Experiential Learning to Establish Children's Preferences for Vegetables at Mealtimes

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Intellectual property rights and publications

The candidate confirms that the work submitted is his own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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Abstract

Consuming vegetables as part of a healthy and varied diet has positive effects for the individual (e.g. protection against non-communicable diseases) and environment (e.g. sustainability of food systems). Yet, children from many countries regularly fail to meet recommended intakes of vegetables per-day. This thesis utilised a variety of methods and theoretical perspectives to better understand and encourage vegetable intake by children (2-6 years). Following a narrative review of the literature highlighting the importance of ecological validity in research, secondary data analyses examined how vegetables are commonly eaten by children in the UK. This found that vegetables are eaten at evening mealtimes at home with family, but portion sizes were small. An online study then examined children’s food choices within meals and found that vegetables were selected more frequently when they added variety to a meal and were better liked than competitor foods. Therefore, competitor foods may be of importance when designing interventions to increase vegetable intake at mealtimes. Parents were subsequently surveyed to obtain views and beliefs for implementing different vegetable feeding strategies at home. Although parents reported high intentions to use such strategies, many parents did not believe that they would work for their child. Lastly, vegetables-served-first and experiential learning strategies were tested in schools. Children ate more vegetables when served before meals, yet there were large differences between schools. Overall, findings suggest that vegetable intake by children can be increased by ~10g if they are served in isolation at mealtimes, without competitor foods. However, this may be dependent on the individual child’s experience of the eating occasion, including impacts from stakeholders (parents, schools), environmental and contextual factors. Findings have implications for the implementation of vegetable feeding strategies at home and at school, as well as for policy that could enhance the impact of such strategies at school lunchtimes.

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List of Abbreviations

ASD: Autism Spectrum Disorders

BMI: Body Mass Index

CEBQ: Child Eating Behaviour Questionnaire

CF: Complementary Feeding

CFI: Comparative Fit Index

CFPQ: Comprehensive Feeding Practices Questionnaire

CFQ: Child Feeding Questionnaire

CHO: Carbohydrate

CI: Confidence Interval

COVID-19: Coronavirus Disease 2019

DINO: Diet In Nutrition Out

EDC: Early Development Coordinator

EO: Eating Occasion

F&V: Fruits and Vegetables

FCQ: Food Choice Questionnaire

FF: Food Fussiness

FFL: Flavour-Flavour Learning

FFQ: Food Frequency Questionnaire

FNL: Flavour-Nutrient Learning

GEE: Generalised Estimating Equations

HED: High Energy Dense

HFSS: High Fats, Sugar and Salt

ICC: Intra Cluster Correlation

LED: Low Energy Dense

NCDs: Non-Communicable Diseases

NDNS: National Diet and Nutrition Survey

OR: Odds Ratio

PMAS-R: Parent Mealtime Action Scale-Revised

RE: Repeated Exposure

RMSEA: Root Mean Square Error of Approximation

SD: Standard Deviation

SEM: Structural Equation Modelling

SRMR: Standardised Root Mean Squared Residual

TLI: Tucker Lewis Index

TPB: Theory of Planned Behaviour

VAS: Visual Analogue Scale

WHO: World Health Organization

WTT: Willingness To Try

Chapter 1

Low vegetable intake in children: An overview

Chapter 1 Low vegetable intake in children: An overview

Childhood is a critical period in which to promote and reinforce healthful behaviours, as habits in childhood may track through to adolescence and adulthood (Craigie, Lake, Kelly, Adamson, & Mathers, 2011; Hovdenak et al., 2019; te Velde, Twisk, & Brug, 2007), ultimately to be promoted again to the next generation. Improved quality of diet and physical activity are important target health behaviours, especially for reducing the risk of conditions such as overweight, obesity and other non-communicable diseases (e.g. heart disease and various types of cancer). Within the category quality of diet, vegetable consumption is particularly important to the promotion of the overall health of the population and the planet (Willett et al., 2019). This introduction presents the problem of low vegetable intake in children and the importance of consuming adequate portions of vegetables each day. The food environment, stakeholders of children's vegetable consumption and appropriate goals and outcomes for eating vegetables will be considered, before reviewing relevant theories that help us to understand and address this problem from multiple perspectives. Lastly, this introduction will outline the chapters within this thesis and how they will address specific problems with low vegetable intake in children.

1.1 Why is vegetable consumption important?

Vegetables are an important part of a balanced diet, contributing to the consumption of dietary fibre and a variety of phytochemicals (including vitamins) that are not found (in such quantities) in other foods (Van Duyn & Pivonka, 2000). In the UK, government guidance recommends consuming five portions of fruits and vegetables per-day (NHS-UK, 2018), although there is no specific recommendation for how many of these portions should be fruits or vegetables. It has been documented extensively that this target is not met by the vast majority of UK children (Public Health England & Food Standards Agency, 2021) and across many other countries (Amao, 2018; Lynch et al., 2014), with vegetables in particular commonly eaten less frequently and in smaller portions than fruits (Kim et al., 2014).

Although the prevalence of malnutrition and nutrient deficiencies (e.g. vitamins) in the UK is low (Department of Health & Food Standards Agency, 2011), micronutrients found in vegetables are essential for health and for the development and growth of the child (Savarino, Corsello, & Corsello, 2021). Consuming more vegetables is associated with person level benefits including lower risk of developing non-communicable diseases such as heart disease and different cancers (Aune et al., 2017; Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014; Wang et al., 2014), as well as affording potential protection against obesity (Folkvord, Naderer, Coates, & Boyland, 2021; Yang et al., 2021). Social and environmental level effects are also present and important, including sustainability of food systems by consuming more plant based foods (Willett et al., 2019).

1.1.1 The food environment

For some children, there are many opportunities to consume vegetables in different contexts and throughout the day. This may be at home, in school, at snack times or meal times. The availability of vegetables (or perception of their availability) is essential for consuming vegetables in the diet (Cook, O'Reilly, DeRosa, Rohrbach, & Spruijt-Metz, 2015). However, the current obesogenic environment (available High Energy Dense [HED] food, low physical activity and multi-media advertising that promote weight gain) may be counterproductive to promote vegetable consumption (Schrempft, van Jaarsveld, Fisher, & Wardle, 2015). As HED and more palatable foods are often available, these may be preferred to vegetables (Reale et al., 2018), meaning that vegetables will not be consumed. This could have implications for parents and children choosing HED foods instead of vegetables at the point of purchase and within the home when eating. Whilst not buying vegetables reduces waste and food costs, it also reduces the learning opportunities for the child to consume these foods. Outside of the home, children may also have access to vegetables at school. However in the UK, children currently only have access to vegetables at lunchtimes if the child has a school dinner (instead of a packed lunch from home: Evans, Greenwood, Thomas, & Cade, 2010), where it is not guaranteed that vegetables will be consumed (Haroun, Harper, Wood, & Nelson, 2011).

While the wider food environment may predict consistent vegetable eating over time, the eating context is important for their consumption at an individual eating occasion. The eating context includes various aspects surrounding eating such as the setting, others that are present (social context), the type of eating occasion (e.g. meal or snack), what the individual brings to the meal (e.g. hunger or food preferences) and even the wider cultural context. Even if vegetables are usually eaten at home, they may be refused around peers at school or eating out at restaurants. At home, eating at the table may promote eating vegetables, whilst eating in front of a television is associated with consuming fewer fruits and vegetables (Avery, Anderson, & McCullough, 2017). Within the meal itself, other “competitor” foods available and whether vegetables “go together” with the meal may also determine whether children will eat them or not (Marty et al., 2017). This would suggest that even in instances where children usually eat vegetables, there are factors that suppress their consumption. Children may then learn in which circumstances and contexts it is acceptable (to them) to eat vegetables and when it is not.

1.1.2 Stakeholders of children’s vegetable consumption

Because of their health benefit to children, parents, caregivers and education providers are all groups that are invested in and would benefit from children eating more vegetables. Parents are concerned about their child’s health and educators may be concerned with how eating at mealtimes can influence educational performance (Earl & Lalli, 2020). These ‘stakeholders’ will also be affected in different ways by children’s low intake of vegetables.

1.1.2.1 At home

When eating vegetables, parents may experience refusal behaviours by their child such as pushing food away, not eating or even tantrums (Lewinsohn et al., 2005). This often leads to parental stress and concerns about their child not eating (either enough in volume or variety) (Moore, Tapper, & Murphy, 2010a). For parents and caregivers to address low vegetable consumption, they firstly need to recognise that vegetable intake by their child is low and know that eating vegetables is beneficial for health. Parents then must be interested, motivated, involved and willing to make changes at eating occasions (Mitchell, Farrow, Haycraft, & Meyer, 2013) in order to improve eating vegetables. Parents can address problems of low vegetable intake with specific feeding techniques, although which techniques parents choose to employ is affected by their parenting style and parenting skills. Some parents may encourage or model eating vegetables and others may bargain with their children to eat something new (Carnell, Cooke, Cheng, Robbins, & Wardle, 2011). Different practices used by parents will have differential effects on what and how the child eats (Blissett, 2011) and may or may not be supported by evidence. Therefore, parents as stakeholders of children eating vegetables are ideally positioned to encourage healthful eating habits and behaviours.

1.1.2.2 At school

Schools are often concerned with the time that it takes for children to eat (before returning to lessons) and the amount of waste left by those eating school meals. It may not be seen as the school's responsibility to encourage and increase vegetable intake at lunch times (Verdonschot et al., 2020), so long as the child eats a meal at school. However, schools play an important role in promoting general health, both in food provision and through the taught curriculum. Schools are often the only place within a society that children are all together and can be easily reached. There are few other settings better placed to promote healthy eating knowledge and behaviours. However, even though schools can reach all children at once, they may also have at their disposal fewer tools than parents to address eating vegetables. As schools often have many children to feed, interactions with individual children are limited, which may further limit the feeding strategies and practices available to them. Schools mainly utilise encouragement, rewards and nutrition education as their usual practice (Van Cauwenberghe et al., 2010). Yet, even these strategies may be inconsistently implemented between schools and to pupils within schools. Furthermore, knowledge from education may not transfer into behaviour without further learning opportunities and interventions (Verdonschot et al., 2020). These problems are additionally compounded by the effects of peer modelling of eating vegetables (eating within larger groups), which may be either beneficial or detrimental to the group's vegetable intake (O'Connell, Henderson, Luedicke, & Schwartz, 2012). As both parents and schools are important stakeholders of children eating vegetables in different contexts and throughout the day, targeting both to encourage vegetable consumption may have better effects for children's healthy eating and achieving the UK five-a-day guidelines.

1.1.3 Appropriate goals and outcomes

Eating too few vegetables is a multifaceted and complex problem. Evidence suggests an array of developmental, biological, social, psychological and environmental (as well as contextual) factors (**Chapter 3**) that may influence what and how much a child will eat at both a single eating occasion and as part of a habitual diet (whether children will eat vegetables regularly). These factors may both contribute to the causes of low vegetable intake and additionally function as barriers to improving vegetable intake. Any solution, in whole or in part, to the problem of low vegetable intake will likely include these factors (or a selection of them) as a target of intervention. However, these factors do not occur in isolation and may combine in any number of ways for individual children, thus increasing the difficulty of intervening to increase vegetable consumption.

The overall goal of this field of research is for children to achieve recommended guidelines for eating vegetables. Achieving the UK five-a-day recommendation suggests that eating larger portions of one vegetable is insufficient and that children also need to eat a variety of vegetables. Therefore, increased variety (at least 3 vegetables) and consumption (40-80g depending on the child’s age) of each vegetable per-day is the ideal outcome (with two separate portions of fruit). However, due to the complexity of children’s eating, eating larger portions or increasing intake is an unreasonable short-term goal for many children. More realistic goals may include becoming familiar with vegetables, tasting, trying and accepting them (rather than refusing them completely). Increased intake and acceptance of vegetables, regardless of how much is eaten could signal progress for an individual child’s diet and overall health. Therefore, goals and outcomes to increase vegetable consumption are not ‘one size fits all’, but rather they will be appropriate to the individual child, or a particular group of children with similar characteristics.

The problem with aiming to increase vegetable intake as a positive and healthful behaviour change is that at the beginning of encouraging intake there will be food waste if vegetables are not eaten. Serving larger portions often encourages intake (Mathias et al., 2012), yet a balance is needed between serving what will (likely) be consumed and how much waste is acceptable whilst children are learning. How much waste is acceptable to parents (Hayter et al.,

2015) may further determine the feasibility of serving vegetables at home, which could reflect a barrier for parents wanting to encourage their child's vegetable consumption. Whereas in schools, food procurement policies indicate that vegetables must be offered, regardless of the waste that may result.

1.1.4 Summary of children's low vegetable consumption

Vegetable intake in children is generally lower than is recommended and potential causes are multiple and complex. Without increasing vegetable intake, children will not benefit from the protective health effects that the phytochemicals from vegetables can confer. However, ways to promote eating vegetables must consider the wider food environment, stakeholders that will be involved in change and appropriate goals to achieve for both children's learning and eating behaviours. As it is important to address low vegetable intakes, theories of child development, child learning, parental behaviour and environmental models may help to understand the problem better, which in turn might be used to support interventions and behaviour change.

1.2 Theories to understand and address low vegetable intake

The potential barriers and problems that may inhibit vegetable consumption can be addressed to some extent through learning, education, parenting and changes to the environment. Theories that are relevant and useful to improving vegetable intake will be introduced here, with a focus on early childhood (2-6 years).

1.2.1 Behavioural Susceptibility Theory

Behavioural Susceptibility Theory (Carnell & Wardle, 2007) considers the biological origins of eating behaviour. The theory was originally used to explain the differential risk of overweight and obesity in individuals, considering that people in similar environments often have different weight outcomes (e.g. siblings). Much of the research into this theory has used twins to separate genetic and environmental influences on obesity (Llewellyn & Fildes, 2017). The theory suggests that whilst individuals have a genetic risk for developing overweight, the extent to which this risk is actualised depends on interactions with environmental exposures. For overweight, the mediating mechanism between genes and interaction with the food environment is through appetitive traits that are highly heritable. Variations in appetite and appetitive traits may produce different eating outcomes such as overeating.

Although the theory has not been directly applied to vegetable consumption, there are overlapping concepts. Children may be genetically susceptible to disliking vegetables, possibly with genes influencing taste receptors (Bachmanov & Beauchamp, 2007; Feeney, O'brien, Scannell, Markey, & Gibney, 2011). However, interactions with the environment may also help to shape what is eaten. If vegetables are always available in the home and cooked at mealtimes, children become more familiar with them and this could moderate the genetic tendency to avoid these foods.

Whilst the theory highlights the role of genetics in children's eating behaviour, it does not preclude the contribution of environment, experience and exposure to overcome genetic factors. Thus, theories which emphasize learning through mechanisms such as familiarisation, association, observation and maturation (Mura Paroche, Caton, Vereijken, Weenen, & Houston-Price, 2017), are also important to consider.

1.2.2 Children's cognitive development

Before considering how children learn about foods and eating, it is important to first understand maturation effects and children's capabilities throughout different developmental periods. Piaget's model of cognitive development (Piaget, 1971) proposes four primary stages through which a child's cognitive development proceeds. The first stage is the sensory-motor stage between ~0-2 years. In this stage, learning occurs mostly by feeling, touching and interacting with objects in the infant or toddler's immediate environment (sensory stimulations). With feeding, this stage is characterised by breastfeeding (or formula feeding), followed by complementary feeding and weaning (Betoko et al., 2013). Children start to become familiar with foods and begin to learn directly about tastes, textures and appearances of food. Through familiarisation, children also begin to categorize foods and distinguish between food and non-food items (Rozin, Hammer, Oster, Horowitz, & Marmora, 1986), which helps to shape early food preferences (Pliner, 2008). However, as the child has few schemas (theories) in which to assimilate experiences (taking new information and fitting it within existing theories), the main cognitive ability used is accommodation (adapting existing theories so that the new information can fit). Other notable milestones of this stage include achieving goal-directed behaviour (e.g. the child reaching for a particular food, grasping it and feeding themselves) and starting to imitate the behaviour of others (18-24 months). The learning that occurs in this stage sets the foundation for learning at the next stage (Vereijken, Weenen, & Hetherington, 2011).

The end of the sensory motor stage coincides with the age that food neophobia develops and children's taste perception changes. Piaget suggests children then enter into the representational stage (~2-6 years). Here, the child begins to develop their reflective abilities, internalise actions and convert them into images. The child still requires concrete experiences, but begins to create mental representations and conceptualise experiences more abstractly. Learning through play and using imagination is also characteristic of this stage as it helps the child to develop mental representations of their existing schemas. For eating, grouping stimuli or foods into categories and schemas helps children to learn about foods (Nguyen, 2007). Nguyen (2008) states that between 3-4 years, foods are categorised into different groups, such as good or bad, healthy or unhealthy and familiar or unfamiliar. These categories help to determine whether a food will be accepted or refused. However, although the child may know that a food is unhealthy, they may not hold an abstract concept of what unhealthy is and therefore they will require further concrete experiences to learn this. As children mature, they may update their previous schemas and theories about foods and vegetables through the use of assimilation and accommodation.

The next stage is the concrete operations stage (~7-11 years), where abstract thinking and symbolic abilities improve and the child develops logical thinking and inductive abilities. Assimilation is used more frequently as the child relies more on their existing theories and schemes to make sense of their new experiences. The last stage of the theory is the formal operations stage (~12-15 years), where children begin to think abstractly and logically, similar to adults. Although this last stage is not addressed in this thesis, the theory demonstrates the progression of the child's capability to learn about foods (and vegetables in particular) linked to their stage of cognitive development.

1.2.3 Learning theories

Learning permeates through many different aspects of eating behaviour, including food choice, food preferences, whether to eat or not and how much to eat. Learning can be defined in different ways, including acquiring knowledge or information, modifying behaviour, gaining abilities and encoding new information within memory (Barron et al., 2015). Whilst most definitions agree that learning requires transactions between the person and the environment, some definitions consider learning as a process (of perceiving, thinking, feeling and behaving), and others deem learning as an outcome. Although there are many theories of learning, only a few will be introduced here as they are most relevant to theoretical underpinnings of interventions used in the literature (Mura Paroche et al., 2017; Varman et al., 2021) and in this thesis.

1.2.3.1 Classical and instrumental conditioning

Learning theories related to eating behaviour are focused on the child's interaction with foods. The most basic theory of learning is the mere exposure effect (Zajonc, 1968). The more exposures children have to a particular food, the more positive their affective response to that food will be, meaning that children may be more likely to accept it. However, this is often not enough to develop a preference for vegetables. Classical conditioning occurs when a neutral stimulus (e.g. a novel vegetable) is paired with a second stimulus (e.g. a rewarding consequence, or a flavoured dip) through association, initially resulting in an unconditioned response to the second stimulus (either positive or negative)(Birch & Anzman, 2010). If the pairing is made often, the neutral stimulus becomes a conditioned stimulus and the unconditioned response will become a conditioned response to the conditioned stimulus. This means that the vegetable will no longer have to be paired with a second stimulus to elicit the same response. For example, after learning the child may no longer need praise after eating a vegetable as they associate eating the vegetable with the feeling of happiness. In the vegetable eating literature, associations may be achieved by pairing a disliked vegetable flavour with liked flavours (Flavour-Flavour Learning) or by pairing vegetables with foods or substances that are more energy dense (Flavour-Nutrient Learning) (de Wild, de Graaf, & Jager, 2013; Havermans & Jansen, 2007).

Learning about foods may also be achieved through instrumental conditioning, reinforcing eating with a consequence such as an activity or reward that is contingent upon eating. The consequence that follows eating (or non-eating) may be reinforcing (e.g. positive reinforcement such as social praise) or (potentially after non-eating) punishing (e.g. negative punishments such as withdrawing a favourite food like dessert because the child did not eat their vegetables). Instrumental learning often has consequences in the short and longer term on children's consumption, such as reduced preference for foods (Birch, Birch, Marlin, & Kramer, 1982). This may be explained by the response deprivation or over-justification hypotheses, as children's motivation to consume the food becomes dependent on the rewarding consequence (Deci, 1971; Timberlake & Allison, 1974).

1.2.3.2 Social Learning Theory

Building on classical learning theory, Social Learning Theory proposes that learning also occurs through direct experiences and observing other's behaviour (Bandura, 1971). Observation not only encompasses watching a behaviour, but also watching the consequences of that behaviour. Consequences can be both directly and vicariously experienced by the learner depending on who performed the behaviour, which is informative for children's learning. It can serve to strengthen the likelihood of repeating a behaviour through incentives, or weaken the likelihood of performing the behaviour through punishments. Future actions by the learner (performance or non-performance of the behaviour) may then be regulated by the anticipation of consequences after performing the behaviour.

Social learning acknowledges that learning through reinforcement and trial and error may be an extensive and prolonged process and that not all behaviours are learnt in this way. Modelling is another way that children can learn behaviours, by observing a teacher (or role model) and copying their actions. Miller and Dollard (1941) suggest that for imitative learning to occur, the child must be motivated to perform the behaviour, pay attention to the behaviour and finally create a memory for the observed behaviour (Bandura, 1971). The child then has to reproduce the behaviour themselves using their symbolic representation (memory) to guide their action. This ability is developed in Piaget's representational stage of development. After the behaviour is repeated, it is then reinforced. The behaviour may not be performed after learning if it is subsequently met by negative consequences, whereas positive reinforcement may see the behaviour performed more frequently.

The theory can be applied to vegetable intake as children constantly observe others eating. Learning by observing the consequences of others eating vegetables is most commonly through facial expressions. Parents may model positive and happy facial expressions after consuming vegetables (Edwards, Thomas, Higgs, & Blissett, 2022) signalling that they like the food or feel good after eating it. However, others may model disgust-like facial expressions, signalling that they dislike the food or feel bad after eating it. Depending on which model the child observes may affect the likelihood of the child eating the vegetable themselves. Similarly, a child may be more likely to eat a vegetable if they observe another child being verbally praised or receiving another type of reward for the behaviour (Lowe, Horne, Tapper, Bowdery, & Egerton, 2004).

1.2.3.3 Experiential Learning theory

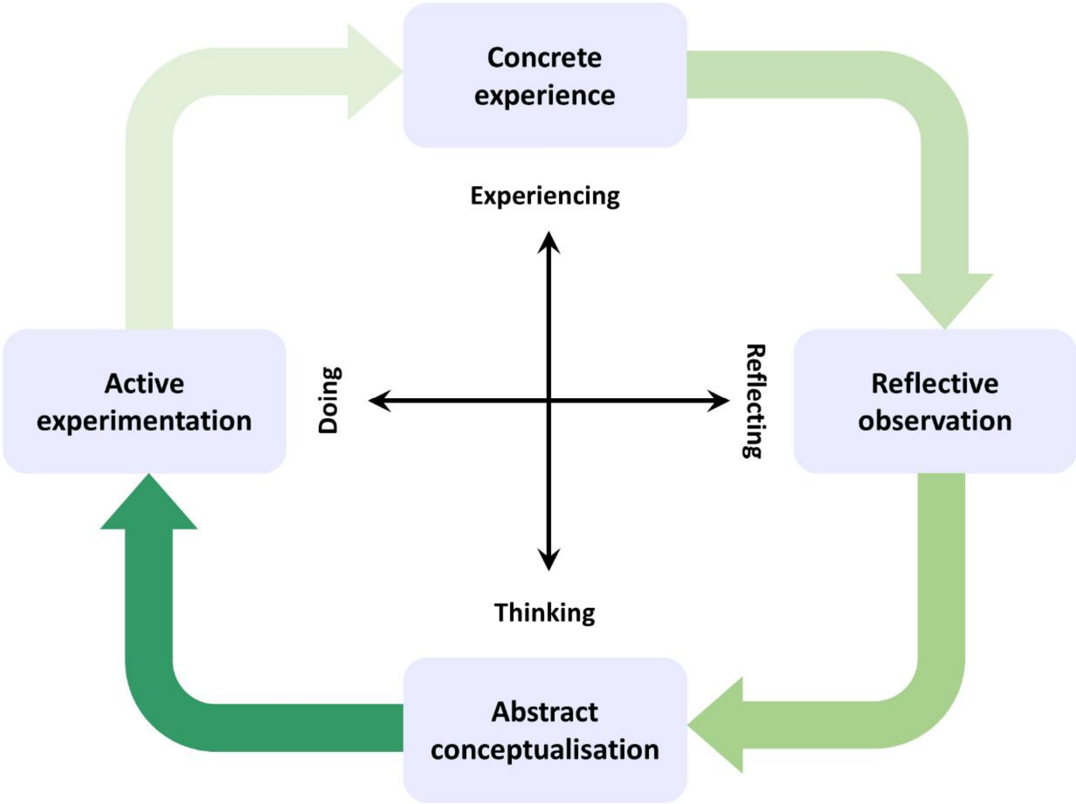
Whereas social learning puts much emphasis on observing others, Experiential Learning Theory holds one's own experience as most important to learning and development (Kolb, 2014). It is positioned as a holistic perspective of learning that combines experience, perception, cognition and behaviour. This means that unlike other learning theories, subjective and conscious experiences are acknowledged.

Experiential learning theory is derived from the learning models of Lewin, Dewey and Piaget. Kolb (2014) presents the view that knowledge is continuously created and updated through experience. This is a transformational process that allows children to adapt their knowledge through experience. Therefore, children's ideas and thoughts are not rigid, but flexible and malleable to new experiences. Importantly, Kolb highlights that learning is a long-term process, rather than an outcome, as defining learning by outcomes may define non-learning. Kolb (2014) posits that "failure to modify ideas and habits as a result of experience is maladaptive" (pp. 26). Therefore, learning is seen as a continuous process, whereby knowledge is created through transactions between the child and their environment.

For learners to be effective, they require four different abilities: concrete experience, reflective observation, abstract conceptualisation and active experimentation (Figure 1.1). However, it is not possible for children to perform each ability simultaneously, they can only bring certain abilities to each learning situation. Which abilities the child may bring is explained by Kolb's two main dimensions to the learning process, from experiencing to thinking, and from doing to reflecting (Figure 1.1). During learning, the learner may move along these dimensions and therefore bring different abilities to learning situations.

With regards to vegetables, learning requires children to have different and varying experiences with vegetables at eating occasions and opportunities to watch others eat. Children then must have opportunities to reflect on their own experiences and learning, thinking about their experience and how it fits within their existing ideas and theories. The child may then act on their thoughts and perform behaviours based on their learning process and experiences. During this learning process, children may experience a range of situations that may be conflicting (e.g. both in support of and against eating vegetables). Experiential learning theory states that resolution of these conflicts is necessary for learning to occur. For Piaget, resolution occurs through either accommodation or assimilation into existing conceptual schemas, which could determine whether vegetables are eaten (accepted) or not.

Figure 1.1. Experiential learning model adapted from Kolb (2014).



1.2.4 Theory of Planned Behaviour

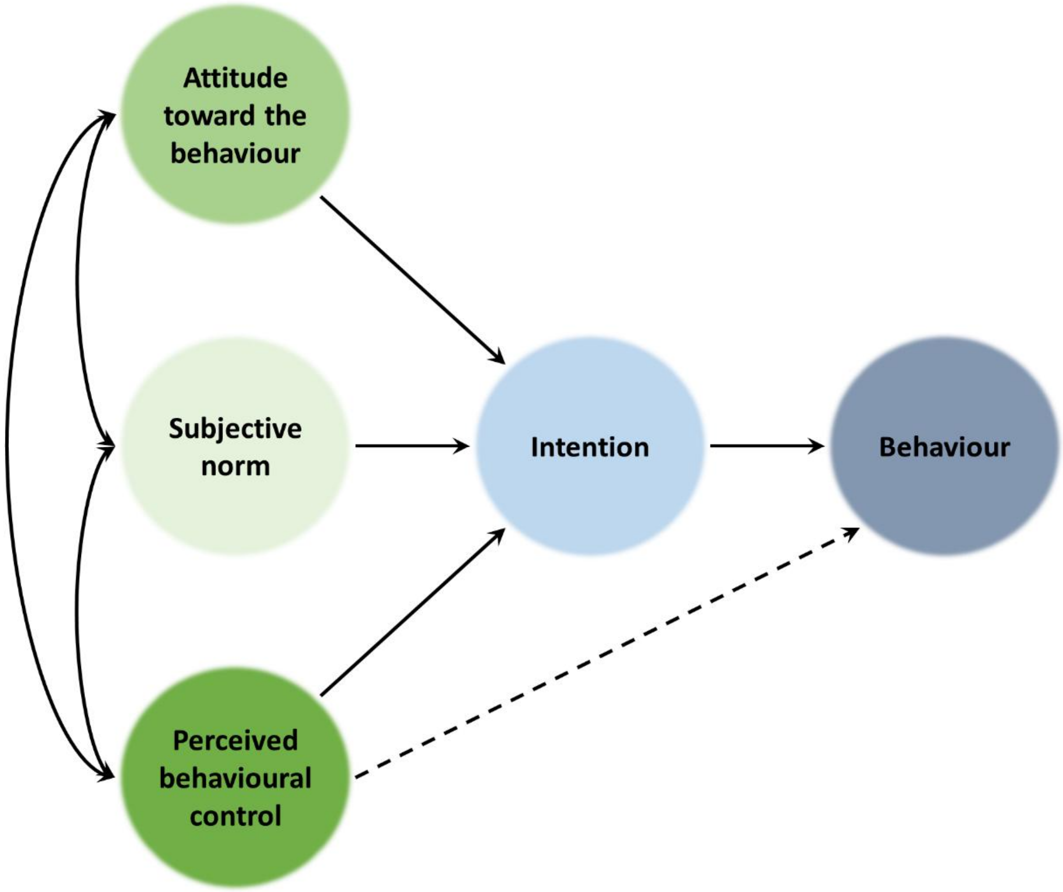
So far, we have considered theories that impact on children's behaviour and how children learn to eat vegetables as a result of cognitive abilities, direct experiences with eating and observing behaviour. However, parents and caregivers are the main source of buying and serving vegetables to children. If vegetables are not served to the child and encouraged to be eaten, children may not have the opportunity to learn to eat vegetables via experiences. Therefore, parental behaviours must be considered.

The Theory of Planned Behaviour (TPB: Ajzen, 1991) allows us to understand parental actions (or non-action) in a specific context. Although parent's behaviours might change from one eating occasion to the next, parental traits might be implicated in mealtime behaviours more generally. The theory can therefore be applied to children's eating in a number of ways, through parenting styles and techniques, to implementing feeding strategies that address low vegetable consumption in children. A central part of this theory is accounting for motivation of parents to perform a behaviour (Figure 1.2), stated as parent's intentions to carry out the behaviour. Parents with higher intentions to perform a behaviour will be more likely to carry it out, if it is under volitional control (the parent can decide whether to perform the behaviour or not).

There are three further antecedents that may determine a parent's intention to perform a behaviour (Ajzen, 1991). The first antecedent is parental attitudes towards the behaviour. This is whether the parent has a favourable or unfavourable view of the behaviour. With a new parenting practice as the behaviour, parents may have more favourable views if it aligns with their own parenting style or beliefs about parenting. The more favourable the behaviour is viewed, the more likely it will be performed. The second antecedent is subjective norms. This is a social factor that refers to social pressure to perform the behaviour. If others are perceived to be performing the behaviour, an individual may feel the need to conform to the social norm. For parents offering vegetables as a new strategy, they may be more likely to perform the behaviour if they believe that other parents are already implementing similar strategies (Duncanson, Burrows, Holman, & Collins, 2013). The third and final antecedent is perceived behavioural control. This encompasses an individual's perception of how easy or difficult performing the behaviour will be. If the behaviour is a parenting practice, parents may be more motivated to perform the behaviour if they perceive it as easy to implement. However, with feeding, this could also extend to perceived behavioural control of the child, whereby parents may be more likely to implement a practice or strategy if they perceive it will change their child's eating behaviour (Duncanson et al., 2013).

Although TPB is a model of health behaviour and it may be used to predict behaviours and intentions to perform a behaviour in a specific context, it does not explain how to change behaviour. For behaviour change theories relevant to eating behaviour see Atkins and Michie (2013).

Figure 1.2. The Theory of Planned Behaviour model, adapted from Ajzen (1991).

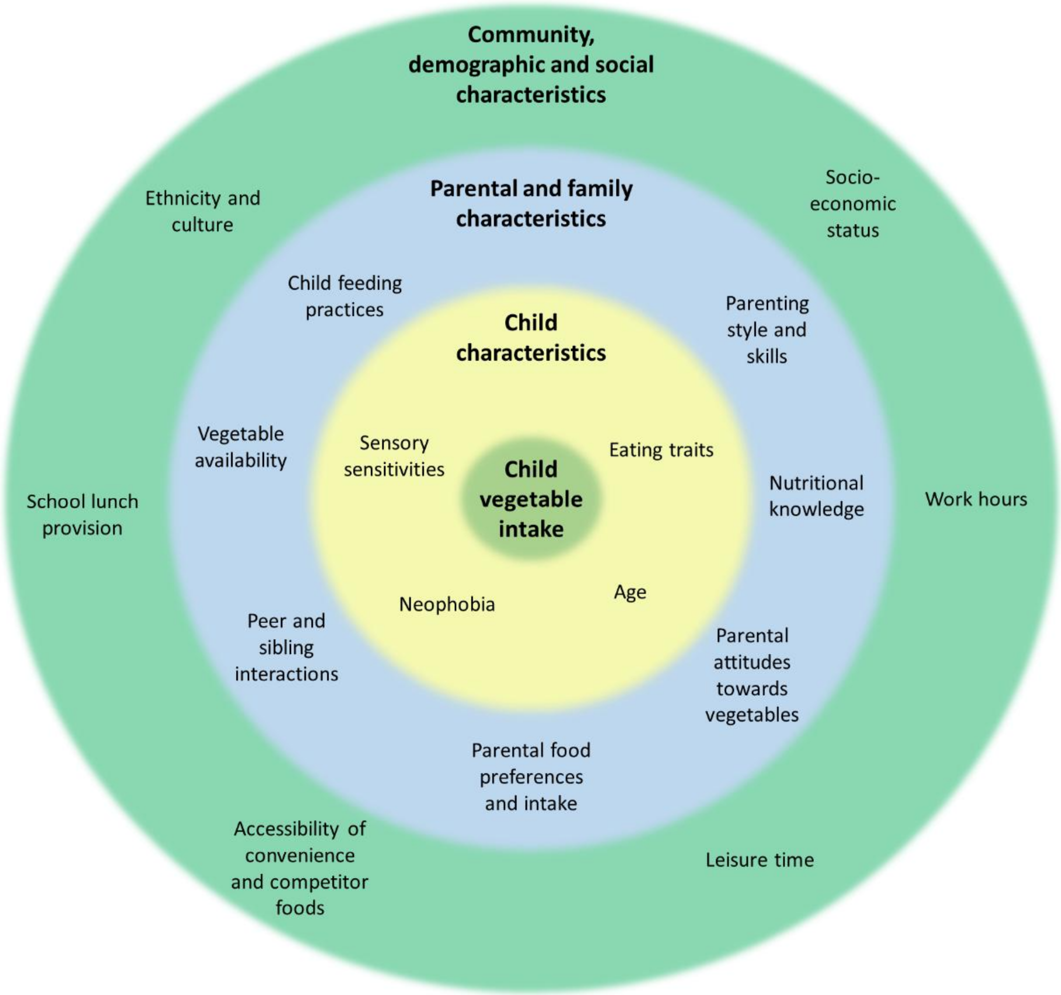


1.2.5 Ecological Systems Theory

Although promoting vegetable intake and learning about vegetables is the focus of this thesis, it is important to understand how the behaviour emerges for a child and how this sits within, or is influenced by, wider contexts. Ecological Systems Theory allows consideration for the context in which the child is embedded (Bronfenbrenner, 1986), whilst recognising that each context may also be embedded within further larger contexts, all of which may have indirect effects on behaviour. Therefore, development occurs as a result of interactions within and between contexts. For child development, personal characteristics (genetics, gender and age) interact with characteristics of the environment, including the child's family, school and larger community.

Davison and Birch (2001) utilised this framework in the eating behaviour literature to predict the risk of childhood overweight by focusing on children's dietary intake, physical activity and sedentary behaviour. Predicting weight status was conceptualised in an ecological model comprised of three sections (child's characteristics; parenting styles and family characteristics; community, demographic and societal factors) (Figure 1.3). To apply this framework with vegetable intake, starting with the child level characteristics, behavioural patterns such as sensory sensitivities, neophobia and disliking of vegetables may place the child at risk of eating very few vegetables. Considered together, rather than in isolation, these factors may help with building a profile of the child in determining how likely they are to eat vegetables or to change their eating behaviours through learning. At the parenting and family level, interactions can occur through parents challenging their child's fussiness (encouraging vegetable intake and utilising techniques available to them), or accepting that their child is fussy (accommodating their child's food preferences). These behaviours may be further embedded within social norms of what and how much vegetables children (and parents) think that others eat (e.g. children at school, extended family). Furthermore, parenting practices and children's intake of certain foods could be embedded within demographic factors, with culture of the family impacting what is eaten, when and how parents might address low vegetable intake. Therefore, within this framework it is possible to examine how child eating characteristics may interact with different contexts to produce changes in development. However, there are countless possibilities for each individual child's development and which interactions between contexts will affect behaviour.

Figure 1.3. Ecological systems model of child vegetable intake, adapted from Davison and Birch (2001).



1.3 Aims and objectives of the thesis

This chapter has outlined the problem of low vegetable intake in children and highlighted some important theories underpinning children's eating behaviour and learning. Whilst each theory promotes our understanding of a specific part of children's vegetable consumption and learning, taken together they may help to understand the wider context that each specific research question of this thesis addresses. The overarching aims of this thesis are:

1. To better understand vegetable consumption by children in the UK.
2. To examine children's eating behaviours within the mealtime context.
3. To improve children's intake of vegetables at mealtimes.

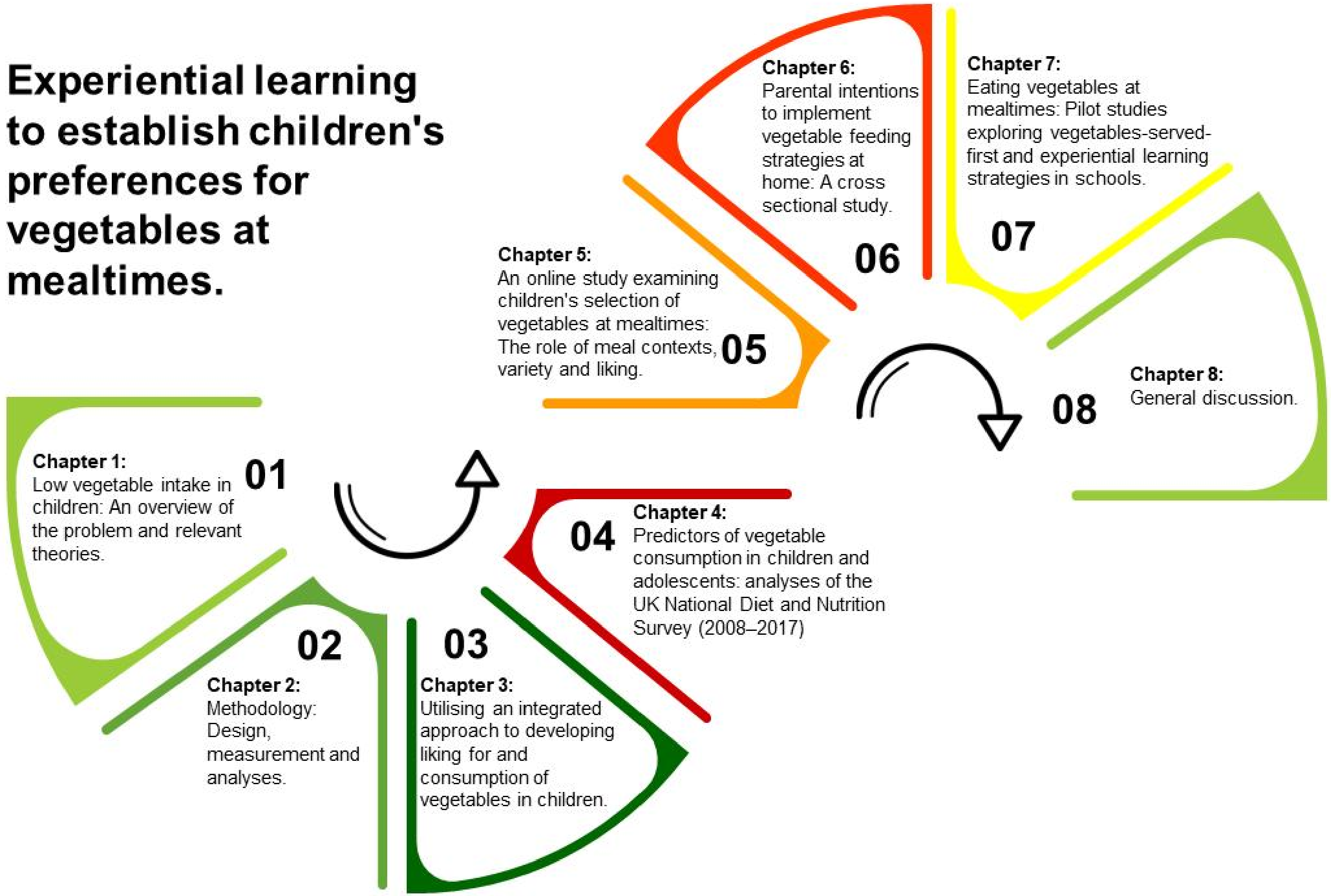
The remainder of the thesis will evaluate methodologies used in this thesis (**Chapter 2**), before reviewing the current literature surrounding children's development of vegetable preferences (**Chapter 3**). Specific research questions are then addressed in the chapters that follow:

- What are the characteristics of child vegetable intake in the UK? Which vegetables do children eat, how much is eaten, when, and alongside which other foods (**Chapter 4**)?
- When do children choose to add vegetable items to a meal if other food options are available (**Chapter 5**)?
- Do parents believe that vegetable feeding strategies will improve their child's vegetable consumption? What are parental intentions to implement such strategies (**Chapter 6**)?
- Can meal service and experiential learning strategies be used at school lunchtimes to increase children's vegetable intake (**Chapter 7**)?

