environment. This chapter is presented in the format of a published paper that is in preparation for submission to a scientific journal.

6.2.1 Background

Children's nutritional intake is responsive to the amount of food served (Mrdjenovic & Levitsky, 2005), such that the more food children are offered the more they will consume (Fisher et al., 2007a; Fisher & Kral, 2008; Mathias et al., 2012). This is known as the PSE which has been found to be robust and reliable for up to 11 days, without compensatory behaviours in adults (Rolls, Roe, & Meengs, 2007) and up to 5 days in children aged 3- 5 years (Smethers et al., 2019). Caregivers take responsibility in determining appropriate food portion sizes for their young children, thus caregivers may inadvertently encourage over consumption by providing larger than age appropriate portion sizes for meal items (Johnson et al., 2014). USA-based research suggests that mothers have definite ideas related to food portion sizes for children at meal times to ensure satiation is achieved (Johnson et al., 2015). Most mothers describe relying on previous experiences of feeding their child and thus learn to offer meals in quantities they believe their child will consume (Herman et al., 2012; Johnson et al., 2015; Lindsay, Sussner, Greaney, & Peterson, 2011). In the UK, there is limited research exploring caregiver's portion size decisions however influences on food choices are well documented (Ohly et al., 2013a; Ohly et al., 2013b; Potter et al., 2018). In one study, questionnaire responses from 261 caregivers revealed a wide range of factors influencing parental food choices, and these were associated with educational attainment (Ohly et al., 2013a). For example, food liking, cost and familiarity were important considerations made by parents with fewer education qualifications compared to more highly educated parents who were influenced somewhat more by a food's quality and freshness.

Between meals, British (Kerr, McCrorie, Rennie, Wallace, & Livingstone, 2010) and American (Piernas & Popkin, 2010) children consume approximately 21% of their TDEI from HED snacks. Frequent consumption of HED snacks is related to an increased body weight and risk of associated disease (Kachurak et al., 2018). Snack foods have been described in relation to meals as smaller and containing less items (Younginer et al., 2016). One study in the USA explored low-income mother's awareness and use of portion control strategies when serving pre-school children snack foods (Blake et al., 2015b). The study found that very few parents regularly use measurements or expert recommendations. Instead, caregivers rely on situational variables such as time of day, proximity to next eating occasion and child hunger to determine an appropriate portion size to serve. Several portion control strategies were also discussed by parents including the use of bowl sizes, small containers and hand size. However, over half of the sample were unable to articulate how they determined an appropriate child snack portion size to serve suggesting that portioning practices may be somewhat automatic rather than a deliberate process, or difficult to verbalise (Blake et al., 2015).

Mothers have unique perspectives and experiences feeding their children and these may not be unveiled using qualitative methods that rely on memory e.g. semi-structured interviews (Johnson et al., 2015). The think aloud method invites participants to describe their actions and feelings during execution of a task, and provides the opportunity for more thoughtful considerations of feeding behaviours that mothers often struggle or may not verbalise (Johnson et al., 2015). Therefore, adopting the think aloud method may stimulate thoughts and actions to provide a deeper understanding of mother's decisional processes, motivations and use of portion size recommendations to inform the development of interventions that seek to improve parental portioning practices of HED snack foods.

A recent systematic review (Kairey et al., 2018) revealed that parental portioning practices are influenced by caregiver portion size, perceived child hunger, body size and employment status. More importantly the review identified that no study has yet to explore the parental portioning practices adopted by UK caregivers in the home environment, with a specific focus on snack foods for preschool children. Therefore, the aim of the study was to explore UK mother's decisional processes and snack portion control strategies using the think aloud method during snack preparation in the home environment. The primary aim was to explore what factors influence mothers' decisions and judgements about a suitable snack portion size to serve preschool children and to further explore what portion control methods mothers adopt in the home environment, using the think aloud method. The secondary aim was to compare the portion sizes mothers served in the home environment to a) the portion size consumed by the child, b) to recommended amounts and c) to portion sizes selected in an online study (data from the online study presented in chapter 6.1). The third aim was to explore associations between maternal and child portion size.

6.2.2 Methods

Participants and recruitment

Mothers (n= 40) of children aged 2 to 4 years old were recruited to take part in a home-based study. Half of the sample were recruited via university emailing lists, social media advertisements (e.g. Facebook, Twitter) and within toddler groups whilst the remaining 20 participants (from Sheffield (UK) and surrounding areas) were recruited on completion of the previous online study (results presented in Chapter 6.1). Inclusion criteria: caregivers who were ≥ 18 years old and responsible for the food their child consumed in the home environment. Exclusion criteria included those with food allergies. The study was reviewed and approved by the School of Health and Related Research Ethics committee at the University of Sheffield (#011913). Mothers were compensated for their time with a £10 high street voucher and provided with all the snack items required for study participation.

Design

The study was carried out in the participant's home and took place 2.5 hours following lunch. This was carried out to ensure ecological validity for a typical snack time and to replicate the scenario provided in the previous chapter (*"It is 2:30pm, your child/ you had a sandwich 2.5 hours ago for lunch and they/ you are now hungry. Please select which snack you would provide*") (results presented in chapter 6.1). The order of studies was counterbalanced with 20 participants completing the present study first followed by the online study, and vice versa. In the present study, the qualitative component included a think aloud task and a semi-structured interview to explore decisions surrounding food portion sizes. The think aloud method produces more reliable data from participants than conducting interviews alone (Kuusela & Paul, 2000), and the combined method has been found to stimulate thoughts (Ericsson & Simon, 1980) and unveil feeding behaviours that are rarely verbalised (Johnson et al., 2015). The quantitative component included an objective measurement of snack portion size served in grams and these were compared to More and Emmett's (More & Emmett, 2015) recommended portion sizes.

Procedure

Prior to taking part in the study participants were given information that they were required to consume a sandwich for lunch and to also offer the same lunch to their child in attempt to standardize hunger levels across participants. Upon arrival at participant's houses a check was carried out to verify what participants had consumed for lunch and the rough time of consumption. 100% of participants complied with the requests made and no data/ participants were excluded from the analysis. This was carried out to ensure ecological validity for a typical snack time and to replicate the scenario provided in the previous chapter.

Mothers were provided with 5 commonly consumed snack items (Table 11) one at a time, and they were invited to verbalise their actions and thoughts whilst preparing and plating each snack item for their child as they normally would. For example, "*I'd like you to show me how you prepare your child's snack. I want you to imagine that your child has asked for a snack, they are hungry, having not eaten for two and a half hours following lunch. This is where we will use the think-aloud method. I would like you to explain what you are doing and what you are thinking about."* Mothers were also asked to prepare each snack for themselves, and the order was counterbalanced in order to avoid any order effects. To reduce priming effects and emphasise that mothers should consider how much of each individual snack they would serve in isolation, rather than collectively, all snacks remained out of participant view in an opaque bag. Once each snack had been served onto the plate or bowl, it was immediately placed into a pre-labelled opaque bag and removed from view.

Following the think aloud part of the study mothers then chose or gave their child permission to choose one snack item to consume. In line with previous research (Looney and Raynor, 2011), children were given access to the snack for 30 minutes, before it was removed, to maintain consistency across participants and prevent grazing. If the child requested more, the mother was informed to respond in a normal fashion. Whilst the child was consuming the served snack, follow up questions were asked to the mother in the style of a semi-structured interview to elicit further information (Ritchie, Lewis, McNaughton Nicholls, & Ormston, 2014) and to prompt description of underlying decisions and motivations for serving the chosen snack portion sizes. The think aloud task and semi-structured interviews were audio recorded. At all times the prepared snacks and plate/ bowl were in view for reference. Interviews lasted on average 20 minutes. On completion of the interview, the child's height (Leicester height measure: child growth foundation) and weight (Marsden M-420W portable floor scale) were measured and snacks were weighed to the nearest gram (Salter Essentials Bowl Scale). The researcher completed field notes before, during and after the home visit.

Table 11: Nutritional value of each snack item (per 100g serving)

	Energy (kcal/g)	**Protein (g)**	**Total Fat (g)**	**Saturated Fat (g)**	**Carbohydrate (g)**	**Sugar (g)**	**Salt (g)**
Carrot[a]	0.4	0.6	0.3	0.1	7.9	7.4	<0.01
White Grapes[a]	0.7	0.4	0.1	<0.01	15.4	15.4	<0.001
Cereal [b] (Cornflakes, Kellogg's ™, ®, ©)	3.8	7.0	0.9	0.2	84.0	8.0	1.1
Chocolate biscuit (Digestives, McVities ®)	5.0	6.7	23.6	12.4	62.2	29.5	1.0
Ready salted crisps [b](Walkers ©)	5.3	6.1	31.9	2.6	51.5	0.4	1.4

[a]LED [b]HED as defined by Albar et al. (Albar et al., 2014)

Materials and measures

Development of the interview guide

Sample questions relevant to the research questions were devised (Appendix 5). The questions were all open-ended to assist participants in providing detailed responses. Prompts and follow-up questions were developed to elicit more detail where necessary. The interview guide was edited during pilot interviews, in alignment with Bryman's development of a finalised interview guide (Bryman, 2012). A few questions were re-worded for clarity and an additional question, regarding availability of smaller packaged snacks, was added. The final interview guide consisted of 20 open-ended questions.

Snack foods

One snack item from each snack food group, as defined by More and Emmett (More & Emmett, 2015) was selected to ensure inclusion of sweet and savoury, unit and amorphous and HED and LED snacks. The selected snack items (Table 11) were identified as being familiar and regularly consumed by children (NDNS, 2018) and adults (Albar et al., 2014; NDNS, 2018), readily available in supermarkets, would not get damaged during transportation to the study site and would not require immediate consumption after being placed into a food bag, to prevent food spoilage and waste. Snack items were presented in quantities four times the recommended amount to prevent a ceiling effect.

Portion size selection and consumption

Each snack food item was removed from its original packaging, pre-weighed to the nearest gram (Salter Essential Bowl Scales) and placed into an opaque zip lock bag to preserve freshness and maintain palatability. All snack items served by the mother for the mother and the child were weighed to the nearest gram, as a measure of portion size selection.

All snack items consumed by the child, including any additional servings, were weighed before and after consumption to the nearest gram (Salter Essential Bowl Scales). The proportion of each snack consumed by the child was recorded to provide insight into the appropriateness of the portion size served to the child and to observe how mothers respond to their child's food refusal or requests for additional/

alternative snacks. Further information regarding the snack chooser (mother or child), the snack chosen (carrot, grapes, cereal, chocolate coated biscuit, salted potato chips), the number of requests for additional servings made by the child and additional servings provided to the child (snack type and amount) were also documented.

Anthropometrics

Each child's height (cm) (Leicester height measure: child growth foundation) and weight (kg) (Marsden M-420W portable floor scale) was measured. Weight-for-height z-scores were calculated using the WHO anthropometric calculator (http://www.who.int/childgrowth/software/en/).

Data analysis

Qualitative

The qualitative data (think aloud task and semi-structured interview) were combined as demonstrated previously by Johnson et al., (Johnson et al., 2015), and transcribed verbatim. Transcripts were imported into NVivo for thematic analysis. Thematic analysis was chosen as it emphasises, records and examines patterns within the data following six phases to reveal how each theme is related to the narrative as a whole (Braun & Clarke, 2006). The analysis began with data familiarisation; transcripts were read and re-read at least once to achieve immersion in the data and to begin to identify possible patterns (Rohleder & Lyons, 2014). Initial codes were formed by clustering patterns in words and phrases and the data was coded inclusively with surrounding words to ensure context was maintained during the analysis (Miles & Huberman, 1994). Codes were then grouped into themes using an inductive approach to ensure themes were connected to the data as opposed to viewpoints or interests of the researcher (Braun & Clarke, 2006). Sub-themes were also formed to provide structure and demonstrate hierarchy within themes. A thematic map reflecting the hierarchy of themes related to participant's speech during the think aloud task and interviews was created. A total of 10% of manuscripts were independently coded by a second reviewer (CK) and key themes were agreed. In the final phase, a description of the entire data set was written to provide a deeper understanding of participant's actions. Data extracts were chosen based on their relevance to the area of interest and were embedded within an analytical narrative to describe and support the outcome of the research question.

Quantitative

Quantitative data were entered into SPSS for analysis (IBM SPSS Statistics v22, Armonk, NY, USA). Portion sizes selected in the online survey were converted into grams and are presented as means (±SD) and ranges (Table 13). Amounts of snacks consumed (g) by children are also presented as means (±SD). Frequencies were explored to identify the number of children who were provided permission to choose their own snack, the percentage of children who consumed their snack in its entirety and the percentage of children who requested and received additional servings. Paired sample t-tests were also conducted to examine potential differences between the amounts of snacks served by mothers and the amount consumed by the child for LED and HED snacks respectively. Significance was established at $p < 0.05$.

The portion sizes served at home were compared to recommended portion sizes for each food using independent sample t-tests. Paired sample t-tests were also carried out to explore differences between portion size selections in the home environment and online, for both children and adults. Significance was established at $p < 0.05$. Furthermore, a Pearson correlation was conducted to explore the relationship between maternal and child portion size.

6.2.3 Results

Participant demographics

A total of 40 mother-child dyads completed the home-based study. Mothers had a mean age of 35.0± 4.5 years. Most mothers were educated to at least high school level (95% ≥ A-level or equivalents), employed (85%), white British (95%) and on average classified as marginally overweight ($M = 25.5 \pm 5.4$ kg.m^2). According to the index of multiple deprivation, caregivers were from diverse socioeconomic backgrounds (40% residing in one of the 50% most deprived neighbourhoods in the UK) (Ministry of Housing, 2015) with almost a quarter of caregivers earning below the average household income for 2017 (ASHE, 2017). Children had a mean age of 34.7±8.6 months, (62% male; n = 26) and on average were of a healthy weight (BMI centile = 82.2±17.3, z-score = 1.2±0.8).

Qualitative results

In depth discussions regarding the factors that influence mothers when serving themselves and their children snack foods occurred during the think aloud task and interviews. These were categorised into three themes: situational effects on portion size; portion control methods and awareness of portion size recommendations.

Theme 1 Situational effects on portion sizes

Several situational factors were revealed which were categorised into 4 subthemes (Table 12). Situational factors included proximity to the next or last meal occasion, attributes of the mother herself (including what she was served as a child), features of the foods (including how much that food is liked by the child) and child characteristics.

Features of the environment

When deciding upon a snack portion size to serve, mothers discussed how this varied significantly throughout the day based upon their child's intake thus far and proximity to the next meal occasion. When the snack offering was close to a meal, a smaller portion would be provided. Alternatively, if the child had missed a meal or had to wait a significant amount of time before the next eating occasion, then a larger portion would be served ("*Like today she didn't eat much at lunchtime so I probably would tend to give her a bigger snack", P19, daughter, 43 months).*

Other factors that vary throughout the day, such as children's activity levels, behaviour and hunger were also discussed in detail. Mothers felt their child required more food if they had been, or were about to be, physically active.

Factors within the immediate environment of the snack offering, such as food availability appeared to be largely influential in mother's decisional processes when determining an appropriate snack portion size to serve ("*sometimes I find, oh there's just three left so I'm like Oh, I may as well dish them out" P7, daughter, 42 months*). When limited quantities of food remained, a smaller portion would be provided.

Mothers identified observing other mothers feeding practices, and that of their own parents, and mirroring these when serving their child snack foods ("*More often I think I just judge based on maybe what my parents would have given me as a child or what I see other children having", P8, son, 29 months).*

Maternal motivations

Mothers were aware that sometimes their own hunger, food liking and portion size influenced the snack portion size they would serve to their child ("*I suppose it is often based on how much I think I might eat", P14, son, 47 months)*. For example, when hungry, a mother was more likely to provide their child a larger snack portion size as they assumed their child must also be hungry. Furthermore, many mothers discussed having a desired amount they wanted their child to consume ("*I do have it in my head that I want her to have had a certain amount in the day", P3, daughter, 45 months)*. This was often not based on recommendations but merely a quantity that they felt suitable for their child, possibly based on past consumption experiences.

Features of the food

Nutritional content (sugar, salt and fat) and perceived healthiness of snack items appeared to influence the portion size mothers serve. For example, food items that are perceived to be healthy were served in larger portions or *ad libitum*, to encourage healthy consumption ("*Generally if it's healthy I'll give her lots and lots. If its healthy stuff she can have as much as she likes", P18, daughter, 28 months).* Alternatively, foods containing larger quantities of sugar and salt were served in smaller portions to encourage heathy consumption and good dental health.

Mothers also considered ease of consumption and messiness of the food when deciding how much to provide. Foods such as raw carrot, that may be difficult, and thus take more time for a child to eat, were served in smaller portion sizes. Similarly, food that creates mess during consumption, such as chocolate biscuits, were served in smaller portions.

Features of the child

Child food liking and the amount mothers believed their child could consume appeared to influence the amount mothers were willing to serve to their child. A selection of mothers felt that their child would always eat the entire snack that was offered to them ("*I tend to give him snacks he likes; I expect he would eat all of it. I think snacks aren't something that you leave", P17, son, 41months)*. However, other mothers felt that their child may leave a small amount, especially if it was a novel or less liked item. Therefore, mothers provided small portion sizes or none at all, to prevent food waste, when a less-liked food was on offer ("*If I give him a snack and* *he doesn't like it, I'm probably not going to give it to him again", P17, son, 41 months).*

Similarly, mothers expressed relying upon interpretations of their child's momentary hunger and appetite to guide their decision regarding portion size, and they did not believe their child could over-eat ("*it depends how hungry she is. If she is hungry she's going to eat. If she's not hungry then she's not going to eat", P10, daughter, 30 months*).

In some cases, mothers would provide their child with the quantity their child requested and thus allowed their child to directly guide their decisions. In other cases, mothers identified a suitable portion size based on how much their child usually eats (*"I think just experience really because I've been putting things in her sandwich box most night and I just kind of know what she is going to eat", P11, daughter,39 months).* Alternatively, mothers expressed providing larger food portion sizes of HED snacks to control behaviour ("*if he finished off the crisps and wanted more, and it was going to lead to upset I'd definitely give him more*", *P20, son, 29 months).*

Theme 2 Methods used to control portion sizes served

Mothers discussed and also demonstrated a variety of methods to control the portion size that they offered to their child including: package/ unit or dishware size, subdividing larger portions into small portion sizes, sharing snacks between multiple children, offering an initial small portion size in anticipation that the child will request more or breaking units into multiple smaller items to create an illusion that more is being offered. These portion control methods were categorised into 4 subthemes (Table 12).

Package or dishware size

Most mothers discussed using package size as a cue for an appropriate portion size to serve ("*It's generally based on the packaging I think. It does influence you. So if we are out and about and there's a packet of crisps or biscuits or a smoothie or a yoghurt, I'll just think yeah that's fine. At home, I think you have more control don't you, so you can put it in a bowl", P35, son, 39 months)*. Package size acted as both the minimum and maximum amount mothers would offer to their child at any one time. Therefore, when children requested additional servings, mothers found it easier to say no and communicate portion size limits with their child (*"They're actually* *quite helpful (packaged snacks). I can say that is your snack, you can eat what's in there but then there is no more. I think for them as well they understand a bit more when they get to the bottom of the packet, they have all gone and that's it", P32, son, 31 months*).

Other mothers mentioned removing snacks from their original packaging and serving them on plates/bowls. Dishware size acted as a cue for mothers to determine how much to serve to their child independent of the type of food on offer. Some mothers preferred using dishware to packaging since they could visualise the quantity served to the child and be in full control of how much their child receives. This method was used for all food types e.g. LED and HED snacks. ("*See we've actually got a small plastic bowl that I would normally serve her from, so I use those as a way of judging things. It's funny actually I don't even think about it, I get the same bowl every time", P27, daughter, 45 months).*

Sharing snacks

Some mothers discussed sharing snacks between multiple children or themselves to ensure their child received a reduced portion size ("*If it was say a biscuit, I might kind of share one with her", P27, daughter, 45 months) ("Well it would usually be him and his brother so I would probably do this *breaks in half* and give half to him and half to his brother" (biscuit), P25, son, 35 months)*.

Subdividing larger portions

During the think aloud task mothers subdivided large portion sizes into smaller units before serving. This included chopping (grapes) or breaking an original larger unit (chocolate coated cookies) into one or multiple smaller units. When asked about this, mothers said this was a method used to make their child feel like he/she was receiving a larger quantity of food ("*We would cut these up for him obviously so that it looks like slightly more for him", P13, son, 25months)*.

Alternatively, mothers discussed setting minimum and maximum portion sizes that they would happily serve to their child at one snack occasion. Some would then choose to provide the minimum portion size from a larger serving in the first instance knowing that their child would request more. Often the child would receive a second serving but the total snack portion size would remain within their acceptable range set ("*I'd probably start with not that many crisps because she would probably ask for* *more. So, I'd probably go for a little handful but assume she would probably have some more", P27, daughter, 45 months*).

Unthinking, automatic processes

Despite the variety of portion control methods discussed/observed during the think aloud task and interviews, many mothers were unable to verbalise portion control methods used or give reason for the portion size that they served ("*I don't really think about it, I just kind of do it without thinking really", P9, son, 47 months).*

Theme 3 Awareness and use of portion size recommendations

Mothers reported confusion about portion size recommendations for preschool children. They discussed the nutritional information they were aware of and the sources of these. Barriers to following recommendations, as well as which agencies to trust for portion size guidance, were also discussed. The importance of ensuring information is from a trusted source, easily accessible and clear was mentioned (Table 12).

Confusion around portion size guidance for snack foods

Mothers mentioned receiving information regarding the types of food they should be offering to their young children and were aware of/or had used portion size guidelines for adults. However, most mothers were unaware, or simply did not know, if portion size guidelines for preschool children exist and believe that many other mothers feel this way ("*I'm sure that there are some (portion size guidelines) actually, no, I'm not. I don't know what they are", P1, son, 42months).*

Despite mothers being unaware of portion size recommendations for their children, when thinking about it, they presumed they were probably providing their children larger than recommended amounts and that packaged snacks are too large for preschool children. For those who were aware of portion size recommendations, they felt that in some cases, portion size recommendations are too small ("*I did look it up on the internet (portion size of broccoli) and I was really surprised how small it was actually", P16, son, 48months)*. Furthermore, mothers think portion size recommendations for preschool children are not easily accessible or well-advertised.

Trusted sources

Mothers reported that their primary source of information about solid food introduction had come from a health visitor. They reported that they had received information on complementary feeding but no portion size information was given. Mothers mentioned using online sources and social media groups to gain information, but again this information was focussed on complementary feeding ("*I remember years ago when you wean, you get a health visitor but I don't remember talking about portion sizes, I don't recall that", P14, son, 47 months).*

Mothers felt that adhering to recommendations would be difficult when their child is in the care of others (fathers and grandparents), who habitually provide larger portion sizes than themselves. However, despite this barrier, mothers expressed a desire to see portion size guidelines available for preschool children. They emphasised that guidelines must be clear, child-centred, realistic and from a trusted source. There was no preferred format for the information other than it being clear and easily available ("*I do think guidelines, they need to write them in an easy to understand way so you can maybe pin it to the fridge and it be simple and it would be easy", P18, daughter, 28months)*. Examples were provided such as online, in leaflet format or via a health professional. Mothers also felt that the government and food industry should reduce food advertisements to children and increase the availability of child friendly portion sizes. (*I don't really trust the portion sizes that are out there anyway. They are made by manufacturers. If the government thinks there's a problem with kids getting too much, eating too much rubbish then I think they do have a responsibility to at least educate the public (P14, son, 47months).*

Importance of packaging as a guide to portion size

Mothers felt confident in their child's ability to self-regulate their appetite and expressed fear of their child going hungry or becoming upset if a small portion was served, as this could cause an argument which they would rather avoid. Instead the general consensus was that packaged snacks are convenient, cost-efficient, guarantee consumption and cheaper than fresh fruit ("*The reason I like the little bags is, they are handy and you can take them out and about", P24, son, 24months).*

Table 12. Quotes supporting the themes constructed from interviews and the think aloud task

Theme	Subtheme	Supporting quotations
1. Situational effects on portion sizes	1.1 Features of the environment	*"erm, depends what she's previously eaten in the day and if I know we are going to have an early tea or a late teatime, something like that. Like today she didn't eat much at lunchtime so I probably would tend to give her a bigger snack" (P19, daughter, 43 months).* *"If we are going to do something like swimming, then I might try and make sure she eats more because I know that she needs a bit more energy. Or if we've been out in the park I might give her a bigger snack because I think, well I'd be hungry if I'd been running round" (P12, daughter, 38 months).* *"More often I think I just judge based on maybe what my parents would have given me as a child or what I see other children having" (P8, son, 29 months).*
	1.2 Maternal motivations	*"It's the wrong thing to do I suppose but I think how much do I eat, and judge it on that" (P40, son, 31 months).* *"I don't know. I think it must be to do with how hungry I am because I think that's the only way you can really imagine it" (P12, daughter, 38 months).* *"I do have it in my head that I want her to have had a certain amount in the day. It's just what I think is an appropriate amount for her age. I have nothing really to gage that against, it's just when I look at it I think that looks alright" (P3, daughter, 45 months).*
	1.3 Features of the food	*"Generally if it's healthy I'll give her lots and lots. If its healthy stuff she can have as much as she likes" (P18, daughter, 28 months).* *"I think eating too many crisps would be bad for her. I worry about the salt. I worry about fat" (P27, daughter, 45 months).* *"Carrots, I think they are quite hard to eat so I don't think I'd give her loads" (P3, daughter, 45 months).*
	1.4 Features of the child	*"Yeah, it's very led by him. So, I'm not very good at being boundaried with him so it would be very much, he would choose what he wants and then yeah, that's how we go about it" (P20, son, 41months).*

Theme	Subtheme	Supporting quotations
		"He would eat chocolate until it came out of his ears, but obviously he can't so I do try to limit chocolate and things like that" (P2, son, 40months). *"If I give him a snack and he doesn't like it, I'm probably not going to give it to him again, because I don't see the point. There are other snacks available" (P17, son, 41 months).* *"If I wanted to keep her quiet to get through a more tricky time then I am more likely to give her more. So sometimes I might give more just to keep children quiet" (P3, daughter, 45 months).*
2. Methods used to control portion sizes served	2.1 Package or dishware size	*"There actually quite helpful (packaged snacks). I can say that is your snack, you can eat what's in there but then there is no more. I think for them as well they understand a bit more when they get to the bottom of the packet, they have all gone and that's it" (P32, son, 31 months).* *"Probably if it's in a packet, yeah, I give the packet. And I think sometimes that means you give them more" (P17, son, 41 months).* *"Probably for ease I give the whole things quite often but it does depend" (P19, daughter, 43 months).* *"I'd normally give her what's in a packet really, in a small packet, so I reckon that's about right (crisps)" (P23, daughter, 47 months)* *"If it was a packet of crisps, I'd give one. I go from what the manufacturer packs probably without even questioning it. And like one apple, so like base it on unit size" (P17, son, 41 months).* *"See we've actually got a small plastic bowl that I would normally serve her from, so I use those as a way of judging things. It's funny actually I don't even think about it, I get the same bowl every time and I just look at what it looks like in the bowl and use that as a judgement" (P27, daughter, 45 months).*
	2.2 Sharing snacks	*"Crisps, she would usually share a packet with her cousin, so half a bag" (P28, son, 35months).* *"I buy snacks from the supermarket, they are quite good portion sizes because they are snacks for kiddies aren't' they but if not, if it's a bigger pack I will just share it so he doesn't eat it all" (P31, son, 27months).*

Theme	Subtheme	Supporting quotations
	2.3 Subdividing larger portions	*"She's a big fan of grapes. Sometimes I cut them in half to make it look like there's more" (P15, daughter, 42months).* *"We would cut these up for him obviously so that it looks like slightly more for him" (P13, son, 25months).* *"Like the chocolate biscuits I just give him one but I know in my mind he might ask for another one. If he asks for another one I will let him have two" (P16, son, 48 months).* *"I'd probably start with not that many crisps because she would probably ask for more. So, I'd probably go for a little handful but assume she would probably have some more" (P27, daughter, 45 months).*
	2.4 Unthinking, automatic processes	*"I don't really think about it, I just kind of do it without thinking really" (P9, son, 47months).* *"How do I decide how much I want him to consume? Erm, I don't know. How do I decide?" (P8, male, 29months).*
3. Awareness and use of portion size guidelines	3.1 Confusion around portion size guidance for snack foods	*"Just literally gone on my own ideas. In terms of the advice I sought it was about the type of snacks rather than the portion size" (P17, son, 41months).* *"I know like what counts as a portion of vegetables. Like those posters that they put up in the GP surgery, but that doesn't say whether it's for toddlers or adults" (P14, son, 47 months).* *"I'm sure that there are some (portion size guidelines) actually, no, I'm not. I don't know what they are" (P1, son, 42months).* *"When I first had my son I did read things. I know 10 grapes is a portion, things like that. I know to use your fist as a size" (P39, daughter, 24months).* *"I think parents might generally feed their child more than the recommended amount" (P3, daughter, 45months).* *"I think most of the time individual packets of things like pom bears, or the rice cakes, I think they are very generous for a toddler portion and they may be aimed more at primary school kids than toddlers" (P7, son,*

Theme	Subtheme	Supporting quotations
		42months). *"I did look it up on the internet (portion size of broccoli) and I was really surprised how small it was actually for kids because I thought it might have been a bit bigger" (P16, son, 48months).*
	3.2 Trusted sources	*"I remember years ago when you wean, you get a health visitor but I don't remember talking about portion sizes, I don't recall that" (P14, son, 47 months).* *"If there were guidelines it would help, it would make life easier, especially if nursery and school follow them. Although I do think guidelines, they need to write them in an easy to understand way so you can maybe pin it to the fridge and it be simple and it would be easy" (P18, daughter, 28months).* *"I don't mind who provided it as long as I know it was a trusted source" (P39, daughter,24months).* *"A leaflet from the government or the health visitors when they come, I think that would be useful. You know when they have their one year visit and two-year visit, I think that would be quite useful to receive that (guidelines). It might help with the obesity epidemic" (P16, son, 48months).*
	3.3 Importance of packaging as a guide to portion size	*"The reason I like the little bags is, they are handy and you can take them out and about" (P24, son, 24months).* *"Like it's really expensive to buy fresh fruit all the time and a lot of people would find that really expensive wouldn't they" (P16, son, 48months).*

Quantitative results

Portion size selection and consumption

Table 13 shows the portion size of each snack food (in grams) mothers served themselves and their child at an afternoon snack time. Three quarters of mothers allowed their child (n = 30) to select which snack they would like to consume (prepared by the mother), of which 77% (n =23) selected a HED option. The remaining children (n = 10) were served a LED (n = 6) or HED (n = 4) snack by their mother. None of the participants were offered or selected the vegetable snack for consumption.

Most children (88%; n = 35) consumed their entire snack and some children requested more (20%; n = 8). As a result, four children received additional servings of the same (3%; n=1) or an alternative snack/s (8%; n = 3), whilst 4 mothers negotiated that their child could have an additional snack once the researcher had left the family home. Overall, 4 children did not consume their snack in its entirety. These children were all offered a LED snack which had been chosen by their mother. On average children were served 90.67±30.16g of LED snacks and consumed 73.67±25.00g. For HED snacks, children were served 18.89±6.76g and consumed 18.04±7.01g. Paired sample t-tests revealed no significant differences between the amount children were served and the amount consumed of HED snacks ($t(27) = 1.28$, $p = 0.21$), however children consumed significantly less (17g) LED snacks compared to the amount they were served.

Table 13. Snack portion sizes (g) served by caregivers for themselves and their child with a comparison to recommended amounts (More & Emmett, 2015; "WHO | WHO calls on countries to reduce sugars intake among adults and children," 2016)

	Snack food	**Recommended portion size (g)**	**Portion size served in the home environment**	
			mean (±SD)	Range (g)
Adult	Carrot	80	79.0(49.2)	10 – 320
	White grapes	80	104.3(46.0)**	40 – 320
	Cereal	30	25.5(14.6)	10 – 67
	Chocolate biscuit	35	38.3(20.1)	12 – 114
	Salted crisps	25	27.3(14.6)	9 – 100
Child	Carrot	40	40.2(22.1)	8 – 95
	White grapes	40	66.0(33.2)***	8 – 160
	Cereal	18	13.7(5.4)***	3- 24
	Chocolate biscuit	15	21.4(8.2)***	8 – 38
	Salted crisps	10	15.3(6.8)***	7 – 40

* indicates a significant difference to recommended portion size ($p < 0.05$), **($p < 0.01$), ***($p < 0.001$)

Portion size selection compared to recommended amounts

Four out of five snack foods served to children were significantly different to recommended amounts (Table 13). Mothers served their children larger than recommended amounts of crisps (mean difference = 5±7g, 28 kcal) (t(39) = 4.9, $p <$ 0.001), biscuits (mean difference = 6±8g, 30 kcal) (t(39) = 4.9, $p < 0.001$) and white grapes (mean difference = 26±33g, 18 kcal) (t(39) = 5.0, $p < 0.001$), and smaller than recommended amounts of cereal (mean difference = 4±5g, 15 kcal) (t(39) = -5.1, $p <$ 0.001). Similarly, mothers served themselves significantly more grapes than recommended (mean difference = 24±46g, 17 kcal) (t (39) = 3.35, $p < 0.01$). All other food items (crisps, chocolate digestives, carrot, and cereal) were served in line with recommended amounts ($p > 0.05$).