Finally, the thesis will conclude with a general discussion that will synthesise findings from these studies and offer some general conclusions and insights into children's vegetable eating behaviour at mealtimes (**Chapter 8**). The outline of this thesis is presented in Figure 1.4.

Lastly, it is important to consider this thesis and the chapters it contains in relation to the COVID-19 pandemic. Between March 2020 and December 2021, the UK entered three separate national lockdowns, including schools closing for long periods, as well as wider measures of social distancing, mask wearing and limits to the number of people allowed at social gatherings. This resulted in numerous effects on the planned studies in this thesis, including delays to research, abandoning planned in-person research studies, adapting research questions and changing the methods to online measures. Schools closing further restricted access to children as participants and when schools reopened, significant strain was placed on teachers (catching up with missed education) as well as notable numbers of staff absences. Nevertheless, the adapted research offers interesting, useful and novel research findings that have been adapted in the face of restrictions applied during the pandemic.

Figure 1.4. Outline of chapters in this thesis.



Chapter 2

Methodology: Design, measurement and analyses

Chapter 2 Methodology: Design, measurement and analyses

Due to the complex aims of understanding, examining and improving children's vegetable consumption at mealtimes, various methodological techniques and statistical analyses have been employed throughout this thesis. This section provides an introduction to each method and statistical analysis approach used, the participants and how they were recruited and the main materials used in each study.

2.1 Methodological procedures

Four different methodologies were used in **Chapters 4-7** to address the complex aims of the thesis, detailed below.

2.1.1 Secondary data analyses

To address the aim of better understanding vegetable consumption by children in the UK, analyses of secondary data were conducted. The National Diet and Nutrition Survey (NDNS) (NatCen Social Research, 2019) provides dietary data for a large, representative sample of UK children's (1.5-19 years) eating habits and nutritional intake. As the NDNS reports all foods that children eat over a four day period, it is possible to investigate which vegetables are eaten, how they are prepared, which other foods are present in the eating occasion, where vegetables are eaten and who with, as well as the amount eaten. Using this secondary data therefore allows in-depth examination of thousands of eating occasions involving vegetables, which would not be possible to obtain via other methods (Johnston, 2014).

2.1.2 Online experiment

To achieve the aim of examining children's vegetable eating behaviours at mealtimes, an online experimental design was used. Online experiments allow the manipulation of variables that cannot be manipulated during a real meal (Kraut et al., 2004). Children's food choices can therefore be examined with multiple different meals and configurations of foods, without the child having to consume many meals over a longer period of time. A laboratory equivalent of researching children's food choices may offer the child a buffet meal, however this does not represent a usual meal as so many food options are available to the child. A buffet also means that foods are not directly competing with one another to be selected, as it is possible to eat a small portion of all foods available. Therefore, the online experimental method allows specific changes to be made to components of a meal, so that different research questions involving children's food choices can be addressed.

2.1.3 Online survey

To meet the aim of exploring parental beliefs and intentions to use feeding strategies, an online survey design was used. This method allows different question types, so that both quantitative (from validated and non-validated questionnaires) and qualitative (from open ended questions) data can be collected. The benefit of this method is that quantitative data can be collected from questionnaires to test specific hypotheses and relationships between important constructs (e.g. how feeding practices might affect parental intentions to deliver vegetable feeding strategies). These data are then complemented by open ended survey questions which allow parents to provide a wider perspective on issues of child feeding that are not addressed by closed questions. Although survey designs can be useful for these reasons (Gosling & Mason, 2015), there is the possibility of social desirability effects from parents when responding to questionnaires (e.g. parents may report using more positive feeding practices than are actually used at home). With written, qualitative responses, parents also tend to provide shorter answers, resulting in less rich data than would be collected in an interview setting. However, this could also indicate that parents are only reporting the information that is most important them.

2.1.4 In school experiments

To address the aim of improving children's vegetable consumption, vegetable feeding strategies were tested in-person using experimental designs. By testing children's vegetable intake both with and without an intervention, it can be determined whether an intervention is useful for children's vegetable consumption. The school is an ideal setting for an experiment as the procedures can be delivered to a large number of children and controlled carefully. This includes controlling for order effects (of treatment/control), completing multiple arms of the intervention (or just one) and randomisation of participants and procedures (Akobeng, 2005). Controlling for these factors provides more certainty that changes in children's vegetable consumption can be attributed to the intervention used. At home is also an important setting to deliver interventions, yet fewer children are available in each family and it is more difficult to control the fidelity of intervention implementation (Holley, Haycraft, & Farrow, 2015).

2.2 Methods of data analysis

Different methods of analysis were used in this thesis depending on the methods used, the types of data collected and the research questions that were being addressed. The main types of analyses used will be introduced in this section.

2.2.1 Regression and multi-level models

Throughout the thesis, the main types of statistical analyses used were based on regression techniques. These are predictive models that describe the relationship between one or more predictor (independent) variables and an outcome (dependent) variable. When more than one predictor variable is put into the model, estimates of independent (each predictor separately) and collective effects (on the outcome) can be obtained. Different types of regression analyses were performed throughout the thesis, including linear, logistic and ordinal regression, as well as multi-level modelling versions of each of these.

Multi-level modelling is a variant of regression modelling which takes into account the structure of the data (Nezlek, 2008). In many cases in this thesis, the observations of interest are nested within the individual participants, meaning that there is more than one level to the data. For example, in the NDNS data the amount of vegetables eaten on days 1-4 are four separate data points that relate to one person (**Chapter 4**). These data points will therefore be more similar to each other than to another person's data points. Each of the four data points (level-1) can therefore be thought of as nesting within an individual (level-2). Therefore, multi-level modelling can account for both within-person and between-person differences in the outcome of interest.

Different types of multi-level (regression) model are used based on the outcome variable type. When outcome variables are dichotomous (e.g. were vegetables eaten, yes or no), logistic regression models are used (e.g. **Chapter 4**). Instead of estimated values of the outcome variable, logistic models provide odds ratios that determine the likelihood of the outcome, based on the value of the predictor variable(s). Similarly, when the outcome variable is ordinal (e.g. the proportion of vegetables eaten by a child: none, ¼, ½, etc., **Chapter 7**), ordinal regression models (or cumulative link multi-level models) are used.

2.2.2 Structural equation modelling

In **Chapter 6**, Structural Equation Modelling (SEM) was used along with mediation analyses. SEM is a combination of factor analysis and path analysis (Morrison, Morrison, & McCutcheon, 2017). SEM therefore consists of a measurement model, where latent factors can be determined, as well as a structural model, to specify the hypothesised relationships between latent factors. Latent factors are variables that are inferred indirectly through observed variables, meaning that they are not measured directly. This reduces measurement error as the correlations between observed variables that create the latent variable are reduced to zero, effectively meaning that associations can be made between latent variables with no measurement error. The structural model of an SEM permits relationships between multiple variables (multiple independent and dependent variables) to be tested simultaneously. Specifying the structural model takes a confirmatory, hypothesis testing approach.

Mediation can be used within this framework to expand the hypothesis testing approach and examine specific pathways of association between latent factors. Associations between factors may be direct (e.g. from an independent variable to a dependent variable) or indirect (e.g. the independent variable has an effect on a dependent variable through another variable, the mediated effect). Different types of mediation can therefore be inferred, such as complementary mediation (the mediated and direct effects point in the same direction), competitive mediation (the mediated and direct effects point in the opposite direction) and direct only non-mediation (direct effect exists, but no indirect effects) (Zhao, Lynch Jr, & Chen, 2010).

2.2.3 Content analysis

In **Chapter 6**, content analysis was used to analyse data from open ended written responses to questions. Content analysis is a technique to determine whether specific words, themes or concepts are present within qualitative data (Erlingsson & Brysiewicz, 2017). Whilst this is a replicable and simple technique that can capture the central aspects of the data, it has the limitation of reducing potentially rich, qualitative data into quantitative data (frequencies) and also disregarding the context surrounding the main themes in the data. This could potentially yield very different results compared with using other qualitative approaches, such as thematic analysis.

2.3 Participants

Participants were recruited both online and in person. Participants included children between the ages of 3-7 (**Chapter 7**), 9-11 (**Chapter 5**) and parents of children 3-7 (**Chapter 6**). Although the sample of interest was young children, the pivot to online studies meant that older age groups were required due to their ability to complete an online experiment (since a certain level of computer literacy and reading comprehension was needed). Parents were also recruited to provide consent for their child to participate online and to take part in the survey as it was important to gain their perspective on feeding strategies, which could affect the amount of vegetables that children eat at home.

Parents and children were recruited online via Prolific (https://www.prolific.co/) in **Chapters 5** and **6**. This is due to restricted access to participants during the Covid-19 pandemic and since the main route to recruiting parents and children (at school) was closed. Children were then recruited through schools as restrictions were lifted in **Chapter 7**. Participating schools were identified via Phunky foods, an early years programme that delivers healthy lifestyle curriculums and resources to schools and nurseries (https://www.phunkyfoods.co.uk/).

2.4 Materials and measures

To address the research aims and assess different associations between child and parental eating factors, it is necessary to utilise different materials and measures that can address the predictor and outcome variables of interest.

2.4.1 Validated questionnaires

Validated questionnaires were used throughout the thesis. These were utilised to explore the relationship between certain traits or characteristics of participants with the outcome variables. They also allowed description of the samples, indicating whether participants generally scored high or low for a particular trait, parenting skill or amount of vegetables eaten by the child. Each validated questionnaire used is described briefly below. Where questionnaires consisted of multiple subscales, only subscales relevant to the specific research questions of each chapter are used.

CEBQ. The Child Eating Behaviour Questionnaire (Wardle, Guthrie, Sanderson, & Rapoport, 2001) is a measure of eight dimensions of children's eating style or traits, including traits that are food avoidant (e.g. fussiness, slowness in eating, satiety responsiveness), as well as traits that show food approach (e.g. enjoyment of food, food responsiveness).

CFQ. The Child Feeding Questionnaire (Birch et al., 2001) is a self-report questionnaire that measures parental beliefs, attitudes and practices concerning aspects of child feeding. Parental practices assessed are specific to restriction of high energy dense foods (e.g. those that are high in fat, sugar and salt), pressuring the child to eat 'enough' or what is on their plate, and monitoring the high energy dense foods that their child eats.

FCQ. The Food Choice Questionnaire (Steptoe, Pollard, & Wardle, 1995) is a measure originally developed to explore adult motives for food choices. The nine factors that are measured include food choice because it is healthy, the food contains natural content and the food is convenient. This questionnaire has also been used as a measure of parent's food choices when feeding their child (Russell, Worsley, & Liem, 2015).

CFPQ. Compared with other questionnaires, the Comprehensive Feeding Practices Questionnaire (Musher-Eizenman & Holub, 2007) includes a wider variety of different parenting practices that are used when feeding children. In addition to pressure to eat and monitoring, this questionnaire includes positive practices such as encouraging balance and variety, modelling food intake, involvement of children in meal planning and preparation and the food environment (ensuring that healthy foods are available in the home). It also includes scales for negative feeding practices such as using food as a reward, using food to regulate the child's emotions and allowing the child to control what is eaten.

PMAS-R. The Parent Mealtime Action Scale-Revised (Hendy, Harclerode, & Williams, 2016) is a questionnaire developed to assess which feeding practices are used by parents at mealtimes to encourage their child to eat. The questionnaire consists of nine subscales, many of which are similar to the CFPQ. However, subscales such as special meals (whether parents make separate meals for their child), many food choices (the child has a choice of foods) and use of positive persuasion are scales that are unique to this measure and also relevant to chapters in this thesis.

FFQ. The Food Frequency Questionnaire chosen to be used was Hammond, Nelson, Chinn, and Rona (1993). Although this FFQ records an exhaustive list of different food groups and sub-food groups that may be eaten, only the vegetable sub-food groups were utilised in this thesis (green cooked vegetables [e.g. peas, broccoli, green beans, Brussels sprouts], other cooked vegetables [e.g. carrots, turnip, etc.] and salads [e.g. tomatoes, lettuce, raw vegetables]). This indicates how often and the frequency with which each vegetable is eaten by children.

2.4.2 Non-validated questionnaires

Throughout the thesis, it was also necessary to use non-validated measures to address specific aims of the thesis and research questions of the chapter. This included measuring children's liking for foods (with the use of Likert scales), ranking foods by children's preference (**Chapter 5**), as well as measuring parental beliefs and intentions surrounding vegetable feeding practices (**Chapter 6**). Each non-validated questionnaire used was based on similar questions used elsewhere in the literature, albeit modified for a specific purpose in the current studies.

2.4.3 Study foods

Food intake was only measured in **Chapter 7**. Specific vegetables were chosen as targets to improve vegetable intake so that children had multiple exposures to the same vegetables. The vegetables chosen were carrots and peas. Although choosing a target vegetable provides benefits to an experiment in terms of type (sweet, familiar), the disadvantage is that children do not normally eat the same vegetables every day, which could become monotonous. Therefore there is a trade-off between familiarity, controlling for variety and liking effects on vegetable intake and monotony.

2.4.4 Software used

For online studies, different software is required. To create an online experiment (**Chapter 5**), Gorilla experiment builder (https://gorilla.sc/) was used. Experimental procedures are created within this software, as well as the order of the experiment, controlling for times and display of stimuli and randomisation of participants and procedures.

Online surveys (**Chapter 6**) were hosted on Qualtrics (https://www.qualtrics.com/uk/), providing a display platform for the questions asked to parents. This also allows the order of questions to parents to be randomised.

Lastly, R was used to analyse all quantitative data throughout the thesis. This ensured that data analyses were reproducible when sharing code of the analyses. R also allows for greater control when tidying data and adjusting statistical parameters for more advanced analyses.

A summary of methods, analyses, materials and softwares used in each of the thesis chapters is provided in Table 2.1.

Table 2.1. Summary of methods, analyses and tools used throughout the thesis.

Study (Chapter)	***Methodological design(s)***	***Main type of analyses conducted***	***Tools/Questionnaires used***
Predictors of vegetable consumption in the UK (**Chapter 4**)	Analyses of secondary data	Linear and logistic multi-level models	National Diet and Nutrition Survey (Years 1-9)
Online study of children's selection of vegetables (**Chapter 5**)	Online experiment with child participants, Online parental survey	Logistic multi-level models	Gorilla experiment builder. CEBQ, CFQ, PMAS-R
Parental intentions to implement vegetable feeding strategies (**Chapter 6**)	Online parental survey	SEM, Mediation analyses, Content analysis	Qualtrics Intention and belief questionnaires Open ended questions CEBQ, FCQ, CFPQ, FFQ
Eating vegetables at mealtimes (**Chapter 7**)	Experimental intervention, Parental survey, Process evaluation	Linear and ordinal multi-level models	CEBQ, PMAS-R, FFQ

2.5 Impact of Covid-19 pandemic on choice of methodology

Ideally, children's eating behaviour would have been investigated in person to assess intake of vegetables under different conditions. This could have been achieved in school, home or laboratory settings. However, due to the Covid-19 pandemic this was not possible in some chapters of this thesis and therefore research was adapted to be conducted online. The adaptation in methodology (from in person to online studies) is accompanied by changes to research questions, making them better suited to online methods. For example, improving vegetable intake cannot be achieved without actually eating food, yet food choice and parental feeding factors are possible to study using online methods. Online research is common in the child vegetable eating literature and can be predictive of food intake, although this research is usually survey based rather than experimental and focuses on parental feeding (Kaar, Shapiro, Fell, & Johnson, 2016; Kiefner-Burmeister, Hoffmann, Meers, Koball, & Musher-Eizenman, 2014; Stone, Haycraft, Blissett, & Farrow, 2022). In contrast, online experiments are more commonly implemented with adult samples than with children. These studies often use pictures of food stimuli as an alternative to actual foods (Blechert, Meule, Busch, & Ohla, 2014; Dai, Cone, & Moher, 2020; Schomaker, Vriens, & Jarva, 2022), providing evidence that foods do not have to be eaten to examine eating behaviour. However, these online experimental paradigms are often limited to single food items rather than meals, which are the focus of this thesis. When vegetable intake is measured in this thesis (**Chapter 7**), there were still restrictions from the Covid-19 pandemic which affected both the types of intervention strategy used, how it was delivered and the methods of data collection used.

Chapter 3

Utilising an integrated approach to developing liking for and consumption of vegetables in children

Chapter 3 Utilising an integrated approach to developing liking for and consumption of vegetables in children

Abstract

Children eat too few vegetables and this is attributed to disliked flavours and texture as well as low energy density. Vegetables confer selective health benefits over other foods and so children are encouraged to eat them. Parents and caregivers face a challenge in incorporating vegetables into their child's habitual diet. However, liking and intake may be increased through different forms of learning. Children learn about vegetables across development from exposure to some vegetable flavours *in utero*, through breastmilk, complementary feeding and transitioning to family diets. Infants aged between 5-7m are most amenable to accepting vegetables. However, a range of biological, social, environmental and individual factors may act independently and in tandem to reduce the appeal of eating vegetables. By applying aspects of learning theory, including social learning, liking and intake of vegetables can be increased. We propose taking an integrated and individualised approach to child feeding in order to achieve optimal learning in the early years. Simple techniques such as repeated exposure, modelling, social praise and creating social norms for eating vegetables can contribute to positive feeding experiences which in turn, contributes to increased acceptance of vegetables. However, there is a mismatch between experimental studies and the ways that children eat vegetables in real world settings. Therefore, current knowledge of the best strategies to increase vegetable liking and intake gained from experimental studies must be adapted and integrated for application to home and care settings, while responding to individual differences.

3.1 Introduction

The World Health Organisation (WHO) advocates consumption of at least 400g of fruits and vegetables each day, to prevent non-communicable diseases (NCDs) (WHO, 2003). This is often translated by public health agencies around the world into a healthy eating message to consume 5-a-day (or more) portions of fruits and vegetables. Added to this encouragement to eat more fruits and vegetables (F&V) are pressures to improve human health and at the same time, support the environmental sustainability of our food supply (Willett et al., 2019). At a population level, we are transitioning towards including more F&V, wholegrains and plant proteins into our diet. At an individual level we must learn to like these foods especially vegetables, since these have selective benefits to health, produce fewer greenhouse gases and can be grown locally in more communities than animal-based food sources.

3.1.1 Why eat more vegetables?

Advice to eat more F&V is based on epidemiological evidence demonstrating that diets high in plant-based foods reduce the risk of cardiovascular disease, stroke, diabetes, stomach and colorectal cancers (Aune et al., 2017; Boeing et al., 2012; Hartley et al., 2013; Lee, Shin, Oh, & Kim, 2017; Wang et al., 2014; WHO, 2014). Where evidence has been aggregated to examine a dose-response relationship between F&V intakes and relative risk of various NCDs, consuming double the WHO minimum reduced risk of cardiovascular disease, and premature deaths (Aune et al., 2017). Phytochemical and antioxidant actions from F&V protect health through preventing carcinogen formation at the cellular level, also dietary fibre content of plant-based foods improves gut health (Liu, 2003; Slavin & Lloyd, 2012). There are specific benefits of consuming vegetables compared to fruits (Blekkenhorst et al., 2018; Carter, Gray, Troughton, Khunti, & Davies, 2010; Liu, 2003; Slavin & Lloyd, 2012). Selective promotion of vegetables may improve health and reduce premature mortality (Oyebode et al., 2014).

Despite advocacy of increased vegetable intakes at the population level, few countries around the world report that they achieve the WHO recommended intakes, even in affluent nations (Tennant, Davidson, & Day, 2014). Increasing vegetable intake at an individual level is more challenging than increasing fruit intake (Osborne & Forestell, 2012). Children consistently have low intakes of vegetables, despite being amenable to accepting them at the time of complementary feeding (Harris & Mason, 2017). This early period, between complementary feeding and early childhood, is an ideal time to introduce vegetables, since as they get older, children are more resistant to acquiring a liking for vegetables. This is illustrated by a systematic review with meta-analysis by Evans, Christian, Cleghorn, Greenwood, and Cade (2012) who reported that school-based interventions improved intakes of fruits but not vegetables. Therefore, after school age it appears to be a challenge to encourage children to like and to eat vegetables even with intervention. Current evidence suggests that acquiring a preference for vegetable flavours and establishing regular consumption of vegetables requires frequent and consistent experience with these foods over time. However, routinely providing opportunities for vegetable consumption is neither the default nor the norm in modern obesogenic environments.

Set out below, is a proposal for a more integrated and individualised approach to increasing liking and intake of vegetables. There are many systematic reviews (Appleton, Hemingway, Rajska, & Hartwell, 2018; Holley, Farrow, & Haycraft, 2017b; Nekitsing, Blundell-Birtill, Cockroft, & Hetherington, 2018) and narrative reviews (Anzman-Frasca, Ventura, Ehrenberg, & Myers, 2018; Ventura & Worobey, 2013; Wadhera, Phillips, & Wilkie, 2015) on the topic of learning to eat vegetables. However, these reviews focus on a particular facet of experiences with vegetables or a particular age range, and so there is a need to integrate these evidence-based approaches to provide an overarching view of vegetable learning in children. The present approach is built on behavioural studies where learning facilitates the transition towards acquiring and establishing acceptance of vegetables leading to increased intakes. The specific focus is on how exposures, experience and environment shape liking and intake of vegetables in early life and how this can be applied to real life eating contexts.

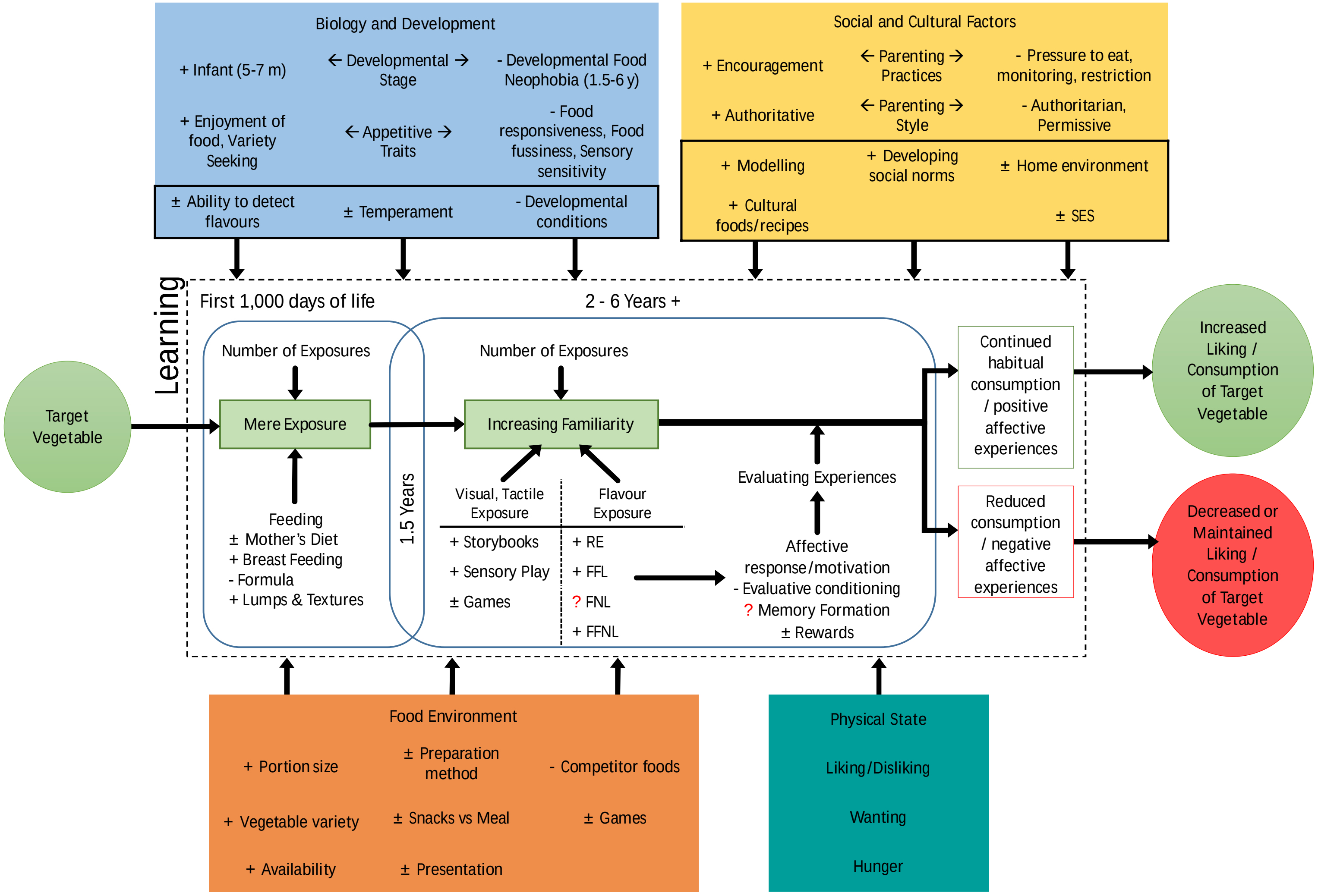
3.1.2 An integrated approach

Encouraging children to eat vegetables and incorporate them into their habitual diet is a multi-faceted and complex problem. Eating habits and experiences with vegetables, along with numerous biological, social and environmental factors, guide familiarity, liking and consumption of vegetables. Therefore, we propose adopting an integrated and personalised (individual) approach to feeding children in order to increase habitual vegetable consumption in infancy and early childhood (Figure 3.1). Integrating the current available evidence from systematic reviews and elsewhere in the literature is essential to understand the complex eating environments that children experience, and personalised approaches are required to increase the potential for children with different individual needs to expand vegetable variety and intake. Typically, techniques designed to increase vegetable intake are studied in isolation by controlled experiments. However in children's eating environments, there are many factors impacting simultaneously on liking and intake. Therefore, there is potential for enhanced real-world impact if interventions are multi-faceted and more ecologically valid, resembling how vegetables are typically consumed. There are additional possibilities of additive effects if approaches are combined, complementing and building on positive effects from single techniques. Furthermore, building interventions around individual differences in child development, temperament, appetitive traits and potential responses to intervention could further improve outcomes for individuals. This approach is evidenced in the developmental disorder literature (although mostly case studies), where it is common practice to use multi-component interventions to increase food acceptance when a single technique fails (Chawner, Blundell-Birtill, & Hetherington, 2019).

The model presented in Figure 3.1 builds upon that developed by Johnson (2016), incorporating a wider range of influences on child learning, proposing directional associations between factors and their impact on learning (whether beneficial or detrimental to vegetable liking and consumption) and acknowledging that a ***decrease*** in consumption of vegetables after learning is also possible. This model is not comprehensive but identifies the major influences on learning to eat vegetables. Learning is dynamic, impacting on biological (e.g. appetitive traits), social (e.g. how parents encourage their child to eat) and environmental (e.g. availability/purchasing of vegetables) factors over time. However, examining all of these bidirectional relationships is beyond the scope of this review and we will only consider the effects of these factors on learning and not vice-versa.

The following sections will illustrate the main influences on children's learning to eat vegetables, compare how studies are typically conducted with how vegetables are typically consumed, link findings to individual differences where possible and offer practical applications of the model along with potential for future research.

Figure 3.1. An integrated (biopsychosocial) model illustrating how biological, social and cultural and environmental factors influence learning to eat a target vegetable in both infancy and throughout childhood.



+ Positive effect on vegetable learning and liking/consumption; - Negative effect on vegetable learning and liking/consumption; ± The effect of the factor on vegetable learning is variable depending on more specific sub factors (e.g. rewards + non-food rewards, - food rewards); ? The effect or association is not yet known or fully understood.

3.2 Biological and developmental considerations to learning

3.2.1 Exposure and learning begin in utero

Across species, including humans, flavour learning occurs *in utero, a*nd prior exposure to the flavour components of the maternal diet predict later liking and intake of these flavours by their offspring. It has been suggested that this is adaptive since foods consumed by the mother are likely a safe source of energy and nutrients, therefore programming preferences for these flavours in early life serves to guide infants towards a suitable diet (Hepper, 1996).

Whilst food intake is driven by an innate, biological need for energy, early life food preferences and selection are shaped by experiential learning (Figure 3.1). Maternal diet and food choices during pregnancy and lactation contribute to the chemical continuity of flavour experience from food-based volatiles *in utero* to the sensory/nutrient profiles of breastmilk then complementary foods (Beauchamp & Mennella, 2009; Mennella, Johnson, & Beauchamp, 1995). The foetal programming hypothesis predicts that early life exposure to plant-based foods, during pregnancy, lactation and complementary feeding will amplify flavour learning and help to establish preferences for vegetables (Beauchamp & Mennella, 2011).

3.2.2 Early exposures in infancy (0-2y)

Throughout development, children are exposed to diverse vegetable flavours and textures in a variety of ways. Whilst F&V flavours are not present in Breast Milk Substitutes, they are in breastmilk (Beauchamp & Mennella, 2011). Experience with vegetable flavours, especially in breastfed babies whose mothers consume vegetables, may have potentially long-lasting effects on infant preferences and intake (Beckerman, Slade, & Ventura, 2020; Hausner, Bredie, Mølgaard, Petersen, & Møller, 2008; Mennella, Jagnow, & Beauchamp, 2001; Moss, Dobson, Tooth, & Mishra, 2020).

During complementary feeding (CF) at 5-7 months, babies' reactions to new foods are mostly positive and even bitter tasting foods are easily accepted (Schwartz, Chabanet, Lange, Issanchou, & Nicklaus, 2011). This suggests a sensitive period where infants are amenable to a wide range of foods. Introducing different food textures during CF (lumps vs purée) is important between 6-9 months (Coulthard, Harris, & Emmett, 2009) for the child's later tolerance and preference for complex textures in food and a variety of food groups. Late introduction of lumpy foods (after 9 months) predicts higher levels of picky eating in childhood (Emmett, Hays, & Taylor, 2018). Children may also become over-responsive to tactile sensations and therefore eat less vegetables if they are introduced to solid foods later in the CF period (Coulthard, Harris, & Fogel, 2016). A balance needs to be struck between introducing solid foods too early (before 4-6 months), and too late (6-9 months).

3.2.3 Early exposures in childhood (2-6 years+)

Beyond the CF period, as toddlers begin to move around independently, children may develop food neophobia (see Dovey, Staples, Gibson, & Halford, 2008 for a review). This is where novel and sometimes previously accepted foods, are refused (Figure 3.1). Between the ages of 2-6 years, feeding becomes more difficult and may require additional support or intervention to increase familiarity and encourage acceptance of vegetables. Vegetable intake tends to plateau at 2 years (Duffy et al., 2019) and this may be due to children being offered fewer vegetables as they get older (Eldridge, Catellier, Hampton, Dwyer, & Bailey, 2019). Another potential reason for small intakes in childhood is that children's growth velocity slows until puberty (Haymond et al., 2013), with the potential for appetite to fluctuate as energy demand changes. Neophobia and periods of lower appetite compound reluctance to consume vegetables.

During interventions where children are exposed to and are encouraged to try new foods, sensory exploratory behaviours (e.g. spitting, licking) decrease over time (between 4-7 years) with maturity and familiarity. A reduction in sensory exploratory behaviours was associated with increased acceptance of new foods (Moding, Bellows, Grimm, & Johnson, 2020). Overall, early life food preferences and intake are shaped by experiential learning through sensory exposure and familiarisation.

3.2.4 Exposures in later childhood (7-12 years)

Learning to consume vegetables in older children (7-12 years) is comparatively understudied. In this review, we do not offer specific guidance for this age group, but limited research with older children is used to illustrate learning throughout childhood.

3.2.5 Genetics and taste

Genetic factors influence food preferences in early childhood, with preferences for vegetables more heritable than preferences for other food groups (Fildes, van Jaarsveld, Llewellyn, et al., 2014). The specific genes underpinning preferences are not known and so heritability measures encompass multiple candidate genes which influence eating behaviours. One aspect of eating that is genetically determined is the degree to which certain tastes are perceived and then liked.

Substances such as phenylthiocarbamide (PTC) and 6-n-propylthiouracil (PROP) are perceived as bitter. Although not present in foods, similar bitter tasting compounds are found in Brassica vegetables, with potential to affect children's dietary outcomes. There is variability in the degree to which these tastes are perceived between individuals (see Keller & Adise, 2016 for a review) and whether they are perceived as strongly bitter, mildly bitter or tasteless is determined by an individual's TAS2R38 receptor gene (see Mennella & Bobowski, 2015; Ventura & Worobey, 2013 for reviews). The potential for sensitivity to bitter tastes to affect eating habits is disputed. Some evidence suggests that bitter tasters consume fewer bitter green vegetables than non-tasters (Bell & Tepper, 2006), but this has not been replicated elsewhere (O'Brien, Feeney, Scannell, Markey, & Gibney, 2013).

For bitter-sensitive children, using dips/dressings can enhance intake of raw broccoli (Fisher et al., 2012). This may be due to masking bitterness with a familiar and palatable dip or dressing, or due to the salt content of the dip which dampens the bitter quality of raw broccoli (Fisher et al., 2012). Evidence is emerging that children who are sensitive to bitter tastes will consume more vegetables compared with non-tasters when herbs and spices manipulate or mask the bitter taste (Carney et al., 2018). Flavour manipulation may be needed for some bitter tasters, but others may respond well to repeated exposure learning to increase intake of vegetables such as turnip (Nor, Houston-Price, Harvey, & Methven, 2018).

3.2.6 Temperamental and appetitive traits

A further role of heritability is observed within children's temperament and eating traits that underpin interactions with food (Figure 3.1). Temperament is a relatively stable group of traits describing characteristics of the child such as reactivity, self-regulation and emotionality (Sanson, Hemphill, & Smart, 2004; Stifter & Moding, 2019). Children characterised as high in emotionality and internalising (anxious/dependent) consume fewer vegetables and more foods high in energy density daily, than those with low emotionality and internalising temperaments (Vollrath, Stene-Larsen, Tonstad, Rothbart, & Hampson, 2012). Similarly, low sociability, high emotionality and negative affectivity may predict the ineffectiveness of school-based interventions and parental practices to increase acceptance of vegetables (Holley, Farrow, & Haycraft, 2016; Holley, Haycraft, & Farrow, 2020; Kidwell, Kozikowski, Roth, Lundahl, & Nelson, 2018). However, negative affectivity has not consistently been linked to changes in vegetable consumption, and further temperament traits such as surgency (high activity level, extraversion, enjoyment of high intensity activities) and effortful control (high attention capacity, inhibitory control, ability to self-regulate) may be better linked to vegetable consumption and specific vegetable feeding practices used by parents (Kaukonen et al., 2019). For parental practices in particular, parents who perceive their child as fussy or with a difficult temperament may offer less structured mealtimes (Searle, Harris, Thorpe, & Jansen, 2020). Thus, temperament may moderate the impact of parent feeding and learning paradigms, as well as invoking different feeding practices by the caregiver.

Children also exhibit specific appetitive traits that are highly heritable and that contribute to determining children’s eating behaviours, such as fussy eating (Smith et al., 2017). Food fussy children tend to have a limited diet and are unwilling to consume novel or disliked foods (Dovey et al., 2008). Children with tactile defensiveness (Smith, Roux, Naidoo, & Venter, 2005) and sensory sensitivity more generally (Farrow & Coulthard, 2018) tend to display fussy/selective eating and food refusal. Tactile defensiveness and food refusal due to texture are often associated with developmental disorders including learning disability and Autism Spectrum Disorders (ASD) (although not limited to this population) (Seiverling, Towle, Hendy, & Pantelides, 2018; Smith, Rogers, Blissett, & Ludlow, 2020) and many children will only eat a handful of foods, usually from a limited variety of food groups (Ledford & Gast, 2006; Sharp & Postorino, 2017).

In contrast, children with an avid appetite (Cooke et al., 2004) and/or those that seek variety when eating (Nicklaus, Boggio, Chabanet, & Issanchou,

2005) may enjoy eating vegetables. Others that are food responsive, or external eaters, may have reduced preference for vegetables according to parental report data (Russell & Worsley, 2016). However, there is little evidence to support this claim through measured food intake. Some research suggests that food responsive children tend to eat large amounts of any foods offered, but this does not generalise to eating more vegetables when portion sizes were doubled (Smethers et al., 2019). For food responsive children, avidity of appetite for foods may depend on their palatability. However, enhancing palatability (added butter and salt) did not result in increased consumption of broccoli and sweetcorn (Diktas, Roe, Keller, Sanchez, & Rolls, 2021).

3.2.7 The importance of individual differences

With the range of individual differences described and incorporated into our model, it would be unreasonable to assume that single intervention techniques (those that are typically implemented) would have the same effect for all children's vegetable liking and intake (Figure 3.1). Children's responses vary within the same exposures/interventions, and these experiences may continue to affect eating practices throughout development. This amplifies the need for more personalised interventions to take account of temperamental and/or appetitive traits. Many studies control for these differences between children, but few actively design interventions for them (apart from fussy eating, which receives more attention). An alternative approach may be utilising multi-component interventions, as they may include techniques that work at some level for most children. This approach builds on existing learning literature, incorporating different mechanisms of learning.

3.3 Mechanisms for learning to eat vegetables

3.3.1 Repeated Exposure

Learned safety through exposure to, and familiarity with new foods teaches children to approach and accept these foods (Birch, 1999). Increased familiarity results in increased liking and preference towards the novel food (Birch & Marlin, 1982; Pliner, 1982). Learned safety requires Repeated Exposure (RE) to a food stimulus. RE is a very simple and effective learning technique to increase vegetable intake (Holley et al., 2017b; Nekitsing, Blundell-Birtill, et al., 2018).

RE is most effective when used with infants during CF (Barends, de Vries, Mojet, & de Graaf, 2014; Hetherington et al., 2015). At this time, approximately 5-10 separate exposures can be required for children to acquire liking for, willingness to try (WTT) and to increase intake of a target vegetable, even when it is initially novel or disliked (Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007). The number of exposures is likely to vary based on the type of food, child age and individual characteristics (e.g. temperament, appetitive traits). Throughout childhood, evidence supporting positive effects of RE are robust (Appleton et al., 2018). Yet, effect sizes for intake are small (average 5-10g: Holley et al., 2015; Nekitsing, Blundell-Birtill, Cockroft, & Hetherington, 2019; O'Connell et al., 2012; Wardle, Herrera, Cooke, & Gibson, 2003) and positive effects gained during CF and early infancy may only be maintained up until the age of 2 years (Barends et al., 2014; Hetherington et al., 2015). It is also important to note that liking and intake are assessed more often than WTT in RE studies. If children are not WTT any vegetables they may be removed from analyses, therefore limiting the generalisability of these studies (Caton et al., 2014).

Individual differences influence effectiveness of RE, with some children responding well by eating a little more each time the vegetable is offered while others are more hesitant or variable in their response (Figure 3.1). Modelling individual differences in response to RE to artichoke purée revealed four eating patterns among infants (aged 4-38 months): “learners” with a clear, linear increase in intake over exposures, “plate-clearers” who generally consumed most of what was offered each time; “non-eaters” who ate little over time and “others” who displayed high levels of variability across exposures (Caton et al., 2014). Eating traits entered into the model showed that plate clearers scored high on food approach traits (high enjoyment of food, low satiety responsiveness) and non-eaters scored high on food avoidance traits (high food fussiness, low satiety responsiveness (Caton et al., 2014). However, even among fussy eaters learning occurred.

Effects of RE vary by type of vegetable (Nekitsing, Blundell-Birtill, et al., 2018; Zeinstra, Vrijhof, & Kremer, 2018). RE may increase intake for one vegetable type, but may not generalise to other vegetables. Stimulus generalisation is an important feature of learning, in which learning about one stimulus will transfer to other similar stimuli (Pearce, 1987, 1994). The magnitude of generalisation is determined by the extent of shared characteristics between stimuli. It is important to distinguish between generalisation which occurs across foods and across contexts. For generalisation to different foods, infants repeatedly exposed to a target vegetable were found to increase intake of the same vegetable and to other similar foods (e.g. other vegetables), but this did not generalise to other food groups (Birch, Gunder, Grimm-Thomas, & Laing, 1998). This finding, that liking of vegetables failed to transfer to other food groups (e.g. fruits) has been reported consistently across studies (Barends, de Vries, Mojet, & de Graaf, 2013), as well as failure to transfer to some other vegetables (Hetherington et al., 2015). For generalisation or transfer effects to occur, vegetables may need to share sensory properties, possibly in colour, shape and flavour components (Olsen, Ritz, Kraaij, & Møller, 2012), however few studies on RE test this systematically.

Secondly, generalisation may be difficult to achieve for other contexts (Gardner & Rebar, 2019). Therefore, it is important that RE studies are ecologically valid. Chawner, Blundell-Birtill, and Hetherington (2020) demonstrate that most vegetable intake by UK children occurs at mealtimes at home, in the evening, with family members. Therefore, consumption of vegetables as a snack in school during an intervention may not generalise to increasing vegetable intake during mealtimes at home when vegetables are commonly served, due to context dependent learning. Offering more contexts in which vegetables are usually eaten may establish habitual practices across contexts.

Lastly, RE to vegetables is often mere exposure plus. This means that exposure to vegetables occurs alongside other foods/flavours during CF (Hetherington et al., 2015), as a spread on a cracker or in a soup medium to prevent boredom (Zeinstra et al., 2018) and alongside other children (e.g. preschool). In these studies, the exposures occur in the context of commensality – the atmosphere is convivial, encouraging and positive, therefore increased intake of a novel vegetable such as mooli (Nekitsing, Blundell-Birtill, Cockroft, Fildes, & Hetherington, 2019), may be enhanced by social learning. Even here, some children remain non-eaters despite enthusiastic engagement in the intervention tasks (nutrition education, sensory learning). These observations reflect the multiple and varied influences of the wider eating and learning context (e.g. social setting, with or without accompanying foods etc.) on vegetable consumption, revealing that learning by repeated exposure is often more than just mere exposure. Associations between the target food, context and other stimuli that are present at the eating occasion are therefore significant to learning.

3.3.2 Associative Learning

Associative conditioning to acquire liking for vegetables pairs a target vegetable with an already liked taste (FFL: flavour-flavour learning), a more energy dense nutrient (FNL: flavour-nutrient learning) or a rewarding consequence (see Johnson, McPhee, & Birch, 1991; Wadhera et al., 2015; Yeomans, 2010; Zellner, Rozin, Aron, & Kulish, 1983 for reviews). Alternatively, studies have attempted to produce a change in affective response to foods by pairing initially neutral foods with a food that already possesses a negative or positive valence, called evaluative conditioning (Martin & Levey, 1978). However, there is limited evidence to support this technique increasing preferences, with evidence showing that dislikes are more easily produced (Osborne & Forestell, 2012; Van den Bosch, van Delft, de Wijk, de Graaf, & Boesveldt, 2015).

Associative techniques work on the premise that the disliked (or novel) vegetable will be associated with a more pleasant taste stimulus or post-ingestive consequence and this pleasant feeling will transfer to the vegetable itself (Birch, 1999). FFL and FNL are both reported to increase intake of vegetable purée in infants, yet RE alone often results in effects similar in magnitude to FFL and indeed larger effects on intake than FNL (Ahern, Caton, Blundell, & Hetherington, 2014; Bouhlal, Issanchou, Chabanet, & Nicklaus, 2014; Caton et al., 2013; de Wild et al., 2013), even with fewer exposures (Hausner, Olsen, & Møller, 2012). However, it is important to note that these findings are reported for the average child and associative conditioning techniques (such as those discussed later in this section) can be helpful to increase vegetable liking and intake among certain subgroups of children.

When adding energy or FNL, studies report little or no effect on intake of vegetables for children 2-4 years (de Wild et al., 2013), though preference may increase. FNL appears to have variable effects, perhaps due to insufficient intakes by children (Johnson et al., 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993) or detectable differences between foods presented, for example mouth coating or fatty taste.

For FFL, there is concern that vegetable liking may not transfer to the unmodified vegetable (Hausner et al., 2012). Using dips instead of manipulating the sweetness or saltiness of a vegetable can increase WTT during first exposures compared to RE (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012) and also increase intake of bitter vegetables for bitter sensitive children (Fisher et al., 2012). Similarly, when combining FFL and FNL, such as presenting Brussels sprouts with sweetened and unsweetened cream cheese, liking and consumption of vegetables increased above that of RE alone (Capaldi-Phillips & Wadhera, 2014). Appleton et al. (2018) report that effect sizes consistently favour RE to FFL and FNL in studies examining both liking and intake. Yet when used together, FFL and FNL may be of selective benefit to novel and bitter tasting vegetables and/or certain children. This could be because the additives used in these studies resemble combinations typically eaten within a meal (e.g. cauliflower and cream cheese) and therefore offer greater ecological validity to the eating experience. Parents often provide vegetables to their children in this way as a function of cultural norms (Ahern et al., 2013). They may also add vegetables to other foods by stealth (Caton, Ahern, & Hetherington, 2011) with a goal of relying on implicit learning or lack of awareness to enhance intake.

3.3.3 Intake in the absence of explicit learning

Hiding vegetables in composite meals has been popularised by cookbooks aimed at parents (“The Sneaky Chef”; “Deceptively Delicious”). When this approach has been tested in the laboratory, hidden vegetables produce a net increase in vegetable intakes. Spill, Birch, Roe, and Rolls (2011) found a dose-response effect with significantly greater intake of vegetables when vegetable content was tripled and quadrupled compared to the standard vegetable condition. In addition, hiding the vegetable content in this way did not influence intake of the vegetables provided as side dishes. In a school setting with older children (7-10 years), the provision of vegetable enriched snack bars increased liking for the snack bars following exposure, but liking for the vegetables included in the bars was either stable or decreased (Jønsson, Angka, Olsen, Tolver, & Olsen, 2019). This is an interesting finding because if no explicit learning occurs, with no exposure to the vegetables on their own, decreases in liking of vegetables would not be expected. This effect, after exposure to hidden vegetables, could therefore be due to measurement error (children rating their liking for each vegetable *compared* with the more palatable snack bars they are tasting) or context dependent learning (the child expects to eat snack bars at snack time, so when vegetables are presented, children may rate them as less liked). Therefore, whilst providing vegetables by stealth may increase overall intake of vegetables, if there is no opportunity for explicit associative learning to occur, then future intake/liking of vegetables (when explicitly present) may remain unaffected. Nonetheless, offering vegetables by stealth may be one of a limited number of techniques for increasing vegetable consumption in fussy eaters who might otherwise reject them.

3.3.4 Rewards

Learning theory predicts that using incentives will increase liking and intake of vegetables. Rewards can range from social praise to tangible gifts such as toys or stickers and may have both facilitating and undermining effects on children's intake of food (see Cooke, Chambers, Añez, & Wardle, 2011 for a review). When administering rewards, problems arise when the behaviour becomes a means to the reward and there is a reduction of intrinsic motivation to perform the 'target' behaviour (Deci, Koestner, & Ryan, 1999). Therefore, where rewards are deemed necessary potential adverse effects should also be considered (Figure 3.1 illustrating both positive and negative outcomes of learning).

Rewards offered for consuming vegetables may elicit positive changes in liking and intake with effects that are larger than those using RE alone (Appleton et al., 2018) and more persistent effects at follow-up (Cooke, Chambers, Añez, Croker, et al., 2011). However, there are caveats; the type of reward offered is very important. Food rewards for tasting or eating vegetables (e.g. "eat your vegetables and you can have dessert") have been shown to be detrimental for preference of the target food (Newman & Taylor, 1992), whereas small non-food rewards may have more positive long term outcomes. Tangible rewards (small toys and stickers) increase intake more than verbal praise during interventions (Morrill, Madden, Wengreen, Fargo, & Aguilar, 2016) with effects being present at 3 month follow-up (Remington, Añez, Croker, Wardle, & Cooke, 2012). Using RE with stickers can also increase WTT and intake of vegetables (Corsini, Slater, Harrison, Cooke, & Cox, 2013; Wardle et al., 2003), as well as decreasing the number of refusals by children (Fildes, van Jaarsveld, Wardle, & Cooke, 2014). However, this may work only for liked or neutral vegetables. When vegetables are already disliked, use of rewards can increase rated liking but may not increase intake in all children (Holley et al., 2015). For incentives to work, the food cannot be disliked to the extent that even a reward fails to encourage its intake. Individual differences in reward sensitivity may determine the effectiveness of incentives for vegetable consumption. Children with high reward sensitivity may try vegetables immediately with a reward, but those with low reward sensitivity may try only vegetables together with verbal encouragement (Vandeweghe, Verbeken, Moens, Vervoort, & Braet, 2016).

3.3.5 Non-taste exposure

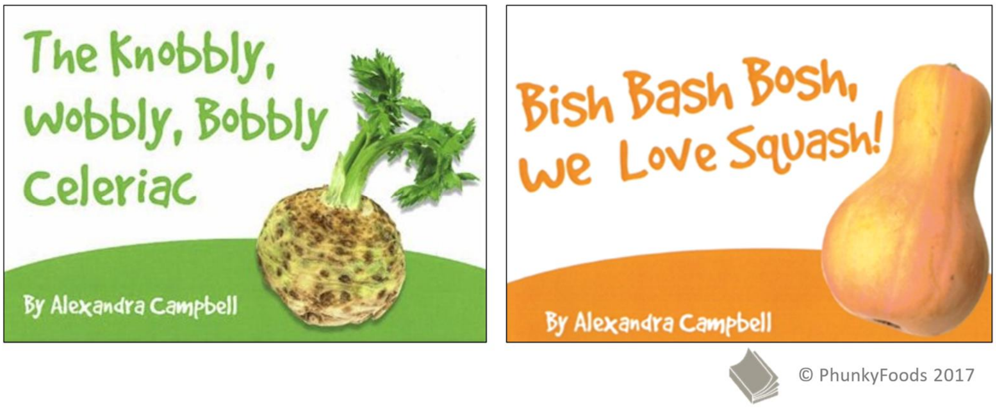
Young children will see, smell and touch the food before deciding to taste. These non-taste exposures are also effective for increasing vegetable familiarity and WTT. Children learn by doing and involving them in playful activities enhances their learning (Barab, Arici, & Jackson, 2005). Sensory play where children are encouraged to “play with your food!” results in increased willingness to try the foods and generalises to other new foods (Coulthard & Sealy, 2017).

Sensory education programmes such as the “SAPERE” method (https://www.sapere-association.com/) use play and sensory awareness tasks within school lessons to encourage children to be curious about the foods they eat. Play is fundamental to children’s learning, but where the focus is too heavily on education rather than enjoyment, learning declines (Hughes, 2009). Sensory education has been shown to increase WTT new foods and to reduce neophobia in 8-12 year old children (Mustonen & Tuorila, 2010). Unlike RE studies, sensory education places no expectations on the child to consume the novel vegetable, and so the emotional tone of the lesson is encouraging and positive (see also Flavour School: https://www.flavourschool.org.uk/the-program).

Even in the absence of real food, familiarity with vegetables can be achieved with picture books (Dulay, Masento, Harvey, Messer, & Houston-Price, 2020; Heath, Houston-Price, & Kennedy, 2011; Houston-Price, Butler, & Shiba, 2009; Osborne & Forestell, 2012), facilitating WTT and preference development through recognition skills (Houston-Price, Owen, Kennedy, & Hill, 2019) and storybooks that provide a narrative or develop a character to enhance the playful element of the learning experience (de Droog, Buijzen, & Valkenburg, 2014; de Droog, van Nee, Govers, & Buijzen, 2017). Studies where reading a storybook about a novel vegetable, presented alongside experiential learning (seeing, smelling, touching and exploring different shapes), increased intake of a novel vegetable (Nekitsing, Blundell-Birtill, Cockroft, Fildes, et al., 2019) (Figure 3.2). For children who were fussy (non-eaters), intake increased when experiential learning was provided with the book, illustrating additive benefits of integrating techniques during intervention for children with different individual needs.

There are further opportunities to increase vegetable familiarity and preference/liking (and possibly intake) through nutrition education (Dhandevi & Jeewon, 2015), gardening (Ohly et al., 2016), cooking/preparing meals (Ehrenberg, Leone, Sharpe, Reardon, & Anzman-Frasca, 2019; Van der Horst, Ferrage, & Rytz, 2014) and visual nudges (e.g. pictures of vegetables on plates; Sharps, Thomas, & Blissett, 2020). Additionally, non-tasting games (Coulthard & Ahmed, 2017), computerised apps that enhance familiarity with vegetables (Farrow et al., 2019) and personalised apps (Dulay et al., 2020) have also been used to encourage WTT. The use of games to promote vegetable intake has not been tested extensively yet digital platforms, videos, gaming and play are clearly important routes to explore. Animated characters and videos of other children eating vegetables have been used to promote intake across several studies (Horne et al., 2011; Staiano, Marker, Frelier, Hsia, & Martin, 2016). Though less direct than providing actual foods, storybooks, play and digital media increase familiarity and encourage WTT in those children that are non-eaters, through facilitating positive affective experience during exposure to vegetables.

Figure 3.2. Non-taste exposure through storybooks with pictures of real vegetables. Included with permission from ©PhunkyFoods.



3.4 Social, cultural and food environments

Most studies of food learning take place in environments where investigators may control (laboratory) or change (pre-school) the setting to suit the study. Beyond these settings, parenting styles (e.g. authoritarian, authoritative etc.), parental practices (e.g. restriction, monitoring etc.) and physical aspects of the food environment (e.g. food availability, presentation/preparation method etc.) influence healthy eating behaviours (Bassul, Corish, & Kearney, 2020; Burnett, Lamb, McCann, Worsley, & Lacy, 2020; Pearson, Biddle, & Gorely, 2009; Yee, Lwin, & Ho, 2017). Here, children's learning can be implicit – learning about social norms and expectation of which foods to eat and how much. In a child's life, external influencers are multiple and varied (Alruwaily et al., 2020).

Children learn through modelling the behaviour of others, whether real or virtual (Farrow et al., 2019) and are influenced by perceived or actual social norms (Sharps & Robinson, 2015). For instance, when children aged 6-11 years were led to believe that other children had eaten a large amount or small amount of carrots, intake was greatest when assigned to a large norm, compared to a low, no norm or control condition (Sharps & Robinson, 2015). In unfamiliar circumstances informational social norms increased intake of carrots (Sharps & Robinson, 2017). What other children are doing, the social norms they are exposed to and visual prompting encourage intake of vegetables, especially if they are already liked.

Social learning outcomes favour some foods over others. In a study from the Netherlands involving much-loved TV characters – Ernst and Bobbie (http://www.ernstbobbie.nl/), children watched characters eating carrots during a classroom snack (Zeinstra, Kooijman, & Kremer, 2017). The TV characters promoted injunctive norms (eat carrots to make you strong and fast) and modelled consumption of carrots with enthusiasm. However, viewing the video had no effect on intake after 8 sessions, but at 9 months follow-up children in the experimental conditions (video, or video plus positive restriction) increased their intake. The authors suggested that this delayed effect may be due to the novelty of eating carrots in a classroom initially then to the impact of evaluative conditioning in the long term. Children may have learned to associate the convivial atmosphere, positive role model and eating carrots in class over time (Zeinstra et al., 2017). This illustrates the importance of ecologically valid interventions, as children may not have had opportunity to assimilate intervention practices into their everyday life. In this study around 40% of children were classed as “non-eaters” eating less than 10g of carrot. In contrast, children 3-5 years watching videos of peppers being eaten by other children increased preference for and consumption of peppers compared with the control (no video) group (Staiano et al., 2016). Therefore, in a social setting, even with encouragement, playful support and modelling, children differ in the extent to which they respond to social learning interventions and to the type of models used during interventions.

Furthermore, foods high in energy density (HED) and palatability are often favoured in social learning contexts. This was demonstrated by Coates, Hardman, Halford, Christiansen, and Boyland (2019), who randomly allocated children aged 9-11 years to view Instagram kid influencers promoting HED foods (e.g. cookies), non-food products or nutrient dense foods (e.g. banana). The children were then offered a snack, and the children who had viewed the HED snacks, selectively consumed more of these foods compared to those in the other conditions. In response to viewing the influencer promoting nutrient dense, “healthy” foods, there was no concomitant increase in intake of these foods. There appears to be a selective advantage of food promotion on HED, palatable foods compared to more nutritious, low energy density foods such as fruits and vegetables.

3.5 Practical applications of the model

In updating the current model (Johnson, 2016), evidence has been integrated from studies of the complex environments that children eat and learn in, the individual differences that children bring to each eating occasion and the features of foods they are exposed to (Figure 3.1). The model illustrates the timeframe through which different strategies support children's learning to like and to eat vegetables. Evidence is largely from experimental studies, but most intake of vegetables occurs at home. Therefore, an integrated intervention to facilitate habitual intake of vegetables is ecologically valid, provides feasible and realistic strategies suited to the child's age, ability, appetite, temperament and context.

To achieve this more integrated approach in practice involves consideration of the child, the setting and the target food (Figure 3.1). An integrated approach acknowledges how and where vegetables are typically consumed, characteristics and current state of the child and strategies that can be assimilated into everyday habits. It may also consider specific combinations of biopsychosocial factors and/or learning techniques which influence consumption. In practice, integrated approaches will succeed if adapted to individuals or groups of children with similar trait profiles, with specific aims to increase WTT, liking and/or intake, within a typical eating context.

Advice to parents might include regular exposure (without pressure to eat) however, this form of learning is scaffolded by other techniques. Anzman-Frasca et al. (2018) suggest that simple techniques such as RE, modelling and praise could be used before moving on to other methods including non-food rewards or changing the presentation or flavour of the vegetable using associative conditioning. The authors reason that these latter techniques can then be reserved to motivate initial tastings for vegetables that are consistently avoided or refused. This approach may reduce parental frustration when RE is suggested, but does not work for their child.

Sensory experience with vegetables must be positive to promote pleasure to facilitate liking (Nicklaus, 2016). Parents and caregivers might enhance enjoyment of food and eating through participating in food preparation, with the potential to reduce neophobia or fussy eating (Van der Horst, 2012; Van der Horst, Mathias, Patron, & Allirot, 2019). This is a holistic and gradual approach, but is important because it is *easier* to learn to dislike than to like vegetables (Van den Bosch et al., 2015). Although liking is necessary for consumption it is *not sufficient* and the relationship between liking and consumption is non-linear (see Hayes, 2020 for a discussion). Therefore, in addition to developing liking, the overall evaluative experience of the eating occasion needs to be pleasant, positive and rewarding.

Engaging in food preparation and tasting vegetables can be fun but overemphasis on eating more vegetables and/or restricting access to highly liked, HED foods (e.g. desserts) can lead to paradoxical effects (Fisher & Birch, 1999). Such practices can be viewed by the child as pressuring and coercive, inhibiting learning (Vollmer & Baietto, 2017). Like adults, children may not be hungry when foods are offered or they may not be ready to try them. During or after a meal is eaten, appetite for vegetables, such as those that are bitter, may decrease compared to before the meal, when hunger facilitates intake (Olsen, Ritz, Hartvig, & Møller, 2011; Spill, Birch, Roe, & Rolls, 2010). Understanding and adapting to individual child needs is an example of responsive feeding, which is associated with low fussiness and high enjoyment of food (Finnane, Jansen, Mallan, & Daniels, 2017). Therefore, eating without pressure or expectation (e.g. SAPERE) but encouragement to taste or try, reduces conflict. If children try the vegetables offered, if these vegetables are offered regularly and the tone is positive and encouraging, then the overall experience is enjoyable, which is conducive to learning.

In contrast to many studies included in this review, children's day-to-day intake of vegetables is typically accompanied by other foods. For example, in the UK children consume only one portion of vegetables per day, with the largest daily amount eaten in the evening, most frequently accompanied by foods high in proteins and complex carbohydrates (e.g. plant or animal proteins and potatoes, pasta or rice: Chawner et al., 2020). Therefore, while RE to vegetables increases familiarity exposure to a single vegetable rarely occurs in the child's usual environment. Consequently, the role of competing foods (other available foods; e.g. more palatable, highly favoured foods such as chicken nuggets, chips) must be acknowledged. Ideally, if children learn to eat vegetables alongside competing foods for a balanced and varied diet, then establishing liking beforehand increases the likelihood that the vegetable component of the meal will be eaten. Evidence suggests that specific pairings of vegetables and entrées (the main meal) affects levels of food waste (Ishdorj, Capps Jr, Storey, & Murano, 2015). However, it is not known whether this is due to entrée items being more palatable than the vegetables, whether specific food pairings are an unfamiliar combination, or for other reasons that may influence eating combinations of foods, such as the disparity of liking between vegetables and entrée items (Chawner, Blundell-Birtill, & Hetherington, 2022a).

3.6 Future research and problems/gaps

There remain many gaps in the current literature concerning factors that influence children's ability to learn to like and consume vegetables. Firstly, little is known about the transition between developmental stages. The progression of learning from vegetable pureés during infancy to eating 40g (one portion) of a vegetable on a plate during childhood is poorly understood. Reductionist approaches of using one technique at a time has been useful to determine which practices are effective for food preference development. However, effect sizes for single techniques are generally small (Appleton et al., 2018) and could be improved by use of techniques that complement each other. Holley et al. (2015) found that using modelling and rewards together with RE resulted in larger effect sizes for vegetables than any one method alone.

Using multiple techniques may ensure that children with additional or individual needs (e.g. fussy eaters that require more time and familiarity) receive an appropriate intervention. Alternatively, studies that design interventions for specific groups of children with similar individual needs may see larger (or at least more consistent) effects than studies aggregating intake for all children, regardless of individual differences. Therefore, a personalised approach is necessary.

Further study on generalisation and transfer effects is also warranted with children 2-6 years and older. RE to one vegetable does not lead to acceptance of different vegetables at separate eating occasions (Hetherington et al., 2015), yet it is not known whether children will require fewer exposures to a second vegetable after being exposed to and accepting a first vegetable. It is also not clear how to transfer effects to other foods and across contexts once learning occurs.

At mealtimes especially, children may develop habits for refusing foods without trying them, which may not be linked to liking (Birch & Marlin, 1982). It is not yet understood whether children refuse certain foods because they have refused them previously (especially when the result is the removal of the food) and whether this extends to other novel vegetables. Furthermore, previous experiences with vegetables could impact on the success of future interventions, and so taking learning history and familiarity into account could be important.

Lastly, this review has focused on learning to eat vegetables in infancy and early childhood. Research with older children and adolescents is sparse and interventions that are implemented tend to produce modest or no effects (Coates et al., 2019; Fritts et al., 2019; Pedersen, Grønhøj, & Thøgersen, 2016; Sharps, Hetherington, Blundell-Birtill, Rolls, & Evans, 2019). Studies to examine which techniques succeed in increasing vegetable intake through learning in older children are needed to promote healthier dietary intakes.

3.7 Conclusion

Learning to like vegetables and to eat them regularly presents a challenge to parents and caregivers. Biology, environment and individual differences may interact to reduce the appeal of vegetables, yet these foods confer selective health benefits. Learning theory and interventions developed to apply these principles have provided a substantial platform on which to base more integrated research on how children (and their families) will transition to eating more vegetables as part of a more plant-based diet. In order to achieve enhanced impact, future research could implement interventions within an ecologically valid context resembling habitual eating behaviour, combining multiple complementary techniques for potential additive effects and taking account of individual differences between children that may constrain or enhance their learning.

Chapter 4

Predictors of vegetable consumption in children and adolescents: Analyses of the UK National Diet and Nutrition Survey (2008-2017)

Chapter 4 Predictors of vegetable consumption in children and adolescents: Analyses of the UK National Diet and Nutrition Survey (2008-2017)

Abstract

Children's vegetable consumption is generally below national recommendations in the UK. This study examined predictors of vegetable intake by children aged 1.5-18 years using counts and portion sizes derived from four-day UK National Diet and Nutrition Survey food diaries. Data from 6,548 children were examined using linear and logit multilevel models. Specifically, we examined whether demographic variables predicted vegetable consumption, whether environmental context influenced portion sizes of vegetables consumed and which food groups predicted the presence (or absence) of vegetables at an eating occasion (EO). A larger average daily intake of vegetables (g) was predicted by age, ethnicity, equivalized income, variety of vegetables eaten and average energy intake per-day (R^2 = 0.549). At a single EO, vegetables were consumed in larger portion sizes at home, with family members and at evening mealtimes (*Conditional* R^2 = 0.308). Within EOs, certain configurations of food groups such as carbohydrates and protein predicted higher odds of vegetables being present (OR: 12.85, 95% CI: 9.42–17.54); whereas foods high in fats, sugars and salt predicted a lower likelihood of vegetable presence (OR: 0.03, 95% CI: 0.02–0.04). Vegetables were rarely eaten alone without other food groups. These findings demonstrate that only one portion of vegetables was eaten per-day (median) and this was consumed at a single EO, therefore falling below recommendations. Future research should investigate ways to encourage vegetable intake at times when vegetables are not regularly eaten, such as for breakfast and as snacks, whilst considering which other, potentially competing, foods are presented alongside vegetables.

4.1 Introduction

The habitual daily consumption of vegetables contributes towards a balanced and healthy diet, in line with UK government recommendations to eat five portions of fruit and vegetables (F&V) per-day (NHS-UK, 2018). The five-a-day message is a practical compromise since research suggests that health benefits are observed in dietary intakes of up to 10 F&V per-day (Aune et al., 2017). In 2018, less than 18% of UK children aged 5-15 ate five portions of F&V, with the average intake at three portions per-day (NHS-Digital, 2018). Girls and younger children tend to have larger and more frequent intakes of vegetables than boys and older children (Jones, Steer, Rogers, & Emmett, 2010), and families with lower socio-economic status and low availability or accessibility to vegetables at home have been linked with reduced intake (Rasmussen et al., 2006). Additionally, children with eating traits such as high food enjoyment and low food neophobia have associated increased intakes of vegetables (Jones et al., 2010), whereas children with fussy eating traits consume few vegetables (Van der Horst, Deming, Lesniauskas, Carr, & Reidy, 2016). Low intakes of vegetables track consistently across children's development (Nicklaus & Remy, 2013; Ventura & Worobey, 2013).

For adolescents, many of the same reasons for not eating vegetables apply (Pearson, Griffiths, Biddle, Johnston, & Haycraft, 2017), as well as issues around image and gender identity (Krølner et al., 2011). Furthermore, F&V are more nutrient dense than other food groups, but less energy dense, leading to weaker feelings of perceived "fullness" or satiation (Krølner et al., 2011), and therefore higher energy dense foods may be preferred to vegetables. Thus, for older children social influences (Pedersen, Grønhøj, & Thøgersen, 2015) and energy density of vegetables may add to explanations of low vegetable intake.

Research on the environmental context of eating suggests that vegetables are most often eaten as part of a composite meal (O'brien, Kiely, Galvin, & Flynn, 2003). This vegetable consumption at home during family mealtimes is associated with improved dietary quality (Gillman et al., 2000). At mealtimes, children are often served the same foods as the rest of the family (Sweetman, McGowan, Croker, & Cooke, 2011) and parents have the opportunity to model intake, which is positively associated with child and adolescent vegetable intake (Pearson et al., 2009). Furthermore, since fewer vegetables are eaten than recommended, making changes to serving sizes at mealtimes has long been a strategy to change intake for F&V. Research that has increased vegetable serving sizes within a meal demonstrates increased intake of vegetables in children (Miller et al., 2015; Spill et al., 2010), though this method can also produce increased plate waste. Additionally, overall vegetable intake may be stimulated by variety. Offering a variety of vegetables has been shown to increase consumption (Roe, Meengs, Birch, & Rolls, 2013), but this is mitigated by the presence of other food items (Carstairs et al., 2018; Miller et al., 2015).

Little is also known about the relationship between the environmental context, portion sizes and other foods present at separate eating occasions (EO) on children's habitual daily intake of vegetables. This has been investigated for palatable, high energy density food items (Blundell-Birtill & Hetherington, 2019), showing that age, time of day and context (TV on, at home, out of home) were important determinants of portion size in children and adolescents, however these relationships have not been determined for vegetables. Therefore, the present study investigated predictors of vegetable intake based on environmental context, time of day and the types of foods that vegetables are eaten alongside. Vegetable consumption is examined without fruits in order to identify differences in intakes and eating contexts compared to previous research examining both food groups together. It is important to examine vegetables separately as vegetables are often rejected or not eaten by children (Cooke, Wardle, & Gibson, 2003; Kim et al., 2014) despite having potentially greater health benefits than fruit (Aune et al., 2017; Nguyen et al., 2016; Oyebode et al., 2014; Yang et al., 2014). Therefore examination of vegetables alone may provide more specific insights to children's eating habits compared to fruits and vegetables when examined together. This study examined characteristics that predict vegetable intake in children and adolescents aged 1.5-18 years, by conducting secondary analysis of data on the UK National Diet and Nutrition Survey (NDNS). This is a nationally representative sample of four-day food diaries collected between 2008 and 2017. We examined whether daily intake of vegetables could be predicted by demographic variables, if the environmental context of an EO influenced whether, and how much, vegetables were eaten, and which food groups predict the presence (or absence) of vegetables being eaten in an EO.

4.2 Methods

4.2.1 Sample.

Secondary data analysis was conducted utilising years 1-9 of the UK National Diet and Nutrition Survey (NDNS) (NatCen Social Research, 2019) collected between 2008 and 2017. The NDNS is a rolling cross sectional survey that runs continuously throughout the year to collect detailed information on food consumption and nutritional intakes of the UK population. The survey aims to include around 1000 participants total each year from England, Scotland, Wales and Northern Ireland, with an equal split of 500 children (1.5-18 years) and adults (19+ years). Due to some households only containing adults, at many addresses only a child participates in order to boost the number of children in the sample to match that of the number of adults. The sample is drawn from the postcode address file of all private households in the UK. Full details of the NDNS design and sampling procedure are reported elsewhere (NatCen Social Research, 2019).

Data collection for the NDNS is composed of interviewer visits and a nurse visit. During interviewer visits, data is collected from face-to-face interviews, self-completion questionnaires, a four-day food diary and height and weight measurements. This is followed by a nurse visit which involves taking physical observations and blood samples of the participant, as well as detailed information regarding medication and dietary supplements taken. Field work is conducted throughout the year, to ensure an even representation of months and days of the week. Therefore, the data includes potential seasonal variations in food intake, as well as differential intakes during the week compared to weekends. The current analysis considers only data from the interviewer stage of the survey and includes only the subsample of children aged younger than 19 years (n = 6,548, *female* = 3,197). Full participant characteristics are reported in Table 4.1.

Table 4.1. Participant Characteristics.

Participant Characteristics.	
Total, Male (%)	6547, 3351 (51.18)
Ethnic group, N (%)	
White/White British	5717 (87.32)
Black/Black British	161 (2.46)
Asian/Asian British	374 (5.71)
Mixed ethnic Group	190 (2.90)
Any other group	105 (1.60)
Age Group, N	
1.5-3 years	1172
4-10 years	2554
11-18 years	2821
BMI Category, N (%)	
Normal Weight	4577 (69.91)
Over Weight	871 (13.30)
Obese	1099 (16.78)
Equivalised income	
Mean (SD) [Range]	25952 (18896) [-1.00 – 137195]
Parental Employment Status, N (%)	
Higher managerial and professional occupations	1056 (16.13)
Lower managerial and professional occupations	1618 (24.71)
Intermediate occupations	589 (9.00)
Small employers and own account workers	731 (11.17)
Lower supervisory and technical occupations	591 (9.03)
Semi-routine occupations	916 (13.99)
Routine occupations	714 (10.91)
Never worked	229 (3.50)
Other	104 (1.59)

4.2.2 Dietary Data

During the interviewer phase, the NDNS collects a four-day estimated food diary to observe dietary habits. Participants are asked to write down everything that they eat and drink over this period, along with the time, who they are with and where they are. Children aged 13 years and older can complete their own diary, however for children 12 years and under, a parent/carer is requested to complete the diary. The diary is completed at the time of eating rather than from memory and records should indicate how much food was consumed (not amount served or including leftovers). To assist with amounts of each food eaten, participants are asked to describe food consumption in terms of weight (g) or household measures (e.g. tablespoons, teaspoons, cups, slices etc.). When reviewing the diary, children are additionally asked to select pictures of portion sizes served and amount of leftovers using the Young Person's Food Atlas (Foster et al., 2017), to complement reported portion size data. To further supplement food data, participants are instructed to keep food packaging and labels with weights and nutrient information for each food. To ensure compliance with this procedure and to allow the participant to ask questions, the interviewer conducts a mid-diary visit, before returning at the end of the four days to collect and review the diary. Only children that completed three or four diary days were included in the survey (3 days *n* = 121, 1.85%, 4 days *n* = 6,426, 98.13%).

Diaries were coded by trained coders and editors from the NDNS research team and all food intakes were entered into a modified Diet in Nutrient out (DINO) (Fitt et al., 2015) assessment system. Each food was given the corresponding food code and portion code from the NDNS nutrient databank. For composite recipes, each food component was assigned a food code. If portion sizes were reported as a weight, this was directly input into the DINO. Alternatively, if the portion size was described as a household measure, the appropriate weight for each type of food given the measure was selected. Where foods were consumed at school, portion sizes and nutrient information were determined from data collected by school meal surveys.

For this study, all food data were selected from the full NDNS dataset (Years 1-9, n = 6,548). Beverages, sweeteners and supplements data were not included in analyses. This is because the NDNS reports sweeteners and supplements in terms of a base unit rather than grams and beverages impact on the overall weight and energy intake at each EO (e.g. water provides no energy content, whereas alcohol provides a large amount of energy). However, beverages were still included in the total energy intake per day for each individual. All other potion sizes of foods were given in grams, which were converted to energy intake by the NDNS research team.

4.2.3 Variables

For each participant, to create the outcome variables of interest, the mean number (absolute count) of vegetables eaten per day was derived from the food diaries. Similarly, the mean portion size (g) of vegetables that were eaten per day was also calculated. Each EO was coded for inclusion of vegetables, and the total portion size (g) of vegetables consumed in each EO was also calculated.

Within the NDNS dataset, age in full years and gender were recorded for each participant, as well as the diary month and day number of the diary (1-4). Age was centred, but not scaled, to make parameter estimates easier to interpret. Age squared was also included in models to examine the non-linear fit of age. Participant’s ethnic group, whether they were vegetarian or vegan, BMI category and equivalized household income were also included. BMI was categorized within a range of weight categories from normal weight (including underweight), to having overweight and obesity. These categories utilise the BMI WHO cut-offs (85th/95th centile for 2–3-year olds (inclusive) and UK90 for 4–18-year olds. For the 435 children with missing BMI values, these were assigned as healthy weight. Z-score equivalized household income (a measure of household income that is derived from the size of the household and the relationships between the people within) was included, however, this was missing for 526 (8%) participants. We assume that the data is missing at random because the chance of observing this variable (equivalised income) may depend on its value, as adults were asked about income during interview. Therefore, missing values were estimated using multiple imputation (Rubin, 2004). Demographic variables of adult employment status, number of children under-18, ethnic group and known equivalized income values were input into a classification and regression trees (CART) algorithm to impute the missing data.

To account for seasonal effects on vegetable consumption, the months of November, December and January were classed as “Winter”, February, March and April as “Spring”, May, June and July as “Summer” and August, September and October as “Autumn”. Where the EO took place and who with were collapsed into fewer categories (Blundell-Birtill & Hetherington, 2019; Ziauddeen et al., 2017). Places were categorised as “at home” for any location within the home, “at school or work” included all locations at school (as well as locations in the workplace for some older children in the sample), “food outlet” including restaurants, cafeterias and any place that food can be brought outside of the home, “on the go” for foods that were consumed outside, on the street or in transportation, “leisure” including leisure centres and leisure activities, and all other places were categorized as “other”. Similarly, categories for who the individual was eating with were reduced to eating “alone”, “with parents only”, “with children only”, “with friends only”, “with multiple groups-family and friends” and all other EOs were categorised as “other”. Lastly, food group categories were compressed to those representing mainly “vegetables”, “fruit”, “carbohydrates” (including rice, pasta, bread, cereal etc.), “protein” (meat, fish, eggs and nuts and seeds), “dairy” (not including milk as this was categorised as a beverage) and “high fats, sugar and salt (HFSS)” (including foods such as puddings, pastries, sweets, biscuits, chocolate, crisps and savoury items). These food groups were guided by those described in the UK Eatwell guide (Public Health England, 2018a). Fats and oils, mainly including butter and cooking oils, were not used in any analyses.

4.2.4 Data analysis

NDNS data sets for years 1–4 (2008/09–2011/12), years 5–6 (2011/12–2013/14), years 7–8 (2014/15–2015/16) and year 9 (2016/2017) were combined. These datasets were weighted to adjust for differential selection probabilities, differences in sample selection between years and non-response to certain NDNS procedures. Weights were calculated for all children (18 years and under) in the sample using NDNS instructions (NatCen Social Research, 2019), and these weights were incorporated into all analyses. Individual weights for each data collection period (i.e. years 1-4, 5-6, 7-8 and 9) were summed separately. Individual weights were then divided by the sum of weights for that data collection phase and multiplied by the sum of all phase weights. Finally, this was multiplied by the number of years in that phase/total number of survey years (e.g. years 1-4 would have been 4/9, as there were 9 total years). We then checked that the $SD = 1$ and the $Mean = 0$ of all weights combined.

EOs that were within 15-minutes of each other, in the same place and with the same people were combined into a single EO (Blundell-Birtill & Hetherington, 2019; Ziauddeen et al., 2017). For determining average daily absolute count and average daily consumption (g) of vegetables in the individual, data were analysed at the person level (n = 6,548) using linear models. Two multiple regression analyses were conducted predicting daily vegetable consumption in both counts and total portion size. Demographic variables including age, age^2, gender, ethnicity, equivalized income, parental employment status and BMI category were used as predictors, along with vegetable variety index (number of different vegetables eaten across diary days), vegetarian or vegan status, season (winter, spring, summer and autumn), year of NDNS survey and number of children in the household were included in the model.

For analyses to determine the outcome of vegetable portion size consumed at a single EO, portion size of vegetables (g) was totalled for each EO. Data were analysed only for EOs that included vegetables (n = 25,059), using multi-level linear models. The intercepts were allowed to vary by participant. This analysis included the predictor variables age, gender, BMI category, weekday, location of meal, who with, time of day, daily energy intake (kcal) and vegetarian or vegan status, along with amounts (g) of each food group in the meal and interactions of each predictor with age.

Lastly, analyses were conducted to determine which food groups predict the presence of vegetables within an EO. Data were analysed using all EOs, apart from those that only included vegetables (n = 124,023), using multi-level logit models. Binary variables were created for whether the EO contained each food group type, and main effects and interaction terms for each food group were added to the model.

For all models, data were split into model building and test datasets (all 50:50 split) using different pseudo-random seeds for each analysis. All predictors that significantly added to the model in the model building phase were included in the model testing phase, whereas predictors that did not add to the model were left out of the testing phase. An alpha level of .01 was used to determine significant predictors. Only results of test datasets are reported here as the predictors all had significant main effects in the model building samples.

Data analyses were conducted using RStudio 1.1.383, with R (version 3.5.2, Eggshell Igloo), tidyverse 1.3.0, haven 2.2.0, lme4 1.1-21 and lmerTest 3.1-0.