Portion size selection: home versus online

Child

Paired sample t-tests revealed no significant difference in portion sizes served at home and selected in the online survey for biscuits [t(39) = .04, p = .97, 95% CI = -2.35-2.45] or grapes [t(39) = 2.01, p = 0.05, 95% CI = -0.06-19.73]. However, there was a significant difference in the portion size of crisps [t(39) = 6.35, p =.00, 95% CI= 4.68-9.06], cereal [t(39) = 4.48, p =.00, 95%CI = 2.17-5.73] and carrot served [t(39) = -2.38, p =.02, 95% CI = -18.17- -1.48]. Mothers served their children 6.9±6.9g more crisps at home equating to an additional 36 kcal. Furthermore, mothers served their children 4.0±5.6g more cereal at home equating to an additional 15 kcal. Contrastingly, mothers served their children 9.8±26.1g less carrot at home equating to a reduction of 4 kcal.

Adult

Paired sample t-tests revealed no significant difference in portion sizes served at home and selected in the online survey for biscuits [t(39) = 0.75, p = .46, 95% CI = -2.94-6.41], grapes [t(39) = 0.44, p = 0.66, 95% CI = -9.24-14.35] or cereal [t(39) = 0.83, p = 0.41, 95% CI = -2.54-6.08]. However, there was a significant difference in the portion size of crisps [t(39) = 2.72, p =.01, 95% CI= 1.36-9.20] and carrot served [t(39) = -3.06, p < .01, 95% CI = -30.07- -6.16]. Mothers served themselves 5.3±12.3g more crisps at home equating to an additional 28 kcal. Contrastingly, mothers served themselves 18.1±37.4g less carrot at home equating to a reduction of 8 kcal.

Correlation between maternal and child portion size selection

Pearson's correlation was conducted to explore the association between maternal and child portion size selection. The analysis revealed a positive and significant correlation between maternal and child portion size selection of crisps (r = 0.63, $p < 0.001$), carrot (r = 0.43, $p < 0.01$) and cereal (r = 0.59, $p < 0.001$). There was no significant association between maternal and child portion size of grapes (r = 0.24, $p = 0.13$) or biscuits (r = 0.31, $p = .056$).

6.2.4 Discussion

The aim of the present study was to explore what factors influence mothers' decisions and judgements about a suitable snack portion size to serve preschool children and what portion control methods are used in the home environment, using the think aloud method and semi-structured interviews. The results demonstrated that decisions regarding snack portion sizes are complex, dynamic and centred around three main themes: situational influences, portion control methods and awareness of portion size recommendations. Mothers alter the portion sizes that they serve based on personal feelings of hunger, their children's behaviour or appetite and the perceived healthiness of the food item. Food packaging often acts as a minimum and maximum portion size to serve with other portion control methods including the use of bowl size, hand size or sharing food between family members. The secondary aim of the study was to compare the portion sizes mothers served in the home environment to a) the portion size consumed by the child, b) to recommended amounts and c) to portion sizes selected in an online study (chapter 6.1). HED snacks were consumed in their entirety whilst some children produced leftovers when served LED snacks. Caregivers self-served portion sizes tended to reflect recommended portion sizes for adults. However, four out of the five snacks foods served to children were significantly different to portion size recommendations for children aged 2 -4 years. Furthermore, portion size selections online and in the home were similar thus suggesting that online stimuli may stimulate actual food portioning practices. The third aim was to explore associations between maternal and child portion size. A positive relationship between maternal and child portion sizes of crisps, carrot and cereal were revealed.

Portion size influences

Factors within the external environment encouraged mothers to alter the usual amount of a snack food that they would serve to their child. For example, snacks offered in close proximity to a meal tended to be smaller than their normal offering, or if their child had missed a meal then a larger snack portion size would be offered. These findings support those reported in a qualitative study exploring low income mothers views and use of portion size strategies in the USA whereby mothers were less likely to offer a snack in close proximity to a meal (Blake et al., 2015), thus suggesting that mothers may be able to adjust portion sizes to meet the varying energy demands of preschool children. In the present study, maternal personal feelings of hunger influenced the portion sizes caregivers served to children suggesting that mothers may transfer their personal hunger onto their child, regardless of their child's actual hunger and energy needs. Similar, findings have been demonstrated in American mother-child dyads at a buffet style meal whereby mothers who were hungry perceived their child to be hungry and thus served their child a larger meal (Stromberg & Janicke, 2016). As such, educational interventions focussing on techniques to evaluate preschool children's hunger, independent of personal feelings of hunger, may be beneficial.

Mothers were also influenced by the perceived healthfulness of a food, which determined whether portion size restrictions were enforced and to what degree. These beliefs support previous research whereby mothers reported that providing children with a balanced diet was of greater importance than providing appropriate portion sizes (Croker et al., 2009; Martin-Biggers et al., 2015). In the present study, "Healthy snack foods", described as foods low in salt and free sugars (i.e. fruits and vegetables), were provided in large portion sizes or the child was given unrestricted access to them as a method to encourage consumption and prevent poor dental hygiene. Providing fruits and vegetables as snacks to young children might confer an advantage compared to offering them as part of a meal, since offering fruit and vegetables in the absence of competing foods results in increased fruit and vegetable consumption (Spill et al., 2011; van Kleef, Bruggers, & de Vet, 2015). For example, findings from an intervention in the home revealed that serving fresh fruit and vegetable snacks were served in isolation of HED foods, significantly increased total daily vegetable intake and reduced TDEI (Reale et al., 2018). Mothers discussed restricting portion sizes of HED foods by breaking items in half or eating part of a packaged snack so their child received less. Blake et al., (2015) reported that mothers perceived HED snacks to be less healthy due to their high sugar and fat content resulting in mothers offering their child a reduced or restricted portion size. Previous research has highlighted that parents restrict HED snacks/ foods as a method to reduce the development of overweight and obesity in their children (Croker, Sweetman & Cooke, 2009) and to prevent poor dental hygiene (Carnell et al., 2011). However, restricting access to HED foods can result in adverse eating outcomes including increased desire for and consumption of a food once the restriction is removed (Jansen et al., 2007). Whilst young children are usually good at self-regulating their appetite (Cecil et al., 2005; Hetherington, Wood, & Lyburn, 2000) they may quickly become attuned to external signals of food consumption related to increased desire (Mela, 2001).

Based on past feeding experiences, some mothers were confident that they had learned how much their child would usually consume and were able to adjust portion sizes based on features of the child such as food liking and behaviour. For example, in some instances liked foods were reported to be offered in large portion sizes as per child request to avoid creating upset, a finding that has been previously reported by a cohort of UK mothers of children aged 3-5 years (Carnell et al., 2011). In Carnell's (Carnell et al., 2011) study, mothers discussed emotional feeding practices whereby they provided chocolate or crisps to control their child's behaviour or to prevent upset. In contrast, disliked items were offered in reduced portion sizes, or not at all, to prevent food waste and associated financial costs. These findings are consistent with previous work conducted in an American sample of low income mothers whom indicated that they were financially constrained by food waste and therefore have a strong desire to avoid wasting both time and money (Johnson et al., 2015).

Portion control methods

Within the home environment, a variety of portion control methods were utilised consistent with methods described previously by a cohort of low-income mothers in the USA (Blake et al., 2015) and mothers attending a Head Start centre in Southwestern USA (Vittrup & McClure, 2018). For example, mothers demonstrated subdividing large portion sizes into small containers, breaking items into smaller pieces or sharing snacks between family members. Mothers also mentioned using bowl or spoons to measure portion sizes, however these vary widely in their size thus emphasising mother's uncertainty regarding appropriate portion sizes (Vittrup & McClure, 2018). In the current obesogenic environment, family/ share size foods are easily accessible and of good value for money, which makes these items more appealing to the buyer. This finding emphasises the need to educate and inform consumers on how to accurately select portion sizes appropriate for children from *ad libitum* quantities.

Mothers expressed a preference for serving their children pre-packaged snacks since they are well liked, convenient and provide a portion size limit that can be communicated to children. These findings are consistent with previous research in the USA, where mothers have reported reliance on pre-portioned snacks to simplify, or replace entirely, the need to make decisions related to an appropriate portion size to serve (Blake et al., 2015). Pre-portioned snacks are typically larger than age appropriate for young children (Sothern, 2004) and may explain mothers tendencies to serve their children snacks in portion sizes larger than recommended. One solution might be for the food industry to increase the availability of smaller packaged snacks or to offer more nutritious options (Blake et al., 2015). However, this may require industrial modifications which may not be environmentally friendly or of sufficient profit to the food industry. Instead, it may be more appropriate to encourage feasible methods of downsizing in the home environment such as snack reduction or replacement (Reale et al., 2018).

Awareness (or lack of) and use of portion size recommendations for children became a prominent discussion point in interviews. Consistent with previous findings (Eck et al., 2018) mothers were confused and unaware about the existence of portion size recommendations, despite them being publicly available. This is unsurprising since the current UK Eatwell Guide and other similar resources e.g. (NHS, 2016) simply state that 'treat' foods should be eaten less often and in small amounts with no further indication as to what constitutes a 'small' or 'child' portion. Instead, mothers referred to following advice from healthcare visitors which focussed more on complementary feeding and types of food to offer rather than how much to offer. Moreover, previous experiences of adhering to guidelines for adults were discussed, demonstrating mother's competence and willingness to follow advice. In previous studies mothers have generally expressed an unwillingness to weigh foods (Croker et al., 2009; Curtis et al., 2017) and so advising parents to weigh foods might not be the best approach. However, simple visual guidelines or measures such as those proposed in the British Nutrition foundation "Find your balance" (British Nutrition Foundation, 2018) might be more effective.

In the present study, following portion size advice when their child is in the care of someone else (e.g. father or grandparents) was identified as a barrier. Informal care providers such as grandparents, friends and babysitters have always been an important source of childcare worldwide due to the expanding female workforce and cost of nursery/ day care centers (Bell, Perry, & Prichard, 2018). In particular, grandparents are an important source of support in the UK, with over a quarter of children < 5 years of age receiving care from grandparents (Rutter, 2016). Evidence suggests that fathers and grandparents offer larger portion sizes of less healthy foods to their children than mothers (Herman et al., 2012; Jingxiong et al., 2007; Lora, Cheney, & Branscum, 2017) therefore, further investigation into the factors that influence fathers and grandparents portion size decisions may be beneficial for the development of tailored interventions.

Portion size selection

The results of the current study demonstrate that mothers were generally accurate at self-selecting appropriate portion sizes of the snack foods on offer. However, mothers were less accurate at selecting age appropriate snack portion sizes for their children which may be attributable to caregiver confusion and unawareness of children's portion size recommendations, consistent with previous work (Eck et al., 2018). In focus group discussions, Eck et al., (2018) identified that parents of children aged 6-11 years perceived their lack of knowledge and uncertainty of child portion sizes to be a barrier to serving portion sizes in line with recommended amounts for children. Snacks served in larger than recommended amounts for children tended to be energy dense or contain large amounts of sugar. In contrast, cereals were served in smaller than recommended amounts which might be due to this being a less familiar mid-afternoon snack compared to the rest of the snack foods on offer. Portion size recommendations for preschool children were produced to guide caregivers towards the provision of adequate nutrition (More & Emmett, 2015). As such, children who are served snack foods smaller or larger than recommended amounts may be exceeding, or not meeting, energy and nutrient requirements set for their age group.

Portion size selections online and in the home environment were similar thus confirming the possible advantages of using an online survey to replicate actual feeding behaviours. In some instances, small differences were noted but these may simply reflect daily variations in children's eating behaviours based on situational factors such as appetite and activity levels (Kral & Hetherington, 2015). Alternatively, these differences may be explained by study design. The online survey limited caregivers to select one portion size per snack item, therefore it did not account for additional servings or snack variety, which was demonstrated in the natural food environment.

Associations between maternal and child portion size were revealed for 3 out of the 5 snack foods in line with previous work (Johnson et al., 2014). Johnson et al. (2014) revealed a positive relationship between maternal and child portion size at an evening meal. However, maternal and child portion sizes of grapes and biscuits were not related. It is possible that this outcome is related to the small number of participants taking part, the small array of snacks on offer or due to demand characteristics, whereby mothers did not serve themselves their "usual" portion size due to the presence of the researcher (Radnitz & Todd, 2016). Although the latter is not likely since larger than recommended portion sizes were served for children.

Portion size consumption

Most children consumed snacks served by their mother in their entirety thus providing some indication that the portion sizes served were appropriate for their child and may reflect habitual portioning practices. However, consistent with previous findings (Spill et al., 2011), children often did not select, or consume in full, LED snacks. Spill et al. (2011) revealed that when multiple foods are on offer children often choose and thus consume their preferred foods, which tend to be energy dense. HED snacks consumed in portion sizes exceeding recommended amounts has been linked to poor diet quality and an increased risk of excessive weight gain and associated disease (Evans et al., 2015; Larson & Story, 2013). Therefore, highlighting the importance of serving children HED snacks in line with portion size recommendations.

Strengths and limitations

The current study was designed to investigate decisions and portion control strategies employed by mothers when determining the amount to serve their child of a variety of snack foods. This is the first UK-based study to characterise the influences mothers report on amounts they served their child for an afternoon snack. Data were collected in a naturalistic environment to enhance ecological validity. Furthermore, the think aloud method was used to elicit real time decisions, reveal portion control methods that were not verbalised in interviews and rely less on memory. The study was conducted in a diverse cohort of mothers, however very few caregivers were of the lowest income category or from the most deprived neighbourhoods. Consequently, the generalisability of findings may be reduced since decisional processes and desire for portion size advice has been found to differ between those of middle and high income and education (Ohly et al., 2013a); especially in relation to food waste (Johnson et al., 2015). Furthermore, mothers voluntarily expressed an interest in participating in the study therefore it is possible that they had a prior interest in the topic and may be more health conscious than other cohorts of mothers, thus further reducing the generalisability of findings.

The study was conducted in a naturalistic setting to encourage habitual behaviours, however the presence of a researcher may have produced a social desirability effect (Radnitz & Todd, 2016), although similarities between portion size selection at home and online were revealed and children tended to consume all that was served to them. Moreover, the sample size was small and the selection of snack foods were limited. The researcher commuted to participant's homes alone via public transport therefore was restricted on the number and type of snack foods that could be carried. Packaged snacks tended to be chosen to prevent spoilage in transportation therefore findings may be limited to portioning practices of packaged snacks. However, snack foods were removed from their packaging and the chosen snacks were identified as liked and regularly consumed by young children. Future work may seek to explore portioning practices of a larger range of snacks including snack foods commonly consumed by preschool children that may have not been suitable for inclusion in this study e.g. yoghurts.

6.2.5 Conclusion

The current research demonstrates that decision making focusing on children's portions sizes is complex, dynamic and multifaceted. When determining an appropriate snack portion size to serve, mothers were influenced by a variety of factors within their immediate environment, such as maternal hunger, perceived or inferred child hunger, child liking and perceived food healthiness. Mothers demonstrated the strategies they used to limit children's portion sizes of certain foods by subdividing large portion sizes into smaller containers or sharing snack foods between family members. The most convenient portion control method was package size, which acted as both the minimum and maximum quantity to serve. Mothers tended to serve children snack portion sizes smaller or larger than recommended amounts and positive associations between maternal and child portion size were revealed. Moreover, portion sizes of HED snacks were positively associated with the quantity children consumed thus highlighting the importance of serving portion sizes in line with recommended amounts. Despite confusion about the recommended portion sizes for preschool children, particularly of snack foods, mothers reported a desire for portion size guidance which is clear, child-centered, realistic and from a trusted source. The findings of this study may assist in the development of downsizing interventions, and highlight methods to effectively communicate portion size recommendations to families with young children.

Summary of study 1 and 2

The findings from study 1 and 2 represent maternal portioning practices due to the dominance of female respondents further signifying the role mothers play in shaping young children's dietary intake (Brown & Ogden, 2004). Findings reveal that mothers are generally good at downsizing portions for young children however still a number of mothers are offering larger than recommended portion sizes of HED foods and smaller than recommended portion sizes of LED foods, despite portion size recommendations being available. Furthermore, the portion size of HED snacks served to children was positively associated with the amount consumed thus highlighting the importance of serving children portion sizes in line with recommended amounts.

Mothers demonstrated a variety of portion control strategies employed at snack times and provided an insight into their decisional processes and motivations for determining an appropriate snack portion size to serve. Furthermore, mother's awareness, use and desire for portion size recommendations were explored. The studies identified that producing HED snacks in smaller packaging may encourage healthier portioning practices and thus child snack consumption, however it is neither a sustainable or profitable method. Instead, developing interventions that incorporate current portion control methods used in the home environment, alongside practical advice, may be a more feasible method to achieve public health messages.

6.3 Study 3: The effect of food type on the portion size effect in children aged 2- 12 years: A systematic review and meta-analysis.

Findings from study 1 and 2 highlighted the need to examine feasible snack portion control methods which are simple and clearly communicated and that adhere to nutritional recommendations (More & Emmett, 2015). Therefore, a feasibility and acceptability study was designed to explore two novel methods of snack portion control: snack reduction and snack replacement. The decision to collect data in the home environment was made on the basis that working with children in free living environments is more feasible and ecologically valid compared to laboratory studies (Hetherington & Rolls, 2018).

Food properties, such as energy density and portion size, influence intake e.g. (Kling et al., 2016. Furthermore, food shape (unit or amorphous) has been found to influence portion size estimation (Weber et al., 1999) which in turn may stimulate consumption expectations and the quantity children consume. However, to date comparisons between unit and amorphous food have not been made, despite this data being available thus it has been identified that there is a gap in the literature. Therefore, a systematic review and meta-analysis was conducted to determine the effect of food shape on the PSE. Furthermore, the review was conducted to contribute to the development of a feasibility and acceptability study by determining inclusion of unit or amorphous snack foods into the study protocol in addition to adding knowledge to the current evidence base on moderators of the PSE. The decision to include an age range of 2 to 12 years was undertaken so that the findings were not of interest exclusively to this thesis but to the scientific community in general.

Authors: S Reale, J Hamilton, R Akparibo, M. M. Hetherington, J. E. Cecil & S. J. Caton

Reale, S., Hamilton, J., Akparibo, R., Hetherington, M. M., Cecil, J. E., & Caton, S. J. (2019). The effect of food type on the portion size effect in children aged 2–12 years: A systematic review and meta-analysis. *Appetite*, *137*, 47–61. https://doi.org/10.1016/J.APPET.2019.01.025

This chapter is presented in the format of a published paper that has been published in Appetite (Reale et al., 2019). Permission to present this material is provided in Appendix 2, part A. The primary author was responsible for the study design, data extraction and synthesis and primary writing of the paper. Detail of the co-authors, including their contribution to this work can be found in Appendix 1.

6.3.1 Background

Parents are often perceived as role models for their children's health related behaviours (Hart et al., 2010). They shape their children's food preferences, consumption and general diet quality due to modelling behaviours (Brown & Ogden, 2004) and the type and quantity of food they make available within the household (Cullen et al., 2003). However, when it comes to determining an acceptable portion size for children, most parents describe various strategies for determining portion size, however, few mothers said they use actual measurements or expert recommendations (Blake et al., 2015). Instead, contextual factors such as time of day, proximity to last eating occasion, adult portion sizes or package size are considered (Blake et al., 2015; Johnson et al., 2014). Whilst appropriate portion sizes are typically given for adults on pre-packaged foods, this is not adjusted for children's age or stage of development, often leading to an overestimation in the amount children require. Since the 1970's, food portion sizes and the size of serving utensils and equipment used to prepare food have increased (Nielsen & Popkin, 2003b). This may promote overeating and change perceptions of portion size norms (Lando & Lo, 2013).

Children's eating patterns track into later life, therefore, early experience is critical for setting the foundations of healthy eating (Cashdan, 1994). As infants develop they move from appetite driven by internal cues to becoming more susceptible to external cues which can override self-regulation (Cecil et al., 2005) and lead to eating in the absence of hunger (Fisher & Birch, 2002). Exposure to large food portion sizes is one environmental cue that has been positively associated with an increase in energy intake. When individuals are presented with a larger than normal portion size they tend to consume larger amounts, thus their total energy intake increases (Kral & Rolls, 2004; Rolls, Roe & Meengs 2006; Rolls et al., 2004; Rolls, Morris & Roe, 2002). This is known as the portion size effect (PSE), which has been reported to affect consumption in adults and children from as young as two years old

(Fisher, 2007; Fisher & Kral, 2008; Mathias et al., 2012). A meta-analysis including 65 studies and 109 observations revealed that doubling the amount of food served to children and adults leads to an average increase in food intake of 35% (Zlatevska et al., 2014). Increased portion sizes of high energy dense (HED) foods may play a role in contributing to the rising prevalence of overweight and obesity. For example, when manipulated over 2 Rolls et al., 2006), 4 (Kelly et al., 2009) and 11 days (Rolls, Roe & Meengs, 2007) the PSE has been associated with a sustained increase in energy intake, without compensatory behaviours (Jeffery et al., 2007).

One explanation that has been offered to explain the PSE is that people consider a single unit to be an appropriate amount to eat. Consumption norms promote the tendency to consume one unit of food in its entirety, assuming that the unit is of some minimal size. This is known as unit bias, which has been found to influence the quantity consumers eat regardless of the unit size offered (Geier et al., 2006). Subtle visual cues pertaining to the portion size of foods are also thought to contribute to how much one consumes. For example, both adults and children perceive circles of a given size as being larger when surrounded by smaller sized circles in comparison to larger circles (Van Donkelaar & Drew, 2002), such that the context in which an object is presented can affect judgement of its size (Krider, Raghubir, & Krishna, 2001). This is known as the Delboeuf illusion (Delboeuf, 1865). Both children and adults demonstrate greater difficulty in judging the portion size of amorphous foods compared to unit foods. This may be because unit foods have a distinct shape whereas amorphous foods take the shape of its container (Weber et al., 1999). When children make judgements about food size it tends to be influenced by food diameter and height, rather than mass or volume (Piaget, Inhelder, & Szeminska, 1960), therefore when amorphous foods were doubled in size in a laboratory setting, children seemed largely unaware of this change (Fisher, Rolls & Birch 2003).

Food shape is a potentially important dimension underlying the PSE as the amount of food available appears to impact portion size judgement which may in turn affect the amount of food children consume. In one study children served themselves on average 238.9kcal more of unit food compared with amorphous food, leading to a 102.73 kcal increase in consumption (Disantis et al., 2013). However, it is unclear if this was a result of food shape or children's preference for the unit food items. The aim of this systematic review and meta-analysis was to investigate the impact of offering unit or amorphous food on the PSE in children aged 2 to 12 years.

6.3.2 Methods

This systematic review and meta-analysis was registered with the International Prospective Register of Systematic Reviews (PROSPERO) (record # CRD42016035321) and conducted in two phases. Phase 1 included an extensive systematic review of literature, conducted to identify whether food type interacts with portion size to influence intake in young children aged 2-12 years. No restrictions were applied to the publication date. The search was limited to peer-review journal articles published in English (see Table 14). Phase 2 comprised a meta-analysis, including studies identified from the systematic review process that contained the required statistical information.

Search Strategy

Initially a scoping search was conducted in MEDLINE to map out the literature that exists on children's susceptibility to the PSE and to establish whether any current review had been undertaken on the topic. The scoping search was divided into a series of concepts (population, exposure, comparison), and alternative terms were formed. Search terms were adapted during the scoping search to include key words used in relevant studies and additional free-texts search terms were added to our initial MESH search terms. Using the revised search strategy, searches in MEDLINE, PsycInfo and Web of Science databases were conducted in February 2018. Search terms were combined as follows: (portion* NEAR/4 (food* or meal* or snack* or eat* or consum* or diet*)) AND (portion* NEAR/4 (size* or large* or small* or reference or big or medium)) AND (child* or infant* or schoolchild*). To identify papers not captured by our database searches, we performed additional citation follow up searches by scanning through the reference list of the included studies.

Selection of studies

Papers were included in this review based on their relevance to address the review question based on the priori outcome measure: an objective measurement of food consumption (grams or kcal) and exposure to various food portion sizes. The first author screened titles, abstracts and full papers to determine their relevance using the preferred reporting for systematic reviews and meta-analyses (PRISMA) guidelines (Moher et al., 2010). A second independent reviewer (RA) cross checked all the included and excluded papers, to ensure that no relevant papers were excluded. Any disagreements about the inclusion of papers were resolved via discussions between authors.

The studies included in the systematic review met all the inclusion criteria and none of the exclusion criteria (see Table 14). Where publications included several dependent measures, only the outcomes that met the inclusion criteria were included. Studies were included if the participants were under the age of 12 and had been exposed to varying portion sizes of food. Papers that did not meet the inclusion criteria were excluded.

Table 14: Inclusion and Exclusion Criteria for review of studies

	Inclusion	**Exclusion**
Population	Children aged 12 years and below. No restrictions on ethnicity, socioeconomic class or gender	Children older than 12years
Intervention/ Exposure	Exposed to multiple portion sizes of food. Portion size served measured objectively (grams or kcal)	No exposure to portion size manipulation, portion size manipulation of a non-food item e.g. beverages or subjective/ unknown measure of portion size served
Outcome	Amount of food consumed to be measured objectively (grams or kcal)	Unknown quantity of food consumed, or amount measured subjectively
Study Type	Quantitative (quasi-experimental, observational) primary data, published in English in a peer review journal. Full length text. No restriction on publication date or sample size. Lab based and in natural environments	Qualitative evidence, systematic reviews, meta-analyses and abstracts from conferences

Data extraction and quality assessment

The first author extracted information related to the outcome measure (food intake) and exposure (initial and manipulated portion size). This was crosschecked by a second independent reviewer (RA) to reduce bias. The following information was extracted using a standardised checklist: study design, recruitment method, study location and time, participants (age, sex, ethnicity, socioeconomic status) type of food served, amount of food served (grams or kcal), amount of food consumed (grams or kcal) at each portion size, and study limitations. Some authors did not provide information regarding the amount (grams or kcal) consumed in each portion size condition (McCrickerd & Forde, 2016; Savage et al., 2012). In these cases the lead author was contacted for the relevant information.

Assessment of study quality was undertaken for all studies using a checklist based on a combined measure previously used by Downs and Black (Downs & Black, 1998) and the National Institute of Clinical Excellence (NICE, 2007), and adapted for use in the assessment of quality of studies (Moore, 2012). The scale was chosen based on its appropriateness to appraise a variety of study designs and it has been used previously to grade the quality of studies in a similar systematic review that explored parental styles, feedings styles and feeding practices (Shloim et al., 2015). The quality assessment tool contained 11 items that were scored on a Likert scale using values of 0 = no, 1 = partly and 2 = yes to provide each paper with a total score out of 22 to reflect its quality (Moore, 2012). Papers were rated on their chosen study design, methodology, analysis and interpretations of findings and were sensitive to portion size research. For example, questions relating to baseline hunger, portion size and food liking were included. Two independent authors (SR, RA) scored all the papers, and a third reviewer scored 10% (SC). Minor disagreements were resolved through discussion.

Definition of exposure categories

Baseline portion size varied across studies, according to participant age and food type, and the majority of studies considered multiple experimental groups. Therefore, the PSE was assessed for multiple different magnitudes of portion size increase. Each experimental group was described using the percentage increase in portion size (note that individual studies may contain multiple experimental groups). These experimental groups were categorised according to six exposure groups to describe the percentage increase in portion size from baseline: 0-50%, 51-100%, 101-150%, 151-200%, 201-250%, 250-300%, with a further seventh category used to describe situations when the percentage increase in portion size was not clear.

Meta-analysis

Exposure groups whereby baseline portion size was increased by 51-100% were included in the meta-analysis. Inclusion of only one portion size group per study was necessary in order to avoid introducing correlation due to multiple comparisons (Higgins & Green, 2011); section 16.5.4].

Synthesis

The SMDs were synthesised using a random effects model, which allows for heterogeneity between studies due to differences in individual study protocols. Heterogeneity was explored by considering potential effect modifiers using meta-regression (Dias, Sutton, Welton, & Ades, 2013; Higgins & Green, 2011). Three potential effect modifiers were considered in isolation as past research has suggested these may be influential in the PSE (Fisher, 2007; Mccrickerd, Leong & Forde, 2017; Zlatevska, Dubelaar & Holden 2014): baseline portion size, mean child age and food type.

Analyses were conducted in the R (R core team 2016) statistical software package, using the “metafor” package (Viechtbauer, 2010). Some studies described more than one experimental group (including different age groups and different food types). A multilevel model was therefore used, with random effect (RE) at the study level. Results are presented in a forest plot, showing the overall pooled result for the primary meta-analysis (without inclusion of moderators), as well as the pooled estimates according to food type served.

After synthesis, SMD’s were re-expressed using familiar metrics (Schunemann et al., 2011) for ease of interpretation. The average (mean) daily energy intake from a representative sample of children aged 4-10 years old (NDNS, 2018) was re-expressed in terms of proportionate (%) and absolute change (kcal) following increases to food portion size. Further details on this method are reported in a Cochrane review (Hollands et al., 2015).

Assessment of reporting biases

Funnel plots were created to detect possible reporting biases in the meta-analysis (Egger, Davey Smith, Schneider, & Minder, 1997). The results were interpreted via visual inspection. In the absence of bias the funnel will resemble a symmetrical inverted funnel, whereas asymmetry or skewness indicates bias.

6.3.3 Results

The search returned 1197 articles, and after duplicates were removed (n=294) 903 papers were screened (Figure 4). Hand searches of the reference list identified 21 potential qualified papers. However, after applying the inclusion criteria at the abstract level, only 2 papers qualified. Overall, 57 full text articles were screened. Thirty-six articles were excluded due to the age of the participants, the study design or where portion size had not been manipulated. In total, 21 articles, reporting on 23 studies and 39 conditions/ exposure groups, met the eligibility criteria and were included in the systematic review (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2013; Fisher et al., 2007b; van Kleef, Bruggers, and de Vet 2015; Kling et al., 2016; Kral et al., 2010; Kral et al., 2014; Leahy et al., 2008; Looney & Raynor, 2011; Mathias et al., 2012; Mccrickerd, Leong, & Forde, 2017; Mooreville et al., 2015; Ramsay et al., 2013; Rolls, Engell, & Birch, 2000; Savage et al., 2012; Smith et al., 2013; Spill et al., 2010, 2011) of which 14 articles reporting on 14 studies and 24 conditions/ exposure groups, provided requisite statistical information for inclusion in a random effects model meta-analysis (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2007b; van Kleef, Bruggers, and de Vet, 2015; Kling et al., 2016; Kral et al., 2014; Looney & Raynor, 2011; Mathias et al., 2012; Mooreville et al., 2015; Rolls, Engell, and Birch, 2000; Spill et al., 2010, 2011).