4.3 Results

Across the four-day food diaries, there were 307,205 food entries (after removing beverages, sweeteners and supplements), for 6,547 children (one person did not consume any food, only beverages, during all days of the diary and therefore does not appear in any analyses). Of these, 6,184 children consumed at least one vegetable 54,989 times. There were 116 vegetarians and 5 vegans in the sample. Food entries made up 124,436 unique EOs, 25,059 of which included at least one vegetable. However, in only 413 EOs were vegetables eaten alone, with 489 different counts of vegetables eaten. When vegetables were eaten on their own, raw carrot was the most popular (n = 116), followed by raw cucumber (n = 61) and raw tomatoes (n = 44). Children consumed vegetables on average 8 times over diary days (*Mean* = 8.40, *Median* = 7, *SD* = 7.01) with an average variety intake of 5-6 different types of vegetable (*Mean* = 5.59, *Median* = 5, *SD* = 3.79). A total of 58 different types of cooked (count = 37,880) and 47 different types of raw (count = 17,109) vegetables were eaten by the participants. Table 4.2 presents the most commonly consumed vegetable types eaten both cooked and raw.

Table 4.2. Top ten most consumed cooked and raw vegetables over four-day food diaries and their absolute counts for number of times eaten.

Cooked Vegetables	Absolute Count	Raw Vegetables	Absolute Count
Onions	5678	Cucumber raw	3379
Carrots	5254	Tomatoes raw	2656
Beans	4682	Garlic raw	2446
Peas	3288	Lettuce raw	2156
Tomatoes	2983	Peppers raw	1450
Sweetcorn	2605	Carrot raw	1161
Broccoli	2302	Onions raw	795
Peppers	1953	Ginger root-raw	555
Mushrooms	1312	Coleslaw	352
Mixed Vegetables	789	Mixed leaf salad	284

4.3.1 Demographic predictors of vegetable intake

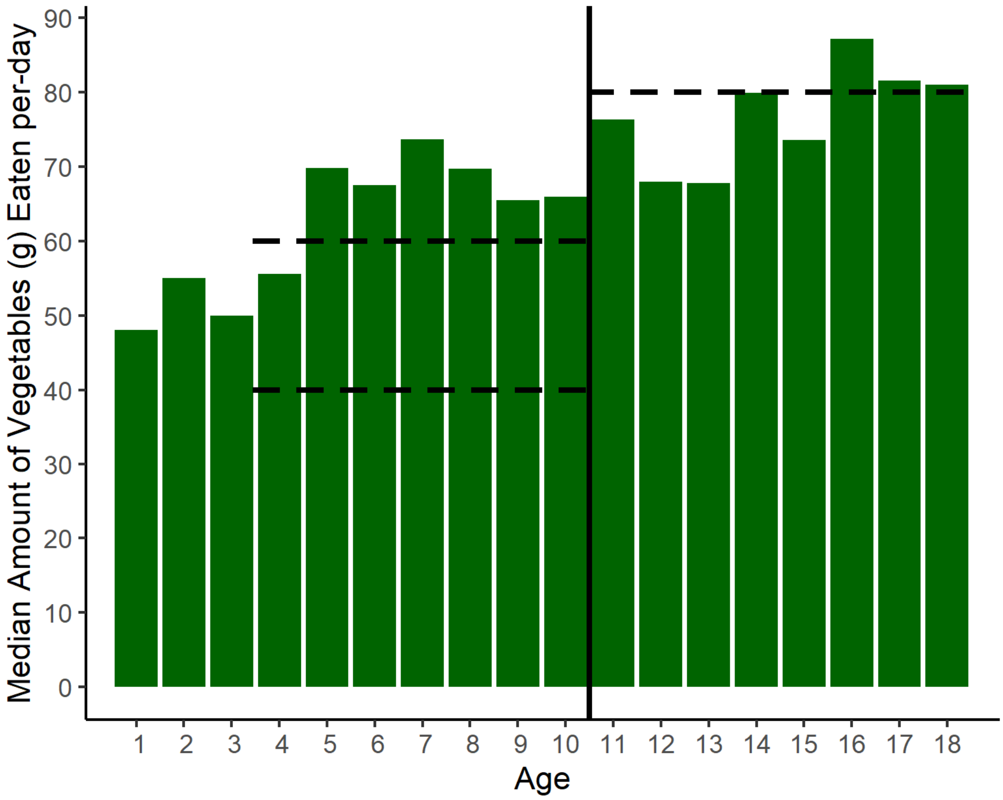
Individual intake of vegetables, average daily absolute counts and average daily weight (g) of vegetables consumed were examined. Regression analyses revealed that older children ate fewer absolute counts of vegetables per day, however when they did eat vegetables, they had larger portions. Ethnicity also affected both amount and absolute counts of vegetables eaten, with white British children tending to eat fewer absolute counts of vegetables than BAME children, yet consuming a larger amount of these vegetables per-day. Additionally, vegetarians and vegans (although small in number) ate more vegetables and had a higher intake than those classed as neither and eating a wider variety of vegetable types in general increased both the count and gram intake of vegetables per-day. Lastly, average daily energy intake suggests that children who consume more energy daily generally tend to eat larger amounts of vegetables per-day, although this did not predict counts of vegetables eaten per-day. Gender of the child, season (time of year), year of NDNS survey and number of children in the household did not significantly add to the model and neither did any interaction terms. Table 4.3 shows the model estimates for each predictor on vegetable intake for the individual. Figure 4.1 displays the median amount of vegetables (g) that were eaten per-day for each age group. This suggests that only one portion of vegetables is achieved by children per-day.

Table 4.3. Parameters for linear models predicting average daily absolute counts of vegetables and average daily intake (g) of vegetables consumed.

	Average Daily Absolute Vegetable Count			**Average Daily Vegetable Intake (g)**		
Predictor/Factor	*Estimates*	*std. Error*	*p-value*	*Estimates*	*std. Error*	*p-value*
(Intercept)	-0.17	0.04	<0.001	-3.47	5.75	NS
Age	-0.01	0.00	<0.001	1.89	0.72	0.008
Age^2				0.01	0.04	NS
Ethnicity	*(Reference category White or White British)*					
Asian or Asian British	0.87	0.05	<0.001	-14.48	3.05	<0.001
Mixed Ethnic Group	0.17	0.07	0.023	-14.97	4.11	<0.001
Black or Black British	0.45	0.08	<0.001	-3.79	4.41	NS
Any other Group	0.36	0.10	<0.001	-5.43	5.52	NS
BMI Category	*(Reference category Normal-Weight)*					
Over-Weight	-0.01	0.04	NS	-0.09	2.48	NS
Obese	-0.03	0.04	NS	1.21	2.23	NS
Equivalized Income	0.00	0.00	NS	0.00	0.00	0.001
Parental Employment Status	*(Reference* category *Higher managerial and professional occupations)*					
Lower managerial and professional occupations	-0.05	0.05	NS	-2.65	2.56	NS
Intermediate occupations	-0.14	0.06	0.019	-2.58	3.47	NS
Small employers and own account workers	-0.14	0.06	0.011	4.23	3.21	NS
Lower supervisory and technical occupations	-0.10	0.06	NS	0.63	3.53	NS
Semi-routine occupations	-0.16	0.06	0.006	2.51	3.27	NS
Routine occupations	-0.08	0.06	NS	-3.21	3.46	NS
Never worked	-0.09	0.09	NS	1.87	5.02	NS

Other	-0.07	0.12	NS	-2.44	6.75	NS
Vegetarian or Vegan	*(Reference category Neither)*					
Vegetarian	0.31	0.11	0.005	35.31	6.11	<0.001
Vegan	1.37	0.49	0.006	79.04	27.77	0.004
Vegetable Variety Index	0.41	0.00	<0.001	2.39	0.46	<0.001
Total Vegetable Count				5.03	0.25	<0.001
Average Daily Energy Intake				0.02	0.00	<0.001
Observations	3228			3228		
R^2 / R^2 adjusted	0.811 / 0.810			0.549 / 0.546		
F- Statistic, *p-value*	F(19, 3208) = 726.7, *p*<0.001			F(22, 3205) = 177.5, *p*<0.001		

Figure 4.1. Median amount of vegetables (g) eaten per-day by age group. The vertical centre line divides 4-10 year olds from 11-18 year olds as government recommendations for vegetable portion sizes change from 40-60g (4-10 year olds) to 80 g for 11-18 year olds indicated by the horizontal dashed lines.



4.3.2 Frequency of vegetable consumption

Table 4.4 reports the frequency (with percentage of total absolute counts) that vegetables were eaten by location, with whom eating occurred and time of day. It also reports the number of EOs that included vegetables and the total number of EOs for comparison. Vegetables were consumed mostly at home, with family members at typical dinner (5pm to 8pm) and lunch (12pm to 2pm) times. School (and workplace) was the location with the second highest intake of vegetables, although intake was far less frequent than that at home. Vegetables were generally not eaten on the go, at food outlets or at places of leisure. Children also ate fewer vegetables when eating alone or with other children and at times of the day not associated with lunch and dinner. However, there was a small peak in eating vegetables between 2pm to 5pm, in the transition period between typical lunch and dinner times.

Table 4.4. Total number of absolute counts and total eating occasions (and percentage of the total) that vegetables were consumed by location, who the child was eating with and time of day.

	Absolute count of Vegetables Eaten (%)		Number of Eating Occasions including Vegetables (%)		Total Number of Eating Occasions (%)	
Location						
Home	42343	(77.00%)	17869	(71.31%)	85104	(68.39%)
Leisure	283	(0.51%)	173	(0.69%)	1947	(1.56%)
Food Outlet	1714	(3.12%)	888	(3.54%)	3349	(2.69%)
On the Go	690	(1.25%)	371	(1.48%)	6014	(4.83%)
School/Workplace	6283	(11.43%)	3959	(15.80%)	18394	(14.78%)
Other	3676	(6.68%)	1799	(7.20%)	9628	(7.74%)
Who with						
Alone	2679	(4.87%)	1291	(5.15%)	15220	(12.23%)
Parents only	11542	(20.99%)	5043	(20.12%)	25449	(20.45%)
Children only	2346	(4.27%)	1133	(4.52%)	7950	(6.39%)
Friends only	6207	(11.29%)	3767	(15.03%)	19827	(15.93%)
Multiple groups – Family and Friends	28066	(51.04%)	11690	(46.65%)	41188	(33.10%)
Other	4149	(7.55%)	2135	(8.52%)	14802	(11.90%)
Time of Day						
6am to 8:59am	367	(0.66%)	279	(1.11%)	17500	(14.06%)
9am to 11:59am	1847	(3.36%)	1223	(4.88%)	20794	(16.71%)
12 noon to 1:59pm	12451	(22.64%)	6752	(26.94%)	23753	(19.09%)
2pm to 4:59pm	6743	(12.26%)	3132	(12.50%)	21049	(16.92%)
5pm to 7:59pm	29597	(53.82%)	12198	(48.68%)	29173	(23.44%)
8pm to 9:59pm	3675	(6.68%)	1359	(5.42%)	10030	(8.06%)
10pm to 5:59am	309	(0.56%)	116	(0.46%)	2137	(1.72%)
Total Counts	**54989**		**25059**		**124436**	

4.3.3 Predictors of Portion size (g) of consumed vegetables

To examine if environmental features influenced portion sizes of vegetables (g) at each EO, predictors were entered into a linear multi-level model as fixed factors, with the individual as a random factor. The model shows that the average portion size of vegetables (when they are eaten) is 40 g. It is demonstrated that larger portion sizes of vegetables are eaten as the child becomes older, when vegetables are eaten at home and at the weekend. Total vegetable portion sizes are 20-40 g smaller outside of the home depending on location, even at school. Children ate larger portions of vegetables at typical evening meal times between 5pm to 8pm and vegetable portions were also slightly larger if the child ate a wider variety of vegetables over the NDNS diary period. Interactions between age and location, age and with whom vegetables were eaten as well as age and time of day all significantly improved the model and so were retained in the final model. Gender and BMI category did not add to the model to predict vegetable portion sizes. Overall, 82% of the variance explained by the model is due to within person variation, suggesting that vegetable portion sizes vary little between children, but vary to a larger degree within an individual based on the context of the eating situation. The final model with all predictors and interactions is presented in Table 4.5.

Table 4.5. Results of analysis of variance by Satterthwaite's method, and parameters from multilevel modelling for portion sizes of Vegetables.

			Portion size of Vegetables (g) in EO				
Predictor/Factor		*F-Test, p-value*	*Estimates*	*std. Error*	*CI*	*t-Statistic*	*p-value*
(Intercept)			40.66	7.30	26.35 – 54.97	5.57	*<0.001*
Age		F(1, 5202) = 11.70, *p<0.001*	2.43	1.41	-0.33 – 5.19	1.72	NS
Week Day	*(Reference category Mon-Fri)*	F(1, 12327) = 9.31, *p=0.002*					
Weekend			4.36	1.43	1.56 – 7.16	3.05	*0.002*
Location	*(Reference category Home)*	F(5, 12243) = 28.40, *p<0.001*					
Place of leisure			-41.43	8.53	-58.14 – -24.72	-4.86	*<0.001*
Food Outlet			-24.50	3.50	-31.36 – -17.63	-6.99	*<0.001*
On the Go			-37.55	5.25	-47.85 – -27.26	-7.15	*<0.001*
At School/Work			-23.54	3.09	-29.59 – -17.48	-7.62	*<0.001*
Other			-3.00	2.63	-8.15 – 2.15	-1.14	NS
Who with	*(Reference category Alone)*	F(5, 12192) = 4.94, *p<0.001*					
Parents Only			7.10	4.46	-1.65 – 15.85	1.59	NS
Children Only			6.93	4.89	-2.64 – 16.51	1.42	NS

Friends Only			-7.10	5.04	-16.99 – 2.78	-1.41	NS
Multiple Groups- Family and Friends			6.33	4.27	-2.05 – 14.70	1.48	NS
Other			1.27	4.85	-8.23 – 10.77	0.26	NS
Time of Day	*(Reference category 6am to 8:59am)*	F(6, 12315) = 5.77, *p<0.001*					
9am to 11:59am			15.36	6.33	2.96 – 27.77	2.43	*0.02*
12 noon to 1:59pm			11.07	5.92	-0.52 – 22.67	1.87	NS
2pm to 4:59pm			11.22	5.96	-0.46 – 22.91	1.88	NS
5pm to 7:59pm			18.05	5.81	6.66 – 29.43	3.11	*0.002*
8pm to 9:59pm			9.21	6.38	-3.31 – 21.72	1.44	NS
10pm to 5:59am			-10.24	14.29	-38.26 – 17.77	-0.72	NS
Day Energy intake (kcal)		F(1, 9351) = 53.71, *p<0.001*	0.01	0.00	0.01 – 0.01	7.33	*<0.001*
Vegetarian Or Vegan	*(Reference category Neither)*	F(2, 2945) = 5.38, *p=0.005*					
Vegetarian			21.19	6.56	8.32 – 34.05	3.23	*0.001*
Vegan			28.34	48.05	-65.83 – 122.51	0.59	NS
Vegetable Variety (count eaten)		F(1, 2425) = 68.99, *p<0.001*	1.95	0.24	1.49 – 2.41	8.31	*<0.001*
Weight (g) of Carbohydrates in EO		F(1, 12356) = 2.62, NS	0.01	0.01	-0.00 – 0.03	1.62	NS
Weight (g) Dairy in EO		F(1, 12174) = 0.00, NS	0.00	0.02	-0.04 – 0.04	0.02	NS

Weight (g) Fruit in EO	$F(1, 12324) = 6.06$, *p=0.01*	-0.04	0.02	-0.08 – -0.01	-2.46	*0.01*
Age x Location	$F(5, 12269) = 5.74$, *p<0.001*					
Age-Leisure		-3.16	1.56	-6.21 – -0.11	-2.03	*0.04*
Age-Food Outlet		-1.01	0.64	-2.26 – 0.23	-1.60	NS
Age-On the Go		-2.98	1.02	-4.98 – -0.98	-2.91	*0.004*
Age-School		-2.68	0.56	-3.78 – -1.57	-4.76	*<0.001*
Age-Other		-0.76	0.53	-1.80 – 0.29	-1.42	NS
Age x Who with	$F(5, 12171) = 2.09$, NS					
Age-Parents Only		-0.40	0.72	-1.81 – 1.02	-0.55	NS
Age-Children Only		-0.66	0.87	-2.37 – 1.05	-0.75	NS
Age-Friends Only		-1.82	0.83	-3.44 – -0.20	-2.20	*0.03*
Age-Multiple Groups- Family and Friends		-0.26	0.69	-1.62 – 1.09	-0.38	NS
Age-Other		-1.31	0.80	-2.88 – 0.26	-1.64	NS
Age x Time of Day	$F(6, 12311) = 3.69$, *p=0.001*					
Age-9am to 11:59am		3.48	1.36	0.82 – 6.13	2.57	*0.01*
Age-12 noon to 1:59pm		1.65	1.29	-0.88 – 4.18	1.28	NS
Age-2pm to 4:59pm		1.63	1.30	-0.92 – 4.18	1.25	NS
Age-5pm to 7:59pm		2.59	1.27	0.09 – 5.08	2.03	*0.04*

Age-8pm to 9:59pm		2.24	1.36	-0.43 – 4.92	1.65	NS
Age-10pm to 5:59am		2.88	2.33	-1.68 – 7.44	1.24	NS
Age x Vegetarian or Vegan	F(1, 2284) = 0.86, NS					
Age-Vegetarian		1.03	1.11	-1.14 – 3.20	0.93	NS
Age x Weight (g) Fruit in EO	F(1, 12344) = 1.30, NS	-0.00	0.00	-0.01 – 0.00	-1.14	NS
Random Effects						
σ^2		3887.61				
$\tau_{00\ participants}$		863.78				
ICC		0.18				
$N_{participants}$		3071				
Observations		12385				
Marginal R^2 / Conditional R^2		0.154 / 0.308				

EO = Eating Occasion.

4.3.4 Food groups as predictors of vegetable presence

To explore whether certain food groups and combinations of food groups predict vegetable presence (or absence) within an EO, each EO was classed as either including vegetables or not. All other food groups were likewise classed as either being present in the meal or not and were used as binary predictors of vegetable presence in the meal. Table 4.6 presents findings from a multi-level logit regression model and reports odds ratios of vegetables being present for each combination of food groups in an EO. The results illustrate that all food groups alone (carbohydrates, protein, dairy, fruit, and HFSS items), without further information of other combinations of food groups present, predicted a lower odds of vegetables being present within the EO. However, for different combinations of these food groups, the likelihood of vegetables being present varied. When carbohydrates were eaten together with protein at an EO, it was 12 times more likely that vegetables were present. Similarly, combinations of protein with dairy and carbohydrates with fruit predicted a higher odds of vegetables being present. In contrast, some combinations predicted the absence of vegetables. EOs that included HFSS food items unaccompanied by a carbohydrate or protein were 33 times less likely to contain a vegetable. Together, combinations of food groups and individual variability between children explains 57% of the variance in the model for when vegetables are likely to be present. Of this variance explained by the model, 87% is due to within person variation, suggesting that combinations of food groups that predict the presence (or absence) of vegetables vary little between children. There is a larger degree of variation within individuals based on the different food groups eaten.

Table 4.6. Results of analysis of deviance with Type II Wald chi-square tests method, and parameters from multilevel logit modelling for whether vegetables are included in the eating occasion or not.

		Odds of EO Including Vegetables					**EO Counts**
Predictors	χ^2 – Tests, p-value	*Odds Ratios*	*std. Error*	*CI*	*Wald Statistic*	*p-value*	*EO Count (with vegetables)*
(Intercept)		0.54	0.15	0.40 – 0.72	-4.25	*<0.001*	
EO Contains Carbohydrates	$\chi^2(1) = 868.31$, *p<0.001*	0.18	0.15	0.14 – 0.24	-11.49	*<0.001*	36,310 (10,775)
EO Contains Protein	χ^2 (1) = 5738.96, *p<0.001*	0.82	0.15	0.60 – 1.11	-1.30	NS	20,339 (9,199)
EO Contains Dairy	χ^2 (1) = 307.82, *p<0.001*	0.11	0.18	0.08 – 0.16	-12.07	*<0.001*	9,049 (2,825)
EO Contains HFSS	χ^2 (1) = 217.67, *p<0.001*	0.73	0.04	0.68 – 0.79	-8.28	*<0.001*	26,942 (3,298)
EO Contains Fruit	χ^2 (1) = 40.15, *p<0.001*	0.04	0.17	0.03 – 0.05	-19.49	*<0.001*	12,037 (1,871)
EO Contains Carbohydrates and Protein	χ^2 (1) = 92.82, *p<0.001*	12.85	0.16	9.42 – 17.54	16.08	*<0.001*	17,288 (8,217)
EO Contains Protein and Dairy	χ^2 (1) = 256.71, *p<0.001*	16.77	0.21	11.01 – 25.55	13.13	*<0.001*	3,709 (1,797)
EO Contains Carbohydrates and Fruit	χ^2 (1) = 101.65, *p<0.001*	28.51	0.18	20.06 – 40.52	18.68	*<0.001*	4,789 (1,582)
EO Contains Carbohydrates and Dairy but not Protein	χ^2 (2) = 394.93, *p<0.001*	36.76	0.19	25.51 – 52.99	19.33	*<0.001*	3,033 (935)

EO Contains Carbohydrates, Dairy and Protein		0.56	0.13	0.44 – 0.72	-4.61	*<0.001*	3,287 (1,612)
EO Contains HFSS but not Carbohydrates or Protein	χ^2 (3) = 468.02, *p<0.001*	0.03	0.17	0.02 – 0.04	-21.39	*<0.001*	15,642 (188)
EO Contains HFSS and Carbohydrates but not Protein		0.99	0.06	0.87 – 1.12	-0.16	NS	5,387 (659)
EO Contains HFSS and Protein but not Carbohydrates		1.04	0.10	0.85 – 1.27	0.37	NS	860 (257)
EO Contains Protein and Fruit but not Carbohydrates	χ^2 (2) = 253.93, *p<0.001*	24.85	0.21	16.58 – 37.24	15.57	*<0.001*	424 (150)
EO Contains Protein, Fruit and Carbohydrates		0.76	0.08	0.65 – 0.89	-3.41	*<0.001*	2,484 (1,149)
	Random Effects						
σ^2		3.29					
$\tau_{00\ participant}$		0.50					
ICC		0.13					
$N_{participant}$		3256					
Observations		61749					
Marginal R^2 / Conditional R^2		0.509 / 0.573					

EO = Eating Occasion, EO Count = Total number of eating occasions with this combination and with vegetables. HFSS = Foods high in fats, sugar and salt (e.g. puddings, pastries, sweets, biscuits, crisps, savoury items and chocolate).

4.4 Discussion

This study conducted secondary analyses of the UK NDNS dataset years 1-9 to investigate predictors of vegetable intake in children and adolescents. Findings indicate that daily vegetable intake (g) is predicted by age, ethnicity and variety of vegetables eaten. These vegetables are most often consumed at home, with family members and at times that are usually associated with meals in the evening (5pm-8pm) and early afternoon (12pm-2pm). When vegetables are eaten, they are rarely eaten alone, do not often meet recommended portion sizes and are likely to be eaten alongside foods that are carbohydrates and proteins, but much less likely to be eaten alongside foods that are high in fats, sugars and salt.

Age was an important predictor of both daily intake and portion sizes of vegetables, indicating that older children tend to eat larger amounts of vegetables than younger children. The median amount of vegetables (g) eaten per-day for each age group was only enough weight to equal one vegetable portion. This was found again when examining portion sizes of vegetables when they were eaten at a single EO. The intercept for vegetable portion size per EO was between 26-55g and estimates of portion size increased by 2-3g for each additional year of age. This suggests that on average, only enough weight for one vegetable portion was eaten at an EO, and this portion is likely to be the only portion consumed per-day. It is also important to note that portion sizes in this study were cumulative of all vegetables eaten within the EO, and not for each vegetable served, meaning that this portion may be comprised of multiple vegetable types. Therefore, not enough variety of vegetables are consumed by children, as well as amount, to meet recommendations for daily intake.

Government recommended vegetable portion sizes for children vary by age, body size, activity levels and the food type. For 4-10 year olds, the guidelines are between 40-60g for a portion of raw or cooked vegetables, and 80g for 11-18 year olds (Public Health England, 2018b). Although between the ages of 3 and 18 years we observe an estimated 45g increase in vegetable intake at an EO, we did not observe an increase of 40 (g) in portion size for children between 10 and 18 years (the age at which the portion size recommendation changes). This suggests that although older children ate a larger amount of vegetables, this was rarely at the recommended level.

However, due to the observational nature of the data, it cannot be commented whether vegetable intake was low because serving sizes were small, or whether serving sizes were larger but not eaten, therefore producing wasted or left-over food.

Individual food groups were good predictors of whether vegetables were eaten or not. We found that vegetables were less likely to be eaten alongside HFSS foods, ingredients associated with high palatability. This is consistent with previous research interventions which have suggested that vegetables were often not eaten due to competition from other foods (Harnack et al., 2012; Ishdorj et al., 2015; Osborne & Forestell, 2012). However, it does not explain why vegetables are more likely to be eaten with carbohydrates and proteins. It is possible that the configuration of different foods together either increases or decreases vegetable intake. As the majority of vegetable intake comes from composite meals made of several foods (O'brien et al., 2003), a finding that we replicate in this study, certain flavours or textures may enhance vegetable intake or vegetable taste in meals (Meinert, Frøst, Bejerholm, & Aaslyng, 2011) (e.g. by masking or enhancing the taste utilising food-food interactions), and decrease intake in other meals (Hoppu, Puputti, & Sandell, 2021) (e.g. because other foods are more palatable). Whilst it is not possible to provide evidence for this explanation using diary data, in future research it may be important to consider the potential competition of other food groups present when promoting vegetable intake by children. However, a further explanation for these food groups being commonly eaten together is due to cultural habit. This is regarding how meals are constructed in the UK and how parents present foods to their children within familiar meals, recipes and composite foods. If children are not presented with vegetables alongside fruit, or HFSS foods, then children may never have the opportunity to eat these foods together, which may be reflected in these findings.

Vegetable portion size was predicted by EOs occurring in the early evening, which is likely because the evening is when the majority of daily energy intake is consumed (Diederichs, Perrar, Roßbach, Alexy, & Buyken, 2018). Vegetables might also be eaten more often within meals as part of a planned and prepared meal (Monsivais, Aggarwal, & Drewnowski, 2014). This was evident as vegetables were eaten alongside cooked items high in carbohydrates and proteins (e.g. pasta, potatoes, meats, fish). Additionally, vegetables were rarely eaten at other times of day or on their own, suggesting that vegetables are not usually eaten as snacks. Overall, vegetable intake appears to require planning since they need to be prepared, chopped, peeled and cooked. Since preparation takes time, and parents are often responsible for children's intake, the time available for parents to prepare these foods may be in the early evening, after the child's school and parental work commitments (Monsivais et al., 2014). This may also partly explain the weekend effect, why more vegetables were eaten on the weekend compared to weekdays, as there may be more time available for planning and preparation of meals. However, this does not explain smaller vegetable portion sizes at school.

Interestingly, although the proportion of meals including vegetables at school was similar to that at home (20% of total EOs at school included a vegetable), vegetable portion size during EOs in school was much lower than that at home. Given the limited opportunities to eat at school (mainly lunch and break times), this could mean that children do not have the opportunity to eat vegetables at schools, either through packed lunches (Evans et al., 2010) or school meals (Prynne et al., 2013), or that children do not eat vegetables served to them at school (Upton, Upton, & Taylor, 2013). Certain age groups are supported in the UK for food intake, such as free school meals for 4-6 year olds. The UK also has a school F&V scheme (NHS-England, 2018) where 4-6 year olds are entitled to a free piece of fruit or vegetable per day. Yet, we found little evidence of eating recommended portion sizes of vegetables at school. One reason for this could be that these schemes are not available to all age groups, though it is important for all age groups to eat F&V regularly. Secondly, fruit is selectively chosen when F&V are offered in class (Ransley et al., 2007). Therefore, simply offering vegetables to children as a snack at school is not enough to encourage intake and this may need to occur alongside a tailored intervention (Appleton et al., 2016; Evans et al., 2012; Nekitsing, Blundell-Birtill, et al., 2018).

Eating vegetables mostly at home in the early evening accords with findings associating dietary quality with family mealtimes (Gillman et al., 2000) and children eating the same foods as their parents (Sweetman et al., 2011). We found that vegetable consumption occurred mostly with family, including parents and multiple groups of family members and friends. Given that vegetable portion sizes generally increased with family members present compared to eating alone, this illustrates the importance of social learning (Pedersen et al., 2015; Suggs, Della Bella, Rangelov, & Marques-Vidal, 2018). Suggs et al. (2018) also found that most vegetable intake for Swiss children occurred at home during family meals using seven-day food diaries. Their conclusion was that eating was better for children at home with the family, meaning that this location has a positive influence on children's eating behaviours and diet. As children spend much of the day at school and parents have many other responsibilities such as work, this conclusion could add further responsibility onto the parents to provide all recommended portions of vegetables for children per-day. Since our findings suggest that vegetables are mainly eaten at mealtimes, this means that children would have to eat at least three recommended portions of vegetables in one sitting (assuming the other two portions are fruit and eaten outside of mealtimes). Yet, we found that only enough for one portion of vegetables is usually eaten at a single EO. Therefore, promoting vegetable intake outside of family evening mealtimes, such as at breakfast, as snacks and in schools at lunch times (where average portion size intake is lower than at home) could be an appropriate solution. Furthermore, if child preference is for smaller vegetable portion sizes (Colapinto, Fitzgerald, Taper, & Veugelers, 2007), eating vegetables in small portions throughout the day may be a more suitable alternative for children, than having all recommended portions in one meal.

For children under 10 years, the importance of context for eating F&V has previously been highlighted within the NDNS dataset (Mak et al., 2012). However, differences between the current and previous study are likely due to inclusion of fruit intake. Findings from Mak et al. (2012) show that fruit intake is more likely to occur outside of the home, meaning that there may be different contexts for eating F&V. As we found no clear relationship of eating F&V together, there is reason for assessing intake of these foods individually. Fruit is often eaten at different times, including as a snack or after meals as dessert (Zellner & Cobuzzi, 2016), but generally not within composite meals (O'brien et al., 2003). Therefore, it has been suggested that fruits could be targeted separately from vegetables in national campaigns (Glasson, Chapman, & James, 2011). This may help to promote the importance of increasing amounts of vegetables eaten daily, as fruit intake is usually higher than vegetable intake in children (Kim et al., 2014). Few countries, such as Australia and Netherlands have implemented this separate message with ‘Go for 2 & 5’ and ‘2+2’ campaigns respectively.

4.4.1 Strengths

A multiple perspective approach to examining vegetable consumption patterns in children was taken. Previous studies have highlighted numerous predictors of vegetable intake, but seldom use national dietary data to observe eating habits further than asking whether children meet the five-a-day guidelines. The current study not only looked at average intake and absolute counts of vegetables eaten per-day as predicted by demographic factors, but also examined the effects of environmental context on portion size and food groups that are eaten together. This is important because child healthy eating is complex and multifaceted and by taking this approach, we can observe another viewpoint of what vegetables children are habitually eating and when.

As a large amount of data was available using the UK NDNS, the statistical models were built on one set of data and then tested on another sample of participants. This reduces the exploratory nature of the research and allows confirmation of models rather than a single exploratory analysis. In particular, this is useful because the EO analyses for vegetable portion sizes initially showed that some food group weights (e.g. the weight (g) of carbohydrates, dairy and fruit in the EO) were found to add to the model, but this was not confirmed in the test dataset. This means that there is either a small or no effect of amounts of other foods groups eaten on vegetable portion sizes eaten. Nonetheless, in the logit models, it shows that these food groups do matter for whether any vegetables are eaten or not.

4.4.2 Limitations

The limitations of using food diaries and estimated intake have been noted extensively elsewhere (Dhurandhar et al., 2015). Estimates of energy intake may be both under and over-estimated. However, the current study attempts to limit this problem by examining counts of vegetables eaten and which food groups were present at EOs. Even if portion size estimates are not accurate, they are supplemented by counts of whole foods and whole food groups. Whilst this mitigates against the limitations of dietary diaries, exploring food groups also introduces its own constraints. Many foods cannot be sorted into groups that are agreed upon. For example, nuts and seeds are sometimes grouped with fruits, and other times with protein (Agudo, 2005). Thus, configurations of food groups could be ambiguous, as some foods within the food group may be better predictors of vegetable intake than others. Furthermore, whilst large-scale diary data is useful for information regarding what children eat (and sometimes how they eat), it is not helpful to answer questions relating to why children are eating particular foods or meals. Research questions regarding choice and palatability of preferred foods cannot be answered and therefore explanations for why children eat certain foods together and in specific contexts are limited.

4.4.3 Future research

Ethnicity predicted that higher counts of vegetables are eaten per-day by non-white children, which may relate to cultural recipes for meals and ingredients used. The study also shows that there are multiple opportunities to increase vegetable intake throughout the day. When looking to different cultures, traditional breakfasts in Asian countries tend to include rice, noodles or soup in the morning complemented by vegetables (Howden et al., 1993). Therefore, future research could investigate increasing vegetable intake outside of home evening meal times by encouraging eating vegetables at breakfast and snack times, as well as in smaller portions throughout the day.

4.5 Conclusion

This study examined children's vegetable intake using the UK NDNS years 1-9. It was found that daily vegetable intake was predicted by age, ethnicity and variety of vegetables eaten. When vegetables are eaten, they are usually consumed at home, with family members and at evening meals. Portion sizes of vegetables were often smaller than recommended, and vegetables were rarely eaten alone. Vegetable presence within an EO was predicted by other food groups present, such as carbohydrates and proteins, whereas foods high in fats, sugars and salt predicted absence of vegetables. Future research may investigate different contexts and opportunities to eat vegetables, whilst considering other foods available, such as eating vegetables with less "competitive" palatable foods, offering them at breakfast and as snacks.

Chapter 5

An online study examining children's selection of vegetables at mealtimes: The role of meal contexts, variety and liking

Chapter 5 An online study examining children's selection of vegetables at mealtimes: The role of meal contexts, variety and liking

Abstract

Associative learning predicts that children expect to eat vegetables together with foods high in carbohydrate and protein at mealtimes. However, choosing to eat and consume vegetables may be less likely if they are presented alongside more palatable, competing foods. This study examined food choices of children (N = 180, 8-11 years, 84 female) in a mealtime context. During an online task, children chose one food for a meal, from a choice of vegetables and either a food high in carbohydrate or protein. Preference was assessed with and without a partial meal stimulus, to test the effect of other foods on the plate. Vegetables were selected more often with a meal stimulus, especially when it consisted of carbohydrate and protein foods, meaning that the vegetable option added nutritional variety to the meal. This effect was moderated by the difference in liking between the food options available. Vegetables were selected more if they were better liked than the competing food option, although it was not necessary that vegetables were better liked if they added nutritional variety to the meal. Food fussy children were less likely to select vegetables, but no other effects of child appetitive traits or parental practices were found on children's food choices. Children may be more likely to select vegetables if they add nutritional variety to a meal and are similarly or better liked than competing food options. Future research could test specific meal configurations which promote children's selection and intake of vegetables at mealtimes.

5.1 Introduction

The home and school environments, including practices at mealtimes and social norms, can help to shape school age children's food preferences and their ability to self-regulate food intake (De Wit et al., 2015; Pedersen et al., 2015; Sharps & Robinson, 2015). This means that although parents and schools are the main providers of food to children, determining the types of food available and their quantities (Ventura & Birch, 2008), children are also able to control which of the available foods they will eat and how much (Warren, Parry, Lynch, & Murphy, 2008). At mealtimes, it is recommended that a balanced meal consists of foods high in protein and carbohydrates, with half a plate of vegetables (Public Health England, 2018). However, children often refuse to consume vegetables in recommended portion sizes due to their appearance or lack of familiarity (Appleton et al., 2018; Houston-Price et al., 2009), bitter (e.g. dark-green vegetables)(Bell & Tepper, 2006) or bland (e.g. cauliflower)(Zeinstra et al., 2018) tastes, varying textures (Farrow & Coulthard, 2018), low energy density (LED) or the availability of more palatable foods (Gibson & Wardle, 2003). This often results in large amounts of plate waste (Marlette, Templeton, & Panemangalore, 2005; Martins, Rodrigues, Cunha, & Rocha, 2020). Therefore, to reduce plate waste, improve children's dietary variety and vegetable intake, there is a need to understand how and why children make choices regarding what to eat at mealtimes.

Previous research examining how to promote healthy eating choices in children has often presented food options differing in energy density, with 'less healthy' food items (high energy dense: HED, often high in fats, sugar and salt) being offered alongside 'healthier' items (LED, often fruits and vegetables), usually as snack or single food (Pearce et al., 2020). The use of simple heuristics facilitates decision making in this context, with the child using only information that is most valuable to them (Rangel, 2013; Schulte-Mecklenbeck, Sohn, de Bellis, Martin, & Hertwig, 2013). Consequently, taste is a strong predictor of food selection in children, overriding cognitive aspects of choice such as the healthiness of foods (Nguyen, Girgis, & Robinson, 2015). When children are hungry, neural food cue reactivity is heightened, especially to HED foods (Charbonnier et al., 2018). Therefore, choosing a HED food may be driven by the desire to eat a specific food (Pearce et al., 2020) and attempting to change this behaviour to selecting healthier food options may be challenging, as this requires inhibitory control by the child (Ha et al., 2016; Pearce et al., 2020).

Individual differences between children further predict habitual food consumption. Children with traits of fussy eating or food neophobia are less likely to consume vegetables or seek a variety of foods (Dovey et al., 2008; Lafraire, Rioux, Giboreau, & Picard, 2016). Conversely, children with high enjoyment of food are found to have larger consumption of fruits and vegetables

(Cooke et al., 2004), as are those that are variety seekers (purposefully choosing foods that are different, or from a different food group) (Nicklaus et al., 2005). However, these traits have seldom been researched in relation to children's food choice (Chawner & Hetherington, 2021). Although, variety seeking traits may promote diversification when choosing snacks for an entire week all at once, compared with choosing one snack each day of the week (Echelbarger, Maimaran, & Gelman, 2020).

Among many influences on children's food choices for snack items, associative learning theory predicts that children may expect to eat some vegetables within the context of a meal, due to previous mealtime learning and experiences of vegetables being paired with other foods (Birch & Anzman, 2010; Bouton, 2010). Children in the UK consume the majority of their daily vegetable intake at family evening mealtimes, most commonly alongside foods high in protein and carbohydrates (Chawner et al., 2020). Therefore, when promoting the selection of vegetables from available choices, the context of mealtimes and presenting familiar foods together (with varying levels of palatability) may be important. Parents and schools often provide children with choices between foods to eat at mealtimes (Hendy, Williams, Camise, Eckman, & Hedemann, 2009), but little is known about children's selection of foods when offered alongside competing meal items. Allowing children to make some food choices may be beneficial for their intake of certain foods, however offering too many choices and consequently providing meals for children that are different from the rest of the family is often problematic in encouraging healthy eating (Harris, Ria-Searle, Jansen, & Thorpe, 2018; Powell, Farrow, Meyer, & Haycraft, 2017).

There is mixed evidence for whether offering a choice of vegetables affects intake of those vegetables at mealtimes. In a study by Zeinstra, Renes, Koelen, Kok, and de Graaf (2010), children were given a choice of two vegetables before meals and this did not increase consumption or liking of vegetables compared with not having a choice. Yet in a later study, de Wild, de Graaf, Boshuizen, and Jager (2015) showed that offering a choice of vegetables increased intake, but this was mediated by liking for the vegetable. Domínguez et al. (2013) suggested that offering a choice increases vegetable intake compared with not having a choice. To date, it is not known how choice affects children's selection of vegetables alongside competing foods in the context of meals. In addition to flavour, hunger and healthiness of food items, the meal context itself and different configurations of several foods within meals is worthy of investigation for their potential effects on food intake and food choice. When entrées (the main course of a meal) are paired with vegetables, it is reported that food waste may be linked to the palatability of the different foods on the plate (Ishdorj et al., 2015). When a highly palatable food (chicken nuggets) was paired with a less liked vegetable (green beans), there was more waste of the vegetable compared with when the same vegetable was paired with a less palatable/liked entrée (steak fingers) (Ishdorj et al., 2015). This is especially relevant to consider at times that children are required to choose their own foods, such as at school lunchtimes, as many children avoid vegetables when competing or more palatable foods are available (Miller et al., 2015).

In the current study, using an online experiment, children's selection of vegetables was examined when food choices were presented within a Meal Context (a partial meal stimulus was presented and children chose a food option to add to it) compared with No Meal Context (food choices were imagined to be eaten with a meal, but no meal stimulus was presented). When the meal context frames the food choices available, it is hypothesised that children will select a food from a food group that is not present in the stimulus, so that a balance of food groups (nutritional variety) is achieved within the meal. Therefore, vegetables will be chosen more often when vegetables are not part of the meal stimulus. However, when the food groups available to choose from are the same as those presented in the meal stimulus (i.e. there is no nutritional variety available to choose), it is hypothesised that the most liked food will be chosen. Furthermore, we predict that children scoring higher on traits of fussy eating will select vegetables less frequently, compared with children that score higher on measures of enjoyment of food.

5.2 Methods

5.2.1 Participants

Parent and child dyads (N = 180) were recruited online via Prolific (www.prolific.co). Parents were invited to take part if their child was aged between 8-11 years old and the child did not identify as a vegetarian or vegan. To ensure that individuals met these criteria, screening questions in Prolific were used. The sample was restricted to individuals from the UK (due to familiarity with food stimuli used), parents living with their child full-time and with children born between 2009 and 2012. All parents (mothers, n = 119) completed the study along with their child (female, n = 84) and monetary payment of £1.75 (rate: £7.50/hour) was received by parents for completing the study. A further 22 parent-child dyads started the study but did not complete the child part and were therefore not included in any analyses. Ethical approval was received from the University of Leeds Psychology Research Ethics Committee (reference number: PSYC-75). Full sample demographic information is described in Table 5.1.

Table 5.1. Participant Characteristics.

Participant Characteristics.	
Total Parents, Male (%)	180, 61 (33.89)
Total Children, Male (%)	180, 96 (53.34)
Parent Age, Mean (SD) [Range]	39.4 (6.77) [25-64]
Child Age, N (%)	
8	62 (34.45)
9	46 (25.56)
10	44 (24.45)
11	28 (15.56)
Ethnicity of child, N (%)	
White/White British	162 (90.0)
Black/Black British	4 (2.22)
Asian/Asian British	1 (0.56)
Mixed ethnic Group	11 (6.11)
Prefer not to say	2 (1.11)
Household Income, N (%)	
Less than £25,000	35 (19.44)
£25,000 to £49,999	81 (45.00)
£50,000 to £74,999	49 (27.22)
above £75,000	9 (5.0)
prefer not to answer	6 (3.33)
Parental Education, N (%)	
Some High School or Less	14 (7.78)
Some college education	54 (30.0)
Associate Degree (AA) or vocational license	8 (4.44)
Bachelor's degree	64 (35.56)
Graduate or professional degree	40 (22.22)

5.2.2 Study design

The study protocol can be viewed at Open Science Framework (OSF: https://osf.io/5jtbr/?view_only=34705e2f47ea479485eb4a16c67238f6). Questionnaires were completed by parents followed by food choice tasks which children completed. All procedures were conducted online using Gorilla Experiment Builder (www.gorilla.sc) to create and host the study. A mixed, within-between individuals design was used in which children made food choices across conditions and comparisons were made between children. The experiment had two main conditions, food choice with a meal context and food choice with no meal context. In both conditions, children made a choice between two foods. In the meal context condition a partial meal stimulus made up of two different foods was presented to children before they made a choice between two other foods. Children were instructed that they should imagine eating the food choices with the foods in the partial meal stimulus. The no meal context condition did not include a partial meal stimulus, only a choice between two food options (*see section 2.4 stimuli for further detail).* In both conditions, the dependent variable was selection of the vegetable item from the choices presented (binary response, selected or not selected).

Within the meal context condition, a further 2x3 factorial design was implemented to examine predictors for why children made their food choices. Changes were made to the food groups presented in the partial meal stimulus and to nutritional variety (a different food group offered) from the response options (i.e. were the response options from the same food group as the foods in the partial meal stimulus, or was there a different food group in the response options). This had three levels (1. stimulus meal included a vegetable and either protein or carbohydrate – choice options were the same as those food groups in the stimulus; 2. stimulus meal included a vegetable and either protein or carbohydrate - nutritional variety available from the competing food option; and 3. stimulus meal included protein and carbohydrate - nutritional variety available from the vegetable option). The second independent variable was the competing foods that were available. This had two levels (vegetable versus protein; and vegetable versus carbohydrate). See Table 5.2 for combinations of the partial meal stimuli and response options

For each trial, two different foods from different food groups were included in the meal stimulus (from vegetable, carbohydrate and protein) and two different foods from different food groups (one option was always a vegetable) were presented in the response options (although these foods could be from the same food groups as a food in the meal stimulus; see Table 5.2). Lastly, for the no meal context condition, only the competing foods presented changed as there was no meal stimulus in this condition.

Table 5.2. Combinations of the partial meal stimuli (meal context condition only) and response options (both no meal context and meal context conditions), referred to as trial type in the results section. Trial type refers to the three levels of combinations of partial meal stimulus and whether a nutritional variety is available from the response options (detailed in *2.2 Study design*).

Trial type levels	Stimulus same as choice	Stimulus same as choice	Competing food adds variety	Competing food adds variety	Vegetable adds variety	Vegetable adds variety
Food groups in the partial meal stimulus	Veg & CHO	Veg & Protein	Veg & Protein	Veg & CHO	CHO & Protein	CHO & Protein
	↓	↓	↓	↓	↓	↓
Food groups in the response options	Veg vs CHO	Veg vs Protein	Veg vs CHO	Veg vs Protein	Veg vs CHO	Veg vs Protein

Veg = Vegetable, CHO = Carbohydrate, & = Presented together in meal stimulus; VS = Competing to be chosen as the response.

5.2.3 Study procedure

Parents were invited to participate in the study using a tablet or a desktop computer (mobile phones were not permitted due to small screen sizes which failed to show food pictures sufficiently clearly). After parental consent and child assent were confirmed, parents were asked a range of demographic questions about themselves and their child (Table 5.1), how much they perceive their child to like each food stimulus used in the experiment (Visual Analogue Scale: VAS, 0-100) and how often each food is eaten at home (familiarity: 5-point Likert scale ranging from Never to Everyday). Parents were then required to complete the enjoyment of food and food fussiness subscales of the Child Eating Behaviour Questionnaire (CEBQ: Wardle et al., 2001), the restriction and pressure to eat subscales of the Child Feeding Questionnaire (CFQ: Birch et al.,

2001) and the food choice subscale of the Parent Mealtime Action Scale (PMAS-R: Hendy, Harclerode, & Williams, 2016). The food fussiness and enjoyment of food subscales of the CEBQ were comprised of six and four questions, respectively. These scales were included to control for the effects of children's appetitive traits on their food choices. The restriction and pressure to eat subscales of the CFQ were comprised of eight and four questions, respectively. These scales were included to control for the effects of parental feeding practices on children's food choices. Lastly, the food choice subscale from the PMAS-R comprised of four items that measure child involvement in choosing meal items (e.g. the child eats whatever he/she wanted, the child can choose which foods to eat but only from those offered). This scale was included to control for children that have restricted or more open choice of foods to eat at mealtimes.

Parents were then instructed to pass the device to their child. Children were firstly required to confirm their age and how hungry they were feeling on a four-point Likert scale (not at all, somewhat, moderately, extremely). Next, children were requested to complete the food choice task (both no meal context and meal context conditions in a randomised order). After children completed the food choice task, they were asked to rate their liking for each food individually (VAS, 0-100; each food was presented in a randomised order) and comparatively for all foods (ranked liking; each food's initial ranked position was randomised), before being debriefed of the study aims.

5.2.4 Stimuli

Nine foods were used throughout the experiment, with three foods each belonging to the food groups carbohydrates (roasted potatoes, mashed potatoes, and boiled potatoes), proteins (sausages, beef slices and chicken slices) and vegetables (peas, broccoli, and green beans) (see Table 5.3 for estimated nutrient compositions of each food used). These foods were chosen because each food is familiar to UK children and commonly eaten at mealtimes (Chawner et al., 2020; Gregory et al., 2000). Additionally, most combinations of these individual foods are also plausible to be eaten together within a meal (with the possible exception of different types of potato being eaten together). For ease of computer presentation individual food items were favoured over mixed dishes and the choice of meat items to represent protein, are more easily distinguishable than high protein, plant based products (e.g. tofu/soya products). Within food groups, the foods were matched to be as similar as possible in taste, texture, colour and general liking, so that each individual food would have a similar chance of being chosen to be added to the meal. Therefore, no one food was prominent in the meal stimulus or as a choice (e.g. carrots are often liked by children and may have been chosen more often than other vegetables. Carrots are also brighter in colour which may be a further reason to choose this food, as carrots would add visual variety to a meal).

Images of each food used were adapted from the Child Food Atlas-Primary (Foster, Hawkins, & Adamson, 2010) where the median portion size was used. For meal stimuli, composite meal pictures were created from two individual foods belonging to two different food groups (e.g. broccoli and roasted potatoes). Each food and meal stimulus image also included text writing of which individual food or meal stimulus was presented (see Figure 5.1 and Figure 5.2 for example stimuli).

Table 5.3. Estimated nutrient composition and energy content of each food used per 100g (McCance & Widdowson, 2021).

Item	Energy (kcal/100g)	Fat (g/100g)	CHO (g/100g)	Sugars (g/100g)	Protein (g/100g)
Sausages	224	22.1	9.8	1.5	14.5
Chicken	114	1.5	2.0	0.2	23.2
Beef	193	6.3	0.0	0.0	34.0
Mashed Potatoes	102	3.9	15.9	1.0	1.9
Boiled Potatoes	74	0.1	17.5	0.8	1.8
Roasted Potatoes	161	5.7	26.4	1.2	2.6
Broccoli	28	0.5	2.8	1.6	3.3
Peas	79	1.6	10.0	1.2	6.7
Green Beans	26	0.3	4.0	3.0	2.1

Figure 5.1. Illustration of a meal context trial. The example is when carbohydrates and protein are in the partial meal stimulus, and the choices available to add to the meal are a carbohydrate or a vegetable. Fixation points were shown for 250ms and all other stimuli were presented on screen until the participant clicked on the “Next” button or an available response option.

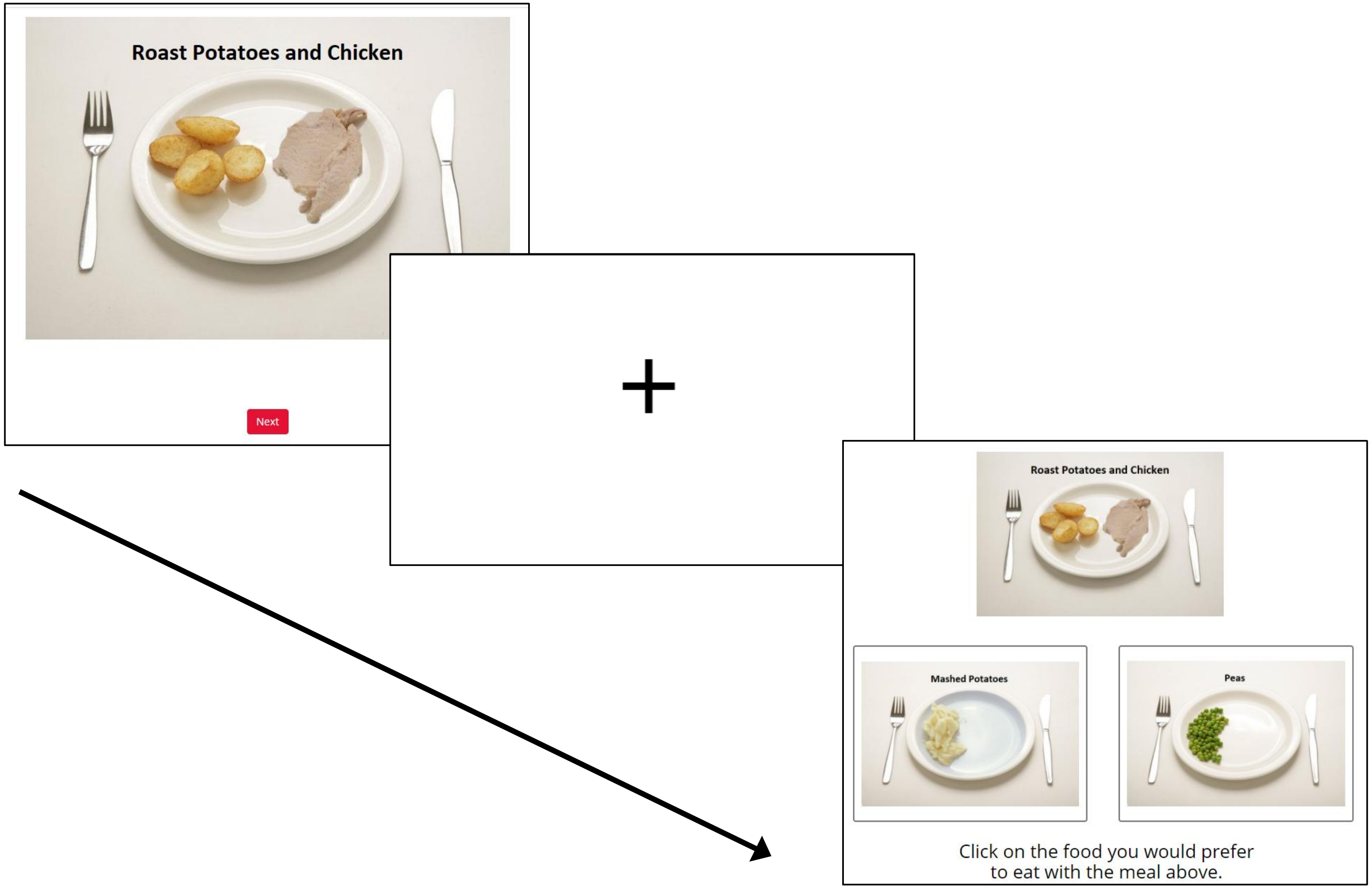
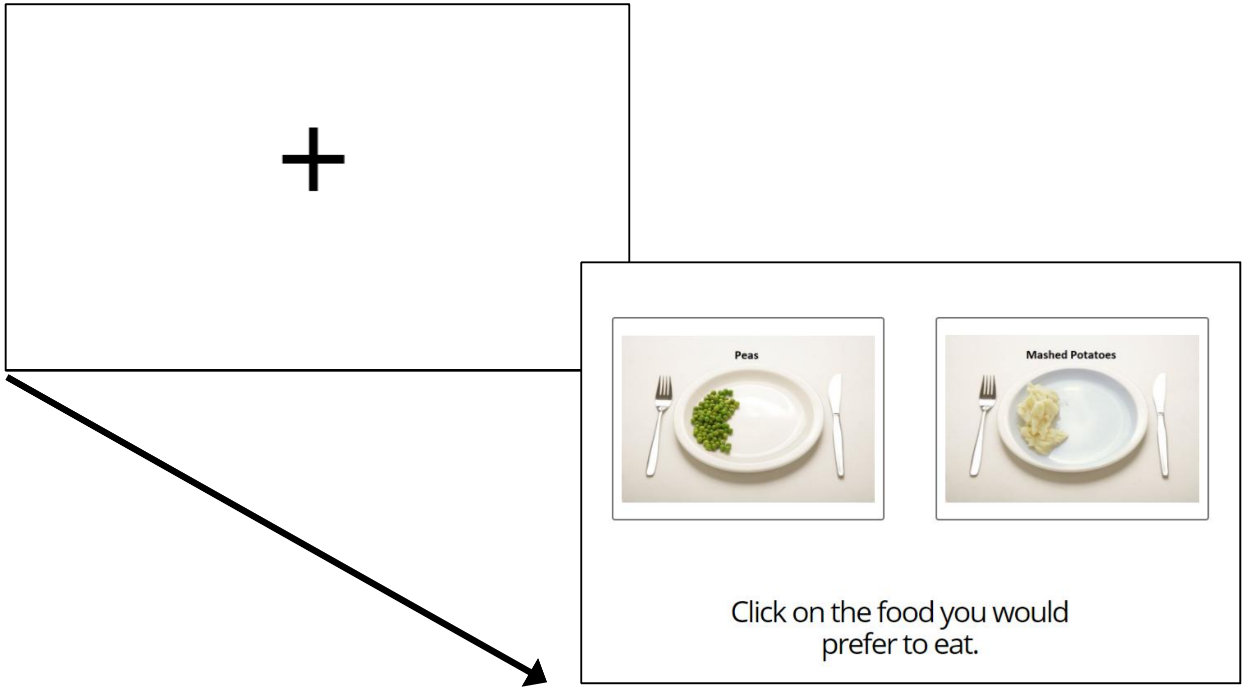


Figure 5.2. Illustration of a no meal context trial. The example is when the choices available to eat at a mealtime are a carbohydrate or a vegetable. No meal stimulus was used in this condition. Fixation points were shown for 250ms and all other stimuli were presented on screen until the participant clicked on the “Next” button or an available response option.



5.2.5 Food choice task

Two parts were included in the food choice task, the no meal context condition and the meal context condition. In the no meal context condition, children were instructed to: “Please imagine that your parent is preparing a meal in the evening. They give you a choice of two foods. You will see two foods side by side. Please click on the food that you would prefer to eat.” The child would then see a fixation cross in the middle of the screen (250ms), followed by two food options that appeared on the left- and right-hand side of the screen. The child was asked to click on the food that they would prefer to eat. For the meal context condition, the wording was changed slightly, adding that the child, “will see a picture of a meal, followed by two foods side by side. Please click on the food that you would most like to eat with the meal shown.” The child was then shown a picture of a partial meal stimulus with two foods. The child was required to click a continue button, before seeing a fixation cross, followed by the meal stimulus and two food choices on the left- and right-hand side of the screen. Children were asked to click on the food that they would choose to eat with the meal presented above.

The same food choices were presented in both conditions, allowing for direct comparisons to be made. The conditions were block randomised (two blocks: no meal context and meal context) as well as randomising individual trials within each condition (six trials per condition). Children were asked to make six food choices per condition (12 choices overall) to reduce the likelihood of demand characteristics, reduced attention of the child and to allow children time to think about their food choices. Children did not complete food choices for every trial or combination of stimuli and responses. Instead, to ensure random presentation of stimuli and response options, all stimuli and responses had an equal opportunity to appear throughout the experiment and children were randomised (and counterbalanced across consecutive dyads using the randomised – balanced node in Gorilla) to receive one of six sets of stimuli. Within these six groups, all stimuli and responses occurred the same number of times. Each individual food was presented as a response a maximum of two times over six trials (vegetables were each presented twice as an option due to being the dependent variable, all other foods were only presented once per condition). This also ensured that any strong preferences for a particular food would not overly affect the outcome.

5.2.6 Food ratings

Children were asked to rate their relative and absolute liking (rank order and VAS) for all nine foods presented. Children were asked to rank each food from their "most favourite" (top) to their "least favourite" (bottom). Each food was also rated for liking on a 100 point-VAS labelled with "I dislike this food" and "I like this food a lot" at opposing ends of the scale. Parents were likewise asked to rate how much they perceived their child to like each food using the same 100 point-VAS.

5.2.7 Statistical analyses

A comparison of the number of times vegetables were chosen (count) between the two main conditions (no meal context and meal context) and between the six groups of children receiving different stimuli, was conducted using Generalised Estimating Equations (GEEs). GEEs were used due to violation of independence for chi-square or regression analyses. GEEs are population averaged (e.g. marginal) models and therefore provide the average effect, rather than the effect for the average person (as multi-level models provide). This method of analysis was chosen as the research question was concerned with comparing groups, rather than level-two individual effects in a multi-level model.

To illustrate differences in liking and familiarity of food options across trials, categories were made for whether the vegetable option was better liked (3 categories: VAS difference > 5 = vegetable is more liked, < -5 = vegetable is less liked, else = both foods are liked the same) and whether the vegetable option was more familiar (3 categories: the vegetable option was offered/eaten most frequently at home = vegetable most familiar, the frequency eaten for both foods was the same = same familiarity, the vegetable option was less frequently eaten = vegetables less familiar).

Parents rated how much they perceived their child to like each food so that comparisons could be made between parental perceptions and children's own liking ratings. Therefore, Pearson's correlations were conducted for ratings of liking for each food (Appendix A1).

We further explored children's specific food choices using two multi-level models – one for each condition (no meal context and meal context). In both models we predicted children's selection of the vegetable option (outcome), with participant as a random factor. The child's age and sex, trial type (see Table 5.2), difference in liking (between the vegetable option and competing option: VAS rating for vegetable option – VAS rating for competing option), vegetable familiarity category, hunger level and subscale scores from the CEBQ (enjoyment of food and food fussiness), CFQ (restriction and pressure to eat) and PMAS (many food choices) were entered as predictors. As the outcome was binary, we used the logit model. All questionnaire scores and difference in liking scores (between vegetable and competing foods) were centred and scaled to ensure model convergence and to allow for simpler parameter estimate interpretation. Interaction terms between trial type and difference in liking, vegetable familiarity category and questionnaire subscales were also included in the models. For no meal context and meal context, trial type was analysed differently. This is because there were three trial types in the meal context condition depending on both the meal stimulus, the available responses and which food group added nutritional variety to the meal stimulus (see Table 5.2: Stimulus same as choice, Competing food adds variety and Vegetable adds variety). However, there were only two categories for the no meal context condition because each trial was essentially a choice between either a vegetable versus a protein or carbohydrate food.

Data analyses were conducted using RStudio 1.1.383, with R (version 3.5.2, Eggshell Igloo), tidyverse 1.3.0, lme4 1.1-21, lmerTest 3.1-0, GLMMapadptive 0.8-0, geepack 1.3-2 and sjPlot 2.8.8.

5.3 Results

5.3.1 Descriptive statistics

Sample characteristics presented in Table 5.1 illustrate that most participants were White/White British (N = 162), with a household income of between £25,000 and £49,999 (N = 81) and parents educated to degree level (N = 64). A third of all participating parents were fathers (N = 61) with a close to equal split by child sex (female = 84) and child ages. Parents were asked to complete questionnaire subscales for children's eating traits, parental feeding practices and children's opportunities to choose foods at mealtimes. On average, children in the sample were scored as being moderately fussy on the CEBQ food fussiness subscale (*M* = 2.88 ± 0.87, *Range* = 1-5), but scored higher for enjoyment of food (*M* = 4.09 ± 0.76, *Range* = 1.5-5). From the CFQ, parents, on average, often reported the use of feeding practices that are restrictive (*M* = 3.38 ± 0.85, *Range* = 1-5) and pressure children to eat (*M* = 2.83 ± 0.91, *Range* = 1-5). Lastly, using the PMAS food choice subscale, parents reported that on average their children are often given some choices of the foods that they eat at mealtimes (*M* = 3.03 ± 0.57, *Range* = 1.5-4.75).

5.3.2 Hunger

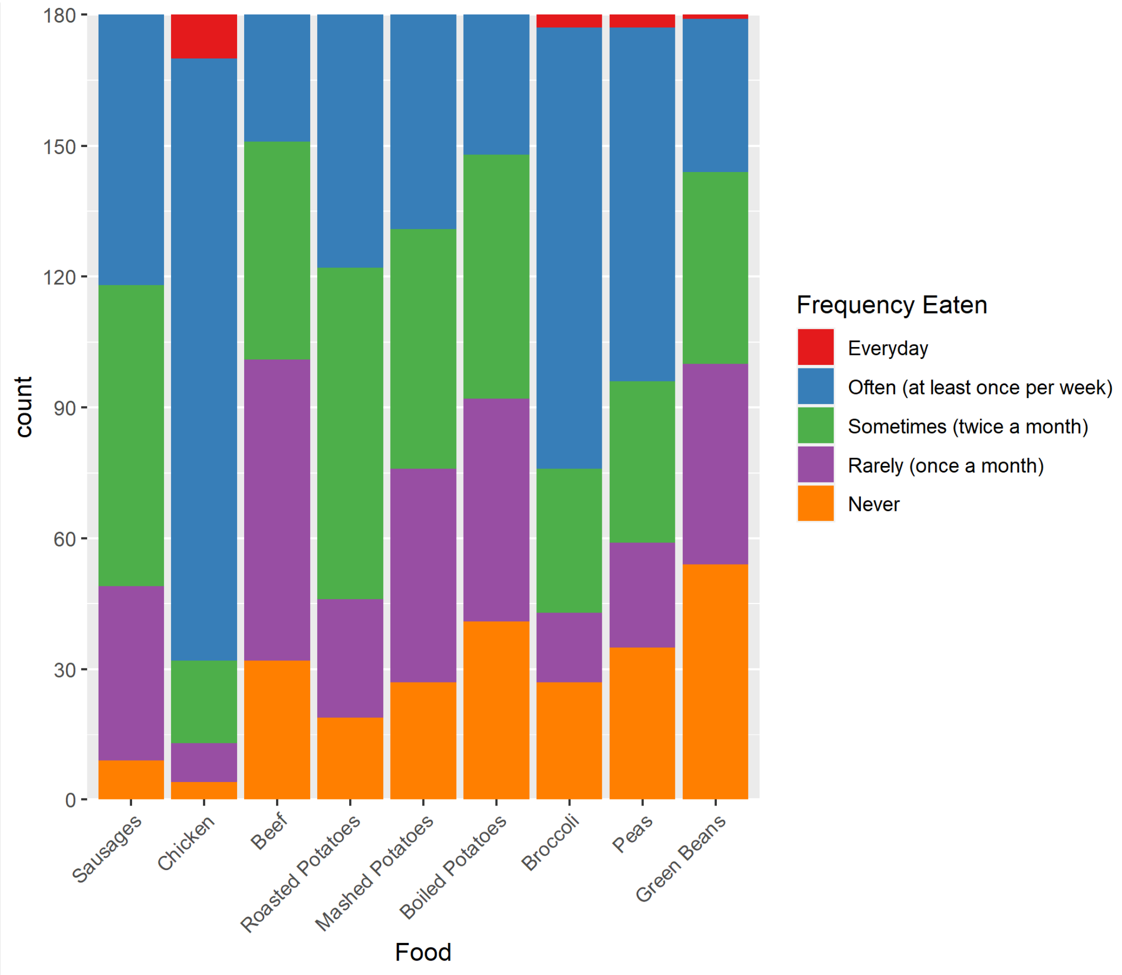
Before completing the food choice tasks, most children reported that they were "A little" hungry (N = 80, 44%), with many other children reporting that they were "Not at all" hungry (N = 44, 24%) or "Moderately" hungry (N = 46, 26%). Only ten children reported that they were "Extremely" hungry (N = 10, 6%) prior to the food choice tasks.

5.3.3 Food familiarity and liking ratings

Using both ranking and VAS methods to rate relative and absolute liking for foods, children ranked foods high in protein as most liked (Median, [Mode]: sausages = 2, [1]; chicken = 3 [2]; beef = 5 [3]), followed by foods high in carbohydrates (potatoes mashed = 5 [4]; boiled = 7 [6]; roasted = 3 [3]), with vegetables rated as the least liked food group (broccoli = 6 [9]; peas = 6 [7]; green beans = 7 [9]). However, individual differences in liking for each food were present as shown by the range of rank and VAS scores using the entire scale for rating each food. Overall, sausages were consistently rated as the most liked food from the foods used, with green beans consistently ranked as the least liked food from the options. Correlation analyses show that parent perceived child liking and child self-rated liking for each food used were highly correlated (Appendix A1).

Each food was reported as either eaten often (once per week) or at least once or twice per-month (Figure 5.3). Few individuals reported that they never eat the foods used in the study, with the exception of parents reporting that their child never eats boiled potatoes (N = 41) or green beans (N = 54). Despite some parents reporting that their child never eats these foods at home, these children remained in the analyses as their preferred choices may have differed to what they are offered at home and the child may still be offered these foods at school or elsewhere. Chicken was found to be the most commonly eaten food item, with 148 participants eating this food at least once per week or more, followed by broccoli (Once per-week or more, N = 104).

Figure 5.3. Frequency of foods eaten at home as reported by caregiver.



For each individual trial, Figure 5.4 illustrates the percentage of trials (for the meal context condition only, as the same foods were also presented in the no meal context condition) in which the vegetable option was more familiar. It is shown that the different conditions had similar proportions of vegetables being more, the same and less familiar than the competing food option. Figure 5.5 similarly illustrates the percentage of trials in which the vegetable option was better liked, similarly liked, or less liked than the competing food option. Vegetables were found to be the less liked food option in up to two thirds of trials across the different trial types.

Figure 5.4. The percentage of trials across trial types that vegetables were more, similarly, and less familiar than the competing food option.

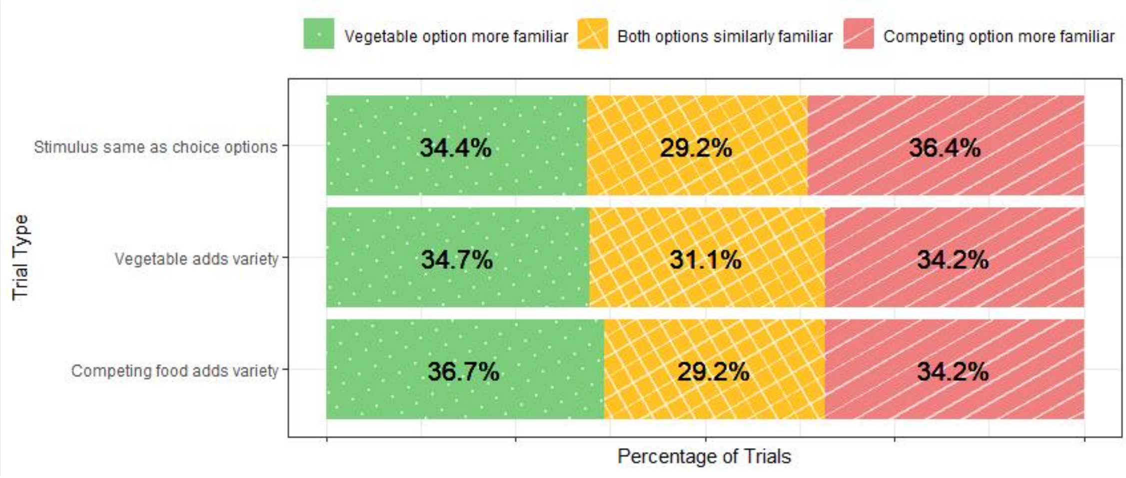
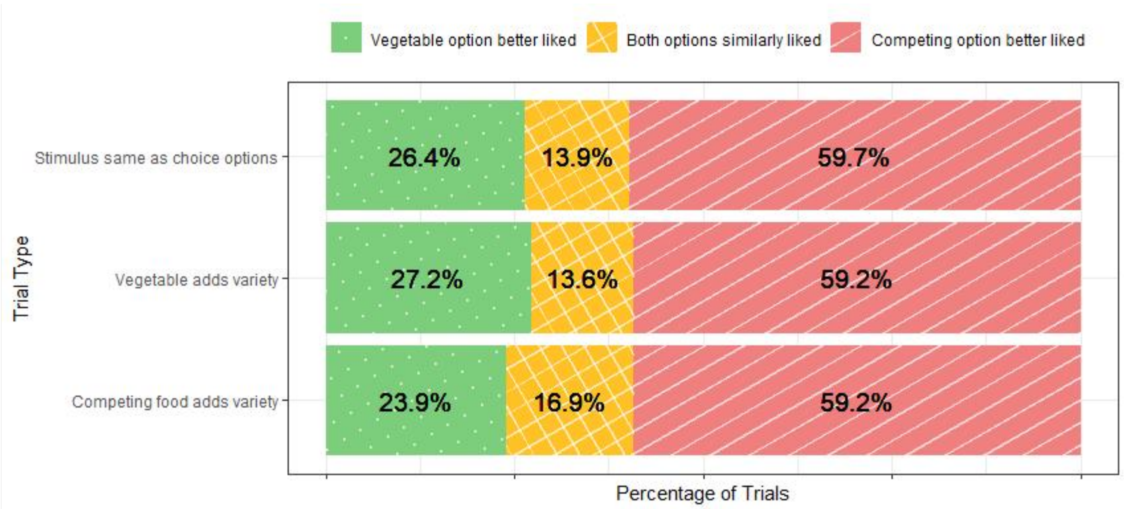


Figure 5.5. The percentage of trials across trial types that vegetables were better liked, similarly liked, or less liked than the competing food option.



5.3.4 Food choices

There were no differences in overall selection of vegetables (count) between the six groups that received different stimuli (different individual foods within trials but still the same trial types) in either the meal context, $\chi^2(5, N = 180$ clusters with cluster size of 6) = 2.2, $p = .82$, or the no meal context, $\chi^2(5, N = 180$ clusters with cluster size of 6) = 3.48, $p = .63$, conditions.

Overall, children were more likely to select vegetables during the meal context condition compared with the no meal context condition, $\chi^2(1, N = 180$ clusters with cluster size of 12 [12 food choices were made]) = 63.3, $p < .001$, *OR* = 1.57.

Figure 5.6 illustrates the percentage of trials in which children chose the vegetable option in the no meal context condition, with Figure 5.7 displaying the percentage of trials in which children chose the vegetable option across different trial types in the meal context condition.

Figure 5.6. Percentage of trials in which children selected the vegetable option versus the competing food option (***no meal context*** condition).

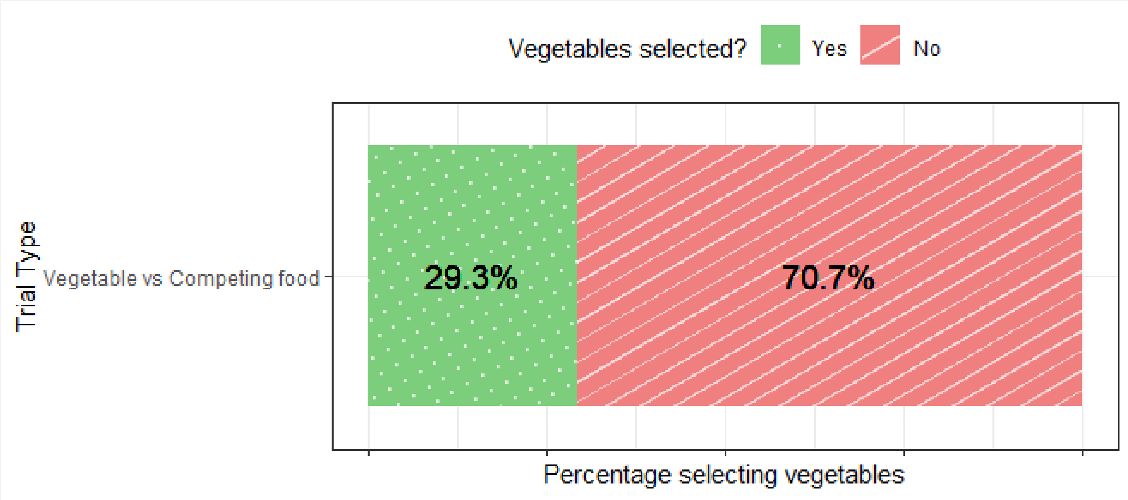
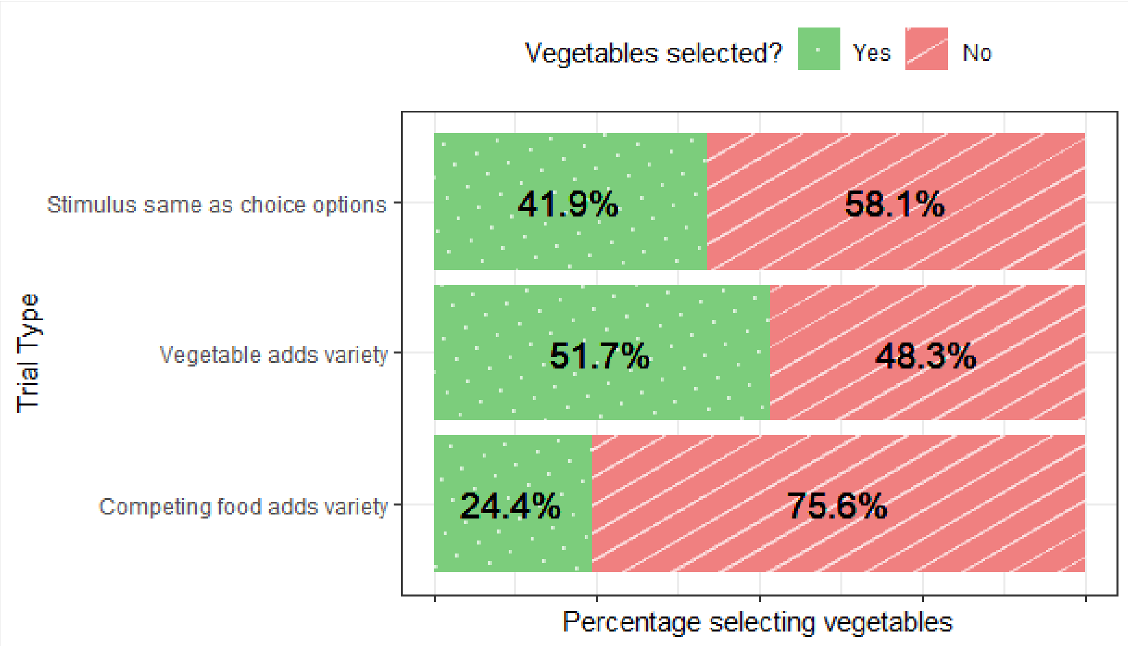


Figure 5.7. Percentage of trials across trial types in which children selected the vegetable option versus the competing food option (***meal context*** condition).



5.3.5 Predictors of children's food choice

Within the no meal context and meal context conditions, we further examined predictors of children's food choice. For the no meal context condition, the initial multi-level model was singular, possibly due to the differences in liking variable explaining all (or most) of the variance. Therefore, we used the GLMMadaptive package in R, which fits the model using an adaptive Gaussian quadrature rule. We found main effects for the trial type, difference in liking (between the vegetable and competing option) and vegetable familiarity category. Children were 25x more likely to select the vegetable option (than the competing option) for every unit increase of being better liked than the competing option and 2x more likely to choose the vegetable option if it was more familiar (Table 5.4).

Child age, child sex, hunger, all questionnaire subscale scores (CEBQ Food fussiness and enjoyment of food; CFQ restriction and pressure to eat; PMAS many food choices) and interaction effects did not add to the model and were therefore not included in the final model. The final model explains 78% of the variance in children's food choices, with almost none of the variance explained by the random effects of participant. This suggests that whether a vegetable was chosen or not was likely to change more within an individual (than between individuals), depending on the food options that were presented on each trial and the child's own liking and familiarity of the options presented.

Table 5.4. Results of multilevel logit modelling using an adaptive Gaussian quadrature rule to predict the selection rate of vegetables during the no meal context condition.

	Likelihood of choosing the vegetable option (no meal context)				
Predictors	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)	0.12	0.03	0.08 – 0.19	-9.35	**<0.001**
Trial Type: Veg vs Carb	*Reference*				
Veg vs Prot	0.76	0.16	0.51 – 1.14	-1.34	0.181
Difference in liking (between vegetable and competing option)	25.72	6.32	15.88 – 41.64	13.21	**<0.001**
Vegetable familiarity category: Both options same familiarity	*Reference*				
Vegetable option more familiar	2.01	0.46	1.28 – 3.15	3.03	**0.002**
Competing option more familiar	1.12	0.34	0.62 – 2.04	0.39	0.699
Random Effects					
σ^2	3.29				
$\tau_{00\ participants}$	0.01				
ICC	0.00				
$N_{Participants}$	180				
Observations	1080				
Marginal R^2 / Conditional R^2	0.780 / 0.781				

Veg = Vegetable, Prot = Protein, Carb = Carbohydrate.

For the meal context condition (Table 5.5), we found main effects for the trial type, difference in liking, vegetable familiarity category and CEBQ Food fussiness score. Children were 8x less likely to select the vegetable option when the competing food option provided nutritional variety to the partial meal stimulus, compared with when no nutritional variety was available (stimulus same as choices). Whereas, children were 2x more likely to select the vegetable when vegetables were not included in the partial meal stimulus and therefore offered the nutritional variety. Further, children were more likely to select the vegetable (than the competing food) when it was the better liked and more familiar option. Children that scored higher on traits of food fussiness were 1.3x less likely to choose the vegetable option than the competing option across all trial types.