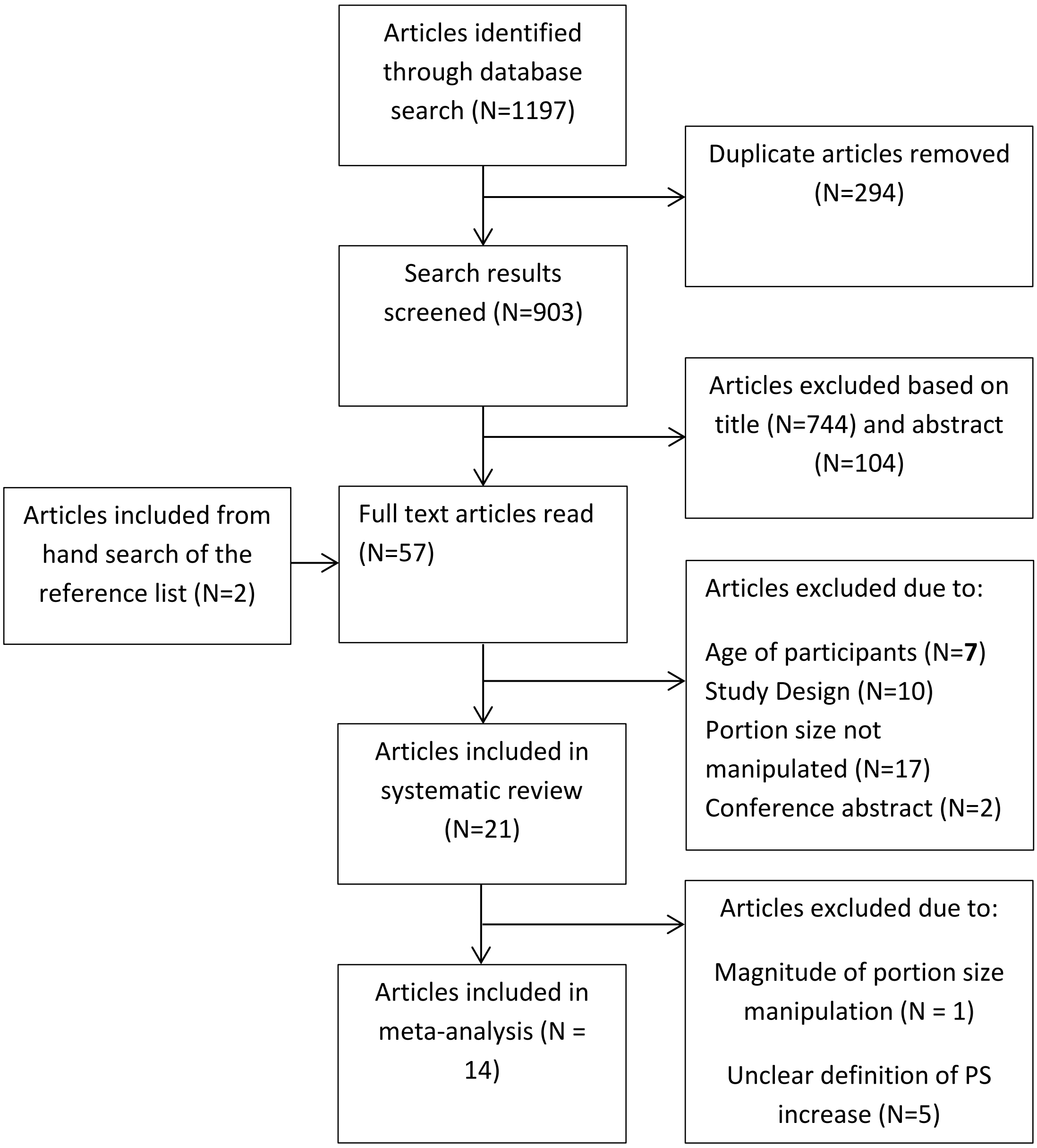

Figure 4: PRISMA flow diagram of search results, screening and included studies

Study characteristics

The characteristics of the studies included are presented in Table 15. Both male and female participants of cross cultural and varying socioeconomic backgrounds, between the ages of 2 and 13 years were included. The sample size ranged between 17 (Looney & Raynor, 2011; Savage et al., 2012) and 225 (van Kleef et al., 2015). Most studies (n=17) were conducted in the USA (Fisher, Rolls & Birch, 2003; Fisher et al., 2007a; Fisher, 2007; Fisher et al., 2013; Fisher et al., 2007b; Kling et al., 2016; Kral et al., 2010; Kral et al., 2014; Leahy et al., 2008; Looney & Raynor, 2011; Mathias et al., 2012; Mooreville et al., 2015; Ramsay et al., 2013; Rolls, Engell & Birch, 2000; Savage et al., 2012; Spill et al., 2010, 2011). One study was conducted in the Netherlands (van Kleef et al., 2015), one in China (Smith et al., 2013), one in Belgium (Aerts & Smits, 2017) and another in Singapore (Mccrickerd, Leong & Forde, 2017). Both laboratory (n=11) and natural environments (n=10), such as day care centres and nurseries were used.

Studies assessed food intake when the portion size of food was amorphous in presentation (n =13) (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2013; Fisher et al., 2007b; Leahy et al., 2008; Looney & Raynor, 2011; Mccrickerd, Leong & Forde, 2017; Rolls, Engell, & Birch, 2000; Savage et al., 2012; Smith et al., 2013; Spill et al., 2011), unit (n=7) (Aerts & Smits, 2017; Fisher et al., 2007a; van Kleef, Bruggers & de Vet, 2015; Kral et al., 2010; Mathias et al., 2012; Ramsay et al., 2013; Spill et al., 2010) or both amorphous and unit (n=3) (Kling et al., 2016; Kral et al., 2010; Mooreville et al., 2015). Two studies (Aerts & Smits, 2017; Fisher et al., 2007b) included both unit and amorphous items, however these were manipulated at separated eating occasions, therefore they feature as individual exposure groups in both the amorphous and the unit section. With the exception of three studies, serving soup (Spill et al., 2011) and a rice, vegetable and protein mix (Mccrickerd, Leong & Forde, 2017; Smith et al., 2013) all studies providing an amorphous meal used a pasta dish such as macaroni and cheese (Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2013; Fisher et al., 2007b; Leahy et al., 2008; Rolls, Engell & Birch, 2000; Savage et al., 2012). Unit food items included chicken nuggets (Ramsay et al., 2013), hash browns (Kral et al., 2014), popcorn (Aerts & Smits, 2017), fruit (Mathias et al., 2012) and vegetables (van Kleef et al., 2015).

Most studies included an exposure group which enhanced food portion size by 51-100% relative to baseline (n=15) (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2007b; van Kleef, Bruggers, & de Vet, 2015; Kling et al., 2016; Kral et al., 2014; Looney & Raynor, 2011; Mathias et al., 2012; Mooreville et al., 2015; Rolls, Engell & Birch, 2000; Savage et al., 2012; Spill et al., 2010, 2011) (Table 16). Four studies also looked at a 150% (Kling et al., 2016; Kral et al., 2014; Mooreville et al., 2015; Rolls, Engell & Birch, 2000) and a 300% serving (Spill et al., 2010). Three studies (Leahy et al., 2008; Smith et al., 2013; Spill et al., 2011) examined smaller increases in portion size < 50% or manipulated portion size unique to the individual using self-serve methods (Fisher et al., 2013; Mccrickerd, Leong & Forde, 2017; Ramsay et al., 2013), thus food intake was examined for a variety of portion sizes and serving methods.

Studies reported intake by weight (grams, n = 16) (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher et al., 2007a; Fisher et al., 2013; van Kleef, Bruggers & de Vet, 2015; Kling et al., 2016; Kral et al., 2010; Leahy et al., 2008; Mathias et al., 2012; Mccrickerd, Leong & Forde, 2017; Ramsay et al., 2013; Rolls, Engell & Birch, 2000; Savage et al., 2012; Smith et al., 2013; Spill et al., 2010, 2011) or energy (kcal, n = 5) (Fisher, 2007; Fisher et al., 2007b; Kral et al., 2014; Looney & Raynor, 2011; Mooreville et al., 2015). The time at which food was served varied between studies (snack time (n=3), lunch (n=9), evening meal (n=7), or over a 24-hour period (n=2)). However, most studies (n=16) accounted for hunger levels by taking a subjective measure of hunger (n = 4) (Aerts & Smits, 2017; van Kleef, Bruggers & de Vet, 2015; Rolls, Engell & Birch, 2000; Smith et al., 2013), provided a set meal before consumption (n = 5) (Leahy et al., 2008; Looney & Raynor, 2011; Savage et al., 2012; Spill et al., 2010, 2011), or requested that parents restricted their child's intake of food and drink 2-3 hours prior to the testing session (n = 6) (Fisher 2007; Fisher et al. 2007a; 2013; Kral et al., 2010; 2014; Mathias et al., 2012).

Table 15: Summary of included papers (The table is split into three sections by type of food that was manipulated; amorphous v unit v unit and amorphous)

Author and Date	**Aims of Study**	**Participant and sample**	**Methods**	**Manipulated Food Items**	**Findings**	**Quality[a]**
			Amorphous Food Items			
Aerts and Smits 2017 (study 1)	To identify if children's snack intake is influenced by portion size and snack sweetness	28 children (16 boys and 12 girls) aged 6-7 years from four schools in Belgium.	A between subject design Morning snack time at school	Sugared and salted popcorn. Reference condition: 30g. Large condition: 60g.	Children ate significantly more popcorn from the large portion compared to the small portion. This relationship was observed for both sugared and salted popcorn; however the effect was more prominent in the sugared condition.	20
Fisher, 2007	The aim of the research was to systematically study the effects of age on children's responsiveness to large and self-selected portions	75 children (44 boys and 31 girls) in three age groups: 2-3, 5-6 and 8-9 years old. Non-Hispanic white	A between subjects design (age group) with a within-subject component (PS) Evening meal in a laboratory	Macaroni and cheese with an energy density of 1.42 kcal/g. Reference condition: 200g (age 2-3) 250g (age 5-6) 450g (age 8-9). The amount provided in the reference condition was doubled for the large condition	Children consumed an average of 29% more in the large condition compared to the reference. The difference did not vary by age, order or preference for the food. Older children consumed more food than the younger children.	18
Fisher et al., 2003	To determine the effects of repeated exposure to a large portion of an entrée on	30 children (16 boys and 18 girls) aged 2.9-5.1 years attending a full-	A within subject crossover design Lunch meal in a	Macaroni and Cheese. Reference condition: 125g (< 4 years) and 175g (> 4 years). The amount provided in the	Doubling the portion size of the entrée increased the children's entrée by 25 % and total energy intake by15 %. Increases in entrée intake were not	19

Author and Date	**Aims of Study**	**Participant and sample**	**Methods**	**Manipulated Food Items**	**Findings**	**Quality[a]**
	preschool-aged children's awareness of portion size, self-selected portion size, and food intake	day day-care programme at The Pennsylvania State University. Diverse ethnicity	laboratory	reference condition was doubled for the large condition	significantly related to sex, age, or the order in which the 2 portion sizes were served	
Fisher et al., 2007a	To test the effects of portion size and ED on children's food and energy intakes at a meal	53 children (25 boys, 28 girls) aged 5-6 years old. Diverse ethnicity	A 2 (PS) × 2 (ED) within-subject factorial design Evening meal in a laboratory	Macaroni and Cheese with an energy density of 1.32 v 1.84 kcal/g. Reference condition: 250g. The amount provided in the reference condition was doubled for the large condition	Children consumed 33% more of the entrée in the large portion conditions than in the reference conditions. The entrée ED did not interact with portion size to influence gram intake of the entrée	**19**
Fisher et al., 2007b	To observe the effect of large portions on daily energy intake in 5-y-old Hispanic and African American children from low-income families	58 children (24 boys, 35 girls) aged 5 attending a Head start programme in Houston. African American and Hispanic	A within subject design Lunch meal in a laboratory	The amount served in the reference condition was: 453 kcal macaroni and cheese and 160 kcal oat ring cereal. The amount provided in the reference condition was doubled for the large condition	Doubling the portion size of macaroni and cheese did not impact intake, however doubling the portion size of cereal led to a 51% increase in intake	20

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
Fisher et al., 2013	This research experimentally tested effects of the amount of entree available and serving spoon size on children's self-served entree portions and intakes at dinner meals	60 children (27 boys, 33 girls) aged 4-6 years. Ethnically diverse.	A 2 (PS) × 2 (serving spoon size) within-subject design.	Macaroni and Cheese with an energy density of 1.55kcal/g. Reference condition: 275g. The amount provided in the reference condition was doubled for the large condition. Fixed portion of unsweetened applesauce (112g) baby carrots (39g), Chocolate chip cookies (33g) and 2% milk (240g) was also provided.	On average, children served 40% more entree when 550 g of the entree was available in the serving dish than when 275 g was available (91.9±14.7 vs 65.6±14.7 g; *P*<0.0001). Children consumed an additional 0.56 kcal of the entree and an additional 0.54 kcal total energy at the meal for every gram of macaroni and cheese served.	19
Leahy et al., 2008	To determine how incorporating extra vegetables in a meal impacts intake	61 (30 boys and 31 girls) aged 3.1-5.6 years attending full day day-care. Diverse ethnicity	A 2 (PS) × 2 (ED) within-subject factorial design Lunch meal in a laboratory	Pureed broccoli and cauliflower served with pasta and spaghetti sauce. Reference condition: 10.1g. Large condition: 30.1g	Vegetable intake significantly increased when the portion size was increased. Children ate half a serving more in the large versus reference portion size condition	19
Looney and Raynor 2011	To investigate the impact of portion size and energy density on intake, both grams and kilocalories, of snacks in preschool-aged children	17 (7 boys and 10 girls) aged 2-5 years attending full-day preschool at the Early Learning Center on the University of	A 2 (PS) × 2 (ED) within-subject factorial design Snack at preschool	Unsweetened apple sauce (0.43 kcal/g) and chocolate pudding (1.19kcal/g). Reference condition: 150g. Large condition: 300g.	A significant main effect of portion size occurred, with greater energy consumed in the large as compared to small portion, however, there was no main effect of energy density or interaction of energy density and portion size on energy intake	20

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
		Tennessee Knoxville campus				
McCrickerd, Leong and Forde, 2017	To determine whether teacher-served portions impact children's food intake when increased in size	22 (11 boys and 11 girls) aged 3-6.8 years attending preschool	A within subject design Lunch meals at preschool	In the reference condition teachers served children a meal containing: mixed rice (white and brown) with protein (fish/ chicken/ egg/ tofu) and either steamed vegetables or vegetable broth. In the large condition, the amount served was calculated by multiply the amount consumed by each child by 1.5	Children served and consumed similar amounts when they served themselves or were served by their teachers. However, when their teacher served them a 150% serving, they ate significantly more.	21
Rolls et al., 2000	To examine the effects of portion size on children's food intake	32 (14 boys and 18 girls) in two age groups: 3-4.1 (mean age =3.6) and 4.3-6.1 (mean age= 55) years attending a day care programme	A within subject design Lunch meal in a day care centre	Macaroni and cheese with an energy density of 1.4kcal/g Reference condition: 150g (age 3-4.1) and 225g (age 4.3-6.1). Medium condition: 263g (age 3-4.1) and 338g (age 4.3-6.1). Large condition: 376g (age 3-4.1) and 450g (age 4.3-6.1).	Older preschoolers consumed more macaroni and cheese when served the large portion than when served the smaller portion. In contrast, for younger children, portion size did not significantly affect food intake	18

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
Savage et al., 2012	To assess whether a linear increase in portion size influences preschool-aged children's intake of the entrée and of other foods served with the entrée, including fruit and vegetables	17 (7 boys and 10 girls) age 3-5 years attending preschool	A within subject design Lunch meal in a preschool	The amount served in the reference condition was 100g of macaroni and cheese. The portion size was increased by 60g in each condition, with the largest serving being 400g	Children consumed more energy from the entrée and more total energy as the portion size increased. Children consumed a decreasing amount of the other foods served with the entrée as the entrée portion size increased. Milk intake was unaffected by variations in the entrée portion size.	19
Smith et al., 2013	The aim of the research was to evaluate the association between age and the effects of portion size on food intake in Chinese children in a field-based setting	172 (93 boys and 78 girls) aged 4-6 separated into two age groups. Attending kindergarten in Kunming, Yunnan Province, China	A between subjects design (age group) with a within-subject component (PS) Lunch meal in a preschool	The amount served in the reference condition was 150 g (age 4) and 261g (age 6) of rice, vegetables and a protein mix. The small and large portion sizes were 30% lighter and 30% heavier than the reference portion size, respectively	Age was associated with a change in food intake. Only the 6-year-old age group ate significantly more with each increase in portion size. The 4 year old age group ate more in the reference and large portion compared to the small portion, however they did not eat more in the large compared to the reference	20
Spill et al., 2011	To determine the effects of serving different portion sizes of a low-energy dense, vegetable-based soup on children's	72 (41 boys and 31 girls) with a mean age of 4.7 ± 0.1 attending one of two daycare centers on the	A within subject crossover design Lunch time in a day-care centre.	The amount served in the reference condition was 225g of tomato soup. The small and large portion sizes were 33% lighter and 33% heavier than the	Intake of tomato soup was significantly affected by the portion size that was served. Doubling the portion size from 150 to 300g led to a significant increase in soup consumption by 23%, however the middle portion	19

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
	energy and vegetable intake within a meal and over the next eating occasion	University Park campus of The Pennsylvania State University		reference portion size, respectively	size was not significantly different than intake from either of the other portions	
			Unit Food Items			
Aerts and Smits 2017 (study 2)	To examine intake when children are served a small and large portion of a nutritious and less nutritious snack	55 children (19 boys, 26 girls) aged 3 to 6 years old from four classes in two schools in Belgium.	A 2 (portion size) X 2 (snack type) within subject design Morning snack at school	The first snack was baby carrots (35 kcal/100g) served in a regular 80g and large portion size 130g. The second snack was ladyfinger cookies (400kcal/100g) served in a regular 30g and large portion size 48g.	Children consumed significantly more cookies when offered the large versus regular portion. However, children did not consume significantly more carrots from the large compared to the regular portion.	20
Fisher et al., 2007b	To observe the effect of large portions on daily energy intake in 5-y-old Hispanic and African American children from low-income families	58 children (24 boys, 35 girls) aged 5 attending a Head start programme in Houston. African American and Hispanic	A within subject design Lunch meal in a laboratory	The amount served in the reference condition was: 185 kcal graham crackers and 368 kcal chicken nuggets. The amount provided in the reference condition was doubled for the large condition	Doubling the portion size of crackers did not impact intake, however doubling the portion size of chicken nuggets led to a 34% increase in intake	20
Kral et al., 2014	To compare energy intake at a meal in normal-weight and obese children when the portion size of	50 (24 boys and 26 girls) aged 8-10 years old. Half of normal body weight and half classified as	A within subject design with weight status as a between-subjects factor and portion size as a within-	The amount served in the reference condition was: 540kcal chicken nuggets, 378kcal hash browns, 94kcal ketchup, 31kcal green	Overall, children consumed significantly more in the moderate and large condition compared to the reference amount. Planned comparisons showed	20

Author and Date	**Aims of Study**	**Participant and sample**	**Methods**	**Manipulated Food Items**	**Findings**	**Quality[a]**
	energy dense foods and a sugar-sweetened beverage was systematically increased	obese. Diverse ethnicity	subjects factor Evening meal in a laboratory	beans, 420kcal brownies and 100kcal fruit punch. 150 and 200% of this amount was served in the moderate and large portion conditions	that obese children consumed significantly more calories during the meal compared to normal-weight children in all conditions	
Mathias et al., 2012	To examine whether larger portions increase children's intake of both fruits and vegetables.	30 children (12 boys, 18 girls) aged 4 to 6 years old. Half were classified as overweight or obese.	A 2 (vegetable PS) x 2 (Fruit PS) within-subjects design.	Fixed portions of rotini pasta and tomato sauce (310g), 2% milk (244g) and a side of light ranch dressing (31g) were offered in all conditions. Only the portion sizes of the drained canned peaches in light syrup and cooked broccoli were manipulated (75 v 150g)	Children consumed 41±6 g or 70% more fruit in the large portion conditions than in the reference conditions (59±5 g vs 101±9 g; $P<0.0001$), which corresponds to a two-fifths-of-a-serving increase. Children also consumed 12±4 g (37%) more of the vegetable side dish in the large portion conditions than in the reference conditions (32±6 g vs 44±9 g; $P<0.01$).	18
Ramsay et al., 2013	To compare kindergarteners' intake of food from a school lunch meal when they are pre-served a larger entrée portion to when they are allowed to choose from three preplated entrée	114-121 kindergarten children attending a Kinder centre	A within subject design Lunch meal at preschool	The amount served in the reference condition was: 4 chicken nuggets. On self-serve days children had a choice of 2, 3 or 4 nuggets	On non-choice days 4 nuggets were served whereas not all Kindergarteners selected the largest nugget portion on choice lunches. This resulted in a significant decrease in chicken nugget intake between choice and nonchoice days	17

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
	portion sizes					
Spill et al., 2010	To determine the effects of serving preschool children different portions of a vegetable as a first course at lunch on vegetable consumption and energy intake at the meal	51 (22 boys and 29 girls) aged 3-6 (mean 4.4 ± 0.1y) enrolled in daycare at the Bennett Family Center at the University Park campus of The Pennsylvania State University	A within subject crossover design Lunch time in a day-care centre.	The amount served in the reference condition was 30 g of carrots. This was doubled and tripled for the moderate and large portion size conditions	Doubling the portion size led to a significant increase in carrot consumption by 47% whilst tripling the portion size led to a significant increase in carrot consumption by 54%	18
van Kleef et al., 2015	To investigate whether unit and portion size can be exploited to seduce children to eat more snack vegetables	255 (112 boys and 142 girls) aged 8 to 13 years. Attending primary school in the centre of the Netherlands	A 2 (PS) × 2 (unit size) within-subject design Morning snack at preschool	The amount served in the reference condition was approximately one third of a cucumber (127g). The amount served in the large condition was approximately two-thirds of a cucumber (248g)	Participants being presented with the large portion size ate about 54 % more cucumber relative to the small portion size	20
			Unit and Amorphous Foods			
Kling et al., 2015	To examine the independent and combined effects on children's intake of changing the portion size and ED of all	120 children (61 boys, 59 girls) aged 3-6 (mean 4.4 ± 0.1y) attending a childcare centre	A within subject crossover design Lunch meal in childcare centre	The experimental meal consisted of chicken (grilled breast or breaded nuggets), macaroni and cheese, a green vegetable (broccoli or peas), applesauce, ketchup,	There was a significant effect of portion size (*P* < 0.0001) but not ED (*P* = 0.22) on the weight of the meal consumed. Compared to the 100% portion size conditions, meal intake was 21% (60 ± 7 g) greater in the 150% portion size conditions and 26% (74 ± 7 g)	19

Author and Date	Aims of Study	Participant and sample	Methods	Manipulated Food Items	Findings	Quality[a]
	components of a meal			and milk. A 395g serving was provided in the reference condition. A 150 and 200% serving were provided in the medium and large condition.	greater in the 200% portion size conditions (both $P < 0.0001$).	
Kral et al., 2010	To examine the effects of doubling the portion size of F&V side dishes on children's intake of F&V at a meal	43 (22 boys and 21 girls) aged 5-6 years old. Diverse ethnicity	A within subject design Evening meal in a laboratory	The amount served in the reference condition was: 75g broccoli, 75g carrots and 122g applesauce. The amount provided in the reference condition was doubled for the large condition	Doubling the portion size of F&V side dishes resulted in a significant increase in the total weight of F&V consumed This resulted in a significant decrease in intake of the main entrée.	20
Mooreville et al., 2015	To evaluate associations of young children's susceptibility to large food portion sizes with child appetite regulation traits and weight status	100 (45 male and 55 female) aged 5-6 years. Non-Hispanic black. Normal weight (n=66) and obese (n=34)	A within subject design with repeated measures Evening meal in a laboratory	The amount served in the reference condition was: 220g pasta, 84g corn, 127g applesauce and 25g cookies.150, 200% and 250% of this amount was served in the moderate, large and extra-large portion conditions	Total energy intake significantly increased from the reference portion to the 250% condition. The effect of portion size condition on total energy intake, however, did not vary by child weight status	19

[a] Possbile score 0 – 22, > 18 = high quality, < 11 = low quality.

Table 16: Summary of evidence categorised by magnitude of portion size increase

Magnitude increase of portion size	**Systematic review**	
	Studies	Study groups
0-50%		4
51- 100 %	15	27
101-150%		3
151-200%		4
201-250%		1
250-300%		1

Quality assessment

The maximum score that could be achieved was 22. The scores ranged between 17 (Ramsay et al., 2013) and 21 (Mccrickerd, Leong & Forde, 2017) providing evidence of reasonable quality across studies. Studies tended to score highly for their rigorous research design and adequately drawn conclusions. However, studies tended to score lower on the question regarding ethical considerations as very few studies provided sufficient detail which may be due to word restrictions. No studies were excluded from the systematic review based on their quality score.

Portion Size Effects

Amorphous foods

Nine (Aerts & Smits, 2017; Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2007b; Looney & Raynor, 2011; Rolls, Engell & Birch, 2000; Savage et al., 2012; Spill et al., 2011) of the included studies reported that increasing the reference portion of an amorphous food by 51-100% significantly affected intake ($p < .05$). Children aged 2-9 years consumed significantly more soup (Spill et al., 2011), macaroni cheese (Fisher, Rolls & Birch, 2003; Fisher, 2007; Fisher et al., 2007a; Rolls, Engell & Birch, 2000; Savage et al., 2012), cereal (Fisher et al. 2007b), chocolate pudding, applesauce (Looney & Raynor, 2011) and popcorn (Aerts & Smits, 2017) when the portion size was doubled. However, children aged 5 years did not consume significantly more macaroni and cheese in the double (M=239, SD = ±118kcal) compared with the reference (M=226, SD = ±125kcal) portion condition ($p > .05$) when served alongside fixed, but generous, portions of carrot, cookies and applesauce (Fisher et al. 2007a).

Four studies (Fisher, 2007; Mccrickerd, Leong & Forde, 2017; Rolls, Engell & Birch, 2000; Smith et al., 2013) examined differences in intake based on age. One study reported that differences in amount consumed were not related to the age or sex of the children (Fisher, 2007). Contrastingly, Rolls et al. (Rolls, Engell & Birch, 2000) found that doubling the portion size of macaroni and cheese did not significantly impact consumption in children aged 3-4 (M= 44.80, SE= ±12.30g vs. M= 54.60, SE = ±15.80g, $p >.05$), although it did significantly impact intake in children aged 4-6 (M = 76.70, SE= ±14.80g vs. M=122.70, SE= ±21.60g, $p < .002$). Similar findings were observed when the portion size of amorphous food was increased by < 50%

(Smith, 2013) or tailored to the individual (Mccrickerd, Leong & Forde, 2017). Increasing the portion size of a rice, vegetable and protein mix by 30% had no impact on intake in children ≤ 4 years old, yet children ≥ 6 years old consumed 36% more ($p < .01$) (Smith et al., 2013). Child age was also found to interact with serving method to influence the amount served and thus consumed at a lunch meal. Total serving and intake of macaroni and cheese were highest in the 150% condition compared with teacher and child-serve days but comparisons were only significant for children ≥ 6 years ($p \leq 0.04$), and not the younger children (3-5 years; $p \geq 0.17$) (Mccrickerd, Leong & Forde, 2017).

In two studies, the portion size of macaroni and cheese was manipulated by <50% (Leahy et al., 2008) or by using self-serve methods (Fisher et al., 2013), however neither study compared the impact on consumption by the age of the child. Leahy et al., (2008) found that increasing pureed vegetable content in pasta by 20g significantly increased vegetable consumption in children aged 3-5, such that they consumed an additional half serving of vegetables. Similarly, when macaroni and cheese increased in 60g increments from 60 to 400g, children aged 3-5 were reported to consume significantly more with each portion size increase. This positive association between portion size and consumption was also observed when children were able to self-serve. On average children consumed an additional 0.56 kcal of macaroni and cheese for each additional gram served (Fisher et al., 2013).

Unit Foods

When the portion size of unit foods were increased between 51 and 100%, six (Aerts & Smits, 2017; Fisher et al., 2007b; van Kleef, Bruggers & de Vet, 2015; Kral et al., 2014; Mathias et al., 2012; Spill et al., 2010) of the included studies reported a significant effect on intake ($p < .05$), similar to those that doubled the portion size of amorphous items (Aerts & Smits, 2017; Fisher, 2007; Fisher et al., 2007a; Fisher et al., 2013; Looney & Raynor, 2011; Rolls, Engell & Birch, 2000; Spill et al., 2011). Children increased consumption of carrots (47%) (Spill et al., 2010), cucumber (54%) (van Kleef et al., 2015) and cookies (28%) (Aerts & Smits, 2017) when doubled in portion size and served on their own as a singular food type. Children also increased consumption of unit foods when a variety of items were served together, such as chicken nuggets, hash browns, green beans and brownie (Kral et al., 2014), or when unit foods were served alongside a fixed portion of an amorphous item (Mathias et al., 2012) or fixed portions of unit items (Fisher et al., 2007a). For example, children consumed 72% more fruit ($p < .0001$) and 38% more vegetables ($p < .01$) when the portion size was doubled and served alongside a fixed portion of pasta (310g) that fell between the 75th and 90th percentile of intake for children aged 2-5 years (Smiciklas-Wright et al., 1994). Furthermore, children aged 5 consumed 34% more chicken nuggets when served alongside a fixed, but generous, portion of corn and bread roll (Fisher et al., 2007a). However, when the same sample of children were served a double portion of crackers, intake was unaffected. Similarly, Aerts and Smit (Aerts & Smits, 2017) reported that children aged 3-6 did not significantly increase consumption of baby carrots at morning snack time when the reference portion was increased by 63%.

When children were able to self-serve unit foods for lunch in kindergarten, children opted for an average of 3.49 chicken nuggets (Ramsay et al., 2013). On fixed portion days children were served 4 chicken nuggets. This significantly affected intake ($p < .009$) such that children consumed 10% more on fixed portion days when more units were served compared to self-selected days when children served themselves less units.

Unit and amorphous foods

When the portion size of unit and amorphous items were increased by 51-100% within the same meal or snack occasion, three (Kling et al., 2016; Kral et al., 2010; Mooreville et al., 2015) of the included studies reported a significant impact on intake ($p < .02$).

When unit and amorphous items were doubled within one meal (Kling et al., 2016; Kral et al., 2010; Mooreville et al., 2015) significant increases in consumption were recorded. However, not all food items contributed to the increase in total energy intake. For example, Kling et al., (Kling et al., 2016) showed that serving a double portion of macaroni and cheese, chicken, vegetables, applesauce and ketchup increased intake of macaroni and cheese (31%), applesauce (64%) and ketchup (49%) ($p < 0.02$). Intake of chicken and vegetables remained similar between portion size conditions. Similar findings were observed when fruit and vegetable side dishes were doubled in portion size (Kral et al., 2010). Total intake increased ($p < .01$), due to a

43% increase in applesauce ($p < .01$); carrot ($p = .60$) and broccoli ($p = .74$) consumption did not differ between conditions. Furthermore, when the portion size of macaroni and cheese, corn, applesauce and cookies was doubled in a laboratory total energy intake increased ($p < 0.01$) (Mooreville et al., 2015). The overall effect on total energy intake was due to an increase in the HED macaroni and cheese (21% increase across conditions) and cookies (a 60% increase across conditions) rather than the other food items.

Meta-analysis

Studies included in the meta-analysis

A total of 14 papers, contributing 14 unique studies and 24 conditions/ exposure groups testing the effect of a 51-100% increase in portion size on food intake in children aged 2-12 years old were included in the meta-analysis. Of the 21 papers (contributing 23 studies and 39 conditions/ exposure groups) initially considered for inclusion in the meta-analysis, one study was excluded as the portion size was not increased by 51-100% (Leahy et al., 2008) and five papers contributing 6 studies did not use a clear definition of portion size increase (Fisher et al., 2013; Kral et al., 2010; Mccrickerd, Leong & Forde, 2017; Ramsay et al., 2013; Smith et al., 2013). Furthermore, two studies were excluded since evidence of plate clearing was detected (Savage et al. 2012; Aerts & Smits, 2017 (study A)). Plate clearing was defined on the basis that the children consumed more than or equal to 90% of what was offered (Caton et al., 2013). Note that although Aerts study A (Aerts & Smits, 2017) was removed due to plate clearing, there was no evidence of plate clearing in Aerts study B (Aerts & Smits, 2017) and so this study was retained for the analysis. Moreover in the Savage et al. paper (Savage et al., 2012) the reference portion size was unusually small. More detail on this is provided in the discussion section.

Results of the meta-analysis

Results of the primary meta-analysis and the meta-regression including food type as a moderator are shown in Figure 5. When children aged 2 – 12 years were offered unit, amorphous or both unit and amorphous food items the pooled SMD was 0.47 (95% CI: 0.39-0.55) indicating a statistically significant PSE (Figure 5). The pooled SMD indicates that a portion size increase 51-100% is associated with an SMD of

0.47, which can be re-expressed as equivalent to a 13% (186 kcal) increase in average daily energy intake.