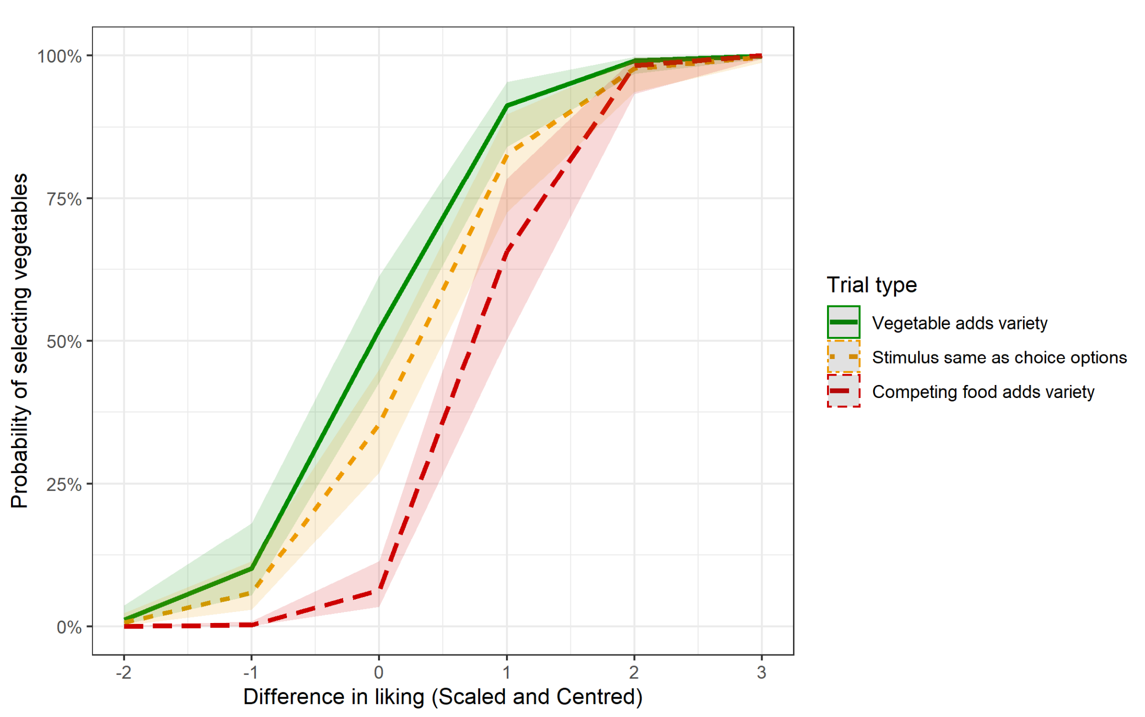
A two-way interaction between trial type and difference in liking was also observed (Figure 5.8). This illustrates that children were more likely to select vegetables if they were better liked. However, the extent of the difference in liking between the vegetable and competing food option that is required to select a vegetable depended on the trial type. For a higher likelihood of being selected, vegetables were not required to be more liked than the competing option if they added nutritional variety to the meal. However, if vegetables were much less liked than the competing option, they would not be selected even if they added a nutritional variety to the meal.

Child age, sex, hunger and all questionnaire subscale scores, except for food fussiness, (CEBQ enjoyment of food; CFQ restriction and pressure to eat; PMAS many food choices) did not add to the model. The final model explains 75.6% of the variance in children’s food choices. Only 9% of the variance explained is between subjects, meaning that whether a vegetable was chosen or not was likely to change more within an individual (than between individuals), depending on both the meal stimulus and the two food choices available during each individual trial.

Table 5.5. Results of Analysis of deviance with type II Wald chi-square tests method and parameters from multilevel logit modelling for the selection rate of vegetables during the meal context condition.

		Likelihood of choosing the vegetable option (meal context)				
Predictors	χ^2 – Tests, p-value	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)		0.55	0.11	0.37 – 0.81	-2.97	**0.003**
Trial Type: *Stimulus same as Choices*	χ^2 (2) = 68.3, ***p<0.001***	*Reference*				
Competing food adds variety		0.12	0.04	0.06 – 0.24	-6.21	**<0.001**
Vegetable adds variety		1.98	0.43	1.30 – 3.02	3.17	**0.002**
Difference in liking (between vegetable and competing option)	χ^2 (1) = 148.06, ***p<0.001***	8.74	2.36	5.15 – 14.82	8.04	**<0.001**
Was vegetable option more Familiar? Both options same familiarity	χ^2 (2) = 10.49, ***p=0.005***	*Reference*				
Vegetable option more familiar		1.60	0.36	1.03 – 2.47	2.09	**0.036**
Competing option more familiar		0.68	0.17	0.41 – 1.12	-1.53	0.127
CEBQ Food Fussiness Mean	χ^2 (1) = 7.46, ***p=0.006***	0.75	0.08	0.61 – 0.92	-2.73	**0.006**
Interaction effects						
Trial type - Competing food adds variety*Difference in liking	χ^2 (2) = 6.03, ***p=0.49***	3.24	1.61	1.23 – 8.56	2.37	**0.018**
Trial type - Vegetable adds variety * Difference in liking		1.10	0.40	0.54 – 2.25	0.26	0.799
	Random Effects					
σ^2	3.29		Observations		1080	
$\tau_{00\ participants}$	0.34		Marginal R^2 / Conditional R^2		0.731 / 0.756	
ICC	0.09					
$N_{Participants}$	180					

Figure 5.8. Relationship between predicted probability of selecting the vegetable option for different trial types and difference in liking between food options (vegetable versus competing food). Difference in liking was calculated by subtracting the VAS liking score for the competing option from the liking score of the vegetable option. Difference in liking was then centred and scaled.



5.4 Discussion

This study showed that in an online food choice setting, children chose vegetables more frequently in the context of a meal than with no meal. Selecting vegetables was more likely when they increased nutritional variety in the meal; whereas vegetables were less likely to be selected if the competing food increased nutritional variety. This effect was moderated by the difference in the child's liking for the food options provided, such that vegetables were more likely to be selected when they were better liked than the competing food option. These effects interacted, illustrating that when vegetables added nutritional variety to the meal, then this promoted choice, even if they were less liked (Figure 5.8). Finally, children that scored high on trait food fussiness were less likely to select the vegetable option in all circumstances.

When presented with a vegetable free meal stimulus, children may select vegetables to increase the variety of their foods, as predicted by associative learning. Whilst children's preference for variety at mealtimes has not been studied extensively, providing a variety of vegetables as a snack increased the likelihood of selecting a vegetable to eat, as well as increasing overall vegetable intake (Roe et al., 2013). Similarly, increasing the variety of vegetables available at a buffet (using fake foods, no consumption) increased the amount of vegetables children chose and served themselves (Bucher, Siegrist, & Van der Horst, 2014). Therefore, increasing the variety of foods and/or the variety of vegetables available may be a useful tool to promote not only vegetable consumption, but also vegetable selection when a choice of foods is offered (e.g. at a school canteen where being served vegetables can be a choice). The current findings add the observation that vegetables may be chosen in place of more palatable foods to accompany a meal if the vegetable adds nutritional variety to the meal.

The main effect of trial type (whether the vegetable or competing food added nutritional variety or not) on the likelihood of vegetable selection was moderated by the difference in liking of the available food options. The more liked the vegetable was in comparison to the competing food, the more likely the vegetable would be chosen. Liking for, and palatability of, individual food items has previously been shown to be an important factor for children's (Nguyen et al., 2015) and adult's (Hayes, 2020) food choices and intake. Hayes (2020) illustrates that although liking is correlated with intake, it is disliking of foods that consistently predicts non-consumption. This may be because a food can be better-liked (e.g. chocolate) but individuals tend to moderate their intake, yet if a food is disliked it is often not eaten. Therefore, it is fitting that absolute liking for vegetables moderates the effect of trial type and variety. To be selected, liking for the vegetable does not have to be greater than liking for the competing food if the vegetable also adds nutritional variety. However, if the vegetable is especially disliked, it is unlikely to be selected, regardless of the context.

This moderation effect between food liking and context (trial type) suggests that children were not only choosing a variety of food groups based solely on schemas and meal scripts to meet expectations of what a meal should comprise of (Pliner, 2008), nor what children may think the experimenter 'wanted' as a typical response. Although associative learning theory predicts that children may expect to eat some vegetables at mealtimes as part of the meal as a whole (Birch & Anzman, 2010; Bouton, 2010), and the development of a meal schema to include a variety of food groups may be positive for selecting vegetables, the palatability of the individual food options is also considered by the child. Due to past experiences with vegetables being paired with other foods in different recipes, previous learning may influence children's selection of food options based on achieving a variety of food groups in the meal; especially as each food choice in this study individually affected the configuration of the entire meal (how well the foods 'go together'). However, each individual food item presented to the child as an option also has an incentive value to the child (Berridge, 2004). Although the individual food may add palatability to the meal, adding variety also considers the different foods already in the meal stimulus. One interpretation is that children may choose to select a variety (potentially informed by meal schemas and previous learning), but only if the vegetable option is acceptable in terms of its palatability.

The interaction between foods that are presented within a meal is also of particular interest. Whilst previous research has not examined choice of vegetables when presented alongside other mealtime food items, it has been illustrated that pairing vegetables with liked foods (e.g. flavour-flavour and flavour-nutrient learning, evaluative conditioning) does not consistently increase vegetable consumption and often leads to less vegetable intake at mealtimes (Correia, O'Connell, Irwin, & Henderson, 2014; Leak et al., 2017). Similarly, when neutrally liked vegetables were served alongside better liked or disliked vegetables, vegetable liking and intake were either stable or decreased across time (Olsen et al., 2012). Together with our findings, this may suggest that both vegetable selection and (potentially) intake may be greatest when liked vegetables are provided at mealtimes alongside competing foods that are of similar palatability. This supports findings from Ishdorj et al. (2015), suggesting that there is often larger plate waste of vegetables when presented alongside much more palatable foods.

Selection of vegetables was further found to be more likely if the child chose the food option that was more familiar. Whilst less liked in comparison to other foods, broccoli and peas were reported as being provided more often at home than other foods. This higher frequency of provision may have influenced some children's selection of vegetables, as greater availability of vegetables in the home is linked with increased consumption (Pearson et al., 2009). However, it is important to note that effects of liking and familiarity are difficult to disentangle and it is likely that these two factors combine to guide the child's decision, as familiarity drives liking (Zeinstra, Koelen, Kok, & De Graaf, 2010). It is important to consider whether vegetables offered at home are more liked, or whether liked vegetables are offered more frequently. Caregivers are reported to offer only vegetables that they perceive as liked by the child and may not buy vegetables that are perceived as disliked (Holley, Farrow, & Haycraft, 2017a). In contrast, there were many instances where children chose a food that was never eaten at home (e.g. beef), but it was highly liked by the child. Overall, beef was reported as the food least often provided by parents, yet most children ranked this food as their third liked food (median placement as 5th out of all 9 foods). This could suggest a disparity between the foods that are being offered at home and what children would like to eat. Disparities have previously been described when children and parents rate food liking. Stage et al. (2019) reported that children rated liking for vegetables higher than what parents estimated their child's liking to be. A possible explanation for this is that children's responses to survey items may be unreliable, or lack stability, especially as in the current study children were asked questions of opinion (food liking) rather than questions of fact (Holaday, Turner-Henson, & Swan, 1991; Vaillancourt, 1973). However, in the current study, the data did not support this for the foods used. Instead, strong correlations between child liking and parental perceived child liking were observed (Appendix A1). This suggests that parents are mostly aware of their child's food likes and dislikes, however we cannot infer whether this influences the foods that are offered at home. Alternatively, it is possible that children are exposed to these foods outside of the home (e.g. at school), or that parents do not offer certain liked foods for reasons not measured (e.g. high cost, reducing beef intake for environmental reasons) and this may impact on children's food choice decisions.

Lastly, we found that children scoring higher on measures of fussy eating were slightly less likely to select vegetables. This is may be linked with general avoidance/neophobia towards vegetables throughout childhood (Maratos & Staples, 2015). However, contrary to our hypotheses we did not find that those who scored higher on enjoyment of food measures were more likely to select vegetables. Though, other studies have found that children with higher enjoyment of food ate vegetables more often (Cooke et al., 2004). We also did not observe any differences in selection of foods based on reported parental practices. It is possible that enjoyment of food measures may not be sensitive to direct competition within food choices. In this study, children were required to choose only one food option to the exclusion of the other. Whereas, if both options were presented on a plate, children that score highly for enjoyment of food may consume both options. Additionally, parental practices such as child control, monitoring, restriction and pressure to eat foods have been better linked to consumption of fruits and high fat/sugar foods than preferences for vegetables (Vollmer & Baietto, 2017). To our knowledge, no studies have yet examined the effects of these practices on children's own food choices. Indeed, the questionnaire subscales of child eating traits and parental feeding practices capture wider behaviours that may impact liking and familiarity of foods. It is possible that enjoyment of food and parental feeding practices may not predict vegetable selection beyond the effects of liking and familiarity. However, when liking and familiarity were removed from the models and these questionnaire scales were the only variables used to predict vegetable selection, only food fussiness continued to significantly predict vegetable selection. This may suggest that either the questionnaires used are more sensitive to consumption behaviours, rather than food choice behaviours, not related to food choice behaviours, or that there was not enough variation in our sample to detect any differences between individuals on these traits and parenting practices.

5.4.1 Strengths

Previous studies of children's food choices at mealtimes have been conducted in school cafeterias (Miller et al., 2015) or a buffet setting (Bucher et al., 2014), where children can choose which foods to eat, which to avoid and sometimes how much to take. However, if children are given a choice of foods at home, the choice is usually fixed or with few available options (Hendy et al., 2009). Although conducted online, in this study we restricted the choices available to the child, so that only one food could be chosen, providing direct competition between food options. During buffets or in school cafeterias, there may be less direct competition between foods because all foods can potentially be selected or avoided, which is less like a home mealtime setting. Furthermore, we measured eating related traits and parental practices and their potential influence on children's food choice. Previously, studies have only examined parental practices on children's consumption of foods rather than their choices.

5.4.2 Limitations

We did not measure actual food choice or intake due to data being collected during the COVID-19 pandemic (August 2020, UK) and therefore only a virtual selection of food choice was assessed. Additionally, children were choosing pictures of foods and therefore were not receiving a full sensory experience to aid their choices (e.g. seeing, smelling the food before choosing). Due to the hypothetical nature of the food choices, demand characteristics of children may mean that children were choosing vegetables more often than they would at an actual meal. Presenting images on a screen is not an ideal way to offer food choices to children, since there are inherent limitations on the visual presentation (2-D, flat, lack of perspective), but this method had to be adopted given restrictions on access to schools during the pandemic. However, even though children were not required to eat the foods they chose, most children were consistently not choosing vegetables. Even when the context prompted a choice of vegetables (vegetables were not in the meal stimulus) around half of the children did not choose the vegetable option. This would suggest that if we were to measure intake, consumption of vegetables would be low among certain subgroups of children (e.g. fussy eaters), as many children would not choose to have them on their plate, especially when other food groups (and potentially more palatable foods) were already present. Alternatively, children may have chosen vegetables more often due to adding colour to the meal (all vegetables were green versus brown or beige meats and potatoes). Vegetables may have been chosen fewer times if less colourful vegetables were used (e.g. a white cauliflower). Similarly, participant's choices may have been influenced by a different context than that provided by the study. Although children with certain dietary requirements (vegetarian, vegan) were excluded, children with other dietary requirements (e.g. halal meats, the family do not eat pork) may or may not have imagined the study foods to be an alternative that they would usually eat, which could have influenced choices made by some children.

Similarly, there may be limitations to presenting protein and carbohydrate foods together as this combination of foods and food groups may be more common in some cultures that others. Whilst meat and potatoes may be most familiar in 'British' meals, many cultures will have protein and carbohydrate present at a meal, but provided by different foods. Therefore, the findings may generalise to other cultures, but this would need to be tested with other carbohydrate and protein foods including rice, pasta, fish and cultural combinations of these meal configurations.

Secondly, as the study was conducted online, it is possible that some parents did not allow their child to complete the study, or may have influenced their child's choices. Precautions were taken to enhance the probability that children would complete the experimental part of the study, such as limiting the scope of participants in Prolific (see 2.1 *Participants* section) and asking the child confirmatory questions before they started the experiment.

5.4.3 Future research

Future research could examine how differences in palatability and liking between competing foods may impact on food choice and how these choices affect consumption of vegetables at mealtimes. Furthermore, it was not within the scope of this study to allow the manipulation of portion sizes. Although children tend to consume larger amounts of vegetables when portion sizes are increased (Roe, Sanchez, Smethers, Keller, & Rolls, 2021; Spill et al., 2010), it is not known how manipulating portion size of vegetables in the context of highly liked competing foods influence a child's decision to select vegetables to accompany their meal.

5.5 Conclusion

This study examined children's food choices within a meal context, where vegetables competed with foods high in protein and carbohydrate to accompany a partial meal stimulus or an imagined meal. It was observed that children were more likely to choose a vegetable depending on the food groups presented in the meal context, specifically when vegetables were not presented in the meal stimulus. However, this effect was moderated by children's absolute liking for the food choices presented, with children being less likely to select vegetables if the competing food was much better liked than the vegetable option. Fussy eaters were further less likely to select vegetables compared with non-fussy children. These findings may indicate that when offering children food choices with the intention to promote vegetable selection, the vegetable food options should be similarly or better liked than competing food options and different from those foods already presented within the meal.

Chapter 6

Parental intentions to implement vegetable feeding strategies at home: A cross sectional study

Chapter 6 Parental intentions to implement vegetable feeding strategies at home: A cross sectional study

Abstract

In order to increase vegetable intake by children, parents are encouraged to implement strategies that promote trying and eating vegetables at mealtimes. Qualitative studies have previously highlighted barriers parents face in implementing healthy eating practices, such as time, monetary costs and child factors (e.g. fussy eaters). This study aimed to specify the relationships between child and parent factors and their effects on parental intentions to implement vegetable feeding strategies at mealtimes. Parental intentions to implement meal service (serving larger portions, offering variety, serving vegetables first) and experiential learning (repeated exposure, games, sensory play) strategies were examined. Parents (*N*=302, 73 male, *M*age=33.5) also explained reasons why certain strategies may or may not work for their child (4-7y). For both types of strategy, higher food fussiness of the child predicted higher parental intentions to implement strategies at home. However, this was competitively mediated by low beliefs that the strategy would work for their child, resulting in weaker overall positive effects on intentions. In the meal service model, parental beliefs that healthy eating is important for their child had a positive, indirect effect on higher intentions, through involved parental feeding practices. However, this was not significant in the experiential learning strategies model. Written parental responses suggest that this may be due to meal service approaches being viewed as easier to implement, with little additional effort required. Increasing parental confidence to implement strategies successfully and managing expectations around successful outcomes of strategies (e.g. tasting, eating) may be important focuses of future interventions to support parents implementing vegetable feeding strategies at mealtimes.

6.1 Introduction

Children’s cumulative daily vegetable intake in the UK is around one full portion (Chawner, Blundell-Birtill, & Hetherington, 2021), which is lower than government recommendations of five portions of fruit and vegetables per day

(NHS-UK, 2018). Systematic reviews highlight the importance of feeding strategies that utilise repeated exposure, adapting foods (e.g. flavour-flavour learning) and social techniques such as modelling and reward (Bell et al., 2021; Holley et al., 2017b; Nekitsing, Blundell-Birtill, et al., 2018) for parents to encourage acceptance of new vegetables and to increase intake of familiar vegetables. However, in contrast to evidence from systematic reviews, strategies to encourage vegetable acceptance through meal service and experiential learning techniques are often omitted or addressed in little detail. Research studies have previously assessed the effectiveness of different strategies to encourage young children to consume more vegetables such as offering vegetables first in a meal (Spill et al., 2010), serving larger portions (Mathias et al., 2012), providing sensory play (Coulthard & Sealy, 2017) and offering a variety (Roe et al., 2013). Applying these strategies at home may help to promote vegetable intake for both children and their families (Cravener et al., 2015; Holley et al., 2015; Varman et al., 2021). However, there are a range of parent feeding and child eating factors that could influence how effective parents believe some strategies will be, and their intentions to implement these at home. A better understanding of these relationships could help to provide caregivers with guidance on serving vegetables in ways that will encourage their children to consume more vegetables. This study aims to examine child eating and parental feeding factors that may predict whether parents hold intentions to implement different types of vegetable feeding strategies at home mealtimes.

Implementing vegetable feeding strategies at mealtimes requires parents to change their serving and feeding behaviours (McGowan et al., 2013). For vegetable feeding strategies to increase intake, vegetables must be served in adequate portion sizes (40-60g of vegetables is one portion for a 4-10 year old child: Public Health England, 2018b), however actual portion sizes are often predicted by parental intake of vegetables (Trofholz, Tate, Draxten, Neumark-Sztainer, & Berge, 2016) and availability in the home environment (Kininmonth et al., 2021). Parents often report practical barriers to providing vegetables, such as monetary cost and parental time constraints (Nepper & Chai, 2016), meaning that it may not be feasible for parents to serve vegetables to their children at each meal. Additionally, parents know that their child's characteristics, such as being a ‘picky’ or ‘fussy’ eater, or having strong preferences for energy dense foods, could present barriers to attempts to increase vegetable intake (Jarvis, Harrington, & Manson, 2017; Ling, Robbins, & Hines-Martin, 2016). In these cases, parents may anticipate that their child will refuse or waste the vegetables, leading parents to pre-empt these behaviours and avoid serving vegetables. This is because many parents view consuming any food as more desirable than consumption of no food when vegetables are served (Moore, Tapper, et al., 2010a). Implementing different vegetable feeding strategies may encourage parents to serve vegetables in new ways at home, whilst also encouraging children to taste, try and eat vegetable portions that are served.

Parents that have children who express traits of food avoidance (food fussiness, slowness in eating and satiety responsiveness; Tharner et al., 2014) may experience the greatest benefit from employing vegetable feeding strategies, as food avoidant children often have lower intakes of vegetables than non-food avoidant children (Cardona Cano et al., 2015; Galloway, Fiorito, Lee, & Birch, 2005; Haszard, Skidmore, Williams, & Taylor, 2015). This has been attributed to food avoidance traits being underpinned by similar genetic mechanisms to liking of vegetables (Fildes, van Jaarsveld, Cooke, Wardle, & Llewellyn, 2016) and children tend not to eat foods that are disliked (Keller, Shehan, Cravener, Schlechter, & Hayes, 2022). Food fussy children therefore require many more exposures and experiences with new foods and disliked vegetables in order to accept or consume them (Caton et al., 2014; Dovey et al., 2008). Therefore, simply offering more vegetables may not increase intake in these children, and other strategies may be needed alongside offering to achieve healthier eating outcomes.

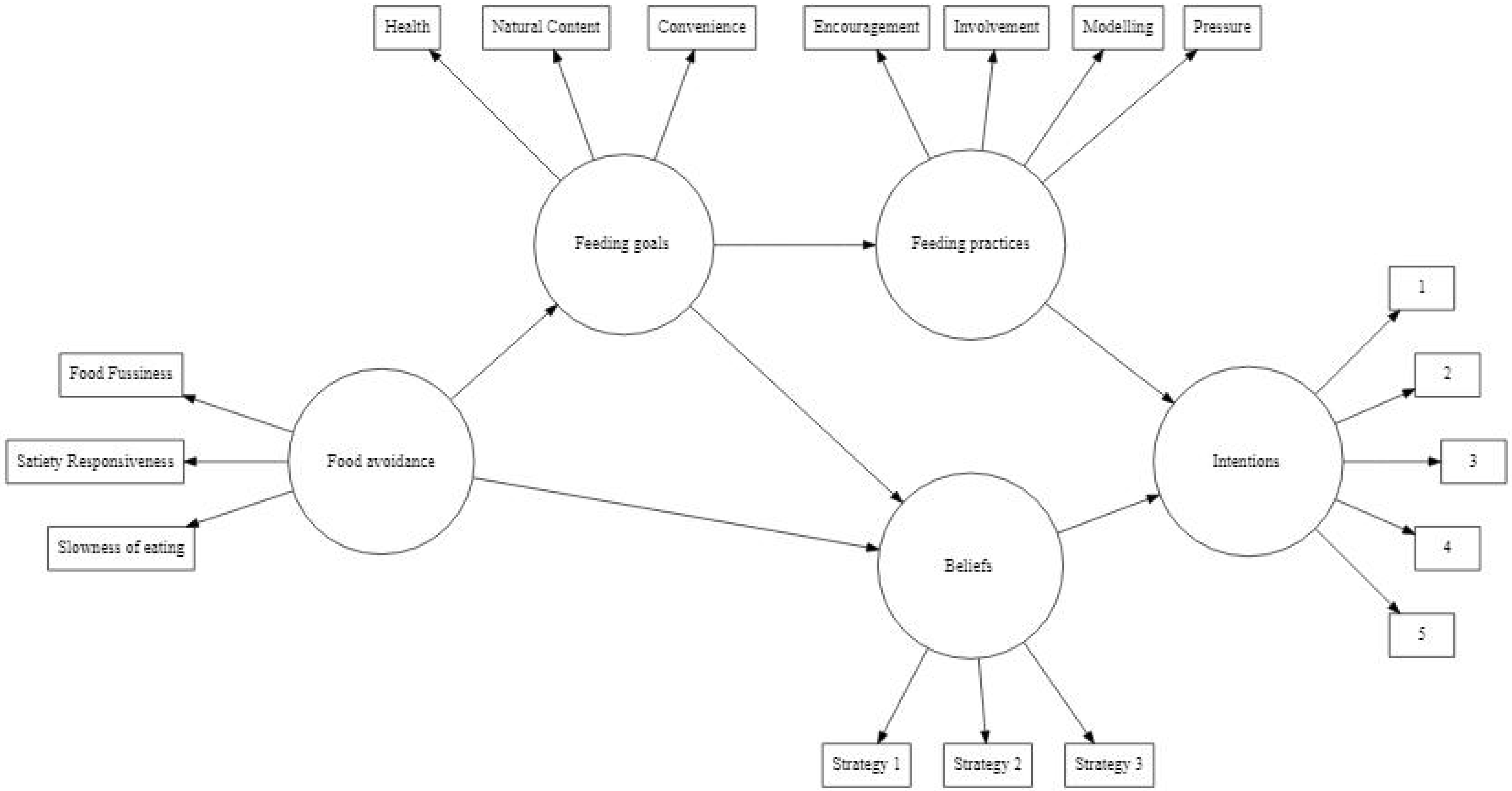
Parents generally identify vegetable intake as important for their child’s health (Hingle et al., 2012). Once this belief is held, parents may adopt suitable feeding goals (what parents aim to achieve through feeding) that centre on the importance of healthy eating. These goals may then inform both the types of food that parents choose to feed their children and the feeding methods that parents employ at mealtimes. Parental healthy eating goals (e.g. it is important that my child eats foods that are healthy) have previously been shown to positively predict reported healthy food (fruits, vegetables, grains) intake in children (Hoffmann, Marx, Kiefner-Burmeister, & Musher-Eizenman, 2016; Kiefner-Burmeister et al., 2014). Whereas, convenience feeding goals (e.g. it is important that foods are simple to cook or easy to prepare) have been associated with self-reported lower healthy food intake (Hoffmann et al., 2016). These findings illustrate that the types of feeding goals held by parents can influence not only which foods parents serve, but also which foods children consume. Therefore, if parents hold healthy eating goals, they may also be willing to implement vegetable feeding strategies to facilitate healthy eating by their child.

Parental feeding practices at mealtimes may further reflect feeding goals held by the parent and help to determine whether parents are likely to implement vegetable feeding strategies. Positive practices such as involving children in meal preparation (Shim et al., 2016) and modelling vegetable consumption (Gregory, Paxton, & Brozovic, 2011) have previously been associated with higher reported child vegetable intake. Similarly, child-centred approaches to encouragement (e.g. saying something positive about the food), compared with parent-centred feeding practices (e.g. instructing a child to eat what is on their plate) are also linked with larger reported vegetable consumption (Vereecken, Rovner, & Maes, 2010). In contrast, negative feeding practices (practices that use pressuring, restriction, instrumental or emotional feeding: Wardle & Carnell, 2007) may reduce intake of healthy foods by children. Although research is limited, there is some evidence that negative feeding practices (e.g. the use of food as a reward) may mediate the relationship between healthy eating goals and lower intake of energy dense foods (Kiefner-Burmeister et al., 2014), as negative feeding practices were found to be associated with greater consumption of high energy dense foods. Therefore, the role of parental feeding practices requires further investigation for its potential effects on parental intentions to implement new feeding strategies (for a comprehensive review of parental feeding practices on general child eating behaviours, see Vaughn et al., 2016).

Child and parental factors are likely to operate together to predict parental intentions to implement vegetable feeding strategies at mealtimes. When considering intentions within the theory of planned behaviour, there are three suggested antecedents: attitudes, subjective norms and perceived behavioural control (Ajzen, 1991). Although these antecedents are not tested directly in this study, the concepts within the child eating and parental feeding literature indicate some similarities with concepts from the theory of planned behaviour (e.g. healthy feeding goals may be similar to parental attitudes towards feeding strategies and beliefs that each the strategy will change their child's vegetable consumption could be similar to measuring perceived behavioural control by the parent). Therefore, the theory of planned behaviour may be useful to contextualise findings in predicting future parental feeding behaviours and their intentions to implement vegetable feeding strategies.

This study aims to specify the relationships between child food avoidance traits (fussy eating, satiety responsiveness and slowness in eating), parental healthy eating goals and parental feeding practices (positive and involved practices) and their effects on parental beliefs regarding the effectiveness of strategies to increase child vegetable intake, and parental intentions to implement those strategies at mealtimes. These relationships will be tested for intentions to implement two types of vegetable feeding strategy: meal service (strategies focused on changing aspects of how vegetables are served) and experiential learning (strategies focused on how children are exposed to vegetables through learning). The initial framework to be tested is presented in Figure 6.1. It is hypothesised that parents will hold stronger beliefs that a strategy will increase their child's vegetable intake if their child scores lower on traits of food avoidance. Consequently, parents will report higher intentions to implement a vegetable feeding strategy if they believe the strategy will work for their child. However, lower intentions to implement strategies will be reported if parents also score lower on the use of positive and involved parenting practices. Additionally, the effect of child food avoidance on beliefs and intentions will be mediated by parental healthy eating goals and positive parental feeding practices. Furthermore, open ended questions will be asked to explore the reasons why parents may or may not implement vegetable feeding strategies and reasons behind beliefs that each strategy would, or would not, succeed in increasing vegetable consumption by their child.

Figure 6.1. The original model to be tested to examine the associations between child eating and parental feeding factors, with parental beliefs and intentions. Parental beliefs that vegetable feeding strategies would be effective for their child (strategies 1-3 indicate three individual vegetable feeding strategies) and whether parents intend to implement these strategies (1-5 represent the five intention questions asked to parents) were the main outcomes of interest. Circles indicate latent variables, boxes represent measured items, arrows from circles to boxes indicate factor loadings and arrows between circles indicate the direct effects between latent variables.



6.2 Methods

6.2.1 Participants and design

Participants were recruited to complete an online, cross sectional survey via Prolific (www.prolific.co). The study invited adults living in the UK, with a child aged between 4 and 7 years and a household income of less than £50,000. This age group was selected as it is an appropriate age range to implement experiential learning strategies with children at meal times. Using younger children that may primarily eat using their hands may have affected the data. Parents might expect younger children to play with foods at mealtimes and therefore could be more comfortable with implementing experiential learning strategies. Income was chosen as a criterion to diversify this sample from other studies that usually include participants with higher household incomes, as there are well documented links between social inequalities and health outcomes, including consumption of vegetables (Giskes, Avendaňo, Brug, & Kunst, 2010; Rasmussen, Pedersen, Johnsen, Krølner, & Holstein, 2018; Sausenthaler et al., 2007). In the UK, those in the highest socioeconomic groups are estimated to eat 128 grams of vegetables more per day than those in the lowest socioeconomic groups (Maguire & Monsivais, 2015). People in lower income brackets may experience different barriers to serving vegetables (e.g. perceived cost, time for preparation, potential waste) compared to higher earners (Nepper & Chai, 2016) and consequently, these factors could affect further barriers to utilising feeding strategies at mealtimes. The income bracket itself was chosen for practical reasons to match the sample size from the power calculations with the number of potential participants on Prolific. Those willing to participate completed a survey hosted on Qualtrics (www.qualtrics.com). A power analysis was calculated using SemPower in R. To detect a medium sized effect (.05) using absolute fit indicies (RMSEA), alpha = .01, power = .90 and df = 129, a sample size of 217 was calculated. Therefore, we aimed for a total of 300 participants to account for quality of responses and loss of information where ordinal data were used.

6.2.2 Materials

The online survey was comprised of a series of questionnaire subscales.

6.2.2.1 Intention and belief questionnaires

Parental ***intentions*** to implement meal service (serving vegetables first, serving larger portions, offering variety) and experiential learning (repeated exposure, games, sensory play) strategies were examined with 5 questions. Participants were provided with a scenario, “Imagine that you are informed from a reliable source that you could increase your child's vegetable intake at mealtimes by 1 portion (40g), by….[*strategies here*]. Given that information, over the next month to what extent would you try it? Reading the statements below, let us know whether you would agree or disagree with these statements”. The five questions were rated on a 7-point Likert scale from Strongly disagree to Strongly agree. These questions included, “I would make an effort to try it”, “I would insist on trying it once” and “I would try it even if it involves some extra effort at mealtimes”.

Parental ***beliefs*** that the strategies would increase their child’s vegetable intake were examined in a similar manner. For each of the three meal service strategies and three experiential learning strategies, parents were asked, “If the methods mentioned by the reliable source included…[*strategies here*], what effect would it have on your child's intake of vegetables?” Parental responses on a 7-point Likert scale ranged from “My child would eat fewer vegetables” to “My child would eat the whole portion”. Full information on questions used can be found in Appendix B1.

The intentions and beliefs questions were developed specifically for this study based on guidelines from Fishbein and Ajzen (1977) and Ajzen (1991). Question content and design were also influenced by other studies that have tested aspects of the Theory of Planned Behaviour from various literatures (e.g. Irwin, O'callaghan, & Glendon, 2018; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017).

6.2.2.2 Open ended questions

For both parental intention and beliefs questions, parents were requested to provide written responses as to why they would/would not intend to implement strategies (“In the space below, please let us know why you would OR would not plan to try these methods at mealtimes”), and whether they thought that each individual strategy would work for their child (“Please suggest reasons why you think that [strategy] would OR would not work for your child”).

6.2.2.3 Child and parental feeding questionnaires

To examine children’s eating behaviour traits, parental healthy eating goals and positive parental feeding practices, a series of questionnaire subscales were employed. Children’s food avoidance was measured using the Food Fussiness, Slowness in Eating and Satiety Responsiveness subscales of the Child Eating Behaviour Questionnaire (CEBQ: Wardle et al., 2001). Parental healthy eating goals were examined using the Health, Natural Content and Convenience subscales of the Food Choice Questionnaire (FCQ: Steptoe et al., 1995). Lastly, to assess parent’s positive feeding practices, the Encouraging Balance and Variety, Modelling, Child Involvement and Pressure subscales of the Comprehensive Feeding Practices Questionnaire (CFPQ: Musher-Eizenman & Holub, 2007) were used. A vegetable food frequency questionnaire (adapted from Hammond et al., 1993) was also used to describe how often different types of vegetables were eaten by children in the sample. Each questionnaire has been validated with low-income samples (although not UK low-income samples) and show good validity and reliability (Domoff, Miller, Kaciroti, & Lumeng, 2015), however validity of the CFPQ may be worse in samples of mixed ethnicities (Arlinghaus et al., 2019).

6.2.3 Procedure

This study’s protocol was previously uploaded to the Open Science Framework (https://osf.io/a2rfp/?view_only=7bc5a9892aab4ff6984f86874572a074). Participants consented online on the first page of the survey before answering some general demographic questions about themselves and their child, including their age, gender, education, ethnicity and household income. This was followed by a series of questionnaires, noted in section 2.2. Questions about parental intentions were answered, followed by questions examining parental beliefs. The questions were randomised such that participants answered about the different strategies in a random order. Participants were then requested to complete the CEBQ, CFPQ and CFQ subscales, randomised both at the scale and question levels. Participants were prompted to answer all questions but were free to skip questions that they preferred not to answer. The survey took approximately 10-15 minutes to complete and participants were compensated £1.52 for their time. The study was approved by the University of Leeds School of Psychology Research Ethics Committee (Reference: PSYC-278).

6.2.4 Data analyses

6.2.4.1 Data preparation

Mean subscale scores were created for CEBQ, CFPQ and FCQ subscales. Appropriate items on each scale were reverse scored. For SEM analyses, the Convenience subscale of the FCQ and the Pressure subscale of the CFPQ were reverse scored for easier interpretation (as these scales are conceptually different to the other subscales loading onto the same latent variable).

6.2.4.2 Structural Equation Modelling of parental intentions

Structural Equation Modelling (SEM) was used to specify the relationships between child food avoidance, parental healthy eating goals, parental feeding practices and parental beliefs and intentions. The original model which was assessed separately for both meal service and experiential learning strategies (two models were tested) is provided in Figure 6.1. The two types of feeding strategy were assessed separately as both meal service and experiential learning strategies have different levels of input by the parent and therefore different child experience with vegetables. Meal service strategies are often focused on changing the way the food is presented (less parental effort is required), whereas experiential learning strategies are focused on positive experiences with the vegetables and learning about their characteristics (more parental effort is required in comparison). Due to the differences between strategies, parental beliefs and intentions to implement could differ, necessitating two separate models. The models were fit with a robust diagonally weighted squares method (WLSMV), that performs well with ordinal data and smaller sample sizes (Finney & DiStefano, 2013; Flora & Curran, 2004). Overall model fit was examined holistically, with general rules for appropriate values being considered (CFI and TLI > 0.95, RMSEA and SRMR < 0.08 are considered as good fit). After examining overall model fit, the measurement and structural models were assessed and respecified based on both theory and modification indices supported by theory. Lastly, both direct and indirect pathways of endogenous to exogenous variables were examined using bootstrapped confidence intervals (BCa) (Cheung & Lau, 2008; Zhao et al., 2010).

All quantitative analyses were conducted in R version 4.1.0, using packages semPower 1.1.0, tidyverse 1.3.1 and lavaan 0.6-8 and graphics were produced using DiagrammeR 1.0.6.9000.

6.2.4.3 Analyses of written responses

For the written responses, the first author initially sought to acquire an overview of responses through the use of text mining. This allowed exploration of the most frequently used words (and two consecutive words: digrams), correlations of words used between strategies and sentiment analysis (whether words used were positive or negative). All text mining was performed in R using packages Tidytext 0.3.2, tm 0.7-8 and qdap 2.4.3.

After exploring the data more generally, content analysis was used to categorise participant responses. Codes (categories) were identified inductively from the data and participant responses were assigned to the relevant code. The same codes were used for both questions regarding parental intentions to implement either meal service or experiential learning strategies. However, different sets of codes were identified for each of the six strategies relating to parental beliefs that the methods would work for their child. This is because for each strategy, parents gave different reasons as to whether the strategy would work for their child. Initially, a large number of codes were constructed to account for the variety of answers parents provided. However, these were later collapsed into fewer codes that were similar to each other, to help with interpretation. All codes were discussed and agreed upon by all authors. Finally, in order to summarize the large number of codes identified between strategies, general themes were created to encapsulate overall trends within the data.

6.3 Results

6.3.1 Participants and descriptive statistics

Three-hundred and two parents completed the online survey. Parents were mostly female (75.8%), white (88.7%), and had a household income of less than £50,000 (GBP) (91.7%). The UK national median household disposable income for comparison is £31,400 (ONS, 2022). Full demographic details are presented in Table 6.1.

Table 6.1. Participant demographic information.

Participant Characteristics.		
Total Parents, Male (%)		302, 73 (24.2)
Total Children, Male (%)		302, 157 (52.0)
Parent Age, Mean (SD) [Range]		33.5 (5.5) [22-51]
Child Age, N (%)		
	4	101 (33.4)
	5	97 (32.1)
	6	64 (21.2)
	7	40 (13.2)
Ethnicity of parent, N (%)		
	White/White British	268 (88.7)
	Black/Black British	14 (4.6)
	Asian/Asian British	12 (4.0)
	Mixed ethnic Group	6 (2.0)
	Other	2 (0.7)
Ethnicity of child, N (%)		
	White/White British	259 (85.8)
	Black/Black British	12 (4.0)
	Asian/Asian British	10 (3.3)
	Mixed ethnic Group	19 (6.3)
	Other	2 (0.7)
Household Income, N (%)		
	Less than £25,000	94 (31.1)
	£25,000 to £49,999	183 (60.6)
	£50,000 to £74,999	22 (7.3)
	Above £75,000	1 (0.3)
	Prefer not to answer	2 (0.7)
Parental Education, N (%)		
	Some High School or Less	35 (11.6)
	A-level	72 (23.8)
	Bachelor's degree	88 (29.1)
	NVQ, BTEC, National Certificate/Diploma or Vocational licence	61 (20.2)
	Graduate or professional degree	46 (15.2)

Modes, means, medians, standard deviations, ranges and reliability (Cronbach's alpha) for each questionnaire subscale are presented in Table 6.2. Overall, parents reported agreement with the intention to implement both meal service and experiential learning strategies. However, for both types of strategy, on average, parents believed that their child would only "try the vegetables", or "eat a few bites more" than they currently would eat. For the food frequency questionnaire, parents most frequently reported their child to eat each category of vegetables "once per week", with the exception of "other cooked vegetables (e.g. carrots, onions etc.)", where the majority of parents reported their child eating "daily". However, it is important to note that the questionnaire only obtained information for how often each vegetable was eaten, and not how much was eaten. Reliability for each validated scale, measured using Cronbach's alpha, was similar in this sample to values reported in the literature. Reliability was high for intentions questions created for this study, however values were lower for the beliefs questions developed for this study. This is understandable because parents were asked whether very different strategies would benefit their child. Parents may believe that whilst some strategies may work, other will not.