The test for residual heterogeneity was not significant (Q = 27, df = 23, $p = 0.24$) suggesting minimal variation in treatment effects between studies.

Three effect modifiers were explored including, initial portion size, mean age and food type (unit, amorphous and, unit and amorphous), testing each one in isolation in a meta-regression. Inclusion of the continuous covariate for initial portion size (in grams for all studies) was found to be non- significant (coefficient = -0.0004, 95% CI: -0.0009 - -0.0001, $p = 0.14$). Indicating the initial portion size does not impact upon the portion size effect. Mean study group age was missing for one study (Fisher et al., 2007b), however the age range was given as 5-6 years, and so mean age was assumed to be 5.5 years. Inclusion of a continuous covariate for mean age was not significant (coefficient = 0.02, 95% CI: -0.03 - 0.06, $p = 0.47$), suggesting that the portion size effect is not associated with age.

The impact of food type was assessed by including food type as a moderator with 3 levels (amorphous; unit; amorphous and unit). The PSE was found to be statistically significant in all subgroups, with the largest pooled SMD for unit (SMD = 0.53, 95% CI: 0.41 - 0.66), then unit and amorphous (SMD = 0.47, 95% CI: 0.32 - 0.62) and amorphous (SMD = 0.39, 95% CI: 0.25 - 0.43) (Figure 5). The overall test for food type as a moderator was not statistically significant (p= 0.33).

Visual analysis of the funnel plot demonstrated relatively good symmetry suggesting the absence of reporting bias (Figure 6).

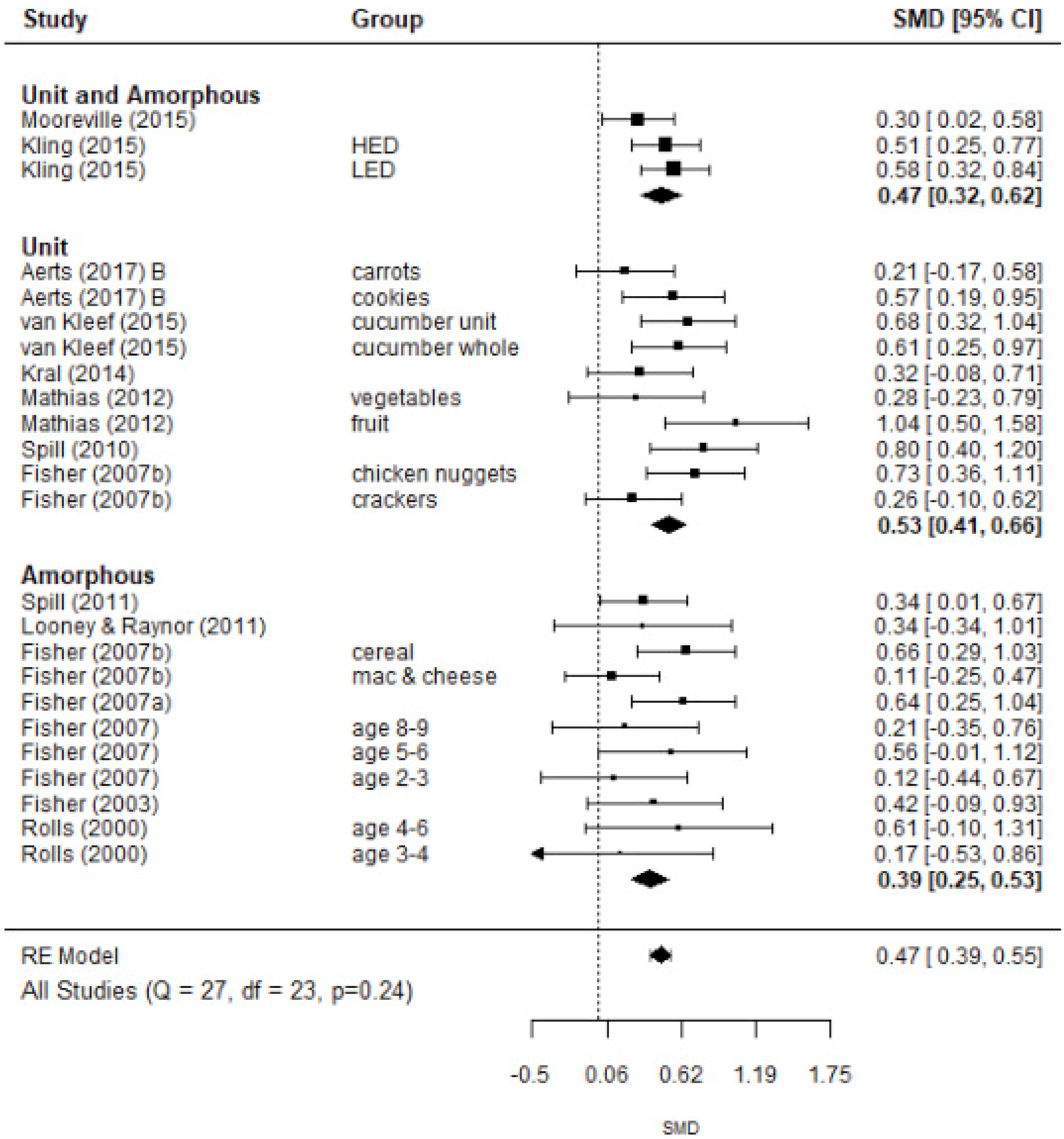

Figure 5: Forest plot of random effects meta-analysis for all exposure groups, and according to food type served

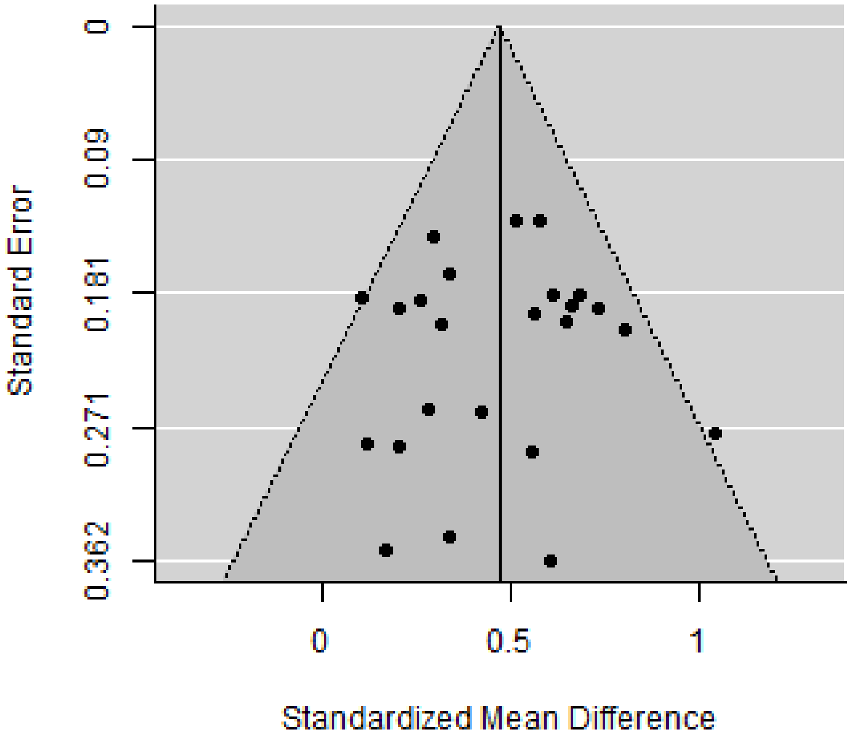

Figure 6: Funnel plot to detect possible reporting bias

6.3.4 Discussion

The purpose of this review was to investigate the impact of offering unit or amorphous food (i.e. food type) on the PSE in children aged 2 to 12 years old. The meta- regression did not reveal a significant difference in the magnitude of the PSE based on food type served, child age or initial portion size served. Overall, the PSE was observed across studies, at all eating occasions, including breakfast, lunch, dinner and snacks, and for all food types.

The analysis revealed no complex interplay between the PSE and the type of food served. However, several studies were removed from the meta-analysis. For example, in one study portion size did not increase by 51-100% (Leahy et al., 2008) and several studies were unclear about the magnitude of the portion size increase (Fisher et al., 2013; Kral et al., 2010; Mccrickerd, Leong & Forde, 2017; Ramsay et al., 2013; Smith et al., 2013). The reference and enlarged portion sizes served in the Savage et al., (Savage et al., 2012) study were much smaller, and thus not comparable to the other included studies. The reference and enlarged portion size used in this study were smaller than the average quantity of macaroni and cheese consumed by children aged 2-5 years in the USA, as demonstrated in the Continuing Survey of Food Intakes by Individuals (Smiciklas-Wright et al., 1994). The small portion sizes offered may explain why children appeared to consume all (90% or more) that was offered to them. Similarly, children in one of the studies (study A) in the Aerts et al. paper (Aerts & Smits, 2017) demonstrated plate clearing; the children consumed all of the popcorn that was offered to them in both the reference and large portion size conditions. As a result this study was also excluded from the meta-analysis. A decision to keep in the second study (study B) from the Aerts et al. (Aerts & Smits, 2017) article was made due to the absence of plate clearing. The inclusion of Savage et al. (2012) and Aerts et al. (2017) studies may have produced an inflated, artificial SMD thus not producing a true effect.

Increasing children's portion size by 51-100% produced a significant PSE. It is possible that children were unable to detect changes to the portion sizes on offer irrespective of food type (Fisher, Rolls & Birch, 2003). Alternatively, children this age typically clean the plate or eat most of what is offered as an expectation placed on them by parents. Given that children are known to eat all that is served to them

(Johnson et al., 2014) and are encouraged to clear their plate (Birch et al., 1987) parents and caregivers may promote overconsumption. Recent survey data suggests that parents are unaware of age appropriate portion sizes for their children and often provide larger portions than deemed suitable (Infant and Toddler Forum, 2014), which may inhibit self-regulation. Interestingly, when children self-served from a regular and large serving dish, they served and thus consumed more from the larger serving dish (Fisher et al., 2013). These findings extend previous research suggesting that large food portion sizes not only stimulate intake when served directly to children, but also when children are allowed to serve themselves. These actions may be acquired through experience from parents or from social norms set by decades of increasingly large food portion sizes on offer in the marketplace (Nielsen & Popkin, 2003).

In a previous meta-analysis Zlatevska et al. (2014) identified the PSE to be curvilinear with a possible ceiling effect, perhaps due to an increase in salience and reliance on internal cues. Similar findings have been reported in a study examining the magnitude of the PSE when all components of a meal with varying energy densities were increased in size (Roe, Kling, & Rolls, 2016). For example, as food portion sizes got larger participants consumed an increasingly smaller proportion of the amount served and the strongest predictor of food intake was the portion size offered. However, the results of the current meta-analysis do not fully support these findings. The initial portion size did not significantly affect the PSE. This finding might be due to the relatively small number of studies included in the meta-analysis. The initial portion size moderator analysis did not account for type of food used. This might be of potential interest in future investigations. There is the possibility of a relationship between portion size and energy density, whereby larger portion sizes may be less energy dense than small ones.

The largest increases in consumption were observed when unit foods increased by 51-100% in portion size. Similarly, to the tendency to clean the plate is a consumer’s tendency to consume a unit of food in its entirety. According to the ‘unit bias’ mechanism consumers associate a single serving as being an appropriate amount to eat, regardless of its size (e.g. one sandwich) (Geier et al., 2006). As such, people tend to eat one unit of food. Moreover, when multiple smaller units are on offer, as demonstrated in the included studies, consumers may justify the need to consume multiple units or additional items due to their smaller size (Benton, 2015).

It is possible that other unaccounted factors also contribute to the PSE. For example, when children were presented with multiple food items, not all items contributed to the PSE (Kling et al., 2016; Kral et al., 2010) and serving method was also shown to be influential. Children increased intake of some foods but not others when presented with a variety. These findings have been observed elsewhere in the literature (Mooreville et al., 2015), with children increasing intake of their preferred foods, which were high in energy density and palatability (e.g., cookies, when served in combination with less preferred foods of low energy density; LED). These findings suggests that in order for children to consume more LED foods such as fruit and vegetables, food preference and the competing foods on offer should be taken into account (Kling et al., 2016). For example, some studies have reported that portion size had no effect on vegetable consumption when vegetables were provided as part of a main meal (Kral et al., 2010). Yet when vegetables were served before the main meal, in the absence of competing foods, the PSE was observed for both unit (carrot) (Spill et al., 2010) and amorphous (vegetable based soup) (Spill et al., 2011) vegetables. Therefore, it is possible that children's familiarity and preference for the competing foods on offer influences the PSE. Thus, the PSE may encourage intake of healthy, core foods such as fruits and vegetables if served in isolation.

Children of all ages within the review demonstrated susceptibility to the PSE by consuming larger amounts when provided with larger food portion sizes. Previous research has shown that infants and preschool children have the ability to self-regulate energy intake in controlled laboratory conditions (Birch & Fisher, 1995; Birch & Deysher 1985) suggesting a developmental shift in children's susceptibility to the PSE. However, the current review suggests that external cues (e.g. portion size) may become more influential in determining how much to eat and thus may promote energy intake in children from the age of 2 years old. Therefore, younger children may not be protected against the effects of portion size, as previously thought (Birch & Fisher, 1995).

Implications

This review demonstrates that children aged 2- 12 years are responsive to the PSE, irrespective of food type or child age. This could have serious long-term implications for children's health given that eating patterns track into later life (Cashdan, 1994). Ubiquitous exposure to large portion sizes of HED foods has the potential to promote overconsumption especially given that large food portion sizes are becoming increasingly accessible within the food environment (Nielsen & Popkin, 2003). Research has demonstrated that modest increases in fruit and vegetable portion sizes can improve children's intake of these nutrient dense, LED foods (Mathias et al., 2012) therefore it is possible that downsizing methods could reduce intake of HED foods. Based on these outcomes, a pilot investigation (ClinicalTrials.gov NCT03339986) (Reale et al., 2018) was designed to explore the efficacy and acceptability of two portion control strategies on intake of HED snacks in preschool children, with a focus on downsizing, since the amount of food served appears to be a central determinant in the amount children consume e.g. (Disantis et al., 2013).

Strengths, Limitations and future research

This review extends current evidence on the effect of large food portion sizes on children's dietary intake (Hollands et al., 2015; Zlatevska et al., 2014) and makes a significant contribution to the literature by examining three moderators in isolation, including the impact of food type. Furthermore, this review revealed that children as young as two years of age are susceptible to the PSE which highlights the developmental stage where intervention is warranted. A funnel plot was created to detect reporting bias of the studies included in the meta-analysis. Visual inspection revealed good symmetry suggesting the absence of reporting bias.

Limitations have been identified at different levels of the review; study selection, study design and analysis. While the review identified a large selection of studies that manipulated the portion size of food served to children, the search strategy was limited to the inclusion of peer-reviewed articles published in English. Therefore, it is possible that studies published in other languages or as part of a thesis, were excluded. Furthermore, many of the laboratory-based studies used a convenience sample of children attending the university nursery. This resulted in parents having an above average level of education and household income (Fisher et al., 2003; Leahy et al., 2008; Savage et al., 2012; Spill et al., 2011). Nevertheless, this review included studies conducted in natural environments where the sample was often diverse (Fisher et al., 2007a; Fisher et al., 2007b; Kral et al., 2014; Leahy et al., 2008; Spill et al., 2010, 2011).

Some studies were excluded based on providing insufficient information regarding consumption. Most of the included studies observed the effects of enlarged portion sizes on children's intake at one meal or snack occasion which automatically biases the outcome towards children consuming more. The inclusion of smaller portion sizes would allow the effects of downsizing to be observed. Furthermore, if these studies were conducted over a longer time frame then possible dietary adjustments or compensatory behaviours could be examined.

The unit and amorphous subgroup was small, contributing little information with which to estimate the between study standard deviation thus resulting in wide confidence intervals. Future research should aim to determine feasible methods parents can adopt to ensure their children are receiving portion sizes in line with nutritional guidelines. Research suggests that intake can be controlled via portion size, however to date these strategies have not been translated into feasible interventions (Steenhuis &Vermeer, 2009) nor have the effects of downsizing been observed. Research should ideally be conducted within a natural environment such as at home or preschool, to enhance ecological validity. Focusing on low-income parents would be beneficial as this population is at greater risk of obesity (Drewnowski, 2009) and are often underrepresented in child feeding research (Wardle & Carnell, 2007).

6.3.5 Conclusion

This review suggests that children aged 2-12 years consume larger quantities of food when provided with larger food portion sizes. It is likely that the PSE is not affected by food type, although further work is required to consolidate this finding. The portion size served to children appears to be a central determinant in the amount consumed. Therefore, the need for portion control interventions is warranted. Future research should consider feasible and acceptable methods to control the portion sizes caregivers offer to their young children by observing the effects of downsizing strategies.

6.4 Intervention Development

This chapter provides detail of the development of a study that explored the feasibility and acceptability of snack reduction and snack replacement in the home environment.

The project was accepted for funding before I began my PhD however I was able to contribute to the development of the study protocol during the design phase. A test meal was removed, weighed food diaries were introduced and the decision was made to provide all participants with the same selection of snacks rather than manipulate their usual snack intake. This chapter is therefore written in a reflective style to provide detail on how the original protocol was changed and how each decision was made before data collection began. The first decision was made based on the results of a systematic review and meta-analysis presented in the previous chapter (Reale et al. 2019). The results demonstrated that there were no significant differences in the PSE based upon the shape of the food that was served (unit or amorphous). Therefore, the first decision was to include both unit and amorphous snack foods in the study protocol.

6.4.1 Background

It is well documented in the literature that increases to portion size lead to a sustained increase in energy intake however the effects of 'downsizing' on children's nutritional intake and behaviour is an understudied area (Fisher et al., 2015). Caregivers make portion size decisions based on package size (Blake et al., 2015) thus one possible method of downsizing would be to offer a reduced portion size. Alternatively, replacing all HED foods with LED foods may be beneficial since repeated exposure is associated with food acceptance and preference (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012). Therefore, a study exploring the feasibility and acceptability of snack reduction and replacement was designed. The approved protocol included a repeated measure design with participants acting as their own controls during a two-week baseline period. The baseline period was followed by a one week wash out period before participants were randomly allocated to reduce or replace their children's usual snacks for two weeks. To examine the effects of snack reduction and replacement on children's energy intake, it was proposed that during each study week caregivers would completed a three-day food diary using household measures and estimations, and on the third day of each week a test meal would be offered and the amount served and left over weighed, to provide an objective measurement of food intake. The test meal was proposed to consist of a pasta dish served alongside two familiar and liked vegetables, and yoghurt for dessert.

Most research examining the effects of large portion sizes on food intake have been conducted under strict laboratory conditions free from external influences e.g. (Mooreville et al., 2015). Typically, a pre-test food is provided followed by a test meal, with fixed characteristics (e.g. weight, volume, energy), to assess adjustments or compensatory behaviours (Rolls et al., 1991, 1994). However, the PSE is not often considered beyond one meal and compensatory behaviours are more likely to occur when an individual has freedom of choice regarding when and what to eat (Benton, 2015). In contrast, conducting research in a familiar environment encourages habitual behaviour and enhances ecological validity. However, when testing the effects of an intervention in naturalistic environments, it is essential to consider how the protocol can be developed to reduce or control confounding variables that could influence food intake (Gibbons et al., 2014). For example, changes in food palatability (Robinson et al., 2005) and serving method (Raynor & Epstein, 2000) have been found to influence energy intake.

Pilot testing is important for study development and refinement (Hassan, Schattner, & Mazza, 2006) and may help to reduce or control confounding variables. The outcomes help researchers determine the most suitable foods to include, highlight possible deficiencies in measurement tools (Kraemer, Mintz, Noda, Tinklenberg, & Yesavage, 2006; Lancaster, Dodd, & Williamson, 2004) and provide an indication of procedural feasibility (Leon, Davis, & Kraemer, 2011). In the present study, the initial protocol included a pasta-based test meal since past feeding studies e.g. (Fisher, Rolls, & Birch, 2003; Rolls, Engell, & Birch, 2000) have predominantly provided children with pasta-based meals (e.g. macaroni and cheese) as they are suitable for vegetarians and relatively familiar and liked by most children. However, assumptions cannot be made that all children in the present study will be familiar and accepting of all test meal ingredients, and this may impact consumption and study outcomes. Therefore, feedback on the proposed test-meals was needed to inform inclusion in the main study.

Similarly, the initial protocol stated that caregivers would be instructed to reduce or replace the snack foods their children usually consume due to familiarity with these items. However, it was then agreed that offering all participants with the same snacks would help to reduce differences between participants and confounding variables (Gibbons et al., 2014), such as differences in the energy density of snacks consumed between study participants. The protocol was therefore amended so that all children within the study would receive identical snack options, in the same order, following a schedule. Baseline was reduced to one week and a subsequent acclimation period was introduced (one week) to accustom children to the snacks and ensure that snack reduction or replacement was the only change made to children's diets in week 3, to increase confidence that any possible change to children's dietary intake was likely to be resultant of the snack reduction or snack replacement. For this same reason, caregivers were instructed to serve the same meals to their child in week 2 and 3. However, to ensure children liked and were relatively familiar with the snack foods provided, the type and portion size of snacks habitually consumed by preschool children were explored using a screening questionnaire.

The aim of this chapter is exploratory in nature and devised to examine preschool children's habitual snack consumption (type, portion size and frequency of consumption) and gain feedback on two test meals to inform the design of the main study. In the first part of this chapter a discussion of the screening questionnaire used to explore potential participants and the type and portion size of snacks habitually consumed by preschool children is presented (part A).The second part of this chapter is a pilot study, exploring caregiver feedback regarding the appropriateness of the food items and portion sizes of two test meals to determine inclusion in the main study (part B).

6.4.2.1 Part A: habitual snack intake

6.4.2.2 Methods

Participant and Recruitment

Participants were caregivers of children aged 2 to 4 years, who were identified as the main food provider for the child. Caregivers were recruited from 38 toddler groups across Sheffield and advertisements were posted online (e.g. toddler group Facebook pages), between April and July 2016 (Reale et al., 2018). There were no strict exclusion criteria for questionnaire participation and formal inclusion and exclusion criteria were developed once screening questionnaire responses had been collated and final decisions had been made about the study design. The study was reviewed and approved by the School of Health and Related Research Ethics committee at the University of Sheffield (#007850). Caregivers provided informed consent in writing or online.

Procedure

Potential participants were provided with the participant information sheet and the opportunity to ask questions, face-to-face in toddler groups or via email. Potential participants who were interested, were provided with the consent form, the screening questionnaire (paper format or online), a stamped return envelope and were assigned an individual identification code. All caregivers were sent reminder emails one, two and four weeks following provision of consent where the questionnaire had not yet been returned. Once questionnaires had been received and final study details refined, inclusion and exclusion criteria were developed for the main study to which questionnaire responses were compared by the primary researcher. Caregivers were excluded from the main study based on meeting one or more of the following criteria: a) food allergy, or b) attendance at nursery for four or more full consecutive days (for more information see Chapter 6.5). Eligibility to the main study was double checked by a research assistant (C.K) and any uncertainties were discussed. Eligible participants were provided with the participant information sheet for the main study.

Materials

Screening questionnaire

A self- developed screening questionnaire collected information related to participant demographics, annual household income, highest educational attainment, current employment status, ethnicity, current accommodation status and current marital status. Furthermore, information regarding child care, number of siblings and the frequency and portion sizes of LED and HED snacks consumed as part of the habitual diet were recorded. Caregivers also reported their child’s 5 favourite snack foods. The screening questionnaire could be completed in paper format or online via a link to a google document form.

Information regarding child care (days per week) was collected in order to seek out potential participants that were mainly fed by their main caregiver to ensure food diaries could be completed on three consecutive days and that the snacking schedule could be followed.

Information regarding the number of siblings each participant had and whether siblings consumed identical snacks were collected to ensure that all siblings present at the child's snack occasions could be provided with an identical snack option if this was normal for them.

The frequency of snack foods (sweet biscuits, cakes and scones, sweet pastries, sweets and chocolate bars, crisps, green cooked vegetables, other cooked vegetables, salads and fresh fruit) consumed were measured using a shortened version of the FFQ (Hammond et al., 1993). For each snack item, participants selected either "Never", "once a month", "once a fortnight", "once a week", "6 days a week" or "every day". This information was collected since it was important that participants were consuming at least one HED snack per day as part of the habitual diet before adjustments were made (reduction and replacement). Furthermore, it was important to avoid introducing novel items into the child's diet. It was also important that all children liked and regularly consumed LED snacks so that HED snacks could be swapped for LED items in the snack replacement condition.

The screening questionnaire also asked caregivers to provide information regarding their child's 5 favourite snack foods to explore the types of snack that children like to consume. These data were used to inform the types of snack that were to be offered in the intervention. Caregivers were also required to indicate how often their child usually consumed each of their favourite snack items using the scale derived from the FFQ (Hammond et al., 1993), and provide an indication of portion size using household measures, in an open ended question.

Statistical analysis

Data was input into SPSS for statistical analysis (IBM SPSS Statistics v22). Descriptives were produced for all variables and are presented as mean±SD. Nutritional information (https://www.tesco.com/) for each participant's favourite snack items were calculated based on the estimated portion size provided. Participants favourite snacks were categorised according to energy density: LED (<

2.5kcal/g) or HED (> 2.5 kcal.g) (Albar et al., 2014) and nutritional information was collated to provide a mean estimate of energy (kcal), sugar (g), salt (g), fat (g) and saturated fat (g) consumed for LED and HED snacks. To examine potential differences in the frequency caregivers offer LED and HED snacks to their preschool child, a paired sample t-test was run. Significance was established at $p < 0.05$.

6.4.2.3 Results

Participants

One hundred and forty six caregivers (age = 33.82±4.30 years; BMI = 24.97±5.38 $kg\cdot m^2$) of children aged 2-4 years completed the screening questionnaire. Most were well educated (81% ≥ A-Level or equivalent), employed (67%), home owners (85%), married (97%), white British (87%) and earned above the average household income for 2017 (68%) (ASHE, 2017). Children had a mean age of 32.2±11.3 months and were predominantly the first child within the family home, however most had 1 (52%), 2 (16%) or 3 (3%) siblings. There was a near to equal gender balance (n = 75 male; n = 71 female). Full participant demographics are presented in Table 17.

Frequency of snack consumption

Within a typical week, caregivers reported their children to receive 13 servings of fruit, 10 servings of vegetables (green and other) and 4 servings of salad. For more energy dense foods, children receive 3 servings of biscuits, 2 servings of crisps and 1 serving of cake per week. Furthermore, children receive diluted drinks (5.44±8.97) more frequently per week than non-dilute (2.32±4.75) and fresh juice drinks (2.07±4.71).

Favourite snack foods

Caregivers reported up to five of their children's favourite snack foods which were taken as a proxy for their most frequently offered snacks. Most caregivers reported 3 or 4 of their children's favourite snacks totalling 644 responses (146 participants with up to 5 possible responses each). HED snacks (n = 458; 71%) featured in children's top 5 snacks more frequently than LED snacks (n = 186; 29%), with more than half of caregivers not including a LED snack in their children's top 3 favourite snacks. Out of the LED foods provided, 127 items were fruit or vegetables of which fruit (n = 119) featured in children's top 5 snacks more frequently than vegetables (n = 8).

Children's favourite HED snacks included commercially available items such as crisps, chocolate and biscuits contributing approximately 101±43 kcal, 7±6g sugar, 4±4g fat, 2±2g saturated fat and <1g salt per snacking occasion. LED snacks included breadsticks, rice cakes, fresh fruit (e.g. banana, grape and apples) and in a few cases vegetables (e.g. carrot, cucumber, tomato, peppers) contributing approximately 59±34 kcal, 10±8g sugar, <1g fat, <1g saturated fat and <1g salt per snacking occasion.

Caregivers provided information about children's frequency of consumption of their favourite snacks. Paired sample t-test revealed that children's favourite LED snacks are offered significantly more frequently per week ($M = 5.19$, $SD = 0.35$) than children's favourite HED snacks ($M=3.38$, $SD = .74$) [$t(169) = -4.87$, $p < .001$].

Caregivers also provided an estimation of the portion size of children's favourite snacks served. Most mothers (85%) reported providing snacks (LED and HED) based on unit, package or adult hand size. Some indicated providing a reduced unit size (8%), such as half a bag of crisps, whilst others (8%) provided portion sizes larger than a typical packet size e.g. two yoghurts.

Table 17: Participant Demographics

Participant	Demographic information
Child	
Gender	51% male
Age (months)	32.2±11.3
First Child	51%
Caregiver	
Age (years)	33.8±4.3years
BMI	25.0 ± 5.4
Ethnicity	White British, mixed or other 93% Asian Indian, Pakistani or Indonesian 3% Chinese 2% Latin American 2%
Highest Education	> A-level or equivalents 80%
Employment Status	65% employed full/ part time or on maternity leave
Residential Status	Own with or without mortgage 78%
Marital Status	97% married or cohabiting
Income	£0 - 10,000 4% £10 – 20,000 10% £20 – 30,000 18% £30 - 40,000 22% £40,000+ 47%

6.4.2.4 Discussion

The aim of the screening questionnaire was to explore the type and portion size of snacks habitually consumed by preschool children. Responses revealed that caregivers are typically providing their children with 2-3 snacks per day, including both unit and amorphous items. LED snacks are offered more frequently than HED snacks, however it is important to note that provision of snacks does not guarantee consumption (Holley, Farrow, and Haycraft 2016). Furthermore, children demonstrated a preference for HED snacks compared to LED snacks.

Based on responses from the screening questionnaire the main study was designed so that all children within the study would receive identical snack options to increase consistency between participants and reduce confounding variables (e.g. differences in snack size or energy density) (Gibbons et al., 2014). Snack schedules were devised offering up to 3 snacks per day based on reported mean frequency of consumption. The 7 most commonly consumed HED snacks from the screening questionnaire were chosen and placed into the schedule once per day to provide snack variety and maintain similarities with the children's habitual diets (crisps, mini cheddars, yoghurt coated raisins, chocolate coated biscuit, Jaffa cakes, oat bar, crackers) (Table 18). Regarding portion size, caregivers in the present study typically provided snacks based on unit or packet size, as previously demonstrated in the USA (Blake et al., 2015). Therefore, portion sizes of HED snacks were chosen based on normal, or where available, child package size.

For LED snacks, the 4 most commonly consumed fruit (grapes, apple, banana, pear) and vegetable (pepper, carrot, cucumber, tomato) items from the questionnaire were chosen and presented together in the schedule with a starch component (rice cake, breadstick, crackerbread), in line with childcare recommendations (*Head Start/Early Head Start Nutrition Handbook*, 2014; *Health Requirements for Child Care Centers*, 2018) (Table 19). The portion sizes were chosen in line with recommendations for children age 1-4 years; 40g/ portion (British Nutrition Foundation, 2018). All chosen snacks were identified as being liked and regularly consumed by children within the study and regularly consumed by a national representative sample of preschool children (NDNS, 2018).