Table 6.2. Descriptive statistics (*Mode*, *M*, *SD, Median* and *Range*) for each questionnaire subscale that participants completed, along with reliability (Cronbach's alpha) from the literature and our sample.

						Cronbach's alpha		
Scale	***Mode***	***M***	***SD***	***Median***	***Range***	***Sample***	***Literature***	***Reference***
Intentions – Meal service	"Agree"	5.55	1.06	5.8	1.8-7	.90	NA	
Intentions –Experiential learning	"Agree"	5.52	1.13	5.8	1-7	.92	NA	
Beliefs - Meal service	"Eat a few bites more"	3.56	1.27	3.33	1-7	.66	NA	
Beliefs - Experiential learning	"Eat a few bites more"	3.66	1.06	3.67	1-7	.48	NA	
Vegetable Food Frequency	"Once per-week"	3.66	0.91	4.0	1-5	NA	NA	
CEBQ – Food fussiness	"Sometimes"	3.15	0.89	3.0	1.17-5	.91	.91	Wardle et al. (2001), Sample 3
CEBQ – Slowness in eating	"Sometimes"	3.29	0.88	3.25	1-5	.86	.80	
CEBQ – Satiety responsiveness	"Sometimes"	3.07	0.68	3.0	1.4-4.6	.78	.83	
CFPQ - Encouraging balance and variety	"Always"/"Agree"	4.43	0.55	4.5	1.5-5	.70	.58	Musher-Eizenman and Holub (2007), Study 3 mothers
CFPQ – Modelling	"Agree"	4.34	0.74	4.5	1-5	.85	.80	
CFPQ – Child involvement	"Slightly agree"	3.68	1.00	3.67	1-5	.73	.77	
CFPQ - Pressure	"Slightly disagree"	3.40	0.94	2.5	1-5	.78	.79	
FCQ - Health	"Very important"	3.37	0.51	3.42	1-4	.85	.81	Steptoe et al. (1995), Study 2
FCQ – Natural content	"A little important"	2.80	0.81	3.0	1-4	.90	.86	
FCQ - Convenience	"Moderately important"	2.88	0.69	2.0	1-4	.85	.84	

When asked to choose which vegetable feeding strategy (from all six strategies) parents thought would work best for their child, vegetable related games (n = 89, 29.5%) was most popular, followed by offering a variety of vegetable types (n = 75, 24.8%) and offering vegetables as a starter (n = 62, 20.5%).

6.3.2 Specifying the relationships between child and parental factors and parental beliefs and intentions.

The initial model (Figure 6.1) that was specified as a SEM was a very poor fit for both meal service ($\chi^2[df = 129] = 280.10$, $p < .001$, CFI = 0.79, TLI = 0.75, RMSEA = 0.06, SRMR = 0.07) and experiential learning ($\chi^2[df = 129] = 226.62$, $p < .001$, CFI = 0.82, TLI = 0.78, RMSEA = 0.05, SRMR = 0.07) strategies (these two SEM models can be found in Appendix B2). As the model fit was poor, the measurement models were examined. The measurement models were similarly a poor fit, therefore factor loadings were checked. Both Convenience and Pressure subscales did not load on to the healthy eating goals and parental practices latent variables respectively. This is likely due to these concepts being orthogonal (rather than opposite) to the other subscales loading onto the same latent variable. Therefore, these two subscales were removed from the model. Similarly, low factor loadings were seen for the food avoidance latent variable. The decision was made to change this latent factor to "food fussiness" and to use each of the six CEBQ Food Fussiness scale items to load onto this new latent variable. This was because support in the literature is stronger for food fussiness affecting children's eating and parental feeding factors, compared with the child eating slowly or getting full up easily. After these changes, the measurement model fit well and the structural model was re-examined. Modification indices were then examined, which suggested that Food Fussiness of the child may have a direct effect on parental intentions to implement vegetable feeding strategies. This effect was therefore added to the model in Figure 6.1. Final model fit indices are presented in Table 6.3**,** along with final SEM models presented in Figure 6.2 and Figure 6.3.

Table 6.3. Absolute and incremental fit indices for the final structural equation models regarding meal service and experiential learning strategies.

Final model	***χ²(df), p-val***	***CFI***	***TLI***	***RMSEA***	***SRMR***
Meal service	χ^2(*df* = 145) = 180.53, p = .024	0.972	0.967	0.029	0.043
Experiential learning	χ^2(*df* = 145) = 212.98, p < .001	0.937	0.926	0.039	0.054

6.3.2.1 Meal service model mediation pathways

The final SEM for meal service strategies is presented in Figure 6.2. Mediation pathways are presented in detail for effects of each latent variable on parental intentions.

Food Fussiness (FF)

The SEM suggests that the effect of child FF on parental intentions to implement vegetable feeding strategies (direct effect = 0.46, CI = 0.23,0.68, p < .001) is mediated through parental beliefs that meal service strategies will increase vegetable intake by their child (indirect effect = -0.24, CI = -0.40,-0.08, p = 0.003). This suggests that parents are less likely to believe that meal service strategies will work for food fussy children, therefore reducing intentions to implement meal service strategies at mealtimes. Other pathways showing the direct effect mediated by parental healthy eating goals and beliefs (indirect effect = -0.02, CI = -0.04,0.01, p = .14) and parental healthy eating goals and positive feeding practices (indirect effect = -0.04, CI = -0.09,0.002, p = .06) were non-significant. The total effect of child FF on parental intentions was reduced compared with the direct effect, but non-significant (total effect = 0.16, CI = 0.01,0.31, p = .04), suggesting that there is a ***competitive mediation*** via beliefs, as the direction of the indirect effect is opposite to that of the direct effect.

Healthy eating goals

Healthy eating goals (it is important that my child eats healthily) were proposed to have an indirect effect on parental intentions. There was a significant indirect effect through positive feeding practices (indirect effect = 0.55, CI = 0.15,0.96, p = .01), yet indirect effects through beliefs was non-significant (indirect effect = 0.20, CI = -0.03,0.43, p = .08). Parents who thought it was important for their child to eat healthily also reported more positive feeding practices, therefore resulting in higher intentions to implement meal service strategies. The total indirect effect through both pathways was positive and significant (total indirect effect = 0.76, CI = 0.31,1.21, $p = .001$), suggesting an **indirect-only mediation** through positive feeding practices.

Positive feeding practices.

Positive parental feeding practices was found to have a direct positive effect on parental intentions (direct effect = 0.68, CI = 0.24,1.11, $p = .002$). The more parents reported using positive mealtime feeding practices, the higher their intentions to implement meal service strategies to increase child vegetable intake. This suggests a ***direct only non-mediation relationship***.

Beliefs

Parental beliefs that meal service strategies would increase their child's vegetable consumption was found to have a direct and positive effect on intentions (direct effect = 0.42, CI = 0.15,0.69, $p = .003$). If parents believed the meal service strategy would increase vegetable intake by their child, they reported higher intentions to implement the strategy. This is another example of ***direct only non-mediation***.

6.3.2.2 Experiential learning model mediation pathways

The final SEM for experiential learning strategies is presented in Figure 6.3 and mediation pathways are described below.

Food fussiness (FF)

Similar to the meal service model, the experiential learning model also suggests that child food fussiness had a direct effect on parental intentions (direct effect = 0.41, CI = 0.21,0.62, $p < .001$). However, the mediation pathways through beliefs (indirect effect = -0.15, CI = -0.30,-0.01, $p = .04$), via parental healthy eating goals and beliefs (indirect effect = -0.01, CI = -0.04,0.02, $p = .40$) and via parental healthy eating goals and positive feeding practices (indirect effect = -0.03, CI = -0.08,0.01, $p =.11$) were all non-significant. Although, the total indirect effect was negative and significant (total indirect effect = -0.198, CI = -0.35,-0.047, $p = .010$). The significant total effect (total effect = 0.22, CI = 0.06,0.37, $p = .006$) again suggests that there is ***competitive***

mediation, however the effect may be weaker than the same effect in the meal service model.

Healthy eating goals

The effect of parental healthy eating goals on intentions was not mediated by beliefs (indirect effect = 0.14, CI = -0.18,0.46, p = .39) or positive feeding practices (indirect effect = 0.41, CI = -0.003,0.83, p = .05). The total indirect effect was positive yet also non-significant (total effect = 0.55, CI = 0.12,0.99, p = .013). Individually, these factors did not mediate the relationship between healthy eating goals and intentions.

Positive feeding practices.

Positive feeding practices had a positive but non-significant effect on intentions to implement experiential learning strategies (direct effect = 0.51, CI = 0.03,0.99, p = .04).

Beliefs

Parental beliefs that experiential learning strategies would increase vegetable intake by their child at mealtimes had a positive and significant direct effect on intention to implement these strategies (direct effect = 0.54, CI = 0.15,0.93, p = .007).

Figure 6.2. The results of the final Meal Service model, examining the associations between child and parental factors with parental beliefs that vegetable feeding strategies will be effective for their child, and whether parents intend to implement these strategies. Circles indicate latent factors, boxes represent measured items, arrows from circles to boxes indicate factor loadings (95% BCa confidence intervals, one measured variable for each latent variable is fixed to one) and arrows between circles indicate the direct effect expected between latent variables (interpreted as a regression coefficient, with 95% BCa confidence intervals).

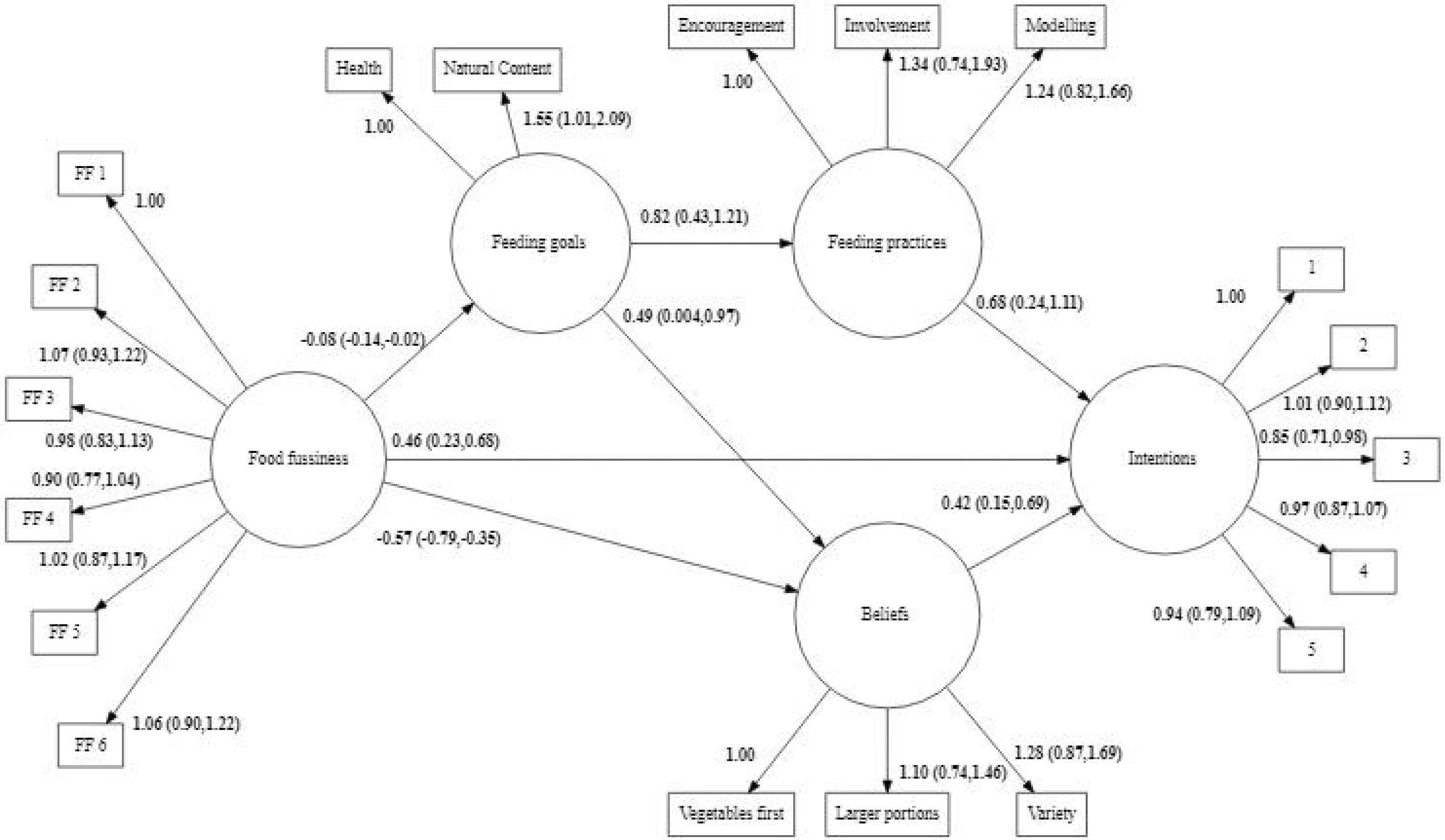
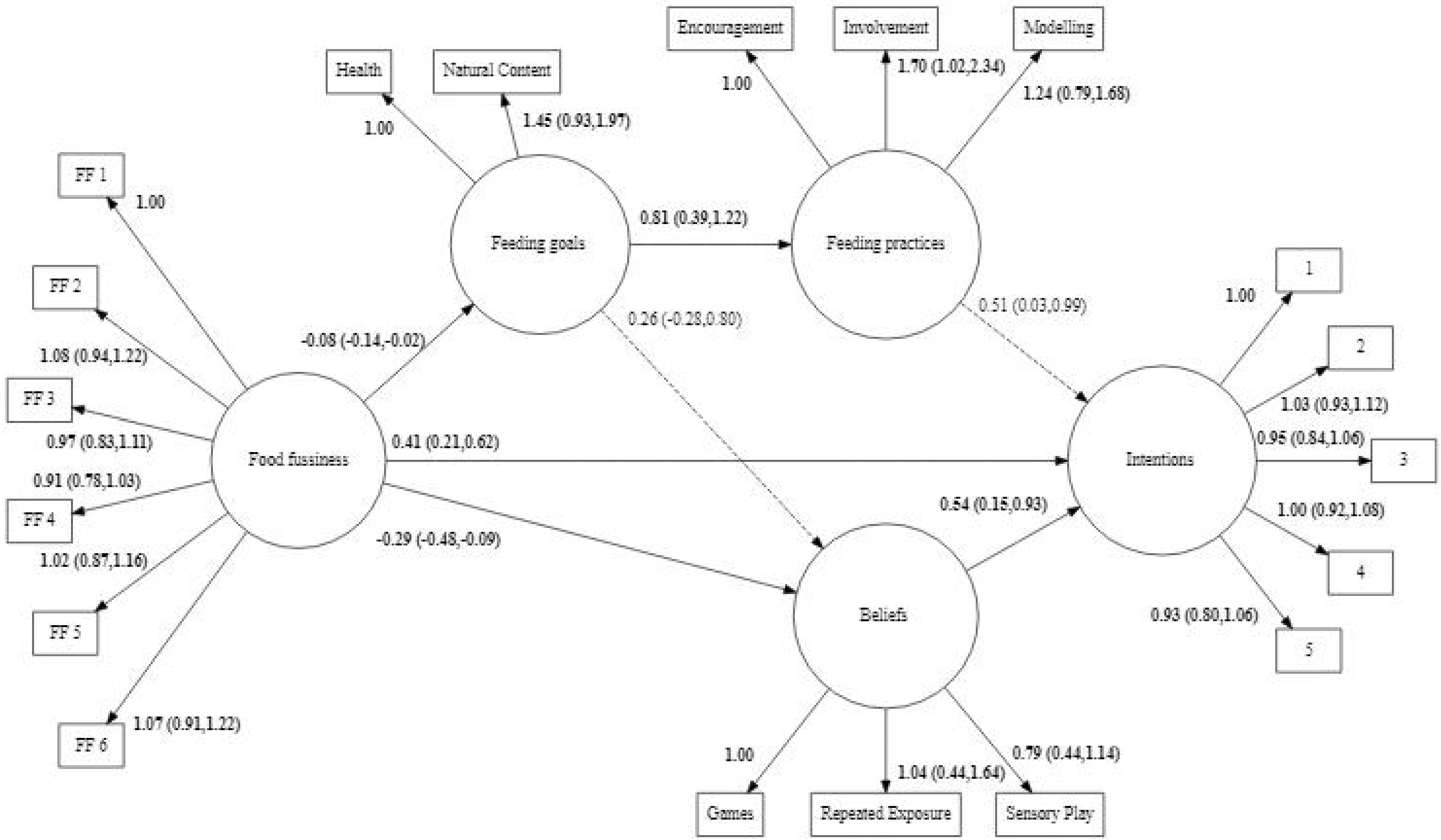


Figure 6.3. The results of the final Experiential Learning model, examining the associations between child and parental factors with parental beliefs that vegetable feeding strategies will be effective for their child, and whether parents intend to implement these strategies. Circles indicate latent factors, boxes represent measured items, arrows from circles to boxes indicate factor loadings (95% BCa confidence intervals, one measured variable for each latent variable is fixed to one) and arrows between circles indicate the direct effect expected between latent variables (interpreted as a regression coefficient, with 95% BCa confidence intervals).



6.3.3 Findings from open ended questions

6.3.3.1 Parental intentions

Table 6.4 shows the different categories of parental response when asked whether they intended to implement vegetable feeding strategies at home or not. Similar responses were given the same code. Where parents were equivocal about a strategy, this was combined with “No” responses, as the qualifying reasons were most similar to each other.

The degree of intentions to implement both types of strategy were similar, with the majority (64%) of parents stating that they intended to try the suggested strategies. Of parents that did not intend to implement the strategies, a few parents reported that their child was too fussy and that the strategies would lead to waste:

(e.g. “I feel like it could create a lot of extra food waste if he doesn't eat any of it”, [P280, 4yr, M, meal service]).

However, more parents were concerned about the cost, time commitments and any extra stress or hassle that the strategies would incur:

(e.g. “my child refuses to eat vegetables so I would love to try it. However, I am worried that I might waste time & money”, [P55, 4yr, M, meal service].

“I wouldn’t try this as it would seem like it’s a lot of hassle and messing about and making meal times a game is not for me”, [P177, 7yr, M, experiential learning]).

The most popular reason for not intending to try these strategies was that the parents believed the strategy would not work, or that there was no guarantee that their child would eat more vegetables:

(e.g. “I have bad experience with playing, it usually ends up playing without eating anything.”, [P104, 5yr, F, experiential learning].

“I don't feel like serving veg or fruit before the meal or putting more of the intimidating food on their plate will create any positive attitudes to that particular food.”, [P258, 5yr, F, meal service]).

Parents more often reported reasons why they would intend to implement the strategies. Parents reported meal service strategies as easy to try with little extra effort:

(e.g. "This…seems like it wouldn't involve changing the mealtime too much. Serving veg first sounds like an interesting idea and wouldn't need that much extra effort", [P41, 4yr, F, meal service])

Whereas, experiential learning strategies were seen as a way for children to enjoy vegetables, or to try them without pressure:

(e.g. "These methods sound more fun, which appeal to me more. They seem more like learning about the vegetable, presenting my child with them rather than pushing them to eat", [P232, 5yr, F, experiential learning]).

Many parents also reported intentions to try these strategies based on wanting healthier diets for their children:

(e.g. "Getting my boy to eat veg is a mission as it is and i'm always on the lookout for ways of trying to get him to at least try [vegetables]", [P39, 7yr, M, meal service].

"I would want to try and vary his diet", [P249, 7yr, M, experiential learning]).

Table 6.4. Using content analysis, codes are presented that were derived from written responses to parental intentions questions. The number of participant's reporting each code as a reason to intend/not to intend on implementing meal service and experiential learning strategies is also presented.

		Type of strategy	
Do I intent to implement the strategy?	**Reason/code**	**Meal service (n)**	**Experiential learning (n)**
-	Left blank / not sure	6	9
No/Maybe	Child already eats vegetables or I already do this	13	13
	Child is too fussy or will waste the food	16	6
	Due to hassle, stress, monetary or time costs	31	34
	Strategy will not work or not guaranteed to work	46	44
Yes	Strategy is easy to do or worth a try	50	30
	For my child to eat or try more vegetables specifically	89	68
	For my child to eat a healthy, balanced diet more generally	45	37
	For my child to enjoy vegetables without pressure	6	61

6.3.3.2 Parental beliefs

Table 6.5 and Table 6.6 illustrate the different codes created from parents’ reasons for whether each strategy would improve their child’s intake of vegetables or not.

6.3.3.2.1 Meal service strategies

Meal service strategies will not work

Parents reported a range of reasons why meal service strategies would not work for their child. For a “vegetables-served-first” approach, some parents suggested that they, or their child, would not like the strategy:

> *(e.g. “My children don't eat starters. They would assume that I'm just serving them a dinner of vegetables. They wouldn't be happy with that” [P258, 5yr, F, vegetables-served-first],*
>
> “He would get upset that the rest of the food wasn't ready.” [*P25 4yr M, vegetables-served-first)*

Many parents also mentioned that their child would say that they are finished, or refuse to eat and wait for their main meal:

> *(e.g. “I don't think this would work. He would want to wait for the better food.” [P183, 7yr, M, vegetables-served-first].*
>
> *“He would want to just eat the main meal so would say he is finished” [P127, 4yr, M, vegetables-served-first])*

For all three meal service strategies (especially serving larger portions), parents suggested that the strategy would not work as their child would be overwhelmed by large portions or complain about the way the vegetables are served:

> *(e.g. “This overwhelms them, they just see a mountain.” [P200, 4yr, M, serving larger portions].*
>
> “She really doesn't like having mixed vegetables at home...she gets very upset, even if they're completely separated and not touching.” [P236, 6yr, F, serving a variety])

For both serving larger portions and a variety, some parents reported that their child has a certain amount that they usually eat, and after they reach this point, the child will stop eating. Other parents suggested that their child already knows what they do and do not like to eat, and therefore would not eat anything else:

(e.g. “He would claim he was full after his usual amount and leave the rest” [P168, 7yr, M, serving larger portions].

“I have tried a range of vegetables and she knows what she does and doesn’t like” [P58, 5yr, F, serving a variety])

Meal service strategies could work

A few parents, whilst thinking that the vegetables-served-first strategy would increase their child’s intake, expressed concern that the vegetables would ‘fill their child up’, leading to fewer other food groups being eaten during the main meal:

(e.g. “He would probably eat all the vegetables but then not eat as much of his dinner which I wouldn’t like ”[P100, 6yr, M, vegetables-served-first])

Secondly, some parents reported that the effectiveness of the methods used will depend on the type of vegetables in the larger portion and variety strategies. Parents reported that if better liked vegetables are used, the strategy may have more success to increase intake:

(e.g. “If it’s vegetables she likes she will eat more” [P234, 5yr, F, serving larger portions])

“If there are options I think it would encourage to eat the preferred one” [P270, 4yr, F, serving a variety]).

Meal service strategies will work

For parents that thought the vegetables-served-first strategy would work for their child, they attributed this to their child being hungry enough to eat the vegetables that are served:

(e.g. “if she was hungry she would have to eat them” [P188, 5yr, F, vegetables-served-first])

or that there were no other food options available to eat instead of the vegetables. This means that other more palatable foods are not available and therefore other foods cannot act as a distraction to eating vegetables:

(e.g. "I think this would work well with my child as she tends to eat her favourite elements of the meal first then claims to be full" [P77, 4yr, F, vegetables-served-first])

Some parents also reported that their child would eat more vegetables if served a larger portion because they have certain rules in place for how much (proportion) of their vegetables to eat at mealtimes:

(e.g. "Because he knows I like him to finish a certain amount of food. Like for him to try and eat half or 2/3 of his dinner if possible]" [P161, 6yr, M, serving larger portions])

For serving a variety, parents that thought this strategy would work for their child referred to reasons such as the child being in control of what they choose to eat and therefore eating more of the foods that they choose to eat:

(e.g. "We try to do this and then give him the choice of two. This seems to empower him as he can make the decision to pick his preferred option" [P164, 5yr, M].

"I think this would work because it gives illusion of choice." [P199, 5yr, M])

Lastly, because there are options available when serving a variety, parents further reported that their child will be able to eat the vegetables that they like without the pressure to eat a certain vegetable:

(e.g. "There would likely be at least one item that he would enjoy and would be finished." [P59, 7yr, M])

Table 6.5. Using content analysis, codes are presented that were derived from written responses to parental beliefs questions. The table illustrates reasons parents provided for why meal service strategies may or may not increase vegetable intake by their child and the number of parents reporting these reasons for each individual strategy.

		Meal service strategy		
Will the strategy work for my child?	**Reason/code**	**Vegetables served first (n)**	**Serving larger portions (n)**	**Serving a variety (n)**
-	Left blank / not sure	11	16	12
No	Parent does not like the strategy	26	-	-
	Child would not like the strategy	33	-	-
	Child would refuse to eat or say they are finished	51	-	-
	Child is fussy and would complain, be overwhelmed or leave leftovers	33	158	43
	Child only eats a certain amount/ the child knows what they like	-	47	41
Maybe	Child will become too full and would not eat their main course	15	-	3
	No difference/child already eats what is served	35	23	45
	It depends on the vegetable type. Other methods or foods could work better	-	19	55
Yes	Child will eat if hungry	54	5	-
	No other options to eat	34	-	-
	Strategy is interesting, engaging and not boring	10	-	45
	Child would eat more due to more food on the plate or pre-set rules (e.g. to eat a certain amount)	-	34	-
	Child likes change, options or control at mealtimes	-	-	35
	Child will eat their preferred vegetable, there is no pressure to eat a specific vegetable	-	-	23

6.3.3.2.2 Experiential learning

Experiential learning strategies will not work

Parents often expressed that they themselves did not like certain strategies involving vegetable related games or sensory play, therefore the strategy would not work for their child:

> *(e.g. "Not sure how i feel about playing games when you're supposed to be eating" [P8, 4yr, M, vegetable related games]*
>
> *"Wont be that helpful because some veggies like broccoli do not smell or look appealing" [P250, 6yr, M, sensory play]).*

Other parents thought that their child would play with the food and not eat, the food would get cold and therefore unappealing, or that their child would be distracted and forget to eat completely:

> *(e.g. "My child would 100% muck about with it and wouldn't eat them" [P267, 5yr, M, vegetable related games].*
>
> *"playing will make her forget to eat." [P104, 5yr, F, vegetable related games])*

Parents that did not think that sensory play would encourage their child to eat more based their responses on child fussiness or not liking to play with their food, stating that their child is too old for the strategy, or that playing would lead to not eating for a variety of reasons:

> *(e.g. "my child he doesn't like anything dirty and is very particular about the state of his food so I feel like this would put him off…" [P91, 4yr, M, sensory play],*
>
> *"I don't think it would work as she's that little bit older now, when she was younger yes I think it would have worked" [P296, 7yr, F, sensory play],*

"if they have time to go cold, she wouldn't eat them" [P263, 7yr, F, sensory play])

Parents that did not think that repeated taste exposure would work for their child reported this to be because their child is too fussy or that they would become overwhelmed at repeatedly being offered the same vegetables at each meal:

(e.g. "My child is very stubborn and would not try anything that he didn't want to." [P26, 5yr, M].

"I feel it would be vegetables overload and she would refuse all" [P129, 7yr, F])

Experiential learning strategies could work

Parents that thought repeated taste exposure could work stated that it would depend on the type of vegetables or that it would only work after a period of time:

(e.g. "It could work, but it depends on the vegetables really. If after multiple attempts my child doesn't like something then I am not going to continue to try for 6 or 7 more times..."[P289, 7yr, F, repeated taste exposure]).

Experiential learning strategies will work

Many parents responded positively to playing vegetable related games and sensory play at mealtimes, suggesting that the games could be fun and therefore, eating vegetables could become more enjoyable for their child:

(e.g. "Games may encourage future eating of veg as [it] is a game not [a] chore." [P123, 6yr, M, vegetable related games]

"He would enjoy the play idea as it is a more chilled and fun way of introducing vegetables" [P193, 4yr, M, sensory play])

Parents also said that this method would work as their child likes playing:

(e.g. "this would work, because my child enjoys learning through play, so vegetable games could be very encouraging" [P265, 4yr, M, vegetable related games])

These strategies were also highlighted to encourage children to try vegetables (although not necessarily consume the entire portion), without pressure to eat them:

(e.g. *"I believe this could be a good way to introduce new vegetables to my child which she might otherwise be suspicious of." [P209, 6yr, F, vegetable related games]*

“It may encourage him to try them as he will see they aren't there to hurt him or some may smell nice so it sparks interest to taste…” [P222, 6yr, M, sensory play]).

Sensory play in particular was reasoned to help overcome sensory sensitivities and assist the child in learning about the sensory characteristics of vegetables:

(e.g. “might help my child understand more about vegetables and their taste/texture” [P217, 4yr, F, sensory play].

Whereas repeated taste exposure was suggested to work for their child due to receiving more exposure to the vegetables, creating habits and eating vegetables at mealtimes becoming the norm over time:

(e.g. “I think this would show him that its a continued thing I am trying to do and he would eventually get used to it.” [P158, 7yr, M, repeated taste exposure].

“This would help him understand that vegetables are a part of his dinner” [P193, 4yr, M, repeated taste exposure])

Table 6.6. Using content analysis, codes are presented that were derived from written responses to parental beliefs questions. The table illustrates reasons parents provided for why experiential learning strategies may or may not increase vegetable intake by their child and the number of parents reporting these reasons for each individual strategy.

		Experiential learning strategy		
Will the strategy work for my child?	**Reason/code**	**Vegetable games (n)**	**Sensory play (n)**	**Repeated taste exposure (n)**
-	Left blank / not sure	18	26	18
No	Parent does not like the strategy	26	21	-
	Child would not like the strategy	17	28	-
	Child will refuse or forget to eat	55	41	34
	Child is too fussy or the strategy too overwhelming	-	19	65
Maybe	Strategy would be better outside of mealtimes	-	8	-
	Child is sensory sensitive	-	4	-
	Strategy could work over time, but depends on vegetable type	-	-	20
	No difference or child already eats what is served	23	17	48
Yes	Child enjoys play, competition or reward	58	17	-
	Strategy is fun, engaging or distracting	75	60	-
	Strategy encourages eating or trying without pressure	30	37	-
	Strategy desensitises to sensory characteristics	-	24	-
	Child will eat more due to number of exposures	-	-	117

6.3.4 Summary of findings from open ended questions

Parents most frequently responded with decisive statements about their intentions to either implement or not implement the strategies and when suggesting whether or not the strategy would increase vegetable intake for their child. Parents rarely responded with statements that were unsure or undecided as to the potential effects of the strategies. For intentions, almost two thirds of parents reported that they would implement the strategies. However, beliefs that meal service strategies would work were reported in around one third of responses, and around half of responses for experiential learning strategies. To summarise the responses for beliefs, parental themes were developed based on whether the parent thought that the strategy would work for their child. Parents believing that the strategy would not work tended to either not like the strategy themselves (e.g. games are not for the dinner table), or they anticipated their child's negative response to the strategy (e.g. my child would complain, they would refuse to eat). However, parents that suggested the strategy would work for their child tended to identify positive aspects of the strategy (e.g. games are fun, engaging and enjoyable, therefore making eating vegetables less of a chore).

6.4 Discussion

This study aimed to explore and specify the relationships between child eating factors, parental feeding factors, parental beliefs that different strategies to encourage vegetable intake in children would succeed and whether parents intend to implement these strategies at home. Structural equation modelling and mediation analyses suggest that for meal service strategies, the effect of food fussiness on parental intentions was competitively mediated by parental beliefs. As food fussiness of the child increased so did parental intentions, however this was also associated with lower belief that the strategy will work. More moderate effects on parental intentions to implement strategies were also observed from parental feeding goals and practices, with more frequent positive parenting practices associated with higher intentions to implement. Written parental responses on why strategies would or would not work were varied. For experiential learning strategies, some parents reported that they would not work due to play conflicting with mealtime goals and appropriate behaviour, whereas meal service strategies were disliked due to the potential for extra food waste and costs. However, many parents believed their child would benefit from play to make eating vegetables more fun, exciting and pleasurable, whereas meal service strategies were seen by parents as easy to do and often parents believed their child would eat more as a result of serving more vegetables.

In both meal service and experiential learning models, the higher the child's food fussiness, the more parents reported a greater intention to implement vegetable feeding strategies. However, interestingly, in the meal service model this effect was reduced by parents having low belief that the strategies would work for their child. This illustrates a potential conflict between parent's having positive intentions to implement vegetable feeding strategies, but negative thoughts about how useful the strategies will be for their child. On one hand, parents may want their child to consume more vegetables and generally they will be willing to try strategies to encourage their child to eat healthily (Hingle et al., 2012). However, when presented with a range of strategies that could promote healthy eating, parents may not believe that they will work to increase vegetable intake by their child, especially if their child is fussy. The effect of lower beliefs further predicted reduced parental intentions to implement strategies. Low beliefs could be a result of past parental experiences with trying different strategies and not having any effect for their child's eating. Consequently, parents of fussy eaters could have developed either a learned helplessness (Duncanson et al., 2013; Russell & Worsley, 2013) or low perceived behavioural control (Ajzen, 1991) over their child's vegetable eating behaviours. Both mean that parents believe they can only influence or change what their child eats to a certain extent and this could in turn discourage parents from trying or persisting with new vegetable feeding strategies (e.g. due to low desire/motivation to implement; Hingle et al., 2012). From the written responses, some parents anticipated their child's negative responses to the strategy (e.g. my child will complain, or refuse to eat). It could be that these parents believe that no matter what they try, their healthy eating goals will be difficult or impossible to achieve (Duncanson et al., 2013). In a review of qualitative studies, parents with low self-efficacy to influence their child's eating habits often had an awareness of healthy eating concerns, but this was not reflected in their behaviours or feeding practices (Pocock, Trivedi, Wills, Bunn, & Magnusson, 2010).

In contrast to the meal service model, there was no mediation effect of beliefs in the experiential learning model. One reason for this difference may be that parents hold more positive beliefs about the effectiveness of experiential learning strategies. Analysis of written responses suggests that experiential learning strategies are regarded as being more engaging than meal service strategies and therefore parents may hold stronger beliefs that this type of strategy could work. Similarly, using concepts from the Theory of Planned Behaviour, parents that have more favourable evaluations of these strategies and therefore more positive attitudes towards them, will be more likely to intend on implementing the strategies. Another explanation is that although the effect was in the same direction as the meal service model, it may have been non-significant due to being a smaller effect. Similarly, due to the ordinal nature of the data, there may have been reduced power to detect this smaller effect in the experiential learning model. This is possible because when examining the total indirect effect of food fussiness on intentions (through parental feeding goals, practices and beliefs) the competitive mediation is negative and significant (in the same direction as the meal service model).

In other mediation pathways, the indirect effect of healthy eating goals on intentions (via parental practices) was significant in the meal service model, but not the experiential learning model. Higher healthy eating goals were associated with more frequent use of positive feeding practices across both models, and this in turn predicted higher intentions to implement meal service, but not experiential learning strategies. It is possible that parents already modelling and encouraging vegetable intake (positive feeding practices) may find meal service strategies more readily acceptable to implement, as these strategies mainly involve changing what and how much is served at mealtimes. In comparison, experiential learning strategies are further removed from these positive feeding practices and may even take more time and effort to implement. This could deter parents from intending on implementing these types of strategy, despite higher beliefs that experiential learning strategies could work for their child. Furthermore, mediation analyses were non-significant and it is possible that these parental factors are underpinned by their child's eating behaviours and/or temperament (Holley et al., 2020). Our models show that higher food fussiness predicted lower healthy eating goals of the parent. If healthy eating goals are less important for parents, they may also perform fewer or more infrequent involved feeding practices at mealtimes (e.g. modelling healthy food intake), resulting in reduced intentions to implement new strategies. This is interesting as research examining the success of parent-led interventions on child vegetable intake found that success was not predicted by parental feeding practices, but instead by the food fussiness of the child (Holley et al., 2016).

When exploring the reasons parents gave for their intentions and beliefs, similar patterns were observed to the quantitative findings. Parents generally had high and positive intentions to implement strategies, whilst holding lower beliefs that the strategy would work for their child. For each question, parents mostly responded with decisive statements, with few parents being unsure of their intentions or potential outcomes of the strategy for their child. This could indicate that parents have very specific ideas about what they will and will not implement at mealtimes, as well as how they think their child will react to any mealtime changes. This could mean that encouraging parents to implement vegetable feeding strategies may first require overcoming parent’s hesitancy to try these strategies and working with parents on developing strategies that might work for them. One factor from the Theory of Planned Behaviour that was not measured was subjective norms. This could play a role in parent’s intentions as they may be more likely to implement strategies if they think that other parents are implementing the strategies with their children. Parents that suggested strategies would not work sometimes reasoned that they did not like the strategy themselves (e.g. games are not for the dinner table). Although these parents may value healthy eating, play based experiential learning appears to be in opposition to their mealtime goals (Schuster, Szpak, Klein, Sklar, & Dickin, 2019). This is because play focuses on improving children’s positive experiences with vegetables, rather than consuming all of the portion. In contrast, the parents that reported strategies would work for their child were more likely to identify the positive aspects of that particular strategy (e.g. games are fun, a distraction from thinking about eating the vegetables; when vegetables are served first, there are no other options to eat, etc.) it is more likely that children will eat more vegetables when offered in a positive and fun environment (see Chawner & Hetherington, 2021; Yee et al., 2017 for reviews), and this could predict more successful interventions if implemented at mealtimes.

When examining these findings in relation to the theory of planned behaviour, parents may have largely positive attitudes towards healthy eating and healthy eating strategies, which could explain their high intentions to implement these strategies (Ajzen, 1991). Parent's perception of subjective norms (that others may use similar strategies) was not tested, however if parents perceive other parents to be implementing vegetable feeding strategies with their children, parents may enhance their own intentions to implement these strategies through social pressure. Yet, low beliefs that the parent can change their child's eating behaviour (low perceived behavioural control) using these strategies may limit parent's intentions to implement them. This might predict a gap between high parental intentions and low behavioural implementation of strategies (Duncanson et al., 2013), although this was not tested directly in this study.

Lastly, it is important to consider these results in light of how the intentions questions were framed. We asked parents if they would intend on implementing these strategies if it would increase their child's vegetable intake by one portion, or 40g. This would be a large increase in consumption of vegetables by most children and may explain some of the high intentions of parents to implement the strategy. Children are much more likely to increase intake by a few bites, or increase their willingness to try the vegetables, especially in the short term as a result of using these strategies. Therefore, parental intentions may have been lower if the question was framed as encouraging your child to try vegetables, rather than eat 40g more of them.

6.5 Strengths and limitations

Prior qualitative studies have identified barriers and experiences of parents when serving vegetables, and quantitative studies have separately sought to link parent and child feeding factors to food intake. In this cross-sectional study, quantitative analyses allowed us to test a specific model examining the relationships between factors that could predict parent beliefs and intentions to implement strategies. Analyses of open ended questions then provided details that explained some of the observed associations, providing a fuller picture to the data and what might influence parents' beliefs and intentions surrounding vegetable feeding strategies.

One limitation of the study is that the impact of the sample characteristics on the model is not known. We do not know if the participants were single parents or if there were multiple adults in the house, whether participants were currently working or the geographical location of participants within the UK. These factors could influence the model as income may go further in certain areas of the country, where living expenses are lower. Single parent households may also have less time and help from family members to serve dinner and implement a new feeding strategy. Therefore, certain environmental factors that have not been accounted for could influence the model in ways that were not measured. Other factors that may influence parental intentions were also not the focus of this study (e.g. general parenting style, child temperament; e.g. general parenting style, child temperament; Blissett, 2011). Similarly, we cannot confirm the income status of the households recruited to the study. In attempting to select a lower-income sample, the majority of participants were within the bracket of £25,000-£49,000 household income. This encompasses values around the median income for households in the UK, in which the median disposable income is around £31,400, but this is not total household income (before taxes) that participants reported. This could impact the generalisability of findings to parents with lower than average incomes in the UK.