Table 18: Snacking schedule developed from screening questionnaire responses regarding most commonly consumed HED snacks

Snacking Schedule							
Day	**Monday ↓**	**Tuesday ↓**	**Wednesday ↓**	**Thursday ↓**	**Friday ↓**	**Saturday ↓**	**Sunday ↓**
Snack 1	Jaffa cakes 37.2g, 144 kcal 391 kcal/100g	Digestive biscuit 33.4g, 142 kcal 481 kcal/ 100g	Ritz crackers 31.6g, 146 kcal 460 kcal/100g	Oaty bar 30g, 121kcal 403kcal/100g	Yoghurt raisins 25g, 112 kcal 447 kcal/100g	Mini cheddars 25g, 128 kcal 512 kcal/100g	Pom bears 15g, 79 kcal 528 kcal/ 100g
Snack 2	Oaty bar 30g, 121kcal 403kcal/100g	Mini cheddars 25g, 128 kcal 512 kcal/100g	Pom bears 15g, 79 kcal 528 kcal/ 100g	Yoghurt raisins 25g, 112 kcal 447 kcal/100g	Ritz crackers 31.6g, 146 kcal 460 kcal/100g	Digestive biscuit 33.4g, 142 kcal 481 kcal/ 100g	Jaffa cakes 37.2g, 144 kcal 391 kcal/100g
Snack 3	Pom bears 15g, 79 kcal 528 kcal/ 100g	Yoghurt raisins 25g, 112 kcal 447 kcal/100g	Jaffa cakes 37.2g, 144 kcal 391 kcal/100g	Mini cheddars 25g, 128 kcal 512 kcal/100g	Oaty bar 30g, 121kcal 403kcal/100g	Yoghurt raisins 25g, 112 kcal 447 kcal/100g	Ritz crackers 31.6g, 146 kcal 460 kcal/100g

Table 19: Snacking schedule developed from screening questionnaire responses regarding most commonly consumed LED snacks

Snacking Schedule							
Day	**Monday ↓**	**Tuesday ↓**	**Wednesday ↓**	**Thursday ↓**	**Friday ↓**	**Saturday ↓**	**Sunday ↓**
Snack 1	40g Pepper, 16kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Apple, 21kcal 40g Pepper, 16kcal 11/2 Crackerbread 7.5g, 28.5kcal	40g Banana ,36kcal 40g Carrot, 16kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Cucumber, 6kcal 40g Pear, 23kcal 1 Rice cake 7g, 30kcal	40g Cucumber, 6kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Apple, 21kcal 40g Tomato, 7kcal 11/2 Crackerbread 7.5g, 28.5kcal	40g Pear, 23kcal 40g Carrot, 16kcal 1 Rice cake 7g, 30kcal
Snack 2	40g Apple, 21kcal 40g Tomato, 7kcal 11/2 Crackerbread 7.5g, 28.5kcal	40g Cucumber, 6kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Cucumber, 6kcal 40g Pear, 23kcal 1 Rice cake 7g, 30kcal	40g Apple, 21kcal 40g Pepper, 16kcal 11/2 Crackerbread 7.5g, 28.5kcal	40g Pear, 23kcal 40g Carrot, 16kcal 1 Rice cake 7g, 30kcal	40g Banana , 36kcal 40g Carrot, 16kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Pepper, 16kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal
Snack 3	40g Cucumber, 6kcal 40g Pear, 23kcal 1 Rice cake 7g, 30kcal	40g Pear, 23kcal 40g Carrot, 16kcal 1 Rice cake 7g, 30kcal	40g Pepper, 16kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Banana ,36kcal 40g Carrot, 16kcal 11/2 Breadsticks 8.25g, 34.5kcal	40g Apple, 21kcal 40g Pepper, 16kcal 11/2 Crackerbread 7.5g, 28.5kcal	40g Cucumber, 6kcal 40g Grapes, 27kcal 11/2 Breadsticks 8.25g, 34.5kcal 7g, 30kcal	40g Apple, 21kcal 40g Tomato, 7kcal 11/2 Crackerbread 7.5g, 28.5kcal

6.4.3 Part B: examining two test meals

Test meals can be used as a measure to quantify the effects of a manipulation, in this case an objective measure of the acute effects of snack reduction or replacement on subsequent energy intake. In the present study, it was important that test meal foods were familiar and liked by the participants to ensure the meals were consumed and thus intake could be compared.

6.4.3.1 Methods

Participants

Six caregivers of children aged 2 to 4 years, who reported primary responsibility for feeding their child were recruited to provide feedback on two test meals. All participants had completed the screening questionnaire but were not eligible for the main study due to their child attending nursery for more than three consecutive days. However, these mother-child dyads were still keen to participate and contribute towards study development, and were able to do so due to the shorter study duration i.e. two single meal occasions vs. three week study.

Procedure

Caregivers were provided with ingredients, weighing scales, and cooking/ serving instructions for two test meals. Caregivers were requested to serve each meal in close proximity to the “usual” snack offering (lunch or dinner) and to serve the two meals a week apart. Caregivers were instructed to provide the same two vegetables at each test meal and prepare them using identical methods each time. The vegetables chosen, as well as the method of preparation, were recorded in the feedback pro-forma (Appendix 7). Caregivers were advised to make no food related comments during consumption of the meals and to let their child decide when to stop eating. Once the child had stopped eating, dessert was to be served, regardless of amount consumed as part of the main meal. No additional food items or condiments were served. On completion of the test meal, caregivers were asked to weigh and record leftovers of each meal component using the weighing scales provided (Salter, electronic bowl scales). Participants then completed a written feedback pro-forma and the researcher arranged to return to the participant’s house within 7 days to collect the feedback pro-forma and weighing scales, and to provide a verbal debrief.

Materials and measures

Test meals

Two test meals (Table 20) consisting of a pasta-based dish were provided to children for feedback since pasta dishes are widely used in young children's eating behaviour studies (Fisher. et al., 2003; Fisher, 2007; Leahy et al., 2008; Rolls et al., 2000; Savage et al., 2012). Intake was determined by weighing the amount served and the amount left over to calculate total energy consumed and the amount of each component consumed, with the exception of pasta and sauce that was weighed together.

For test meal 1, caregivers received a bag of dried pasta (fusilli: 500g), tomato sauce (Goodness (Tesco) original tomato sauce with hidden vegetables: 200g), a fruit puree pot (Cow and Gate: 100g) and mini gingerbread men biscuits (Organix Goodies: 25g). Parents were instructed to prepare and serve 75g of the cooked pasta, 100g of the warm tomato sauce and any two cooked vegetables that were both liked and familiar to their child. Vegetables were served in 40g portions in line with recommendations for children aged 1- 4 years. The pureed fruit pot and mini gingerbread men biscuits were served for dessert to ensure children received a balanced meal that provided at least one third of the 1076-1386kcal daily required energy for children aged 1-4 years, and in line with previous research (Savage et al., 2012).

The second test meal consisted of a spaghetti and tomato and mozzarella sauce ready meal (HiPP Organic) and two vegetable components (40g of each, liked and familiar to the child). The same pureed fruit pot and mini gingerbread men biscuits from test meal 1 were served for dessert. This meal was chosen as it meets nutritional requirements for children aged 1-4 years and could be easily delivered to participants. Furthermore, the ready meal required minimal preparation to minimise participant burden (cooked in a microwave or in boiling water on a hob).

For both test meals, caregivers were instructed to provide their child with 150-200ml of water.

Table 20: Nutritional composition of two test meals

	Amount served (g)	**Energy (Kcal)**	**Fat (g)**	**Saturates (g)**	**Carbohydrates (g)**	**Sugar (g)**	**Salt (g)**
Meal 1							
Fusili pasta (Tesco)	75	270	1.1	0.2	54.8	1.8	0.1
Goodness Pasta Sauce (Tesco)	100	38	0.6	0.1	6.3	3.7	0.2
Fruit puree pot (Cow and Gate, Danone ©)	100	57	0.1	0	12.9	12.5	0.03
Mini gingerbread men biscuits (Organix ®)	25	106	2.9	1	17.2	4.7	0.1
Meal 2							
Spaghetti ready meal (HiPP Organic ©)	230	193	6.4	3	23.2	3.9	0.53
Fruit puree pot (Cow and Gate, Danone ©)	100	57	0.1	0	12.9	12.5	0.03
Mini gingerbread men biscuits (Organix ®)	25	106	2.9	1	17.2	4.7	0.1

Feedback pro-forma

An 18-item feedback pro-forma (Appendix 7) was developed to gain feedback on how much the child liked the test meal ingredients, an objective measure of how much was consumed and caregiver's personal opinion of the appropriateness of the portion size of test meal ingredients for their preschool child. Caregivers completed one feedback pro-forma for each test meal and the feedback was used to decide if the meal items and portion sizes were appropriate for inclusion in the main study as a test meal.

6.4.3.2 Results

Participants

Six mothers (age = 34.2 ± 3.3 years; BMI = 26.3 ± 6.2 kg·m^2) of children aged 2 to 4 years provided written, informed consent to prepare and serve two test meals for their child, and were not eligible for the main study due to their child attending nursery for three or more consecutive days. Most were well educated (83% ≥ A-Level or equivalent), employed (67%), home owners (83%), married (83%), white British (83%) and earned above the average household income for 2017 (67%) (ASHE, 2017). Children had a mean age of 32.0±7.6 months and were all the first child to be born within their family. One child had one younger sibling. Four children were female and two were male.

Feedback Pro-forma

Test meal 1 and 2 received mixed responses with no child liking both meals. One child ate all of the pasta when it was served as a ready meal but ate none of the pasta when fresh ingredients were provided, and vice versa.

For test meal 1, mothers reported that most children refused or spat out the pasta because they did not like the sauce, even when one mother tried adding cheese to enhance the taste, despite receiving instructions to make no alterations to the meal. '*She spat out the pasta as she didn't like it. I tried adding cheese but she still wouldn't eat it'* (P3, daughter, age 24 months). Yet, another child enjoyed the meal and requested more '*She really liked it; she wanted more and was sulking when denied more'* (P2, daughter, age 35 months).

Similar responses were gained for the second test meal, with children refusing to consume the meal due to the taste of the sauce, often referring to it as bland. '*He thought it looked yummy before trying it but he didn't like the sauce. He didn't finish his vegetables because they had sauce on them.'* Overall, the fruit pot and mini gingerbread biscuits were relatively liked '*She ate all of the gingerbread men and would not share when her dad joked if he could have one'* (P5, daughter, age 30 months).

The portion size of both test meals were deemed acceptable by all, however one mother found it difficult to evaluate as their child did not consume a large quantity of the meal due to disliking the pasta sauce and fruit pot.

6.4.3.3 Discussion

The aim of the study was to gain feedback on two test meals to determine inclusion in the main study. Responses from the feedback pro-forma revealed no clear consensus to which meal was preferred and neither meal seemed to be highly liked by a moderate number of children, based on the taste of the sauce. Other commercially available sauces were considered, however many contained large quantities of sugar and salt that exceeded or were close to the limit of recommended daily allowances for young children (More and Emmett 2015; WHO | WHO calls on countries to reduce sugars intake among adults and children 2016). Furthermore, to find a meal liked by all children in the study was deemed challenging due to the vast variety of sauces available. Therefore, neither meal was determined appropriate for inclusion in the main study and finding an alternative meal was thought to be unrealistic since the test meal would need to be transported to participant's homes. The University of Sheffield currently does not have any ingestive behaviour laboratories, and so inviting participants in to consume a freshly prepared test-meal was not an option, despite the issues associated with inviting small children in to the lab (for more information see methods chapter section 5.3). Therefore, as an alternative to providing a test meal, the three day food diary was amended to a four day consecutive weighed food diary as an objective measure of energy intake and portion size. Parents are reliable reporters of their children's intake in the home environment (Baranowski et al., 1991) and thus can complete the food diaries as a proxy for their child.

6.4.4 General Discussion

The aim of the present study was to explore preschool children's habitual snack consumption and to gain feedback on two test meals to determine inclusion in the main study. The study revealed similarities in children's habitual snack intake, however children's test-meal preferences were largely varied. Neither test meal was liked by all of the children therefore it was decided that neither meal was suitable for inclusion in the main study. Instead, the decision was made to replace the test meal with an alternate objective measure of food intake and portion size; the weighed food diary.

On average children are consuming 3 portions of fruit and vegetables per day and thus are not achieving minimum recommendations. Furthermore, consumption of HED snacks is contributing large quantities of free sugar which if consumed 2-3 times per day, exceeds maximum recommendations for preschool children ("WHO | WHO calls on countries to reduce sugars intake among adults and children," 2016). These findings support those from the National Diet and Nutrition survey (NDNS, 2018) demonstrating similarities between the sample's habitual diet and that of a nationally representative population. Furthermore, these findings reflect children's dietary intake in Canada (Hutchinson et al., 2018) and the USA (Shriver et al., 2018).

Food diaries have been frequently used as a measure of energy intake; however they are less often used as an accurate measure of portion size. Household measures and food photographs provide an estimation of portion size (Foster et al., 2006) however they have been found to significantly differ from actual weights of food consumed (Frobisher & Maxwell, 2003). The most commonly used measure of portion size is to weigh foods before and after consumption e.g. (Jansen, Mulkens & Jansen, 2007; Ramsay et al., 2013). However, weighed food diaries require more time than estimation. The food photography method was considered, and enquiries were made with researchers who developed the measure, due to its accuracy and ease of participation (Nicklas et al., 2017). However, it was revealed that each researcher using this method requires specialist training available in the USA, or remotely, however this format of training was discouraged. Furthermore, sending data to the USA was not an option due to financial constraints. Therefore, in line with previous research (NDNS, 2018), and to reduce participant burden and non-compliance due to respondent fatigue, the decision was made to include a 4-day weighed food diary (Gersovitz et al., 1978). Furthermore, weighed food diaries provide a good indication of the habitual diet and adjustments to dietary intake that extend past one meal occasion. It was acknowledged that participants may not own weighing scales, and if they do they may not be calibrated, therefore each participant was to receive identical calibrated weighing scales, instructions and a demonstration (Appendix 8).

Strengths and Limitations

Evidence based refinements to the original research protocol were made to enhance the quality of the main study. Responses from the screening questionnaire identified inclusion and exclusion criteria in order to determine participant eligibility and reduce selection bias (Salkind, 2010). Introducing snacking schedules to mirror children's habitual snack intake may reduce the number of changes to the child's diet in week 3 to ensure that any possible change in intake is resultant of the snack reduction or replacement methods (Gibbons et al., 2014). Furthermore, examination of two test meals identified a weakness in the study design and led to the removal of a poor measure which would otherwise have been included and may have produced unreliable findings (Hassan et al., 2006).

The screening questionnaire was limited by its small sample size however responses regarding children's dietary intake were in line with a large national representative sample (NDNS, 2018) increasing the generalisability of findings. Furthermore, eating patterns reflected that of children in the USA (Shriver et al., 2018) and Canada (Hutchinson et al., 2018). Another limitation was piloting only two test meals. Inclusion of more meals may have led to the discovery, and thus inclusion, of a suitable test meal, however this part of the intervention development was governed by time and financial constraints.

6.4.5 Conclusion

Intervention development is an extremely important aspect of any study design; testing methods and resources before initiating the main study are beneficial for enhancing the overall study design. Furthermore, screening questionnaires determine participant eligibility and in this case increased the likelihood of providing snacks in portion sizes and frequencies that not only reflect habitual intake but also minimise change to dietary intake during acclimation and intervention periods.

6.4.6 Summary

The screening questionnaire provided information regarding the type, portion size and frequency of snacks consumed habitually by children age 2-4 years, and this information was used to develop three snacking schedules (acclimation, reduction and replacement) that reflect the samples habitual diet. Questionnaire responses reinforced the need to develop interventions focussing on healthy snack consumption as children demonstrated a preference for HED foods which contribute a large quantity of sugar to the habitual diet. Furthermore, children do not appear to be receiving the minimum recommended frequency of 5 fruit and vegetables per day.

The pilot study revealed high levels of variability in food preferences resulting in the removal of the test meal from the study protocol. Other measures of food intake were considered but not included due to the poor accuracy of portion size reporting or cost of training required. The researchers decided that the most suitable method was the weighed food diary to be completed on four-consecutive days due to its portion size accuracy and low administrative cost. It was acknowledged that each participant would need to be provided with calibrated weighing scales, instructions and a demonstration to produce more reliable data.

6.5 Study 4: The feasibility and acceptability of two methods of snack portion control in United Kingdom (UK) preschool children: reduction and replacement

Authors: S Reale, C. M. Kearney, M. M Hetherington, F Croden, J. E. Cecil, S. A. Carstairs, B. J. Rolls & S. J. Caton.

Reale, Sophie et al. 2018. "The Feasibility and Acceptability of Two Methods of Snack Portion Control in United Kingdom (UK) Preschool Children: Reduction and Replacement." *Nutrients* 10(10): 1493. http://www.mdpi.com/2072-6643/10/10/1493 (November 4, 2018).

This chapter presents the findings of the intervention which explored the feasibility and acceptability of two methods of portion control: snack reduction and snack replacement. This chapter is presented in the format of a published paper that has been published in a special edition of Nutrients "*Food portion size in relation to diet and health*" (Reale et al., 2018). Permission to present this material is provided in Appendix 2, part B. The primary author contributed to the study design, data collection, data analysis and primary writing of the paper. Detail of the co-authors, including their contribution to this work can be found in Appendix 1.

6.5.1 Background

Despite efforts to address poor dietary intake, children's diets remain less than nutritionally optimal with many young children consuming diets that contain excessive amounts of energy, salt, sugar, and low intakes of fruit and vegetables (NDNS, 2016). It is known that poor diet quality and excess energy intake relative to expenditure contribute to the development of chronic diseases in adulthood (Lim et al., 2012). Dietary habits established early in life track into later life (Nicklaus, Boggio, Chabanet, & Issanchou, 2005), highlighting the importance of establishing healthy eating in the early years. During early childhood the family environment is one of the main influencing factors on diet quality (Maher, Fraser, & Lindsay, 2010). There is a positive relationship between maternal and child intake for core and non-core/ snack food items (Wroten et al., 2012) and a similar relationship for portion sizes served (Johnson et al., 2014). Eating between-meal snacks in young children may be necessary to support growth and development (Larson & Story, 2013). However, data from the US, Canada, and Europe suggest that snack foods contribute a significant amount of energy, salt and sugar to the habitual diet (Dunford & Popkin, 2018; Piernas & Popkin, 2010; Samuelson, 2000). In the present study we tested two strategies to modify snacking behaviour that have the potential to improve children's diets.

High energy dense (HED; >2.5 kcal/g) foods (Albar et al., 2014) including many snacks are thought to contribute to excess energy intake and increase the risk of overweight/obesity in paediatric populations (Davison et al., 2015; Jeffery et al., 2007; Pearson, Ball, & Crawford, 2011). Snacking has also been related to poor diet quality (Evans et al., 2015; Larson & Story, 2013). In the UK half of the sugar children consume is derived from HED snacks, such as confectionary (sweets and chocolate), cakes, buns, biscuits and sugary drinks (NDNS, 2016). A recent survey carried out by the Infant and Toddler Forum (Infant and Toddler Forum, 2014) reported that children as young as age two are being offered large, adult-sized portions of HED snacks. Similarly, in the US 57% of preschool children are consuming cookies and candy daily (Deming et al., 2017). A study examining US preschoolers aged 2-5 years demonstrated that frequency of snacking and body weight are positively related (Kachurak et al., 2018).

In 2018, Public Health England (PHE) launched the campaign *"Look for 100 calorie snacks, two a day max"* advising caregivers to limit the frequency and energy content of children's snacks to twice a day, with a maximum of 100kcal per snack (PHE, 2018). This campaign was launched as a bid to reduce sugar intake at the population level. This advice contributes towards efforts to reduce total daily energy intake (TDEI) from free sugars by 50%, as recommended by the World Health Organisation ("WHO | WHO calls on countries to reduce sugars intake among adults and children," 2016) and dietary guidelines in the US. However, given that most adults and children are exceeding 11% of their TDEI from sugar, reducing this to 5% as recommended by the UK Scientific Advisory Committee on Nutrition (sacn, 2015) constitutes a significant and challenging shift in dietary behaviours. Smaller portion sizes of HED snack foods might facilitate the consumer's ability to achieve this target.

Parents are known to make a judgement regarding portion size based on package labelling (Blake et al., 2015) or how much they serve themselves (Johnson et al. 2014). Thus, one possible approach to portion size reduction could be the provision of smaller snacks. Since many snacks are offered according to package size, a simple message to caregivers might be to split the "usual" snack in half (Blake et al., 2015). Alternatively, caregivers could be instructed to replace HED snacks with liked and familiar fresh fruit and vegetables since children may accept these foods as alternatives (Ogden, 2010, 2012). Repeated exposure increases food acceptance and preference (Ogden, 2010), and therefore replacing HED with low energy dense (LED; <1.51 kcal/g) snacks (Albar et al., 2014) may be a potential strategy to encourage sustained improvements in children's diets. Little is known about the effects on children's habitual diets of reducing or replacing HED snacks with those lower in energy density A US-based study (Roe, Meengs, Birch, & Rolls, 2013) carried out in a child care setting examined the effects of offering preschool children fruit and vegetables as snacks. Whilst the children demonstrated a preference for fruit overall, offering vegetables as snacks increased intake of vegetables as well as fruit. Whilst offering vegetables as a snack seems to increase vegetable intake, we do not know whether children offered vegetables as snacks compensate by reducing their vegetable intake elsewhere in the diet, for example at meals.

Before conducting a randomized clinical trial to evaluate strategies to manage children's portions of HED snacks, it is advisable to test feasibility and acceptability. The NIHR Evaluation, Trials and Studies Coordinating Centre defines feasibility as an important parameter used to design a full-scale study e.g. recruitment, retention, participant eligibility and compliance (NETSCC, 2013), whereas acceptability refers to "judgements by lay persons, clients and others of whether treatment procedures are appropriate, fair, and reasonable for the problem or client" (Kazdin, 1981). Therefore, the aim of the current pilot study was to explore the feasibility and acceptability of two strategies of snack portion control: snack reduction (reducing snack intake by 50%) and snack replacement (replacing all HED snacks with LED fresh fruits and vegetables). The secondary aim was to examine the efficacy of the two methods of portion size reduction to improve the diets of preschool children. For this research, snacking was defined as any food consumed not part of a main meal (breakfast, lunch or dinner).

6.5.2 Methods

Participants

Participants were mothers of children aged 22-56 months who reported primary responsibility for feeding their child. Mothers were recruited from 38 toddler groups across Sheffield once contact and rapport had been made with toddler group leaders. Furthermore, advertisements were posted online (e.g. toddler group websites or Facebook pages) between April and July 2016. Taking into account both the practicality of recruitment and potential drop-out rates, this pilot study aimed to recruit at least 9% (n=46) of the sample size projected for a larger study (Cocks & Torgerson, 2013), with a minimum of 12 per group (Julious, 2005). Inclusion criteria included; parental age of at least 18 years, a commitment to study involvement for three consecutive weeks and consumption of at least one HED commercially available snack per day, as part of the child's habitual diet. Furthermore, the child had to moderately like and be familiar with the snack items provided. Mothers were excluded if their child had a food allergy or were taking medication known to impact appetite. Due to the requirement of a four-day consecutive food diary (including at least one weekend day) mothers were also excluded if their child attended nursery for more than three full consecutive days. The study was reviewed and approved by the School of Health and Related Research Ethics committee at the University of Sheffield (#007850) and registered as a clinical trial (#NCT03339986, https://clinicaltrials.gov/ct2/show/NCT03339986). Mothers gave written, informed consent and they were provided with £25 for their time. All foods for the study were provided free to mothers.

Design

A mixed methods approach was taken to provide flexibility and integrity to address the range of research questions (Powell et al., 2008). A between subjects 3-week intervention was employed with participants acting as their own controls during baseline (week 1) and acclimation (week 2) periods before being randomised to either snack reduction or snack replacement (week 3). Participants were randomised in blocks of ten, to ensure a balanced sample size across treatment groups (Sedgwick, 2014). The study took place within the home to enhance ecological validity (McGuire, 2017). Each week mothers were asked to keep a 4-day weighed food and beverage diary and were provided with snacking schedules to follow in week 2 and 3. Feasibility and acceptability were measured to estimate parameters needed for a full trial, such as participant eligibility, participation rates, compliance and willingness to continue (Whitehead, Sully, & Campbell, 2014). Feasibility was measured by exploring retention rates, participation and compliance. Acceptability was explored via a post intervention questionnaire and semi-structured interviews.

Procedure

Eligible participants, identified from the screening questionnaire, were instructed to keep a weighed food and drink diary, for their child, for 4 consecutive days. Weighing scales (Salter Essentials Bowl Scale), detailed instructions, photographic examples and a demonstration on how to use the scales accurately was provided. Where possible, mothers were asked to partake in the study on weeks where children were not attending parties. All foods and beverages consumed by their child inside and outside of the home were included, without making any changes to their habitual diet. The researchers (SR, CK) visited participants prior to weeks 2 and 3 to deliver all food items required for study participation.

In week 2, mothers were instructed to replace HED snacks with snacks in the snacking schedule, at their child's usual snack time. Mothers were instructed to provide the usual amount (1, 2 or 3 snacks) and to continue providing fresh fruit and vegetables as part of the habitual diet. However, if they normally provided dried fruit they were advised to replace this with a snack from the schedule given the energy density of dried fruit (e.g. raisins).

In week 3, mothers were randomly allocated to the snack reduction or snack replacement condition via a simple randomisation procedure (block randomisation). In both conditions, mothers were provided with a range of snacks that were intended to replace all HED snacks usually consumed (Table 18, 19). Snack types, amounts and quantity offered per day were chosen based on data collected from the cohort prior to the beginning of the experiment, when caregivers expressed an interest in participating (data presented in chapter 6.4). To ensure all children received the same selection and quantity of snacks, snack schedules were devised (week 2 and 3) providing up to three snacks a day for 7 days. There were no snack repetitions in a day, so each child regardless of whether they had 1, 2 or 3 snacks per day could be offered each snack item at least once per week. Those in the reduction condition received the same HED snacks as week 2 but were instructed to provide a 50% portion at each snack occasion. Full portions were provided to allow mothers to decide how to serve the half portion (e.g. in the original packaging or on a plate/ bowl). In the replacement condition, mothers were instructed to remove all HED snacks and sugar sweetened beverages from their child's diet and offer 40g of fresh fruits and 40g vegetables, a starch-based food (bread stick, rice cake or cracker) served together, and no-sugar alternative drinks (see Table 19, 21). In both conditions, zip lock bags and food clips were provided to store left over food items and enable snacks to be consumed outside of the home or saved for a later snacking occasion. If the child was still hungry after the snack offering, caregivers were advised to provide more of the fresh fruit or vegetable components.

At the end of the intervention, mothers were invited to complete the acceptability questionnaire and the follow-up questionnaire, 4-6 weeks post intervention. A random sample of mothers (N = 26 (n=13 reduction/ 13 replacement) were also invited to participate in a short semi-structured interview to explore, in more detail, the feasibility and acceptability of the intervention. Questions were related to the ease of completing the food diaries and how the child responded to the intervention. The number of interviews conducted was determined by the point at which theoretical saturation was achieved (Glaser & Strauss, 2017). All interviews took place within the family home between December 2016 and May 2017, and were audio recorded. Each interview lasted around 30 minutes and took place immediately post intervention.

Table 21: Nutritional composition of snacks provided in week 2 & 3 (per portion).

	Portion (g)	**Energy (Kcal)**	**Energy Density (kcal/ g)**	**Fat (g)**	**Carbohydrate (g)**	**Sugar (g)**	**Salt (g)**
Chocolate coated sponge cookie (McVitie's)	37	144	3.9	3.6	25.8	19.2	0.07
Cookies (McVitie's)	30	142	4.7	6.4	18.6	5	0.4
Crackers (Ritz)	32	146	4.6	5.7	20.5	2.9	0.7
Oat-bar (Organix, Goodies)		121	4.0	4.5	17	7.8	0.01
Yoghurt coated raisins (Whitworths)	25	112	4.5	5.1	15.8	15.8	0
Cheese potato chips (Jacobs)	25	128	5.1	7.3	12.5	1.3	0.6
Salted potato chips (KP snacks)	15	79	5.3	4.2	9.6	0.5	0.26
Bell Pepper (Red, yellow and orange)	40	11	0.3	0.08	2.53	0	0
Grapes (White)	40	28	0.7	0.06	7.24	6.2	0
Apple (Gala)	40	20	0.5	0.25	5.25	4	0
Banana	40	36	0.9	0.1	9	4.9	0
Carrot	40	16	0.4	0.1	3.8	1.8	0
Cucumber	40	6	0.2	0.04	1.45	0.7	0
Pear	40	23	0.6	0	6	4	0.05
Tomato (cherry)	40	7	0.2	0.08	1.57	1.1	0
Rice cake (Kallo)	7	30	4.3	0.2	6.3	0.1	0.1
Breadstick (Tesco)	8.25	34.5	4.2	0.6	6	0.3	0.15
Crackerbread (Ryvita)	7.5	27	3.6	0.15	5.7	0.15	0.1

Materials and measures

Anthropometrics

All children's heights (m) and weights (kg) were measured by the researcher. Weights were measured using digital scales (Seca) and height measured using a portable stadiometer (Leicester SMSSE-0260; Seca). Weight-for-height z-scores were calculated using the WHO anthropometric calculator (http://www.who.int/childgrowth/software/en/).

Screening questionnaire

The screening questionnaire collected demographic data on child age, gender, parental age, BMI (self-report height and weight), income, education, employment, ethnicity, accommodation status and marital status. Information regarding child care (day per week), food allergies and whether the child liked and regularly consumed HED snacks, fruits and vegetables was also collected to establish typical patterns of food intake. This information was collated by the primary researcher to ensure participants met inclusion criteria.

Food Frequency Questionnaire (FFQ)

A shortened version of the FFQ (Hammond et al., 1993) containing snack items (sweet biscuits, cakes/ scones, sweet pastries, sweets/ chocolate bars, crisps, green cooked vegetables, other cooked vegetables, salad, fresh fruit) was administered to mothers during recruitment to determine eligibility to take part. The same shortened FFQ was administered to mothers 4-6 weeks post intervention to identify any longer-term changes to child intake of fruit, vegetables, and HED confectionary/ snacks.

Parent and child characteristics

Information regarding child individual characteristics was collected to examine potential differences between groups. Several validated questionnaires were administered to mothers to provide an overview of child eating traits and parental feeding practices. These included; the Comprehensive Feeding Practices Questionnaire (CFPQ) (Musher-Eizenman & Holub, 2007), the Child Eating Behaviour Questionnaire (CEBQ) (Wardle et al., 2001) and the child food neophobia scale (Pliner, 1994) as child neophobia has been linked to lower intakes of fruits and vegetables (Kral, 2018). Furthermore, impulsivity and inhibitory control have been associated with overweight and obesity (Graziano et al., 2010; Guerrieri et al., 2008) and so the relevant items from the Early Childhood Behaviour Questionnaire (ECBQ) (Rothbart, 2007) were included.

Acceptability Questionnaire

An 18-item questionnaire was developed based on previous work (Fulkerson et al., 2010; Wyse et al., 2011) to explore the acceptability of the study procedures, the types and amounts of snacks provided and the longer-term engagement with the intervention. Each question was scored on a five-point Likert scale ranging from "strongly disagree – strongly agree" "very unlikely/ unwilling – very likely/ willing" (see Appendix 9).

Follow-up Questionnaire

The follow-up questionnaire was administered 4-6 weeks post intervention. It comprised of the FFQ (Hammond et al., 1993) and three open-ended questions regarding the child's current snack intake and familial eating habits. For example, '*Has taking part in the study had any impact on your child's snack intake/ overall diet? If yes, how? If no, why not?' 'Has taking part in the study had any impact on other members of the family? If yes, how? If no, why not?'*

Food diary

Mothers completed weighed food diaries to assess their child's food (meals and snacks) and beverage consumption and to provide information regarding portions eaten. In line with previous interventions, and to reduce participant fatigue, 4 consecutive days were recorded including at least one weekend day (NDNS, 2016).

Data analysis

Qualitative

Qualitative data (semi-structured interviews and responses to open ended questions from the follow up questionnaire) were transcribed verbatim and collated into NVivo for thematic analysis (by SR). As part of Braun and Clarke's (Braun & Clarke, 2006) six phase process of thematic analysis, codes were initially generated by reading each transcript line by line. Data was coded inclusively (text before and after the section of interest was coded) to maintain context throughout the analysis, and in some instances segments of data were coded multiple times due to their relevance to multiple codes. The generated codes were organised into broader themes by collating related codes. An inductive approach was taken; ensuring themes were strongly related to the data itself (Frith & Gleeson, 2004) rather than the researcher's theoretical or analytic interests (Boyatzis, 1998). Each phase of Braun and Clarke's (Braun & Clarke, 2006) guidelines were applied as part of a recursive process, as the analysis developed over time (Anzul, Downing, Ely, & Vinz, 1997). Ten percent of manuscripts were crosschecked by a second reviewer (CK). Discrepancies were discussed until consensus was achieved.

Quantitative

All quantitative analyses were carried out using SPSS (IBM SPSS Statistics v22). Data are presented as mean (±SD) and percentages. Inferential statistics were used to examine feasibility (participation and compliance), acceptability, retention, preliminary efficacy of each intervention on dietary intake and predictors of vegetable intake. Participation was recorded as the number of days' mothers completed the food diary in weeks 1, 2 and 3. Compliance was defined as the percentage of food diary days where mothers followed the snacking schedules in week 2 and 3. Each day was examined individually and recorded as a compliant or non-compliant day. Days were coded as compliant when the mother had provided at least one scheduled snack, and no additional snacks, other than fresh fruit and vegetables. Days were coded as non-compliant if the child had not been offered a snack from the schedule, was provided one or more additional snacks not on the schedule or, when in the reduction condition, a full portion was provided instead of a 50% portion. Individuals were placed in low, medium and high compliance categories depending upon whether they complied <50%, 50 - <75% or ≥75% of the time. Pearson's chi square tests were used to identify if there were differences in compliance and acceptability between intervention groups.

Repeated measures ANOVA were used to examine the effect of intervention on dietary intake. Study week was the within subject's variable and intervention group the between groups variable. Outcome measures were mean consumption per day of vegetables (g), fresh fruit (g), total daily energy intake (kcal), total sugar (g), free sugars (g), total fat (g) and mean number of snacks). For fresh fruit and vegetables, average intakes were calculated from snacks, meals and total (snacks and meals combined). Where Mauchly's Test of Sphericity was violated, Greenhouse-Geisser was reported (Field, 2009). Where significant interactions were found, graphical representation was used to identify suitable follow up tests. This included using one-way repeated measure ANOVA to identify within subject differences and independent t-test to examine between subject differences. Alpha was set at $p < .05$.

Paired sample t-tests were used to examine differences in mean frequency of consumption pre and post intervention (cookies, cakes, pastries, sweets, crisps, green cooked vegetables, other vegetables, salad and fresh fruit).

Linear regression analyses were performed to identify factors that predicted total vegetable intake, total fruit intake, total energy intake, total fat intake and total sugar intake in week 3. Twelve variables were included in the initial model (Intervention group, baseline intake, child age, child BMI, food fussiness, pressure to eat, food responsiveness, satiety responsiveness, child food neophobia, monitoring, modelling and deprivation) as their influential effects on vegetable acceptance and intake have been discussed in the literature (Cooke et al., 2004; Kral, 2018; Shohaimi et al., 2004; Yee, Lwin & Ho, 2017). As part of an automatic procedure, the weakest correlated variable was removed, and a new model created (Field, 2009). This process continued until the final model contained only the variables that best explained the distribution in vegetable intake.

6.5.3 Results

Demographics

A total of 46 mother-child dyads from Sheffield (South Yorkshire, UK) completed the study between December 2016 and July 2017 thus achieving the target sample size. The mean age of the children was 36.6 ±9.5 months (52% male). They were from mixed socioeconomic backgrounds (46.6% residing in the 50% most deprived areas of the city) with over a quarter of families earning below the average household income for 2017 (ASHE, 2017). Most of the sample were white British, mixed or other (93.5%) and had normal weight status (self-reported). There were no significant differences in children's eating behaviours or parental feeding practices between conditions ($p > 0.05$). Participant demographics are presented in Table 22.

Table 22: Demographic information for mother-child dyads (mean±SD)

	Total n = 46	**Reduction n = 22**	**Replacement n = 24**
Child			
Gender	52% male	63% male	39% male
Age (months)	36.6±9.5	35.8±9.9	37.5±8.9
BMI Centile	60.9 ± 26.7	56.0 ± 30.2	66.2 ± 21.8
Mother			
Age (years)	35±4	35±3	35±5
BMI ($kg{\cdot}m^2$)	24.7 ± 5.2	23.2 ± 3.5	23.2 ± 3.5
Ethnicity	White British, mixed or other 94% Chinese 4% Asian Indian 2%	White British, mixed or other 96% Chinese 4%	White British, mixed or other 92% Chinese 4% Asian Indian 4%
Highest Education	> A-level or equivalents 74%	> A-level or equivalents 88 %	> A-level or equivalents 61 %
Employment Status	63% Employed full/ part time or on maternity leave	71% Employed full/ part time or on maternity leave	57% Employed full/ part time or on maternity leave
Residential Status	Own with or without mortgage 78%	Own with or without mortgage 88%	Own with or without mortgage 65%
Marital Status	100% married or cohabiting	100% married or cohabiting	100% married or cohabiting
Income	£ 0 – 10,000 4% £10 – 20,000 28% £20 – 30,000 22% £30 – 40,000 24% £40,000+ 22%	£ 0 – 10,000 5% £10 – 20,000 32% £20 – 30,000 23% £30 – 40,000 23% £40,000+ 18%	£ 0 – 10,000 4% £10 – 20,000 25% £20 – 30,000 21% £30 – 40,000 25% £40,000+ 25%

Participant recruitment and retention

In total, 291 caregivers expressed an interest in participating in the study and were sent the screening questionnaire (Figure 7). One hundred and forty-six potential caregivers completed and returned the screening questionnaire and their responses were screened against the inclusion and exclusion criteria. Ninety-nine caregivers (68%) were excluded due to not meeting inclusion criteria (for example no HED snacks were reported to be habitually offered to children), declining participation, or personal circumstances. The remaining 47 mothers (32%) were eligible and thus contacted to arrange a date to begin the study. In all, 98% of the 47 mothers (n=46) completed the full three-week intervention, demonstrating excellent retention. Over half of the sample completed a semi-structured interview (n=26) and/or the follow-up questionnaire (n=38) 4-6 weeks post intervention.

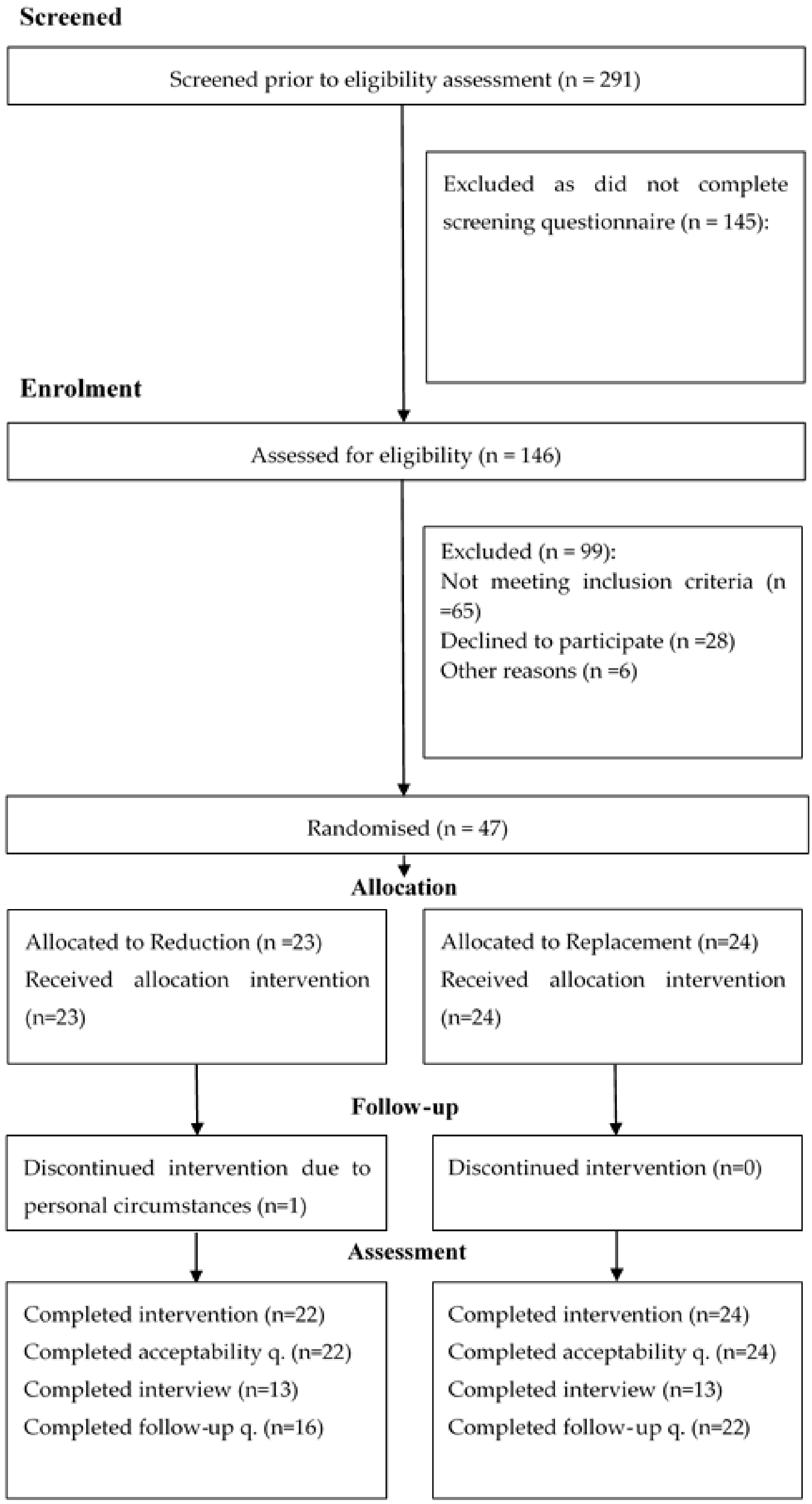

Figure 7: Recruitment and retention rates in accordance to CONSORT guidelines (Eldridge et al., 2016).

Feasibility

Participation remained high across weeks 1 (100%), 2 (100%) and 3 (98%, one mother failed to return the final food diary and was therefore excluded from all diary analyses).

Across the entire study, 22 mothers complied with the snacking schedule on ≥75% of food diary days. Eleven complied on 50-75% of food diary days, whereas 13 complied < 50% of the time. Total compliance was associated with study week ($x^2(4) = 22.89$, $p < 0.001$) but not condition, ($x^2(2) = 1.70$, $p > 0 .05$). Compliance to the snacking schedules was higher in week 3 compared to week 2.

Mothers spoke openly in interviews about why they did not comply with the schedule. Their reasons were categorised into three subthemes: child in the care of others, child health and behaviour, and maternal organisation (Table 23).

Theme 1: In the Care of Others

When children were in the care of others, some mothers lack of compliance with the snack schedule was due to nursery rules regarding the type of snacks that were permitted. Some mothers withheld the snacks to prevent their child feeling isolated or to ensure other children did not see, and therefore want the snacks their child was consuming, as it was not possible to provide all of their nursery peers with an identical snack option.

When children were in the care of their father or grandparents, occasionally the snacking schedule was not followed. At times caregivers did not follow instructions, at other times mothers expressed a fear of placing pressure on others such as their relatives so they did not ask them to follow the schedule. *'I felt like sometimes I didn't want to put too much imposition on them, I felt sorry for my mother-in-law having to deal with him screaming'* (P214, Replacement, male, 30 months).

Theme 2: Children's health and behaviour

When children were unwell, mothers appeared more concerned about whether their child was eating as opposed to what they were eating; therefore, the schedule was not followed during times of illness. During illness children were given autonomy in deciding what they wanted to eat. Children were also allowed to choose what they wanted to eat when they were upset, disliked a snack, or simply requested a different one. However, in most cases it was clear that when some children requested different snacks or refused to eat what was provided, mothers did not accept their child's requests as they were determined to comply with the snacking schedules. *'I just stuck to my guns and said no you're not having it. I mean it's hard at the time but I stuck to my guns'* (P34, Replacement, female, 48 months).

Theme 3: Maternal organisation

Mothers who described themselves as organised had no problems following the schedules as they prepared the snacks in advance of their offering. However, in the reduction condition some mothers were less organised and forgot to reduce the snack portion size they offered to their child by 50%. Instead they tried to remove half once it had been served or allowed their child to consume the full portion. *'I was quite often forgetting to give half. With Pom Bears (chips) I gave her the pack forgetting that it should be half.'* (P84, Reduction, female, 37 months).

Acceptability

Recording in the food diary

Most mothers (76%) reported that recording in the food diary was not a difficult or burdensome task but instead found the food diary a helpful tool. In some, but very few, cases (11%) mothers served their children food items that made record keeping easier. For example, providing a ready meal with predefined weights for each ingredient included.

Week 2 snacks

Most participants agreed/ strongly agreed that the snacks provided in week 2 were appropriate for their child (85%), similar to their habitual intake (67%) and liked by the child (87%).

Week 3 snacks

Most parents (n=31) reported that their child's hunger was satisfied by the snacks provided in week 3, and that the children (n =37) were overall happy with the snacks that they received. Chi square tests revealed no differences between condition and hunger satisfaction, ($x^2(4) = 3.36$, $p > 0.05$), however there was a significant difference between intervention group and children's perceived happiness with the snacks that they received ($x^2(4) = 13.73$, $p < 0.05$). More children in the reduction condition were reported to be happy with the snacks they received compared to children in the replacement condition (95% v 67% respectively).

Sustainability of the intervention

Most participants (74%) expressed an interest in continuing with the intervention in the long term. There were mixed views on the likelihood of the intervention making permanent changes to their child's diets. In the replacement condition, 21% of mothers reported that the intervention was very likely to result in permanent changes to the child's diet. Similar responses were recorded in the reduction condition (18%). Chi square revealed no difference by condition for reported likelihood of the intervention making permanent changes to the child's diet ($x^2(3) = 6.43$, $p > 0.05$). However, a significant difference by condition for willingness to continue with the intervention ($x^2(3) = 9.46$, $p < 0.05$) was identified. More mothers (92%) were willing to continue replacing their child's HED snacks with fresh fruit and vegetables than mothers (50%) willing to continue providing smaller portion sizes of HED snacks.

Qualitative responses regarding the acceptability of the intervention were categorised into four subthemes: Recording in the food diary, snack type, snack preparation and serving method and willingness to continue (Table 23).

Theme 1: Recording in the food diary

Mothers reported that they felt well equipped to record in the food diary as they had been provided with clear instructions, examples and weighing scales. They described the food diary as a task that got easier over time and became part of their routine.

Mothers found it easy when they were at home with their child, had the scales at hand and recorded in the diary after each eating/ drinking occasion, as requested. However, they reported that it was more difficult when they were out of the home. Overall, mothers reported the food diary as a useful tool to see how much their children had consumed over each day and each week. *'easy, it was easy peasy. I just got it into my routine. I just wrote it every time, every meal, I wrote everything straight away, I weighed it, wrote it down, served it and then weighed what was left'* (P33, Reduction, female, 39 months).

Theme 2: Snack Type

Mothers discussed the similarities and differences of the snacks provided in the snacking schedules. Most, felt that the week 2 snacks were similar to their usual snack offerings, well liked and suitable for their children. When children liked and were familiar with the snacks, they accepted the changes made. However, when children reported that they disliked the snacks on offer they were less accepting and sometimes refused to eat. *'I don't think she cared really actually as long as she likes it she'll eat it. She wasn't asking for anything any different'.* (P160, Replacement, female, 28 months).

Theme 3: Snack preparation and serving method

Mothers discussed the impact of preparing and providing the scheduled snacks on their daily routine. The packaged snacks in week 2 were described as convenient and non-disruptive. Mothers reported few problems providing a 50% portion in the reduction condition and most parents were happy to prepare fresh fruits and vegetables for their children. However, they felt that more weighing and preparation was required in the replacement condition compared to week 2, though this was not perceived as a real burden. *'It was obviously a little bit more faffy than the other one because you have to weigh it, erm, washing it and prepping it before you go out and stuff like that* (P132, Replacement, male, 45 months).

In the reduction condition, mothers felt that the snack serving method influenced their child's awareness of the snack reduction and therefore their acceptability of a smaller snack. Mothers who provided snacks on a plate/ bowl found that their child did not notice the reduced portion and accepted the snack change. However, children who received the snack in its original packaging often noticed the reduced portion size and requested the rest of the pack. *'Like the crisps maybe I put them in a bowl or something like that so maybe that's why she didn't notice as much'* (P20, Reduction, female, 52 months).

Theme 4: Willingness to continue with the intervention.

Most parents expressed an interest in continuing to use the methods of replacement or reduction when serving their children habitually consumed snacks, as they thought it was an acceptable method of snack portion control in the home environment. *'I will be carrying on and giving her, I'll mix it all up and make sure I am offering more fruit and veg snacks definitely'* (P77, Replacement, female, 49 months).

Table 23: Quotes supporting the themes constructed from interviews

Theme	Sub theme	Supporting quotations
1: Reasons for non-compliance	1.1 In the care of others	*'Nursery aren't going to follow the plan as the management aren't happy with the snacks'* (P190, Reduction, male, 22 months) *'some days at nursery she didn't want what she was having in her bag but I told them that she's not meant to be isolated with it'* (P77, Replacement, female, 49 months) *'I felt like sometimes I didn't want to put too much imposition on them, I felt sorry for my mother-in-law having to deal with him screaming'* (P214, Replacement, male, 30 months) *'My mum and dad are terrible with him, giving him chocolate and things like that and my husbands a nightmare, like he gave him a mars bar from a celebration pack yesterday morning for breakfast and I was fuming because he knows that he can't have that'* (P74, Replacement, male, 30 months) *'In the morning he asked for snack and his dad gave the whole pack of Jaffa cakes'* (P2, Reduction, male, 39 months)
	1.2 Children's health and behaviour	*'He's been ill; it has been really quite tricky because his appetite is not right. I want him to eat so I am more like have whatever you want. I was like you want crisps go get crisps'* (P2, Reduction, male, 39 months) *'The only problems I guess was when he was ill because it was hard to, because he wasn't eating as normal. Trying to get him to eat, because he just didn't want to'* (P202, Replacement, male, age 29 months) *'She's been crying, not happy, upset, so I've been giving her more tasty or unhealthy snack to be able to manage her behaviour. I gave her cookie at the doctors as she was upset'* (P84, Reduction, female, 37 months) '*I just gave it to him. I said this is what you've got we are going to V club in half an hour, you either eat it or you don't*' (P104, Replacement, male,

Theme	Sub theme	Supporting quotations
		age 50 months) *'I just stuck to my guns and said no you're not having it. I mean it's hard at the time but I stuck to my guns'* (P34, Replacement, female, 48 months)
	1.3 Organisation	*'it was okay because I just did it all at the beginning of the week, it felt a bit strange obviously getting rid of half of it, but mm it was okay. I was just more organised. I think by this stage I had cracked it'* (P148, Reduction, female, 26 months) *'It was kind of helpful to be prompted to be organised. so I would get everything ready the night before, so sometimes I would split one thing into two bags and then I would have another days bag full all ready to go, and that was really convenient'* (P205, Reduction, female, 29 months) *'I was quite often forgetting to give half. With pom bears I gave her the pack forgetting that it should be half.'* (P84, Reduction, female, 37 months)
2: Acceptability	2.1 Recording in the food diary	*'I found it absolutely fine, it was just a case of remembering to weigh everything, but the instructions on how to do it was clear'* (P199, Reduction, female, 34 months). *'easy, it was easy peasy. I just got it into my routine. I just wrote it every time, every meal, I wrote everything straight away, I weighed it, wrote it down, served it and then weighed what was left'* (P33, Reduction, female, 39 months). *'it was just obviously when out and about when I didn't have the scales it became a bit trickier because I realised I have no idea about how much things weigh at all'* (P143, Replacement, male, 46 months)
	2.2 Snack Type	*'I think that was fairly standard but then I think this week wasn't all that dissimilar to what I would have been doing anyway'* (P291, Replacement, female, 26 months) *'I don't think she cared really actually as long as she likes it she'll eat it. She wasn't asking for anything any different'.* (P160, Replacement, female, 28 months)

Theme	Sub theme	Supporting quotations
		'Pear, he wouldn't touch pear, I tried him with the skin on, without the skin, I did all that with him'. (P74, Replacement, boy, age 30 months).
	2.3 Snack preparation and serving method	*'it was obviously a little bit more faffy than the other one because you have to weigh it, erm, washing it and prepping it before you go out and stuff like that* (P132, Replacement, male, 45 months) *'Like the crisps maybe I put them in a bowl or something like that so maybe that's why she didn't notice as much'* (P20, Reduction, female, 52 months) *'I kind of tried to serve the half serving in the packet although she did question to where the other half was erm, I took half of them out and she knew then, she was like ' I want more, there's more' so I gave her another one and she was okay'* (P199, Reduction, female, 34 months).
	2.4 willingness to continue the intervention	*'I will be carrying on and giving her, I'll mix it all up and make sure I am offering more fruit and veg snacks definitely'* (P77, Replacement, female, 49 months) *'if you said you could give him anything as long as you give him half portions that would be fine with me, but giving him just these snacks (in the schedule), I don't think I'd be able to do it'* (P190, Reduction, male, 22 months)
3. Longer term effects of the intervention	3.1 Changes to habitual feeding practices	*'The study helped me think more about what he was eating and whether he needed snacks. Also it has made me focus on his main meals more to keep them more balanced and healthy'(* P261, Reduction, male, 56 months) *The combinations of food I give as snacks has changed. I think it has introduced more variety. I now buy crackers, rather than crisps so often, and I give more vegetable snacks than before'* (P104, Replacement, male, 50 months)
	3.2 Impact on consumption	*'He is more willing to try other items, but that could be because I'll offer different options over favourites'* (P234, Replacement, male, 24 months) *She is tending to finish snacks and meals more often and waste less food'* (P142, Reduction, female, 39 months)

Theme	Sub theme	Supporting quotations
		'My 6year old now eats more fruit as a snack too' (P291, Replacement, female, 26 months) *'His sister now eats similar snacks to him and will ask for things like peppers rather than fruit'* (P104, Replacement, male, 50 months) *'no, we have a food routine which we went back to'* (P208, Replacement, male, 26 months) *'No, she's continued to have the same amount of snacks'* (P199, Reduction, female, 34 months)

Preliminary effects of the intervention

Vegetable intake

Vegetables as snacks

Repeated measures ANOVA revealed a main effect of week [F(1.08, 47.40) = 16.37, *p* = 0.00, η_p^2 = 0.27] and intervention group [F(1, 44) = 14.74, *p* < .001, η_p^2 = 0.25] on vegetable snack intake. Overall in week 3, children consumed 9.8±2.3 (*p* < .001) and 9.7±2.4g (*p* < .001) more vegetable snacks compared to week 1 and 2 respectively. Overall, children in the replacement group consumed 6.1±1.6g (*p* < .001) more vegetable snacks than children in the reduction group. A significant interaction between study week and intervention group was also found for vegetable snack intake [F(1.08, 47.40) = 20.03, *p* < .001, η_p^2 = 0.31]. One-way ANOVA identified a significant effect of study week in the replacement group [F(1.02, 23.39] = 20.70, *p* < .001, η_p^2 = 0.47], children in the replacement condition consumed 20.8±4.5g (*p* < .001) and 20.4±4.4g (*p* < .001) more vegetable snacks in week 3 compared to week 1 and 2 respectively. In week 3, there was also a significant difference in vegetable snack intake between intervention groups [t(23.35) = 4.59, *p* < .001, r = 0.69]. Children in the replacement group consumed 20.5±4.5g more vegetable snacks per day than the reduction group (Table 24).

Vegetables consumed as part of meals only

Vegetable intake at meal times did not vary across weeks or between groups (Table 24). Repeated measure ANOVA revealed no main effect of week [F(2, 88) = 1.91, *p* = 0.15, η_p^2 = 0.04], intervention group [F(1, 44) = 0.59, *p* = .45, η_p^2 = 0.01] or interaction effect [F(2, 88) = 0.02, *p* = 0.98, η_p^2 = 0.001] (Table 24).

Table 24: Nutritional intake per day in week 1, 2 and 3 (mean ± SD)

	Reduction			Replacement			Total		
	Week1	Week2	Week3	Week1	Week2	Week3	Week1	Week2	Week3
Vegetable: Snacks (g)	1.7 ±3.9	1.3 ±3.0	0.5 ±1.8	0.2 ±0.6	0.6 ±2.3	21.0 ±21.8*#	0.9 ±2.8	0.9 ±2.7	11.2 ±18.8*#
Vegetable: Meals (g)	24.8 ±19.1	19.6 ±12.0	20.3 ±17.0	28.5 ±29.8	24.3 ±23.6	24.9 ±23.0	26.8 ±25.0	22.0 ±18.9	22.7 ±20.3
Vegetable: Total (g)	26.5 ±20.3	20.9 ±12.5	20.8 ±17.0	28.7 ±29.8	24.9 ±24.9	45.9 ±35.1*#	27.7 ±25.4	23.0 ±19.8	33.9 ±30.5#
Fruit: snacks (g)	65.6 ±75.7	45.1 ±31.4	65.9 ±50.8	42.0 ±31.6	27.6 ±31.1	65.4 ±41.6	53.3 ±57.7	36.0 ±32.1*#	65.6 ±45.7
Fruit: Meals (g)	34.4 ±42.0	39.1 ±33.3	37.1 ±36.4	36.7 ±28.1	36.7 ±27.4	33.5 ±31.3	35.6 ±35.1	37.8 ±30.0	35.2 ±33.5
Fruit: Total (g)	100.0 ±71.8	84.2 ±40.4	102.9 ±63.0	78.7 ±46.5	64.3 ±49.7	99.0 ±51.8	88.9 ±60.2	73.8 ±46.1	100.9 ±56.8#
Energy (Kcal)	1052.1 ±235.8	1077.8 ±229.1	1063.5 ±284.1	1116.3 ±239.6	1058.5 ±225.2	971.8 ±188.3*#	1085.6 ±237.3	1067.7 ±224.7	1015.7 ±240.7
Total Sugar (g)	71.1 ±21.9	69.9 ±19.6	67.5 ±23.7	79.7 ±28.2	69.8 ±19.5	62.6 ±26.6	75.6 ±25.5	69.9 ±19.3	65.0 ±25.1*
Free Sugar (g)	29.2 ±15.4	24.3 ±17.0	20.8 ±13.0	40.4 ±26.7	27.2 ±14.7	25.2 ±24.6	35.1 ±22.5#	25.8 ±15.7	23.1 ±19.8*
Total Fat(g)	38.2 ±9.1	42.8 ±10.2	41.9 ±15.8	42.0 ±11.5	42.4 ±12.6	34.6 ±9.2*#	40.2 ±10.5	42.6 ±11.4	38.1 ±13.2#
Mean number of snacks	1.6 ±0.6	2.1 ±0.6	2.1 ±0.6	2.0 ±0.6	2.2 ±0.5	2.1 ±0.5	1.8 ±0.6#	2.1 ±0.5	2.1 ±0.6*

(Results from one-way repeated measure ANOVA). *significantly different to week 1. #significantly different to week 2.

Fruit intake

Fruit snacks

Repeated measures ANOVA revealed a main effect of week [F(2, 88) = 8.66, $p < .001$, $\eta_p^2 = 0.16$] on fruit snack intake. Intake of fruit snacks declined in week 2 compared to weeks 1 and 3. Pairwise comparisons revealed that in week 2 children consumed 17.4±38.0g ($p = 0.035$) and 29.3±6.4g ($p < .001$) less fruit snacks compared to week 1 and 3 respectively. There was no main effect of intervention group [F(1, 44) = 1.63, $p = 0.21$, $\eta_p^2 = 0.04$] and no interaction [F(2, 88) = 1.45, $p = 0.24$, $\eta_p^2 = 0.03$] (Table 24).

Fruit consumed as part of a meal

Similar to the results for vegetables, fruit intake as part of a meal did not vary across weeks or between intervention groups (Table 24). No main effect of week [F(2, 88) = 0.10, $p = 0.91$, $\eta_p^2 = 0.002$] intervention group [F(1, 44) = 0.03, $p = 0.85$, $\eta_p^2 = 0.001$] or interaction [F(2, 88) = 0.12, $p = 0.89$, $\eta_p^2 = 0.003$] (Table 24) was found.

Energy (mean intake kcal/day)

Repeated measures ANOVA revealed no main effect of week [F(2, 88) = 2.51, $p = 0.09$, $\eta_p^2 = 0.05$] or intervention group[F(1, 44) = 0.07, $p = 0.79$, $\eta_p^2 = 0.002$] on total energy intake per day. However, there was a significant interaction between study week and intervention group [F(2, 88) = 3.18, $p = 0.047$, $\eta_p^2 = 0.07$). A one way repeated measure ANOVA demonstrated a significant effect of study week in the replacement group [F(2, 46) = 5.40, $p = 0.008$, $\eta_p^2 = 0.19$]. In week 3, children in the replacement group consumed 145±43kcal/d (p 0.003) and 87±40 kcal/d ($p = 0.04$) less total energy intake per day than in week 1 and 2 respectively (Table 24).

Sugar intake

Total sugar

A main effect of week [F(2, 88) = 5.12, p = 0.008, η_p^2 = 0.10] was found for total sugar intake. Pairwise comparisons revealed that in week 3 children consumed 10.32±3.17g less sugar per day than in week 1 (p = 0.002). There was no main effect of intervention group [F(1, 44) = 0.04, p = 0.84, η_p^2 = 0.001] or interaction between group and week [F(2, 88) = 2.28, p = 0.11, η_p^2 = 0.05] (Table 24).

Free Sugar

A main effect of week [F(2, 88) = 9.06, p = 0.00, η_p^2 = 0.17] on free sugar intake was found. Overall free sugar consumption was lowest in week 3. Pairwise comparisons revealed that in week 1 children consumed 9.7±3.2g (p = 0.007) and 11.8±2.7g (p < .001) more free sugar compared to week 2 and 3 respectively. No main effect of intervention group [F(1, 44) = 1.75, p = 0.19, η_p^2 = 0.04] or interaction [F(2, 88) = 1.18, p = 0.31, η_p^2 = 0.03] was observed (Table 24).

Fat intake

A main effect of week [F(2, 88) = 3.30, p = 0.04, η_p^2 = 0.07] on total fat intake was found. Pairwise comparisons revealed that in week 3 children consumed 4.3±1.7g less total fat per day than in week 2 (p = 0.01). There was no main effect of intervention group [F(1, 44) = 0.21, p = 0.65, η_p^2 = 0.005] , however a significant interaction between group and week was observed [F(2, 88) = 5.50, p = 0.006, η_p^2 = 0.11]. A one way repeated measures ANOVA identified a significant effect of study week in the replacement group [F(2, 46) = 7.42, p = 0.002, η_p^2 = 0.24]. In the replacement condition children consumed 7.5±2.0g (p = 0.001) and 7.8±2.2g (p = 0.002) less fat in week 3, compared to week 1 and 2 respectively (Table 24).

Mean number of snacks (LED and HED) consumed per day

A main effect of study week [F(2, 88) = 9.41, p = 0.00, η_p^2 = 0.18] was found for the number of snacks consumed. In week 1, children consumed almost half a snack less than in week 2 (mean difference = 0.4±0.1g, p = 0.002) and 3 (mean difference = 0.3±0.1g, p = 0.009). No main effect of intervention group [F(1, 44) = 1.09, p = 0.30,

η_p^2 = 0.02] or interaction between group and week [F(2, 88) = 2.61, p = 0.08, η_p^2 = 0.06] was observed (Table 24).

Predictors of nutritional intake

Linear regression models were calculated to investigate the predictors of total vegetable, total fruit, total energy, total fat and total sugar intake in week 3 (Table 25). For vegetable intake the final model was strong, accounting for 65% of variance in vegetable intake (R^2= 0.65, F = 17.88, p < .001). Significant predictors included intervention group (reduction or replacement), baseline vegetable intake, child food neophobia and deprivation score. Higher intake of vegetables in week 3 were associated with being in the replacement group (b = 23.91, se = 6.34, β = 0.39, p = 0.001), higher baseline vegetable intake (b = 0.72, se = 0.13, β = 0.58, p = 0.00), higher deprivation score[2] (b = 2.06, se = 0.98, =0.21, p = 0.04) and lower food neophobia scores (b = -1.59, se = 0.62, β = -0.27, p = 0.01).

For fruit intake the final model accounted for 63% of variance (R^2= 0.63, F = 7.07, p < .001). Significant predictors included baseline fruit intake, food fussiness, child food neophobia and modelling. Non-significant predictors included intervention group (reduction or replacement), food responsiveness, satiety responsiveness and child BMI centile. Higher intakes of fruit in week 3 were associated with a higher baseline fruit intake (b = 0.72, se = 0.13, β = 0.63, p < 0.001), higher food fussiness (b = 5.84, se = 2.56, β = 0.53, p = 0.03), lower child food neophobia (b = -7.99, se = 2.21, β = -0.77, p = 0.01), lower modelling scores (b = -10.25, se = 2.38, β = -0.53, p < 0.001), lower child BMI centile (b = -0.41, se = 0.23, β = -0.21, p = 0.08), lower food responsiveness (b = -3.06, se = 1.70, β = -0.22, p = 0.08), and lower satiety responsiveness (b = -4.78, se = 2.38, β = -0.31, p = 0.05).

For energy intake the final model accounted for 47% of variance (R^2= 0.65, F = 11.05, p < .001). Significant predictors included intervention group (reduction or replacement), baseline energy intake, and food responsiveness. Higher energy intake in week 3 was associated with being in the reduction group (b = -125.83, se = 58.49, β = -0.26, p = 0.04), having a higher baseline energy intake (b = 0.71, se = 0.13, β =

[2] Higher scores indicate lower levels of deprivation

0.72, $p < 0.001$) and lower food responsiveness (b = -18.05, se = 7.85, β = -0.29, p = 0.03).

Table 25: Predictors of vegetable intake in week 3: output from a linear regression.

Food item	**Vegetables**				**Fresh fruit**				**Total Energy**				**Total Fat**				**Total Sugar**			
	b	Se	β	p	b	Se	β	p	b	Se	β	p	b	Se	β	p	b	Se	β	P
Intervention group	23.91	6.34	0.39	0.001	23.81	12.42	0.22	0.06	-125.83	58.49	-0.26	0.04	-10.44	3.28	-0.40	<0.01	-16.09	6.05	-0.31	0.01
Baseline intake	0.72	0.13	0.58	< 0.001	0.72	0.13	0.63	< 0.001	0.71	0.13	0.72	< 0.001	0.71	0.15	0.58	< 0.001	0.66	0.12	0.66	< 0.001
Child Neophobia	-1.59	0.62	-0.27	0.01	-7.99	2.21	-0.77	< 0.01	-	-	-	-	-	-	-	-	-	-	-	-
Deprivation score*	2.06	0.98	0.21	0.04	-	-	-	-	-	-	-	-	0.88	0.51	0.22	0.09	1.95	0.95	0.24	< 0.05
Food Fussiness	-	-	-	-	5.84	2.56	0.53	0.03	-	-	-	-	-	-	-	-	1.04	0.61	0.19	0.10
Modelling	-	-	-	-	-10.25	2.38	-0.53	< 0.001	-	-	-	-	-	-	-	-	-	-	-	-
Food Responsiveness	-	-	-	-	-3.06	1.70	-0.22	0.08	-18.05	7.85	-0.29	0.03	-0.83	0.41	-0.25	0.05	-	-	-	-
Satiety Responsiveness	-	-	-	-	-4.78	2.38	-0.31	0.05	-	-	-	-	-	-	-	-	-	-	-	-
BMI centile	-	-	-	-	-0.41	0.23	-0.21	0.08	-	-	-	-	-	-	-	-	-	-	-	-
Child age	-	-	-	-	-	-	-	-	-	-	-	-	0.33	0.16	0.25	< 0.05	-	-	-	-

*Higher scores indicate lower levels of deprivation

For fat intake the final model accounted for 49% of variance (R^2= 0.49, F = 6.88, p < .001). Significant predictors included intervention group (reduction or replacement), baseline fat intake, and child age. Non-significant predictors included food responsiveness and deprivation score[1]. Higher intake of fat in week 3 was associated with being in the reduction group (b = -10.44, se = 3.28, β = -0.40, p = 0.03), having a higher baseline energy intake (b = 0.71, se = 0.15, β = 0.58, p < 0.001), being older (b = 0.33, se = 0.16, β = 0.25, p = 0.001) and scoring lower on food responsiveness (b = -0.83, se = 0.41, β = -0.25, p = 0.05).

For sugar intake the final model accounted for 55% of variance (R^2= 0.55, F = 11.29, p < .001). Significant predictors included intervention group (reduction or replacement), baseline sugar intake, and deprivation score[1]. Higher intake of sugar in week 3 were associated with being in the reduction group (b = -16.09, se = 6.05, β = -0.31, p = 0.01), reporting a higher baseline sugar intake (b = 0.66, se = 0.12, β = 0.66, p < 0.001), having a higher deprivation score[1] (b = 1.95, se = 0.95, β = 0.24, p < 0.05) and scoring high on food fussiness (b = 1.04, se = 0.61, β = -0.19, p = 0.10).

Longer term effects of the intervention on snack frequency (4-6 weeks follow-up)

Responses from the FFQ identified no significant changes to the frequency of snack intake pre and post intervention diet (p>0.05) despite the majority of mothers expressing in interviews and the follow up questionnaire that the intervention had impacted their habitual feeding practices and child's nutritional intake (Table 26). Interview responses were categorised into two subthemes reflecting these experiences (Table 23).

Table 26: Frequency of consumption pre and post intervention (mean±SD)

Food item	**Pre-intervention**			**Post intervention**		
	Reduction	Replacement	Total	Reduction	Replacement	Total
Cookies	5.68±4.98	2.96±2.03	4.26±3.95	3.55±2.32	2.92±2.59	3.18±2.47
Cake	2.36±2.75	1.49±2.06	1.91±2.43	1.66±1.70	1.14±1.07	1.36±1.37
Pastries	0.34±0.47	0.28±0.31	0.31±0.39	0.30±0.32	0.16±0.24	0.22±0.28
Sweets	3.64±3.11	2.52±2.88	3.03±3.00	3.38±3.64	2.09±1.95	2.63±2.82
Potato Chips	3.56±2.69	2.40±2.07	2.93±2.42	3.13±2.18	2.76±2.97	2.91±2.64
Green cooked vegetables	6.61±4.97	4.78±3.01	5.66±4.12	6.27±5.13	5.50±4.60	5.82±4.78
Other vegetables	4.59±3.30	4.06±3.04	4.32±3.14	4.66±3.13	3.98±2.24	4.26±2.64
Salad	4.69±4.07	2.68±2.24	3.64±3.37	4.20±3.42	3.86±4.45	4.01±4.00
Fruit	13.14±8.59	11.42±5.32	12.24±7.05	13.69±6.79	14.73±7.62	14.29±7.21

Theme 1: Change to habitual feeding practices

Mothers reported that participation in the intervention resulted in them thinking more about the type of food to offer their child at meal and snack occasions. In particular, mothers focused on increasing fruit and vegetable offerings to enhance diet variety. Mothers also discussed limiting intake of HED snacks and availability of these items in the home. *'The study helped me think more about what he was eating and whether he needed snacks. Also, it has made me focus on his main meals more to keep them more balanced and healthy' (*P261, Reduction, male, 56 months).

Theme 2: Impact on consumption

Six weeks post intervention, mothers reported noticing that their children were more accepting of novel food items and since being offered more fresh fruit and vegetable snacks, they were consuming more as part of the habitual diet. Mothers reported that their children's eating behaviours at meal times were also noticeably better, with more eaten and less waste. Some mothers also felt that taking part in the intervention had a positive impact on the dietary intake of other family members, including themselves (mother) and the child's siblings. Others reported no differences to their habitual diet. *'His sister now eats similar snacks to him and will ask for things like peppers rather than fruit'* (P104, Replacement, male, 50 months).

6.5.4 Discussion

The current pilot study aimed to explore the feasibility and acceptability of two strategies of snack portion control and examine the efficacy of the two methods to improve the habitual diets of preschool children. The results suggest that the study fulfilled the predefined feasibility and acceptability objectives. Whilst both interventions were rated positively, more mothers rated the replacement strategy as acceptable despite acknowledging that more preparation effort was required. Additionally, the secondary aim of testing the preliminary efficacy of the two interventions on dietary intake demonstrated the potential benefits of the replacement strategy compared to the snack reduction strategy. Vegetable intake was higher in the replacement group compared to the reduction group, total energy (kcal/d), sugar (g) and fat (g) intakes were also decreased in the replacement strategy. Regardless of the apparent benefits of the replacement strategy, overall mothers reported that taking part in the study had prompted them to think about the snacks that they offer their children with a view to reducing HED snack intake. Overall, the findings of this pilot study are useful for informing the development of a larger trial.

The study provided evidence for identifying, recruiting and retaining parent-child dyads for a three-week intervention within the home environment. Once participants had been randomised into the intervention period, compliance rates were moderate with 72% of mothers following the intervention schedule at least 50% of the time. All mothers recruited completed the study and only one mother was removed from the analysis due to not returning the final food diary.

The ratings of study procedures were examined and overall found to be acceptable. Participation was high, supporting the notion that four days is a suitable duration to record in the home environment, and anything above this threshold may result in unsatisfactory reporting and participant burnout (Gersovitz et al., 1978). Weighed food diaries have been found to be more accurate than recall methodologies however; mothers reported that they had to rely on recall and estimation at times. To facilitate record keeping, many parents took photos of their child's food and drink items to prevent having to rely on memory. New technologies have been developed through mobile applications to support better estimation of portion size (Martin et al., 2014; Williamson et al., 2004). These technologies were not used in the present study however, they may be considered for future work as the portion size estimations that are produced are highly correlated with weighed foods (Williamson et al., 2003).

Snack provision and snacking schedules were implemented to standardise exposure across all participants as much as possible and to assess effects on dietary intake. In week 2 when all HED snacks were replaced for all children, mothers reported that the snacks were suitable, well liked and similar to what their child usually consumed. In week 3, there were mixed responses regarding type (replacement) and quantity (reduction) of snacks provided. In the replacement condition, most children accepted the fruit and vegetable snacks if they were relatively liked and familiar. However, when children reported not liking the items offered, they refused these snacks and asked for alternative snacks, and this helps to explain the differing levels of compliance. In the reduction condition, most children accepted the reduced snack portion size and most parents complied with providing 50% of the snack. Parents are therefore willing and able to adhere to recommendations by PHE to provide 100 kcal snacks, and no more than 2 per day (PHE, 2018). Even if the child consumed 3 snacks per day, total snack intake averaged less than 200 kcal in the replacement condition.

At times, children noticed when snacks were smaller than normal, and this shows that young children learn through exposure and social learning what amounts of foods to expect (Ogden, 2012). When snacks were offered on plates and bowls, portion size judgements are more difficult and therefore changes to portion size are less noticeable (Fisher, Rolls, & Birch, 2003). Exposure to packaging may create a portion size norm, which often is too large for young children and may lead to overconsumption of items that are high in sugar and energy (Sothern, 2004). Large portion sizes have become normalised (Robinson et al., 2016) such that consumers no longer perceive themselves to be overconsuming, and this seems to hold true for some of the children in the current study who rejected the 50% portion from the package. Recent work on adults, (Robinson & Kersbergen, 2018) demonstrates that portion sizes can be relearned or "recalibrated" whereby following multiple exposures adults learn to accept a smaller portion size as being "normal". However, to date this has not been investigated in children.

Preliminary efficacy analysis indicates that snack replacement improved dietary intake compared to snack reduction. Vegetable intake was significantly increased in the replacement group compared to the reduction intervention. Offering vegetables as a snack increased total intake but did not displace vegetable intake at meal times. This finding confirms those reported by Roe et al (Roe et al., 2013) demonstrating that when a variety of vegetables was served to preschool children in a child care environment vegetable intake increased. In the current study, overall intake of fruit was higher compared to vegetables and there were no significant differences between intervention groups. Total fruit intake and fruit snack intake was higher in the intervention week (week 3) compared to weeks 1 and 2. This result appears to be driven by the trends observed in the replacement group; fruit intake increased in the replacement group in week 3 by around 20g/d compared to week 1. This trend was not observed in the reduction group.

In the replacement group, total energy intake (kcal) was lower in week 3 compared to weeks 1 and 2 by around 145kcal/d and 87kcal/d respectively. This effect was not observed in the reduction group. Incorporating LED foods in to the habitual diet has robustly been demonstrated in children and adults to be effective at reducing total energy intake (Kling et al., 2016; Leahy et al., 2008; Williamson et al., 2003). It is likely that the addition of extra vegetables and fruit accounts for this reduction in TEI. Alternatively, this may be attributable to reductions in total fat and sugar intake.

The results of the current investigation suggest that snack replacement compared to snack reduction is better aligned with Public Health England (PHE, 2018) and the World Health Organisation (sacn, 2015) sugar reduction aims. Both interventions were designed with the potential to reduce sugar intake. Whilst an overall main effect of study week was observed, trends in total and free sugar intake revealed that in the replacement group intake of total sugar in the intervention week (week 3) declined by around 17g/d and free sugar by 15g/d compared to baseline (week 1). The magnitude of change was not as large in the reduction group. Total sugar declined by around 3.5g/d and free sugar by around 8g/d in the intervention week compared to baseline.

Despite the study not being sufficiently powered to detect conclusive effects of snack reduction or replacement on habitual diet, this pilot study does demonstrate clear advantages of the replacement strategy and more importantly that the necessary data could be collected. Despite the increased preparation required in the replacement strategy more mothers reported that they were content to continue with this strategy compared to snack reduction.

The target sample of 46 was successfully achieved by over recruiting to account for withdrawal and participants who may not have been eligible. Approximately half of the sample was residing in one of the 50% most deprived neighbourhood areas in Sheffield suggesting that identifying, visiting and building rapport with toddler group leaders and attendees in multiple areas of lower socioeconomic status is a suitable method to recruit under researched populations, who tend to be at greater risk of obesity (Newton, Braithwaite, & Akinyemiju, 2017). However, only a minority of the children were from low-income families, with the majority earning more than the average UK household income. Future studies should explore the effects of portion size reduction strategies in lower income populations. Evidence suggests that consumption of HED snacks is inversely related to socioeconomic position (Si Hassen et al., 2018). Recent evidence from the UK suggests that mothers from more deprived backgrounds are more likely to offer young children HED "treat" foods compared to mothers from a higher socio economic position (Campbell & Wolfson, 2017). Data from the US demonstrates a "non-nutritive" role of snacks in lower income compared to more affluent families (Blaine et al., 2015), in that HED snacks are often used to modify children's behaviours and more importantly they are not perceived as foods per se (Younginer et al., 2016). Elevated intakes of inexpensive HED snacks consumed from a young age may contribute in part to inequalities in health.

The results of the current study demonstrate the greatest improvement to children's diets were in the replacement condition, regardless of differences at baseline. For example, the replacement group consumed less fruit and vegetables as snacks, more total energy, sugar and fat. Moreover, the replacement group was disadvantaged in terms of employment and education, and this group had a higher average child and maternal BMI. It is well documented that a healthful diet is more costly compared to a diet containing more HED foods (Mackenbach et al., 2015; Rehm, Monsivais, & Drewnowski, 2015). Furthermore, food waste is an important issue that needs to be carefully considered. For example, children in the replacement intervention group were offered between 40 -120g of vegetables per day depending upon how many snacks they consumed, yet an average increase of 20g/d was observed thus resulting in a significant and costly amount of waste. Replacement snacks were more expensive than HED snacks (£11.59 versus £4.11), and children produced more food waste in the replacement (366g = 51%) versus reduction group (27g = 15%). More research is required to examine this further.

Efforts to standardise snack intake across the participant pool resulted in unintended consequences of increasing snack intake in week 2 compared to week 1 and providing snack options that some children rejected. In future, parents should select snacks (both HED and fruits and vegetables snacks) which are habitually eaten and well-liked by their children on an individual rather than group level. A second limitation of the study was the exclusion of children attending childcare for more than 3 full consecutive days. This criterion implies that the study may not be feasible to all cohorts of preschool children which limits the generalizability of the findings and the impact of the current design.

It is not known whether either intervention would be sustainable over a longer period and so longer-term research is needed. At 4-6 weeks follow up some mothers reported that they felt that engaging in the study, regardless of group assignment, had positively influenced the snacks that they offered their children in that they were offering more fruits and vegetables. Yet, the results of the FFQ did not support this; an increase in the frequency of offering fruit and vegetables was not detected. Individual difference in response to portion sizes have been documented (Kral and Hetherington, 2015); increasing the number of participants in future investigations would allow researchers to further explore how eating traits and family circumstances might impact the success of the intervention. Characterisation of individual differences in response to portion size will aid the development of successful interventions.

6.5.5 Conclusion

This study is the first to explore the feasibility and acceptability of two portion control strategies for snacks in UK-based preschool children in the home environment. Snack reduction and snack replacement appear to be feasible methods of portion control in the home environment. The current study demonstrates that the recruitment strategy, retention rates, and methods of data collection were acceptable; however, the replacement strategy appeared to be associated with more dietary improvement than reduction. Mothers reported being content with the replacement strategy; children’s vegetable intake increased, and fat intake decreased. The results of this pilot study highlight issues for intervention refinement and provide important feasibility, acceptability, and preliminary efficacy information necessary to design a larger and more adequately powered trial.

7. Discussion

The overall aim of this thesis was to explore caregiver snack portioning practices and to investigate downsizing solutions for preschool children. Each thesis chapter presented results and a discussion specific to the chapter aims and research questions. This chapter will integrate findings from each chapter to provide a summary of the thesis outcomes and implications. Firstly, an overview of the literature to date is presented. Secondly, four main thesis findings will be presented and then integrated and discussed in relation to relevant literature. Thirdly, the overall strengths and limitations of the thesis will be highlighted. Finally, proposals for future work will be offered.

7.1 Summary of literature to date

Preschool children in the UK have a less than nutritionally optimal diet; exceeding saturated fat and sugar recommendations and not consuming 40g portions of fruits and vegetables (NDNS, 2019). Contributing to this, is the portion size of meals and snacks routinely offered to children, often exceeding recommended amounts (Infant and Toddler Forum, 2014). More specifically, 61% of preschool children are frequently being offered too many sweets, with 24% of parents offering a whole packet of jelly sweets which equates to three times the weekly recommended amount. It is well documented that increases in portion size correspond with an increase in food intake which can have longer-term impact on TDEI (Smethers et al., 2019). This can be referred to as the PSE which may be moderated by social norms, visual cues or changes in the microstructure of eating (Benton, 2015). Caregivers have personal experiences of feeding their children however previous to the work undertaken in this thesis is was unclear how caregivers in the UK determine what constitutes a suitable snack portion size to serve to preschool children. Therefore, the overall aim of this thesis was to explore caregiver snack portioning practices and to investigate downsizing solutions for preschool children.

7.2 Summary of main findings

Rapid Review

The aim of the rapid review was to synthesise the literature that exists on UK caregiver feeding practices to explore caregiver's motivations, goals and decisional processes when determining preschool children's food portion sizes. The results of the review can be found in Chapter 3. The review revealed a wide degree of variation in the factors that influence portioning practices such as child hunger, weight status, food preferences or caregiver portion size. Caregivers were confused whether portion size information exists and instead rely on 'trial and error', guesswork, food availability or plate size to determine a suitable child portion size. A large proportion of articles did not qualify for inclusion in the review due to the country in which the research took place highlighting a gap in the UK literature. Furthermore, none of the included studies focussed or asked questions related specifically to snack foods or portion control methods highlighting a gap in this research area and a need for future work.

Study 1

This study aimed to identify what factors predict caregivers serving their children HED and LED snacks in portion sizes smaller or larger than recommended amounts, and was answered by performing a multinomial logistic regression on data produced from an online survey. The results from this study can be found in Chapter 6.1. The results suggest that portion sizes served to preschool children are predicted by caregiver portion size, frequency of consumption, food liking, child BMI, pressure to eat, monitoring and satiety responsiveness. Furthermore, it was highlighted that caregivers with a low socioeconomic position may be more likely to provide their children with large portion sizes of HED snacks, however further investigation is required due to the small sample size. Study limitations were highlighted and contributed to the development of study 2.

Study 2

Study 2 primarily aimed to explore mother's decisions and portion control strategies employed whilst preparing an afternoon snack for their preschool child using the think aloud method. The secondary aim was to compare portion size selections in the home environment to the amount consumed by the child, portion size recommendations and portion size selections online (see Chapter 6.1). The results from study 2 can be found in Chapter 6.2. The results suggest caregivers are influenced by multiple contextual and situational factors such as child behaviour and package size. Portion size selections online and in the home were similar thus suggesting that the use of software in research may be suitable for replicating real life portioning practices. Four out of the five snacks foods served to children were significantly different to portion size recommendations for children aged 2 -4 years. Furthermore, there was a significant difference between portion sizes served and consumed when LED snacks were offered; with children consuming on average 17g less than served. Study 2 also observed a variety of portion control strategies that mothers deem appropriate and feasible in the home environment.

Study 3

This study was conducted during the development of a home-based intervention aiming to enhance children's snack intake. The primary aim was investigate the impact of offering unit or amorphous food on the PSE in children aged 2 to 12 years by conducting a systematic review and meta-analysis. Three potential moderator variables were explored: food shape (unit or amorphous), child age and initial portion size served. The results can be found in Chapter 6.3 and have been published in the peer reviewed journal Appetite (Reale et al. 2019). The results suggest that food type (unit or amorphous) does not influence the magnitude of the PSE in children aged 2-12 years. Furthermore, initial portion size and child age did not have an influential effect on the magnitude of the PSE. Therefore, the decision was made to include both unit and amorphous snack foods into the study protocol for the home-based intervention (study 4).

Study 4

Study 4 employed a mixed methods design to explore the feasibility and acceptability of two portion control methods and to examine the preliminary efficacy of the intervention on children's nutritional intake. The results from this study can be found in Chapter 6.5 and have been published in a special edition of Nutrients (*Food portion size in relation to diet and health*) (Reale et al., 2018). The results suggest that both snack reduction and snack replacement are feasible methods of snack portion control in the home environment. However, more mothers rated the replacement strategy as acceptable despite acknowledging more preparation was required. Furthermore, the replacement strategy increased vegetable snack intake, reduced TDEI (kcal) and reduced total fat and sugar intake. In both groups, mothers were more mindful of the types and portion sizes of snacks to offer their children 4-6 weeks post intervention. Limitations to the protocol were identified to suggest further pilot testing is required before initiation of a full trial.

7.2 Integration of main findings

This section of the discussion integrates the main findings and compares them to existing literature. The main findings of this thesis are:

1. Caregivers portion size decisions are dynamic, complex and multifaceted
2. Caregivers report that they lack confidence in identifying snack portion size recommendations for preschool children
3. Some caregivers recruited for studies in the current thesis are relatively good at downsizing snacks for preschool children
4. Snack reduction and snack replacement are feasible methods of portion control in the home environment, short-term.

Caregiver's portion size decisions are dynamic, complex and multifaceted

This thesis makes an original contribution to knowledge on parental feeding practices by revealing the complex, dynamic and multifaceted decisions caregivers make in regards to preschool children's snack portion sizes. For example, caregivers were largely influenced by attributes of the mother herself (including what she was served as a child), features of the foods (including perceived healthiness), child characteristics (including how much that food is liked by the child), and situational variables (including children's momentary behaviour and the proximity to the next or last meal occasion). For example, caregiver snack portion size predicted child portion size of HED and LED snacks in Chapter 6.1. Furthermore, a relationship between caregiver and child snack portion size was revealed in Chapter 6.2 for crisps, carrot and cereal demonstrating that caregivers may judge appropriate portion sizes for their child, related to their own self-selected portion size. This finding extends previous US-based research that identified a positive association between adult and child portion size at an evening meal (Johnson et al., 2014), thus highlighting the significant role caregivers play in shaping their young children's dietary intake.

Young children learn through imitation and mimic eating behaviours by their second year of life (Anzman et al., 2010; Hart et al., 2010), such that children tend to sample readily available foods if they observe their parents consuming the same item (Harper & Sanders, 1975). Therefore, future research examining the effects of downsizing adult and child portion sizes concurrently may have a positive impact on intervention compliance and dietary intake since young children tend to adopt the behaviours they observe from an influential role model (e.g. the mother) (Bandura, 1998, 2001).

During the development of downsizing interventions it may also be useful to consider situational factors that influence portioning practices as potential barriers to compliance. For example, this thesis revealed that snack portioning practices are transient and related to children's momentary hunger, activity levels and behaviour. In line with previous work (Carnell et al., 2011), mothers discussed amending portion sizes of foods as per their child's request to prevent causing upset, especially in environments whereby they wanted their child to behave e.g. in a social environment. Therefore, future downsizing interventions might need to include information about alternative methods of emotional regulation for preschool children. Furthermore, caregivers tended to avoid food waste and child upset by providing vegetables in small portion sizes, or not at all. Therefore, caregivers may benefit from the provision of supplementary information regarding how to respond to an upset child, and the value of repeatedly exposing children to disliked foods items (Cooke, 2007). For example, providing information on the success of repeated exposure, including reassurance that food waste need not be long-term, may address possible barriers of adherence to portion size recommendations and encourage caregivers to serve less liked foods such as raw vegetables (Holley et al., 2016).

Caregivers lack confidence in identifying snack portion size recommendations for preschool children

Findings from study 2 (Chapter 6.2) and 4 (Chapter 6.5) revealed that despite portion size recommendations for meals being available (British Nutrition Foundation, 2019; More & Emmett, 2015; NHS, 2018; Nutrition, 2016; Scotland. Scottish Executive., 2006; Thomas & Bishop, 2007), caregivers in the UK do not use portion size recommendations to guide their decisions on an appropriate snack portion size to serve their preschool child, nor are they aware if portion size recommendations for snacks exist. These findings are consistent with American caregivers awareness of meal (Martin-Biggers et al., 2015; Sherry et al., 2004) and snack (Blake et al., 2015) portion sizes, and UK caregivers' awareness of meal portion size recommendations for children aged 8-11 years (Croker et al., 2009).

Evidence-based portion size recommendations were developed in the UK to encourage adequate provision of nutrients to preschool children and to address parental anxiety that their child is not consuming enough (More & Emmett, 2015). Furthermore, recommendations were developed to provide guidance on appropriate portion sizes to serve, to reduce excess sugar and energy intake from snacks, and to address the rising rates of childhood obesity (More & Emmett, 2015). Consistent with previous findings from mothers with few educational attainments (Ohly et al. 2013a), caregivers in the present study were welcoming to the idea of receiving portion size guidance suggesting that informed decisions in the present study were not compromised by choice but rather by a lack of awareness/ access to available information. Instead, caregivers in the present study used situational factors or features of the child (e.g. hunger) to guide their portion size decisions and were confident that their child would not over consume when served a larger than age appropriate snack, as previously demonstrated (Croker et al., 2009). However, in reality this is not the case since children as young as 2 years old are responsive to the PSE e.g. (Fisher, 2007) which may contribute to weight gain and the prevalence of childhood obesity. As such, it may be beneficial to increase caregiver's awareness of portion size recommendations for preschool children.

This thesis contributes to knowledge by capturing caregiver's thoughts regarding appropriate methods of communicating portion size recommendations. Caregivers suggested providing recommendations via healthcare professionals, or online and in leaflet format, despite resources currently being available online e.g. (British Nutrition Foundation, 2018). Communicating portion size recommendations during routine visits from the healthcare visitor may be a promising solution since other elements of nutrition are already discussed (e.g. types of foods to use during weaning). Alternatively, portion size information for preschool children could be presented on packaging as a prompt at the point of purchase/ consumption since this thesis and previous work (Blake et al., 2015) have suggested that portioning practices are influenced by external cues within the food environment e.g. portion size. One study (Ueland, Cardello, Merrill, & Lesher, 2009) tested the effects of portion size labels on consumption by labelling a 200g bag of pasta as containing 50%, 100% or 150% of a portion size, however the labels did not influence intake. Research suggests that visual attention and consumer attitude towards food labelling influences consumer use (Reale & Flint, 2016) and many labels are presented on the back of packaging often not to be seen. Therefore, the cost of amending packaging may outweigh the beneficial effects on consumption. Furthermore, caregivers in the present thesis acknowledged that all children are different in their eating styles and growth trajectories such that portion size information needs to be adjustable to meet the needs of the individual child.

Caregivers are relatively good at downsizing snacks for preschool children

Despite caregiver's lack of awareness regarding the existence of snack portion size recommendations for preschool children, the majority of caregivers tended to be relatively good at downsizing snack portion sizes for the age and stage of development of their child (More & Emmett, 2015). Most caregivers in the online survey selected snack portion sizes in line with recommended amounts and when converted to grams, portion sizes served in the home environment were similar to those selected online. The implications of these findings are good, and suggest that despite increases in portion size, availability and accessibility of HED snack foods in the obesogenic environment, caregivers may be influenced more so by features of their child than external related cues such as package or unit size. However, caution should be taken in the interpretation of this finding since over a quarter of caregivers selected HED snacks in portion sizes up to four times the recommended amount for preschool children in Chapter 6.1, which relates closely to the statistics for UK levels of preschool children classified as overweight or obese (NHS Digital, 2017).

HED foods are often regarded as unhealthy (Wright, 2017), offering limited nutrient quality (Maillot et al., 2011), which when consumed frequently have been associated with greater risk of excess weight gain and associated diseases such as type 2 diabetes (Larson & Story, 2013). Furthermore, HED foods tend to be served in packaging larger than recommended for preschool children (Sothern, 2004) which may change perceptions of what constitutes an appropriate amount to consume, due to portion distortion (Schwartz & Byrd-Bredbenner, 2006).

This thesis contributes to knowledge on parental feeding practices by identifying characteristics that might be related to unhealthy portioning practices. For example, preschool children who were offered energy dense snacks in portion sizes up to four times the recommended amount were from families with a lower socioeconomic position compared to the sample average. Research suggests that low income families would have to spend 42% of their after-housing disposable income to meet the UK government's nutritional recommendations (Scott et al., 2018). As a result, low income families may opt for energy dense foods which can displace consumption of more expensive foods, rich in protective nutrients (Andrieu et al., 2006). Previous work (Best & Papies, 2018) has demonstrated an association between socioeconomic position and the PSE such that adults with a lower socioeconomic position were more likely to eat more in the presence of large versus small portion sizes of HED snacks compared to adults with a high socioeconomic position. Furthermore, adults from low socioeconomic backgrounds are disproportionately exposed to unhealthy foods and psychological processes predisposing them to overeat in such environments (Best & Papies, 2018). However, due to the small number of participants classified with low socioeconomic position in this thesis, socioeconomic position was not a significant predictor of portion size selection. Furthermore, it is unknown if socioeconomic position influences the PSE in children as previous work has been limited to adult participation (Best & Papies, 2018) and thus further research is needed to explore this association.

In some instances, small differences were noted between portion size selections online and in the home environment however these may simply reflect daily variations in children's eating behaviours based on situational factors such as appetite and activity levels (Kral & Hetherington, 2015). Alternatively, these differences may be explained by study design. Firstly, the online survey limited caregivers to select one portion size per snack item, therefore it did not account for additional servings or snack variety, which was demonstrated in the natural food environment. Secondly, in the online study caregivers were asked to select the snack size that most closely represented their usual portion size offerings, therefore reducing accuracy. Thirdly, snacks were removed from their original packaging before being photographed and viewed as 2D images in the online study in comparison to being presented ad libitum in the home environment. Caregivers in the present study described packaged snacks as convenient and a cue for an appropriate portion size to serve, consistent with previous research (Blake et al., 2015). Therefore, including snacks in their original packaging may have enhanced ecological validity and produced a different outcome. Finally, a limited number of snacks were chosen based on the need to photograph and transport items to participant homes. For example, well liked and frequently consumed snack foods such as bananas and yoghurts were removed from the study protocol due to requirements of refrigeration and potential 'browning' in photographs. However, the included snacks were identified as part of the habitual diet of preschool children in Sheffield (via the screening questionnaire) and nationally (NDNS, 2019).

Feasible portion control methods in the home environment

This is the first study to identify feasible methods of snack portion control in the home environment, for UK preschool children. Observations and qualitative responses in study 2 identified a variety of methods caregivers adopt habitually, mainly in relation to setting upper limits of portion size, or methods of downsizing. For example, sharing foods or subdividing items from larger portion sizes so children receive a smaller portion size. Alternatively, mothers relied upon package, unit or bowl size. These findings mirror responses from an American (Blake et al., 2015) and British (Curtis et al., 2017) cohort of mothers who verbalised the strategies they use to portion control their children's food portion sizes. However, within Blake et al. (2015) study many mothers were unable to articulate the portion control methods they use due to reliance on memory. In some instances, this occurred in the present study during the think aloud task, however the researcher was able to observe portion control methods used and elicit further information using follow-up questions, thus highlighting the advantages of adopting multiple methods to strengthen research outputs.

Study 4 explored the use of two novel methods of portion control in the home environment that are not only feasible and acceptable but also adhere to a population level campaign proposed by PHE in 2018, *"Look for 100 calorie snacks, two a day max* (PHE, 2018). According to the philosophy of 'libertarian paternalism' intervening at a population level is thought to have the greatest impact on public health (Roberto, Pomeranz, & Fisher, 2014) and therefore providing clear and coherent information at a population level is of great importance. One of the advantages of the snack reduction and replacement intervention was that simple messages to meet population level recommendations (e.g. PHE 2018) were offered rather than reliance on calorie information. Calorie information requires health literacy and numeracy skills to understand and utilise the information (Cohn, Larson, Araujo, Sawyer, & Williams, 2012) and thus may not be of help to families of low educational attainment. Similar messages targeted towards adults (caregivers) may also confer advantages to dietary intake, due to positive associations between child and adult consumption (Johnson et al., 2014). However this relationship has yet to be investigated.

The advantages of snack reduction and replacement on children's nutritional intake were also highlighted, with reductions in total daily energy, sugar and fat intake observed (Reale et al., 2018) (Chapter 6.5). Furthermore, increases in FV snack consumption did not displace FV consumed as part of main meal thus confirming that snack replacement may support children towards meeting recommendations to consume 40g of FV per portion (British Nutrition Foundation, 2019). These findings confirm pre-existing literature and make an original contribution to knowledge by identifying the effects of downsizing snacks on total daily energy intake. For example, it is well documented that increases in portion size result in increases in consumption e.g. (Fisher, Liu, et al. 2007; Kling et al., 2016; Spill et al., 2011). Furthermore, preliminary research suggests that reductions in portion size may be associated with reductions in meal consumption (Smith et al., 2013), however, to date no other study has observed the effects of downsizing snack foods on nutritional intake.

Despite this study being the first of its kind, previous interviews have revealed that mothers are reluctant to weigh and measure food items (Croker et al., 2009). On reflection, mothers in the present study discussed having similar apprehensions before initiating the intervention period. However, mothers stated that observing positive changes to their child's eating behaviour was encouraging and reinforced the benefits of complying to the intervention such that weighing foods quickly became habitual. It is possible that these differences were observed due to the study design. For example, participating in a three week intervention requires a larger commitment than a single focus group, therefore despite the study being advertised in multiple ways and locations, the study may have attracted mothers with an interest in health and nutrition, thus the findings may not be generalisable to other populations. Alternatively, in the present study the volume of weighing may have been smaller than anticipated or the perceived positive outcomes of the study (e.g. increased vegetable intake and improved diet for their child) may have outweighed the study demands.

The findings of this study are encouraging and suggest that it may be possible to enhance children's nutritional intake and diet variety by implementing snack replacement in the home environment, due to significant increases in total daily vegetable intake (g). Increases in total daily vegetable intake may have been associated with an increase in food availability or modelling (due to providing additional snacks for sibling consumption); both of which have been linked to acceptance of previously disliked vegetables (Holley, Haycraft, & Farrow, 2015; Wardle et al., 2003). Caregivers were instructed to make no food related comments, however it is possible that vegetable intake may have been enhanced by verbal praise which fulfils and nurtures children's intrinsic needs of relatedness, competence and autonomy (Orrell-Valente et al., 2007) and is also linked to consumption of a previously disliked or novel vegetable (Corsini et al., 2013), as this was not monitored.

Currently, preschool children in the UK are not consuming enough dietary fibre or FV (NDNS, 2019). Vegetable consumption is recommended as part of a healthy lifestyle as the rich nutrients provide protective functions and thus reduce the risk of obesity, cardiovascular disease, diabetes and some cancers (Heidemann et al., 2008). Children have a natural tendency to dislike vegetables due to their bitter taste (Cashdan, 1998; Skinner, Carruth, Bounds, & Ziegler, 2002), however repeated exposure can increase consumption (Caton et al., 2013), acceptance (Pliner & Loewen, 1997) and liking (Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010) of disliked or unfamiliar foods following 10 – 15 exposures. These findings may help to inform the development of public health messages and recommendations. Past Change4Life campaigns have resulted in minimal, or no, impact on attitudes and behaviour towards changing children's habitual diet (Croker, Lucas, & Wardle, 2012) which may be resultant of the level of information and advice provided. A qualitative synthesis of literature revealed that caregivers may benefit from guidelines that present information on resources that are already used, e.g. packet size (Kairey et al., 2018). Therefore, suggesting snack replacement and snack reduction may be a positive method of communicating advice on how to achieve PHE's most recent campaign (*'look for 100-calorie snacks, two a day max'*) (Public Health England, 2018). However, it is important to note that this study was conducted in a small sample size and over a short period of time therefore further investigation into the sustained effects of snack reduction and replacement is warranted.

7.3 Thesis strengths and limitations

This thesis produced novel findings and confirmed pre-existing literature e.g. (Blake et al., 2015; Croker, Sweetman, & Cooke, 2009; NDNS, 2018). However, when conducting research it is important to consider strengths and limitations in order to improve study design for future work. Throughout the thesis strengths and limitations have been discussed in relation to each specific study however there are more general strengths and limitations that warrant further consideration and will be presented in this section.

This thesis employed a mixed methods design to form conclusions based on the strong integrated and corroborative evidence (Tashakkori & Teddlie, 2003). Breadth and depth of understanding on mother's decisional processes, influences and motivations for choosing snack portion sizes were revealed which otherwise may have been missed within a singular method thesis. Furthermore, the qualitative methods explored dynamic and passive processes as well as mother's unique perspectives to provide insight into a range of study outcomes. In contrast the quantitative methods produced numerical data from large samples, and collectively identified complimentary and contrasting results. However, similarly to singular methods, mixed method designs hold some limitations. There are no clear guidelines regarding how each methodology should be weighted (Teddlie & Tashakkori, 2009). Furthermore, the qualitative components are subject to interpretation and bias however field notes were written before, during (where applicable) and immediately post data collection as part of a reflexive process. However, being a young female without a child could have been a barrier to building rapport and eliciting in depth information from participants in interviews. However, this information was disclosed on request and was favourable in that mothers were more likely to provide detailed information to enhance the knowledge of a non-mother and appeared to feel less judged for their actions. These characteristics also reduced bias due to no previous experience of utilising a variety of portioning practices with preschool children.

Findings from previous investigations and current literature were used to inform the development of a feasibility and acceptability study. However, there was no theoretical underpinning. Interventions underpinned by theory are thought to be more effective at changing behaviour as they target key determinants of a desired behaviour and provide an understanding of what works best in practise (Michie, Johnston, Francis, Hardeman, & Eccles, 2008). However, this work was exploratory and did not focus on changing target behaviours. Instead, studies 1-3 provided a sound evidence base and a good understanding of the specific populations current feeding behaviours, portioning practices and consumption habits to ensure the intervention was tailored to the participants needs (Lippke & Ziegelmann, 2008). Furthermore, despite advantages of population level interventions, the person-based approach offers specific advantages related to maximising participant acceptability and effectiveness of the intervention due to eliciting participants views in qualitative work (Yardley, Morrison, Bradbury, & Muller, 2015).

Research was conducted in a naturalistic environment to replicate real-life eating scenarios (i.e. snack portioning practices at an afternoon snack time) and measure subsequent eating behaviours following the snack reduction or snack replacement. Research in the home ensures participants are in a familiar environment to increase the likelihood of responding habitually and to ensure they feel comfortable in interviews (Sivell et al., 2015). However, the duration of the data collection period was short and the presence of a researcher may have introduced a social desirability effect. Firstly, parental feeding practices are dynamic and are often a response to children's eating behaviours (Holley, Farrow, & Haycraft, 2017), therefore observing snack preparation and consumption at one occasion may not have provided a holistic view of habitual feeding practices and subsequent eating behaviours e.g. (Buckland et al., 2014). However, similarities were identified between online portion size selections and portion sizes served in the home environment, a) providing more confidence that the observed outcomes reflected normal behaviours and b) software may stimulate actual feeding behaviours, as suggested previously (Wilkinson et al., 2012). Secondly, in the online survey snacks were removed from their packaging before being photographed. Moreover, snacks in the home based study were removed from their packaging and presented ad libitum in a large opaque bag. Therefore, including snacks in their original packaging may have enhanced ecological validity and produced a different outcome. Thirdly, mothers were requested to reduce or replace their children's HED snacks for 7 days and results suggest both methods are relatively feasible and accepted in the home environment. However, before these methods can be translated into practical advice for caregivers, the feasibility of these methods in other environments (e.g. day care settings), for a longer duration of time and with their own snack foods needs further investigation.

Moreover, research in the home environment required the use of weighed food diaries to measure food intake since the researcher could not be present. Weighed food diaries are frequently used in naturalistic environments and provide more accurate measures of portion size than estimation (Wolper, Heshka, & Heymsfield, 1995). However, accuracy was compromised when caregivers forgot, or were unable to weigh every item immediately before and after consumption. More accurate measures could have been collected using the food photography method (Martin et al., 2014), however due to time and financial constraints this was not possible. To minimise participant variability a cross over design was employed and within subject variance was assumed to be constant across individuals, similarly to data produced from the NDNS (Gay, 2018). However, caregivers were aware that their food records would be read and therefore it is possible that caregivers adapted their normal feeding practices due to a social desirability effect (Stubbs, 2003).

As a single researcher data collection was time consuming and qualitative themes were not fully cross-checked by at least two independent researchers. However, complete submersion and understanding of the data was achieved as a result of conducting and analysing all of the interviews and think aloud tasks. Furthermore, a second independent researcher crosschecked a minimum of 10% of transcripts and consensus was achieved throughout. Moreover, a handful of participants confirmed that the main themes produced had summarised the key points discussed in interviews and during the think aloud task.

This thesis demonstrates the significant role mothers play in shaping children's dietary intake due to the abundance of responses in the online survey. However, informal care providers such as grandparents, friends and babysitters are an important source of childcare worldwide due to the expanding female workforce and cost of nursery/ day care centres (Bell, Perry, and Prichard, 2018). In particular, grandparents are an important source of support in the UK, with over a quarter of children < 5 years of age receiving care from grandparents (Rutter, 2016). Study 1 was advertised to all caregivers using multiple modalities however responses from grandparents were low which may be attributable to restricted access or skills to use technology online. Furthermore, families from the most deprived neighbourhoods were underrepresented despite the researcher's best efforts to advertise the study in multiple locations of varying income and levels of deprivation. Therefore, the findings of this thesis represent moderate-high socioeconomic status and may not be generalisable to populations of low income.

7.4 Future Work

Each study within this thesis makes an original contribution to the literature on parental feeding practices and children's eating behaviours. However, further investigation should be considered to enhance research outputs and understanding in this field. Suggestions for future work are provided in this section based on the thesis outcomes and are related to the recruitment strategy and study design.

This thesis makes an original contribution to knowledge by identifying the complex and transient portioning practices mothers adopt in the home environment at an afternoon snack time, which should be considered during the development of population level interventions (Roberto et al., 2014). Furthermore, attention must be paid to the clarity and simplicity of information provided since increasing levels of overweight and obesity are related to a social gradient. Therefore, including simple messages that meet national recommendations may be suitable for a large target audience. One of the advantages of the snack reduction and replacement intervention was that simple messages were offered rather than reliance on calorie information. However, the impact of snack reduction and replacement on nutritional intake in children with a low socioeconomic position is unknown due to the small number of participants that were residing in the most deprived areas of Sheffield and warrants further investigation.

This study employed various recruitment strategies to maximise participant diversity but failed to recruit a significant number of caregivers from the highest deprived neighbourhoods. Families with a low socioeconomic position are more susceptible to the PSE (Best and Papies 2018) and thus inequalities in health ("Statistics on Obesity, Physical Activity and Diet," 2018). Furthermore, low-income families are not often represented in child feeding and other related research (Wardle & Carnell, 2007) which may be attributable to recruitment strategies. This thesis suggests that online advertisements and discussions in toddler group settings were successful in recruiting families with a moderate to high socioeconomic position. However, families with a low socioeconomic position may not have access to a computer or the internet, and may not attend toddler groups therefore other forms of recruitment must be considered. Furthermore, future work should seek to identify suitable recruitment strategies and accessible forms of data collection for grandparent participants given their possible influence on children's food preferences and eating behaviours (Bell, Perry, & Prichard, 2018), and potentially their limited use of technology e.g. online web browsing.

This thesis pilot tested two novel methods of portion control and the results were encouraging (Reale et al., 2018) (Chapter 6.5). However, before initiation of a main trial to identify the sustained effects of snack reduction and snack replacement on energy intake, further refinements to the protocol are required. For example, all children enrolled in the study were provided with identical snack options, chosen to reflect habitual snack intake. Increases in total daily vegetable intake were observed in the replacement group when the items were liked and the children had previously consumed the item on offer. However, compliance was low if the FV were unfamiliar or disliked. Therefore, future work should seek to remove the snacking schedules and request caregivers offer children FV that they usually provide, ensuring they are liked. Although it is important to note that the removal of subsidised snacks delivered directly to caregivers homes may reduce compliance to the intervention. As such, further pilot testing is required to identify if snack reduction and replacement are still feasible and acceptable portion control methods in the home environment when cost is not subsidised and caregivers have to purchase their own snack foods.

Moreover, the present study excluded children who attended nursery (or other forms of child care) for more than three consecutive days due to the requirement of a 4 day weighed food diary, therefore, potentially limiting the generalisability of findings. Since, a large proportion of children attend child care, and thus consume snacks out of the home, it may be worthwhile investigating the feasibility and acceptability of snack reduction and replacement in other environments e.g. childcare settings. Furthermore, other methods of collecting nutritional intake data could be explored such as the food photography method, which is less burdensome and more suitable for use outside the home compared to food diaries (Williamson et al., 2004; Williamson et al., 2003). However, further investigation into the appropriateness of this method for low income families and grandparents is warranted, due to the requirement of a smartphone (Martin et al., 2014).

A final suggestion for future work would be to intervene at the caregiver level. Consistently throughout this thesis associations between caregiver and child portion size were demonstrated, highlighting the influential role caregivers have on children's nutritional intake, as previously demonstrated (Corsini et al., 2018; Farrow, Blissett, & Haycraft, 2011; Jansen, Mulkens, & Jansen, 2007). Positive role modelling coupled with repeated exposure have been associated with increases in vegetable consumption (Holley, Haycraft, & Farrow, 2015). Therefore, it is possible that snack reduction and replacement may be more effective if caregivers also follow the snacking schedules. However, further investigation is required.

8. Conclusion

This thesis makes an original contribution to knowledge by revealing the complex, dynamic and multifaceted decisions caregivers make in regard to preschool children's snack portion sizes. Furthermore, this thesis lends support by identifying two feasible and acceptable portion control methods in the home environment which are communicated by simple messages that adhere to portion size recommendations for preschool children. Caregivers in the present study reported that they were not aware of snack portion size recommendations for preschool children and instead made portion size decisions related to features of the mother, features of the food, characteristics of the child and situational factors. Most caregivers recruited for this thesis were relatively good at downsizing snack portion sizes in line with the energy requirements of preschool children, however a moderate proportion of caregivers selected HED snacks up to four times the recommended amount for preschool children which may result in sustained increases in energy intake due to the PSE. From the data collected, caregivers who were less accurate at portion size selection were of a lower socioeconomic position with fewer educational qualifications. Replacing HED snacks with LED snacks significantly increased total daily vegetable intake and reduced total energy and fat intake. However, further investigation into the feasibility and acceptability of snack reduction and replacement over a longer duration of time, and in other settings, are required. Furthermore, future downsizing interventions should focus on caregiver and child portion sizes since caregiver snack portion size predicted child portion size and young children tend to adopt the eating behaviours that they observe from an influential role model.

Appendix 1: Author Contributions

The following table identifies each author's contribution to each scientific article.

Article	Study Design	Data Collection	Duplicate data extraction/ screening	Data Analysis	Primary writing of the article	Drafting and revisions of the article
Systematic Review (Reale et al. 2019) Chapter 6.3	SR	SR	SR, RA	JH	SR	SR, SJC, JH, RA, MMH, JEC
Feasibility and acceptability study (Reale et al. 2018) Chapter 6.5	SC, SR	SR, CK	-	SR, CK	SR	SR, SJC, MMH, BJR, JEC, SC, CK

SR- Sophie Reale; RA- Robert Akparibo; JH- Jean Hamilton; SJC- Samantha Caton; MMH- Marion Hetherington; JEC- Joanne Cecil; CM/CK- Colette Marr (formerly Colette Kearney); BJR- Barbara Rolls; SC- Sharon Carstair

Chapter 6.3

The effect of food type on the portion size effect in children aged 2-12 years: A systematic review and meta-analysis

Sophie Reale[1], Jean Hamilton[1], Robert Akapribo[1], Marion M. Hetherington[2] Joanne E. Cecil[3] and Samantha J. Caton [1]*

[1] School of Health and Related Research (ScHARR), University of Sheffield, Sheffield S1 4DA, UK
[2] School of Psychology, University of Leeds, Leeds LS2 9JT, UK;
[3] Population and Behavioural Sciences, School of Medicine, University of St Andrews, St Andrews KY16 9TF, UK
* Corresponding author

This work was supported by the BBSRC, Diet and Nutrition Research Industry Club [grant numbers BB/M027384/1].

I, Sophie Reale contributed to the following sections:

- Study design
- Data collection, including creation and advertisement of the online survey
- Quantitative analysis with support from a statistician (R.M.S)
- Primary writing and formatting of the manuscript

Signed: SReale Dated: 27/01/2019 Print Name: Sophie Reale

Signed: SCaton. Dated: 9/04/2019 Print Name: Dr S J Caton

Chapter 6.5

The Feasibility and Acceptability of Two Methods of Snack Portion Control in United Kingdom (UK) Preschool Children: Reduction and Replacement

Sophie Reale [1], Colette M. Kearney [1], Marion M. Hetherington [2], Fiona Croden [2], Joanne E. Cecil [3], Sharon A. Carstairs [3], Barbara J. Rolls [4] and Samantha J. Caton [1,*]

[1] School of Health and Related Research (ScHARR), University of Sheffield, Sheffield S1 4DA, UK
[2] School of Psychology, University of Leeds, Leeds LS2 9JT, UK
[3] Population and Behavioural Sciences, School of Medicine, University of St Andrews, St Andrews KY16 9TF, UK
[4] Department of Nutritional Sciences, College of Health and Human Development, The Pennsylvania State University, University Park, PA 16802, USA
* Corresponding author

This work was supported by the BBSRC, Diet and Nutrition Research Industry Club [grant numbers BB/M027384/1].

I, Sophie Reale contributed to the following sections:

- the study design (adding qualitative, feasibility and acceptability parameters to a quantitative design)
- data collection with the support of a research assistant (C.M.K)
- quantitative and qualitative analysis, with C.M.K cross checking 10% of interview transcripts
- Primary writing and formatting of the manuscript
- Revisions to the manuscript

Signed: Dated: 27/01/2019 Print Name: Sophie Reale

Signed: Dated: 9/04/2019 Print Name: Dr S J Caton

Appendix 2: Permission to include published materials

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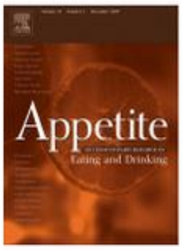

Title: The effect of food type on the portion size effect in children aged 2–12 years: A systematic review and meta-analysis

Author: S. Reale,J. Hamilton,R. Akparibo,M.M. Hetherington,J.E. Cecil,S.J. Caton

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Part 2: Nutrients

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Katarina Tesovic <tesovic@mdpi.com>
to me, Samantha

Fri, 12 Oct 2018, 08:17

Dear Sophie,

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I wish you all the best for your future research.

Kind regards,

Katarina Tesovic
Assistant Editor, MDPI DOO
E-Mail: tesovic@mdpi.com
Veljka Dugosevica 54, 11060 Belgrade, Serbia
+381 11 414 75 49
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Appendix 3: Data Extraction Tool

General Information	Title	
	Authors	
	Year	
Study characteristics	Aims	
	Study design	
	CHILD participant	Number:
		Age:
		Gender:
		Other:
	ADULT participant	Number:
		Age:
		Gender:
		Relationship to child:
		Other:
	Recruitment method	
	Study location	
	Study foods	
	Data Analysis	
Results	Qualitative	
	Quantitative	
Conclusion	Interpretation of results	
	Limitations	
	Future research	

Appendix 4: Participant Information Sheet (Study 6.2)

1. Research Project Title: Eating behaviours and toddlers

2. Invitation paragraph

We would like to invite you and your child to take part in one of our studies that will take place in your own home. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Please ask us if there is anything that is not clear or if you would like more information and please take time to decide whether or not you wish to take part.

3. What is the project's purpose?

We are researchers from the School of Health and Related Research at the University of Sheffield. Our research focuses on nutrition, appetite and eating habits. We are interested in finding out more about eating habits in young children.

4. Why have I been chosen?

You have been approached to take part because you are a caregiver of a child who is aged 2 – 4 years old and you live in the Sheffield area.

5. Do I have to take part?

You do not have to take part in this study, participation is voluntary, and you are free to withdraw at any point without giving reason for doing so.

6. What do I have to do and what will happen to me if I take part?

If you would like to take part in this study we would like to organize a time to visit you within your own home, at afternoon snack time, for a maximum of one hour. On the day of our scheduled visit, we would like both yourself and your child to be home and to have consumed a sandwich for lunch. We will then visit you approximately two – three hours later. During the visit we will ask you to prepare an afternoon snack for both yourself and your child with food items that we bring with us (Cornflakes, Grapes, Carrot batons, Chocolate digestive biscuits and Ready salted crisps). You can then select one for your child to consume. We would then like to ask you some questions in the form of a semi-structured interview about your child's eating behaviors and preparation at snack time. We would like to audio record the interview.

A week after the home visit we would like to send you an online survey to complete. This can be completed at any time, on any computer or mobile device. This will take approximately 15 minutes to complete.

7. What are the possible disadvantages and risks of taking part?

There are no risks associated with this study; however if your child has any known food allergies or is currently taking medication that impacts appetite you will not be eligible to participate.

8. What are the possible benefits of taking part?

By taking part in this research you will contribute to our understanding of eating behaviour and dietary intake in preschool children. Overall our research will hopefully contribute to improving the health of young children. As a thank you for your time you will be offered a £10 Love to Shop voucher at the end of the home study. You will also be entered into a prize draw on completion of the online survey to win one of three high street vouchers (1x£50, 1x£25, 1x£25).

9. What happens if the research study stops earlier than expected?

If for any reason the research has to be stopped earlier than expected, you will be contacted immediately and informed. If you do not meet the eligibility criteria for this study then you will be informed as soon as possible.

10. What if something goes wrong?

If you would like to raise a complaint during the data collection you should contact Dr Samantha Caton (email: s.caton@sheffield.ac.uk). If for any reason you do not feel satisfied with the outcome you can contact Professor John Brazier, Dean of School of Health and Related Research (email: j.e.brazier@sheffield.ac.uk; telephone: 0114 222 0726; Address: School of Health and Related Research, University of Sheffield, Regent Court, 30 Regent Street, Sheffield, S1 4DA).

11. Will my taking part in this project be kept confidential?

The information that is collected about you, your family and your child during the course of the research will be kept strictly confidential and stored in a locked filing cabinet on university premises. Throughout the research you will be given a participant identification number and your name will not be used to ensure your responses remain anonymous.

12. What will happen to the results of the research project?

The data generated from this research will be published in scientific journals and presented at academic and relevant conferences. This includes anonymised quotes from the interviews. Data that is anonymised will be kept on an encrypted hardware for a maximum of 5 years. As the data is anonymous it means that it cannot be traced back to you at any point.

14. Who has ethically reviewed the project?

This project has been ethically approved by the School of Health and Related Research ethics review procedure. The University's Research Ethics Committee monitors the application and delivery of the University's Ethics Review Procedure across the University. The application number is: 011913

15. Contact for further information

If you have any questions regarding any aspect of our research please feel free to contact any member of our research team Miss Sophie Reale (email: slreale@sheffield.ac.uk, telephone: 0114 2159443) or (Dr. Samantha Caton (email: s.caton@leeds.ac.uk, telephone: 0114 2224198

Thank you for taking the time to read the information sheet. If you feel happy with the information provided to you and you are willing to take part, please contact Sophie on the details overleaf.

We will be happy to arrange a date and time convenient for you.

Appendix 5: Topic Guides

Part A: study 2

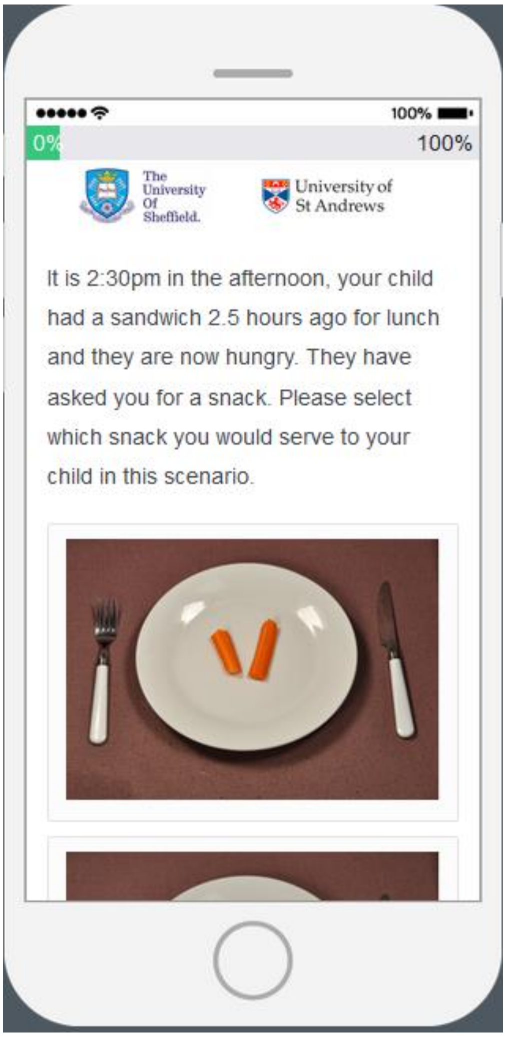
Topic Guide
1. *Can you tell me a little bit about how you normally decide how much food to serve your child at snack time?*
2. *And how did you decide today?*
3. *Is this amount similar or different to what you would normally provide?*
4. *Is there any reasons why you might serve a different amount than you did today?*
5. *I can see you served more X than Y, can you explain your reasons for this?*
6. *Can you tell me about how these portion sizes are similar or different to other snack food items that you usually serve?*
7. *Can you tell me a little bit about how this amount is similar or different to the amount another family member would provide?*
8. *What role does your child play in deciding the amount of a snack that they receive?*
9. *If a snack comes in a packet for one, such as pom bears, how do you decide how much to give?*
10. *How does your child's liking/ dislike of a snack influence the amount you serve?*
11. *How much of this snack would you expect your child to consume?*
12. *How do you decide how much you want your child to consume?*
13. *How would you normally respond if your child asks for more?*
14. *How would you normally respond if your child refuses a snack?*
15. *What information do you use when deciding on a portion size for yourself?*
16. *What information do you use to guide your decision regarding the amount of food to serve your child?*
17. *Can you tell me about a time you were provided with portion size information?*
18. *What is your opinion on receiving portion size guidance?*
19. *How willing would you be to follow portion size guidelines?*
20. *What is your opinion on supermarkets providing packaged snacks in a size suitable for child consumption?*

Part B : Study 4

Topic Guide
1. *Thinking back to week 1, can you describe your experience of completing the weighed food and drink diary?* a. *Who completed the food diary?* b. *Can you describe any instances where you forgot to fill in the diary?* c. *Can you describe any instances you didn't know how to fill in the diary?* d. *Can you describe any instances where you changed what you would normally provide your child as a result of filling in the diary?*
2. *Thinking back to week 2, can you describe your experience of following the snacking schedule?* a. *How often were you able to comply to the snacking schedule?* b. *Can you describe the similarities or differences of the snacks offered in week 2 compared to the snacks you usually offer?* c. *Can you describe a scenario where the snacking schedule influenced your child's intake at a meal?* d. *Can you describe any changes to your child's behaviour as a result of the snacks provided?*
3. *Can you describe your experience of reducing/ replacing your child's snack?* a. *How often were you able to comply to the snacking schedule?* b. *Can you describe the similarities or differences of the snacks offered in week 3 compared to the snacks you usually offer?* c. *Can you describe a scenario where the snacking schedule influenced your child's intake at a meal?* d. *Can you describe any changes to your child's behaviour as a result of the snacks provided?* e. *How likely are you to continue replacing/ reducing your child's usual snacks?*

Appendix 6: Online Survey Materials

6.1 Online mobile display



6.2 Example portion size stimuli

Appendix 7: Feedback pro-forma

Thank you for providing your child with the test meal. We would now like to ask you a few questions regarding your experience.		
1. How old is your child?		**years old**
2. Did you provide the test meal for lunch or dinner/tea?	**Lunch** ☐	**Dinner/Tea** ☐
3. Did you provide your child with a snack in between your child's last meal and serving the test meal?	**Yes** ☐	**No** ☐
a. If yes, what snack did you provide?		
4. What vegetables did you provide with the test meal?	**1.**	**2.**
5. Did your child consume all of the pasta and tomato sauce?	**Yes** ☐	**No** ☐
a. If not, roughly how much was left?		
b. Are there any reasons why your child didn't finish the meal?		
6. Did your child make any food related comments whilst eating the pasta? If so, what were these?		
7. Did your child consume all of the fruit puree pot?	**Yes** ☐	**No** ☐
a. If not, roughly how much was left?		
b. Are there any reasons why your child didn't finish the fruit pot?		
c. Did your child make any comments whilst eating the fruit pot? If so, what were these?		
8. How did you cook the pasta?		
9. Was the pasta hot enough when cooked according to the manufacturer's instructions?	**Yes** ☐	**No** ☐
10. If not, how did you heat it to the correct temperature and how long did this take?		

11. Did your child consume all of the Goodies® Gingerbread biscuits?	**Yes** ☐	**No** ☐
a. If not, roughly how much was left?		
12. Are there any reasons why your child didn't finish the biscuits?		
13. Did your child make any comments whilst eating the biscuits? If so, what were these?		
14. Did your child consume all of the vegetables?	**Yes** ☐	**No** ☐
a. If not, roughly how much was left?		
b. Are there any reasons why your child didn't finish the vegetables?		
15. Did your child make any comments whilst eating the vegetables? If so what were these?		

16. Do you think the whole meal was…	**Too Little** ☐	**The right amount** ☐	**Too much** ☐
17. Is the amount that your child consumed of the test meal…	**Less than normal** ☐	**The same as normal** ☐	**More than normal** ☐
18. If it is less or more than normal, please tell us why			

Any other comments….

Appendix 8: Weighing scale instructions

HOW TO USE THE SCALES FOR WEIGHING FOOD		
1. Turn the scales on by pressing the on/off button 		2. Press the unit button on the base until the screen displays in grams (0 g) 
3. Place an empty plate on the scales and press the zero button 		4. Weigh each item and write down the weight and description in the food and drink diary. (Please state if it is cooked weight or raw weight) 
5. Press the zero button and add the next food item 		6. Don’t forget to weigh any spreads, sauces or condiments 

HOW TO USE THE SCALES FOR WEIGHING FOOD

7. Press the zero button before each additional item is added to the plate

8. Serve the food to your child

9. Press the zero button with the bowl on the scales and weigh any leftover items individually (where possible)

and record this in the diary

10. Don’t forget to press the zero button before weighing the next item

11. Please record this in the food diary as you weigh the items

Appendix 9: Acceptability Questionnaire

<table>
<tr><td colspan="5">1. Please circle the group you were assigned to in the study</td></tr>
<tr><td colspan="2">Reduction</td><td></td><td colspan="2">Replacement</td></tr>
<tr><td colspan="5">THINK ABOUT THE SECOND WEEK OF THE STUDY WHEN WE PROVIDED THE SNACKS FOR YOUR CHILD</td></tr>
<tr><td colspan="5">2. The type of snacks provided in the snack pack for week two were appropriate for my child</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">3. My child liked the snacks in week two</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">4. The snacks offered during this week were similar to the snacks my child would normally eat</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">THINK ABOUT THE THIRD WEEK OF THE STUDY WHEN WE ASKED YOU TO REPLACE OR REDUCE YOUR CHILD’S SNACKS</td></tr>
<tr><td colspan="5">5. My child’s hunger was satisfied by the snacks in week three</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">6. My child was happy with the snacks in week three</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">7. My child noticed the changes to his/ her snacks</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Neither agree nor disagree</td><td>Agree</td><td>Strongly Agree</td></tr>
<tr><td colspan="5">8. My child noticed the changes to his/ her drinks</td></tr>
<tr><td>Strongly</td><td>Disagree</td><td>Neither agree</td><td>Agree</td><td>Strongly</td></tr>
</table>

disagree		nor disagree		Agree
9. Keeping the food diary was inconvenient				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
10. Keeping the food diary was difficult				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
11. Keeping the food diary was helpful				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
12. Whilst keeping the food diary I chose different foods in order to make record keeping easier				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
13. How willing would you be to use this method to reduce your child's portion sizes?				
Very unwilling	Unwilling	Neither willing nor unwilling	Willing	Very willing
14. How likely is this method to make permanent changes to your child's eating habits?				
Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely
15. I found it easy to change my child's snacks				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
16. I found it easy to change my child's drinks				
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

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