6.6 Implications and future research

Although food fussiness may be heritable and to some extent, beyond parent's control, evidence generally suggests that intake of foods can change over time (Wardle & Cooke, 2008). Parents may benefit from support and guidance when introducing similar vegetable feeding strategies at home. This may include acknowledging that eating changes are more likely to happen over time, reassuring parents that strategies have worked for other children and encouraging parents to make mealtimes more fun and encouraging for their child. This could include more tailored strategies for parents to adopt dependent on what their child's eating traits and temperament are perceived to be. For example, fussy eaters may begin with sensory play with a view to taste vegetables, rather than larger portions that focus on outcomes of increased intake. With this strategy, managing parental expectations and illustrating that tasting a vegetable is a success for many children (not just eating a large amount) may be beneficial for parents to consider when implementing vegetable feeding strategies. Without this support and information, parents may be more willing to continue with their current practices than implement new strategies, as they know what outcome they are likely to get and what amount of food waste might be expected (Russell, Worsley, & Campbell, 2015). Vegetable feeding strategies could be further tailored to parental goals and types of strategy that the parent believes could have an impact, as there appears to be a mismatch between intentions and beliefs - parents intend to implement strategies, but they do not believe they will work. This could have unintended consequences, such as either intentions not formulating into behaviour, or that parents will try strategies half-heartedly believing that they will not work in any case, and so the strategy may not be as effective as the literature suggests it could be.

Future research could examine parental intentions to implement vegetable feeding strategies when parents are told that the outcome will be different, such as the strategy will encourage my child to taste the vegetables; encourage my child to eat a few bites more; or encourage my child to eat half a portion. This has potential to identify what reward or outcome parents find acceptable so that they may then implement these strategies at mealtimes.

6.7 Conclusion

The current study examined parental beliefs that meal service and experiential learning strategies would increase their child's vegetable intake at mealtimes, and to what extent parents intend to implement these strategies. The relationships between child eating traits, parental feeding goals and practices were further explored for their associations with parental beliefs and intentions. It was found that overall, parents reported high intentions to implement vegetable feeding strategies, but intentions were reduced when parents did not believe that the strategy would increase their child's vegetable intake, especially for food fussy children. Higher intentions may also be explained by the ease of implementing some strategies by parents and making mealtimes more pleasurable for their child, whereas lower intentions could be explained by parental perception of higher costs and waste, along with strategies not aligning with parent’s personal mealtime feeding goals.

Chapter 7

Eating vegetables at mealtimes: Pilot studies exploring vegetables-served-first and experiential learning strategies in schools

Chapter 7 Eating vegetables at mealtimes: Pilot studies exploring vegetables-served-first and experiential learning strategies in schools

Abstract

Vegetable provision at nurseries and schools in the UK has increased over recent years, however children still eat few of the vegetables that are served to them. Implementing interventions at mealtimes that focus on consuming vegetables before the rest of the meal may increase vegetable intake by children. Two experimental pilot studies were designed and conducted to test a vegetables-served-first approach (study 1) plus experiential learning (study 2) to increase vegetable consumption at lunchtimes. Study 1 (n = 38) found that serving vegetables first, compared with serving all foods together, increased intake of vegetables (~10g) that 3-5 year olds ate with their lunchtime meal. Study 2 (n=69) found that serving vegetables first alongside experiential learning also increased vegetable intake by 4-7 year old children during the intervention. However, disparities in the schools participating in study 2 revealed different eating profiles for intake. Therefore it was not possible to separate effects of the intervention from contextual effects of each individual school. Whilst these pilot studies are promising, future research should design vegetable eating interventions with a systems approach in mind. Interventions which focus on child learning through experience need to consider contextual factors in the school environment including curricular needs, resources available for school lunch (including both time and space) and the culture around eating. All these factors need to work together to provide a healthy eating environment.

7.1 Introduction

In the UK since 2008, policy requires early year settings (e.g. schools, nurseries) to use healthy food procurement standards. This has improved school's purchase of fruits, salads and vegetables and reduced that of foods high in fats, sugar and salt (Afshin et al., 2015; Niebylski et al., 2014). Yet, whilst procurement has improved, much of the vegetables offered to pupils at lunchtime are wasted (Haroun et al., 2011). Meal service and experiential learning strategies are promising ways to increase children's low vegetable consumption at mealtimes (Poelman et al., 2020; Tani, Ochi, & Fujiwara, 2021). Meal service strategies manipulate how the meal is served (e.g. serving vegetables first or in larger portions), whereas experiential learning strategies focus on the child having new and positive learning experiences at eating occasions (e.g. through games or sensory play). Utilising different strategies at mealtimes may encourage children to consume larger portions of vegetables and to develop positive vegetable eating habits. However, as many parents do not believe that these strategies will improve their child's intake of vegetables (Chawner, Blundell-Birtill, & Hetherington, 2022b), it is important to test these strategies in environments outside of the home. The current pilot studies examine the effects of vegetables-served-first and experiential learning strategies on children's vegetable intake at school mealtimes.

Eating vegetables first at mealtimes (before other foods) is common in some cultures. Studies from Japan suggest that around 25% of preschool children eat vegetables first at every meal and around 52% "sometimes" eat vegetables first at meals (Yang, Tani, Tobias, Ochi, & Fujiwara, 2020). This behaviour is associated with greater vegetable intake and lower incidence of overweight, compared with eating meat or fish at the beginning of the meal (Tani, Fujiwara, Ochi, Isumi, & Kato, 2018). Therefore, eating vegetables first at mealtimes may be a positive and healthful habit to teach children in the UK. Serving vegetables first ensures that other, more palatable foods are not present at the same time as vegetables. When more palatable, or "competitor" foods are available simultaneously, children may eat these foods instead of the vegetable portions on their plate (Correia et al., 2014; Ishdorj et al., 2015; Leak et al., 2017). In an online study, Chawner et al. (2022a) found that children (8-11 years) were more likely to select a vegetable to accompany a meal when the vegetable was better liked than the competitor option or if the vegetable added a different food group to the existing meal (a variety). If vegetables within a meal are less liked than other foods on the plate, serving vegetables at the start of the meal and without competitor foods may encourage vegetable intake by children.

Serving vegetables first has been tested in a number of ways. When served alone as a starter, increasing the portion size of a vegetable served increased overall vegetable intake (Spill et al., 2010). A variety of pureed vegetables were also eaten in larger amounts when blended into a tomato soup starter (Spill et al., 2011). Other studies have served raw vegetables in the lunch line at schools, which increased vegetable intake by approximately 5g (Elsbernd et al., 2016; Redden et al., 2015). Differences in the amount eaten in these studies may reflect how vegetables were served, since more vegetables were consumed whilst sitting down, than whilst standing up in the lunch queue. When vegetables were served first alongside fruit, only intake of fruit was increased and not intake of vegetables (Harnack et al., 2012). Similarly, doubling the portion size of fruit and vegetable side dishes increased fruit intake but not vegetable intake (Kral, Kabay, Roe, & Rolls, 2010). In these examples, vegetables are competing with the more palatable fruits for consumption and therefore fruits are favoured over vegetables. In summary, evidence suggests that serving vegetables first works best in isolation and in large enough portions to encourage greater intake, whilst sitting at the table.

Offering vegetables first may facilitate intake due to removing competitor foods and readiness to eat or hunger. However, more general benefits to intake may be achieved through experiential learning, since this may improve liking of vegetables. Experiential learning strategies might offer taste exposure alongside play, touch, and smell activities to encourage children to become familiar with vegetables in a non-threatening way, which in turn promotes willingness to try and to taste these vegetables (Nekitsing, Hetherington, & Blundell-Birtill, 2018). A recent systematic review demonstrated a variety of activities that are used as experiential learning strategies in research, including taste testing, games, creative activities, storybooks, food preparation, sensory play and gardening (Varman et al., 2021). This review found larger effect sizes for increasing healthy eating behaviours where studies used a mixture of experiential learning approaches implemented within short yet high intensity interventions.

In the current pilot studies, the aim was to assess the effects of vegetables-served-first (study 1) and vegetables-served-first plus experiential learning (study 2) approaches on children’s vegetable intake at lunchtimes in the school environment. Feasibility for implementing these strategies was also explored. It was hypothesised that after a single exposure to serving vegetables first at mealtimes (with no additional changes to meal structure), children’s vegetable intake will increase (study 1). We further hypothesised that children would consume larger amounts of vegetables when they are served first (compared with together alongside the rest of the meal) over time as children will develop the habit of eating or trying vegetables first (study 2). Furthermore, after receiving experiential learning, when all foods are served together it was hypothesised that children will continue to eat more vegetables than at baseline, as children will implement what they have learned throughout the intervention (study 2).

7.2 Study 1: Vegetables-served-first only

7.2.1 Methods

7.2.1.1 Participants

Participants were 38 nursery school children (20 girls) aged 3-5y from two schools in the north of England. Schools were identified and approached through Phunky Foods, which is an early years programme that delivers healthy lifestyle curriculums and resources to educational settings. Parents were invited to consent for their child to participate in this study. Children whose parents did not consent still received the study foods and procedure, but data was not collected for these children. This was due to the group nature of the intervention at the nursery mealtime. Ethical approval was provided by the University of Leeds School of Psychology Ethical Review Committee (Reference: PSYC-211, 20/06/2021).

7.2.1.2 Design and materials

Parents were invited to complete a survey about their child’s eating behaviours, eating habits and parenting mealtime practices. These measures were collected to describe the sample and to examine the potential effects of liking and familiarity on food intakes at lunchtimes. The parental survey included demographic questions about the parent and their child, how often their child eats certain foods (Food Frequency Questionnaire: Hammond et al., 1993), how much their child likes those foods (parental perceived liking), the Child Eating Behaviour Questionnaire (CEBQ, 5 subscales: Food fussiness, Enjoyment of food, Slowness of eating, Satiety responsiveness and Food responsiveness) (Wardle et al., 2001) and lastly, the Parent Mealtime Action Scale-Revised

(PMAS-R, 4 subscales: Positive persuasion, Use of rewards, Insistence on eating and Child selected meals) (Musher-Eizenman & Holub, 2007).

Two separate experimental meals were served to children in nursery at their usual lunchtime. The lunchtime meals were delivered in a crossover design within two schools. Meals were served in two experimental conditions, all foods served together or vegetables-served-first (as a starter). The same meal was served twice with a one week washout period between meals. The meals consisted of fish fingers (50-60g), potato wedges (70g), cooked peas (40-60g) and cooked carrots (40-60g). Appropriate portion sizes were guided by UK government portion size recommendations (Public Health England, 2018b). The outcome variables of interest were the weight (g) and energy content (kcal) of each food eaten.

7.2.1.3 Procedure

At lunchtimes, children entered the nursery eating area as usual before being served either the full meal or vegetables-served-first. All foods were weighed before being served to the children. Children then ate the meal as they would usually. If vegetables were served first, after 10 minutes any leftovers were removed and replaced with the remaining non-vegetable food items. After the meal had ended, plates were removed and leftovers were weighed. The next week, the same foods were served using the other experimental presentation of vegetables (either vegetables-served-first or all foods together). All experimental procedures took place during the COVID-19 pandemic (July 2021) and therefore the research team was not permitted to enter schools. Consequently, school staff and not the researchers served and weighed the meals.

7.2.1.4 Statistical analyses

Pre and post lunch weights of all foods were recorded by school staff. Amounts of each food served and eaten (g), total amount eaten (g and kcal) and how much was eaten as a percentage of what was served were calculated. Energy intake was estimated using the nutrition information on the food packaging (Table 7.1). For vegetable items, children often mixed peas and carrots in their meal, therefore energy of vegetables was taken to be in the middle of peas and carrots (mixed vegetables were estimated as 54 kcal/100g of vegetables).

Meal data were then examined using multi-level regression models, with participant as the random factor. Three models were conducted: with total vegetables eaten (g), total competitor foods eaten (g) and total energy eaten (kcal) as outcome variables in each model respectively. Vegetable portions were combined to assess total vegetable intake (carrots + peas), and an aggregated item “competitor foods” was used to assess the total intake of the other available foods (fish fingers + potato wedges). Predictor variables were the amount of vegetables or competitor foods served (g or kcal, continuous data) and the presentation of vegetables (vegetables-served-first or together, factor). School was also controlled to compare effects between schools (factor).

Data were prepared and analysed in R version 4.1.0, using packages tidyverse 1.3.1, car 3.1-0, lme4 1.1-30 and sjPlot 2.8.11.

7.2.2 Results

7.2.2.1 Participants and survey data

Eighteen surveys were returned by parents of nursery children (47% return rate). Of the parents that returned the survey, all were of white ethnicity, 16 were mothers, with various levels of education (high school/college = 7, diploma/degree level or above = 8, did not answer = 3) and household incomes (< £49,999 = 10, > £50,000 = 4, did not answer = 4). Parents rated their children towards the higher end of the CEBQ food fussiness subscale (*M* = 3.2, *SD* = 0.4). Full sample characteristics are presented in Appendix C1.

7.2.2.2 Foods served

Weighed food intake for both meals was collected for 37 children, and weighed intakes for one meal in 38 children (one child’s data was not available for the second meal).

Across both conditions, portion sizes could not be controlled fully due to COVID-19 restrictions and data collection was only possible by school staff since researchers were not allowed into schools. The mean portion sizes served by schools were below the recommended portion sizes for each food to be served (Table 7.1). Individual children received varying portion sizes of each food, with some of the last children to be served receiving smaller portions of some foods.

Table 7.1. The columns on the left of the table show the estimated energy and nutrient composition of the foods used. Columns on the right report descriptive statistics for the actual portion sizes served to children by school staff.

	Estimated energy and nutrient composition					Amount served to children by schools		
Item	Energy (kcal/100g)	Fat (g/100g)	CHO (g/100g)	Sugars (g/100g)	Protein (g/100g)	Range (g)	Mean (g)	SD (g)
Fish fingers	223	9	14	0	12	31-83	58	13.7
Potato wedges	145	5	35	1	3	34-117	56	15.6
Cooked peas	79	2	11	2	7	15-50	34	8.7
Cooked carrots	29	1	6	6	1	10-58	34	14.5

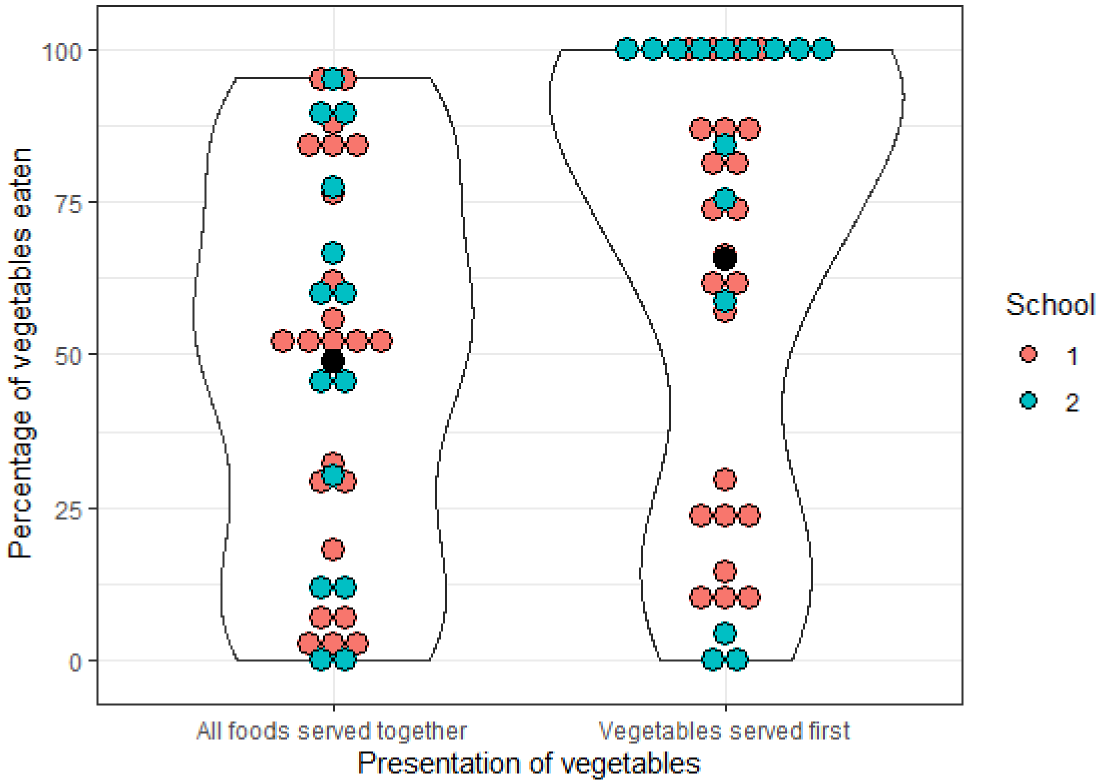
7.2.2.3 Amounts eaten

For some children, weighed intake for individual vegetables was combined due to children mixing the vegetables together at their meal. Therefore all analyses conducted used total vegetables eaten and served, rather than separating carrots and peas. Across both experimental conditions, children ate similar proportions of fish fingers and potato wedges served to them. In the vegetables-served-first condition, children ate a larger proportion of vegetables served, with a mean difference of 6g of vegetables eaten in this condition (Table 7.2). Figure 7.1 illustrates the percentage of vegetables eaten (of the portion served to them) in each condition by children.

Table 7.2. Descriptive statistics for the Range, Mean and Mean proportion (of the portion served) of each food eaten by children across the two experimental conditions.

	All foods served ***together***			Vegetables-served-***first***		
Food	Range (g) eaten	*M* / *SD* (g) eaten	*M* proportion eaten	Range (g) eaten	*M* / *SD* (g) eaten	*M* proportion eaten
Fish fingers	0-83	52 / 18.1	92%	9-70	55 / 16.2	93%
Potato wedges	0-92	38 / 25.9	61%	0-66	36 / 20.3	70%
Vegetables (combined)	0-93	36 / 28.0	49%	0-86	42 / 25.1	65%

Figure 7.1. A violin plot of the percentage of vegetables eaten (of the portion served) in each condition by children. Each school is labelled as a different colour and each dot is an individual child's data point. The black dot represents the mean proportion of vegetables eaten in each experimental condition.



When predicting the total vegetables eaten (g) at each meal, children from school 2 ate slightly larger portions of vegetables, but this was not a statistically significant difference between schools. Portion sizes of vegetables served predicted intake, with larger portions of vegetables served predicting larger amounts of vegetables eaten by children. On average, children ate 10g more vegetables in the vegetables-served-first condition, compared with all foods served together. No order effects were observed from the crossover design. The final model explains 81.5% of the variance in children's vegetable consumption, with 76% of this variance explained by the random effect (between-subjects). This suggests that individual children ate different amounts of vegetables depending on the experimental condition (Table 7.3).

Table 7.3. Results of a multi-level model predicting total vegetable intake (g) by children in each experimental condition.

	Total vegetables eaten in g				
Predictors	*Estimates*	*std. Error*	*CI*	*t-statistic*	*p*
(Intercept)	-20.41	17.40	-55.13 – 14.31	-1.17	0.245
School (reference level School 1)					
School 2	9.74	10.21	-10.63 – 30.11	0.95	0.344
Amount of vegetables served (g)	0.74	0.20	0.35 – 1.13	3.76	**<0.001**
Vegetable presentation (reference level served together)					
Vegetables-served-first	10.13	2.74	4.67 – 15.60	3.70	**<0.001**
Random Effects					
σ^2	117.41				
$\tau_{00\ Participant}$	378.35				
ICC	0.76				
$N_{Participant}$	38				
Observations	75				
Marginal R^2 / Conditional R^2	0.217 / 0.815				

The model for amount of competitor foods eaten (Appendix C2) also suggests a portion size effect, the larger the portions of competitor foods served, the larger the portion eaten. However, there was no effect of serving vegetables first on intake of competitor foods. Similarly, when total energy consumed (kcal) was examined (Appendix C3), the more energy served from competitor foods predicted an increase in the total energy consumed. However, there was also a small experimental effect, as more energy was consumed during the vegetables-served-first condition than the all foods served together condition. This is potentially as a result of consuming more vegetables in the vegetables-served-first condition.

7.2.3 Discussion of study 1

Study 1 set out to examine whether serving vegetables first at school mealtimes could increase vegetable intake by children. It was found that higher intakes of vegetables were consumed by children in the vegetables-served-first condition, compared with the condition with all foods served together. This is consistent with findings from other studies examining vegetables-served-first techniques (Spill et al., 2010). Larger vegetable intakes were also observed when larger portions of vegetables were served to children (portion size effect: Reale et al., 2019). The effect of serving vegetables first could be explained through a few mechanisms. Children may be hungrier at the start of the meal and therefore more willing to eat the vegetables served to them. Also, there are no other more palatable, energy dense foods to become satiated (or distracted) by (Leahy, Birch, Fisher, & Rolls, 2008). Without competitor foods, children had the opportunity to eat vegetables instead of consuming other meal items first (Ishdorj et al., 2015). Lastly, children may have eaten more vegetables due to the novelty of being serving vegetables first on one occasion. These findings suggest that from one exposure to vegetables being served first, children’s intake of vegetables can be increased at that mealtime. Study 2 aims to explore this effect over multiple exposures to serving vegetables first, as well as to enhance the effect with the concurrent use of experiential learning techniques.

7.3 Study 2: Vegetables-served-first plus experiential learning

7.3.1 Methods

7.3.1.1 Design

Study 2 used a treatment vs control with partial crossover design, with each of the two conditions cluster randomised to different schools. The independent variables were the presentation of vegetables at each meal and whether experiential learning was provided or not. Presentation of vegetables had one level (Vegetables presented as a starter). Experiential learning had two levels (experiential learning provided -treatment; experiential learning not provided -control). Partial crossover was used so that both groups had the same baseline and test conditions, with all foods served together. The study lasted for 5 weeks, with weeks 1 and 5 test weeks (vegetables were served together with the meal) and weeks 2-4 experimental weeks (with 3 exposures each week to vegetables served first only or plus experiential learning). It was not possible to blind schools to the condition they were assigned, however they were blinded to the conditions and protocols of the other schools. The main outcome for all conditions was the proportion of vegetables consumed (of those served) at the meal. Ratings were made for the amount eaten by each child (None, ¼, ½, ¾, all) by Early Development Coordinators (EDCs) from Phunky Foods. A process evaluation was conducted with school staff involved in the study. Ethical approval was provided by the University of Leeds School of Psychology Ethical Review Committee (Reference: PSYC-461, 08/02/2022).

7.3.1.2 Participants

Sample size was calculated to take into account power and feasibility. To detect a small-medium effect size (f = 0.15) for a within-between groups interaction, with alpha = .05, power = .80, and 5 measurements, a sample size of 56 was required. However, as the study design was cluster randomised, the design effect also needed to be considered. Based on study 1, the largest observed Intra-Cluster Correlation (ICC) was 0.15 (this is a measure of how similar children are within the same school). This ICC creates a design effect of 3.85. Therefore, a minimum of 12 clusters with 20 participants each (total sample size = 240) would have the same power as an individually randomised trial with 62 participants (240/3.85 = 62, effective sample size).

Schools were identified and approached through contacts with Phunky Foods, since these were schools already receiving nutrition education activities in their curriculum. Children aged between 4 and 7 years (UK reception to year 2 classes) were eligible to participate.

7.3.1.3 Materials

Foods. For each meal, schools provided their usual meals on each of the intervention days. The research team provided two portions of vegetables to add to the child's usual meal; 1/3 cup (~40g) of carrots and 1/3 cup (~40g) of peas per child.

Dinner plates. As part of serving vegetables first, schools in the control condition were provided with blank white plates in which to serve vegetables in isolation. Schools in the experiential learning condition were provided with "Veg first" plates.

Experiential learning resources. In addition to dinner plates, schools were provided with a vegetables-first video, which showed children interacting with vegetables and singing a song including the message "vegetables are eaten first". The song was also provided to these schools for children to sing before lunch times. Short nutrition education about why vegetables are good for us was also provided before each lunch time. The teacher session plan for the experiential learning condition is provided in Appendix C4.

7.3.1.4 Procedure

Head teachers were approached to provide consent on behalf of their school to participate. Parents were then informed of the study and given the opportunity to opt their child out of data collection. An opt-out procedure was used since the procedure only differed in normal food provision via order (vegetables first) and accompanying experiential learning. Schools were assigned to one of two groups, control (vegetables-served-first only) or intervention (vegetables-served-first plus experiential learning), using stratified random sampling based on the number of pupils participating from each school. All study procedures took part soon after the main COVID-19 restrictions were lifted in the UK (February-July 2022). Due to Covid-19, experiential learning procedures were limited insofar that sensory exploration of foods was not possible (limiting spread of disease) and singing was also not permitted in some schools.

Week one involved one test meal (baseline), with vegetables served alongside the child's usual meal at school. At each meal, only vegetable items were controlled for. Two portions of vegetables (cooked peas and carrots) were served alongside the usual menu items that the school serves. This was to ensure that two portions (40g each) of vegetables were available for children to eat.

In weeks 2-4, schools in each condition implemented the intervention procedures three times per-week (e.g. Monday, Wednesday and Friday). At each of these meals in the control condition, vegetables were served first in isolation for 10 minutes, before being removed and replaced with the other usual foods available at school mealtimes. For schools in the experiential learning condition, strategies were first introduced in the classroom five minutes before lunchtime (short nutrition education, watching a vegetables-first video, singing the vegetables-eaten-first song). Vegetables were then served in isolation on the specially designed vegetables-first dinner plates (for 10 minutes – sample Figure 7.2), before the plate and vegetables were removed and children were served the rest of their meal. After 9 exposures had been achieved (over 3 weeks), a test meal which was the same as the baseline meal was provided and intake measured.

To assess the amount of vegetables eaten at lunchtimes, measurements were taken at five time points, once each week. The proportion of vegetables eaten was assessed by EDCs from Phunky Foods (on behalf of the research team). Proportion of vegetables was used as an outcome based on feedback in study 1, since schools reported that weighing foods before and after the meal was not practical. EDCs were trained to rate intake for each of the children's meals. This included taking a picture of a standard meal before eating and comparing vegetable leftovers of each child's meal to the before picture. Intakes were estimated for the amount eaten by each child on a five point scale: None was eaten, ¼, ½, ¾ of the portion was eaten, or All of the portion was eaten (Appendix C5). A sample of meals (n = 3-5 per school per time of measuring) were photographed before and after eating to confirm ratings and ensure that ratings were consistent between schools and between study weeks. A timeline for the procedures described is presented in Table 7.4.

Figure 7.2. Example plates when vegetables were served first at mealtimes before eating (left) and after eating (middle – ¾ eaten; right - ¼ eaten).

Table 7.4. A timeline of study procedures, measurements taken and experimental conditions.

Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Baseline session	1st – 3rd intervention sessions	4th – 6th intervention sessions	7th – 9th intervention sessions	Test session
Test Meal (all foods served together)	***Experimental condition meal*** Vegetables-served-first ***Or*** Vegetables-served-first plus experiential learning			***Test Meal*** (all foods served together)
Rated vegetable intake plus pictures of selected meals before and after eating.				

A process evaluation (Appendix C6) was then conducted by telephone after the study had ended to understand how the intervention worked in practice and its feasibility. School teachers and lunchtime staff were invited to provide feedback. This included questions about contextual factors (factors that shape how the intervention works, as well as how the intervention may affect the usual context), implementation factors (how delivery and training was achieved; and also what was delivered in terms of fidelity and any adaptations) and potential mechanisms of impact (what were children’s responses to and engagement with the intervention; were there any unexpected consequences).

7.3.1.5 Statistical analyses

As the outcome of interest (estimated proportion of vegetables eaten) was ordinal, cumulative link mixed models were employed. Time (week number - categorical), school (categorical) and condition (experimental vs control – categorical) were input into the model as predictor variables, with participant as the random factor. Participants were excluded from analyses if they had fewer than three data points from the five study weeks.

Data were prepared and analysed in R version 4.1.0, using packages tidyverse 1.3.1, ordinal 2019.12-10 and sjPlot 2.8.11.

7.3.2 Results

7.3.2.1 Participants

Four schools were recruited to take part, with 74 children participating in the study. 69 children had outcome data for three or more weeks, with a total of 306 observations at eating occasions (maximum of five per child, data missing for 39 eating occasions). Of the four participating schools, school 1 was assigned to the control condition (20 children) and schools 2, 3 and 4 were assigned to the intervention condition (20, 23 and 6 children respectively). Two schools were located in the midlands and two in the north of England.

A further four schools that were recruited did not participate in the study. Two of these schools noted staffing issues due to COVID-19 as a reason for not taking part. One school indicated that seating arrangements in their school due to COVID was not compatible with the study. The last school stated that there was not enough time to serve vegetables first and expressed concern about children re-joining the lunch queue, which could reduce teaching time.

7.3.2.2 Eating outcomes

Each school that participated had very different profiles for the proportion of vegetables eaten each week. Figure 7.3 demonstrates that 50% of children from school 1 (control condition) ate all of the vegetables served to them each week, with very low levels of vegetable refusal. Children from School 2 ate slightly higher proportions of vegetables on their plate as the study progressed. School 3 children appeared to have high levels of vegetable refusal, with higher proportions of vegetables being eaten during the intervention sessions (weeks

2-4). Lastly, children from school 4 appear to be consistent with the proportions of vegetables they ate, with a higher percentage of children eating the full vegetable portion in weeks 3 and 4. Figure 7.4 further presents the median proportion of vegetables eaten at each school each week, showing that children in school 1 ate a high proportion of vegetables each week. School 2’s median percentage of vegetables eaten increased during the intervention and then increased further after the intervention had finished. School 3 showed an increase in the median proportion eaten in week 2, however the median decreased again each week thereafter. Lastly, school 4‘s median proportion eaten increased during intervention weeks, but then appeared to decrease after the intervention ended.

Figure 7.3. The percentage of children from each school consuming different proportions of vegetables served to them during the study. For weeks 1 and 5, vegetables were served together with other foods on the plate. In weeks 2, 3 and 4, vegetables were served first. School 1 was assigned to the control condition during weeks 2, 3 and 4, with the other three schools receiving experiential learning during these weeks.

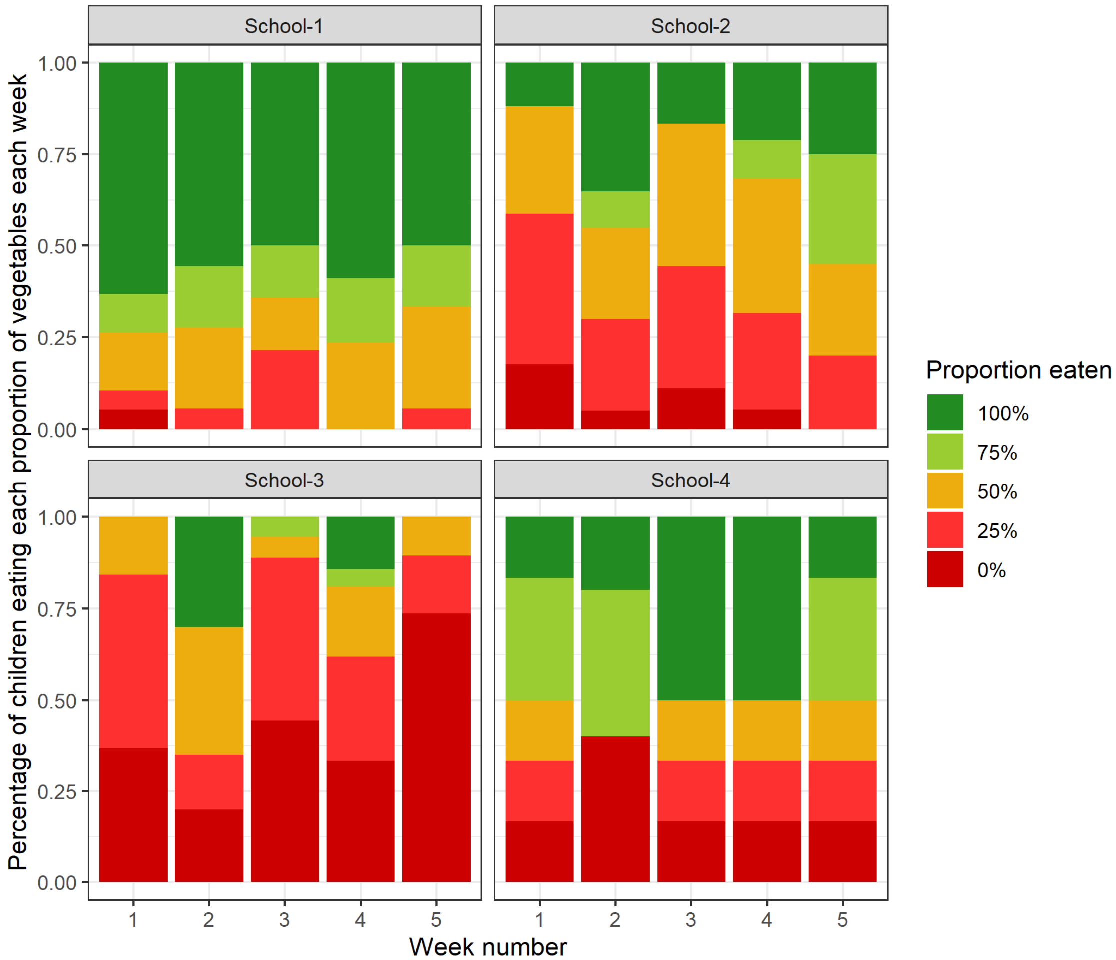


Figure 7.4. The median proportion of vegetables eaten (from the portion served) by children from each participating school each week. For weeks 1 and 5, vegetables were served together with other foods on the plate. During weeks 2, 3 and 4, School 1 was assigned to the control group with vegetables-served-first, whilst schools 2, 3 and 4 were assigned to receive vegetables-served-first plus experiential learning.

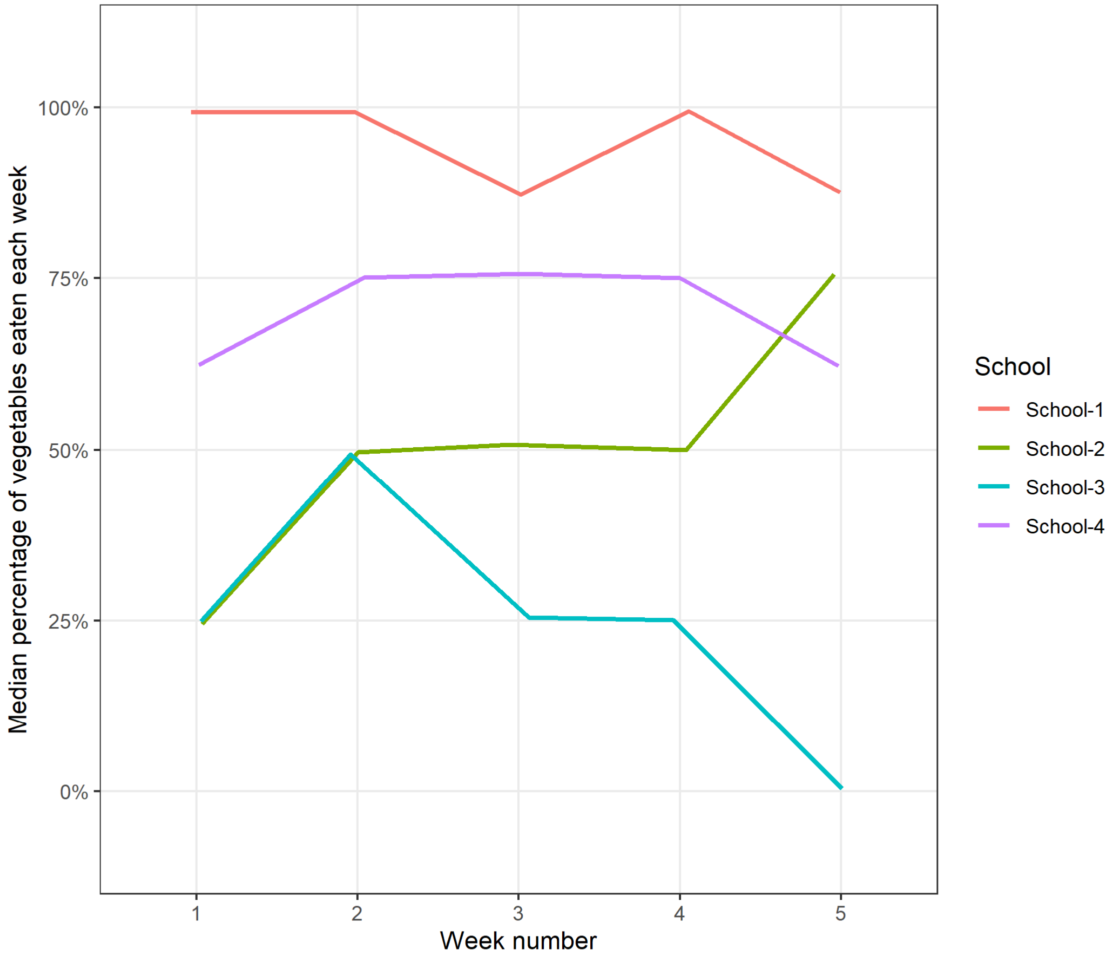


Table 7.5 reports the likelihood of children eating a certain proportion of vegetables (0%, 25%, 50%, 75% or 100%) from the entire portion served to them at lunchtimes. For weeks two and four of the study, children had higher odds of consuming a larger proportion of vegetables compared with week 1. Similarly, children from schools 2, 3 and 4 had lower odds of consuming a larger proportion of vegetables compared with children from school 1. The final model explains 68% of the variance of the proportion of vegetables eaten by children, with 50% of this variance explained by the random effect (between-participants). However, it is important to note that this analysis is clustered on the individual (level-2), but not on the school (level-3). Children within schools are more similar to each other but this has not been corrected for in the analysis due to number of clusters and unequal cluster sizes. Therefore, it is possible

that the standard errors are underestimated and there is a chance of higher Type-1 error rates. Interpreting these results should be done with caution as effects may be overestimated.

Table 7.5. This table reports the parameters from the cumulative link mixed model, which suggests the likelihood of each child consuming a larger proportion of vegetables during each week of the study and between schools.

	Likelihood of eating a higher proportion of vegetables				
Predictors	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
0%|25%	0.01	0.00	0.00 – 0.03	-7.74	**<0.001**
25%|50%	0.07	0.04	0.02 – 0.21	-4.72	**<0.001**
50%|75%	0.43	0.23	0.15 – 1.25	-1.54	0.123
75%|100%	1.06	0.57	0.37 – 3.05	0.11	0.911
Week number (reference week 1 – baseline)					
Week 2	4.60	1.80	2.13 – 9.92	3.90	**<0.001**
Week 3	1.11	0.42	0.53 – 2.31	0.27	0.787
Week 4	2.69	1.00	1.30 – 5.57	2.67	**0.008**
Week 5	1.43	0.53	0.70 – 2.94	0.98	0.327
School (Reference School 1 – control condition)					
School 2	0.10	0.07	0.03 – 0.38	-3.38	**0.001**
School 3	0.01	0.01	0.00 – 0.04	-6.59	**<0.001**
School 4	0.11	0.11	0.02 – 0.77	-2.23	**0.026**
Random Effects					
σ^2	3.29				
$\tau_{00\ Participant}$	3.31				
ICC	0.50				
$N_{Participant}$	69				
Observations	306				
Marginal R^2 / Conditional R^2	0.354 / 0.678				

7.3.2.3 Process evaluation

Two of the four participating schools (schools 3 and 4) agreed to provide feedback through process evaluation.

Contextual factors. In school 3, children queue up for lunch, have the choice of food options (and salad) and are served their dessert alongside their main meal. Although the children have one hour to eat, they are often hurried to eat so that other year groups can access the dining hall and they can go outside to play when finished eating. School 4 was a smaller school. Meals were less hurried, but children tried to finish quickly to go out to play. Those that have school dinners and packed lunches sit separately and staff check whether children have eaten enough before they can go to play.

School 4 reported that the study procedures had little impact on the usual mealtime process. Children in reception class already go to lunch 10 minutes early, so serving vegetables first fit well with this process. However, had other year groups participated, logistically the study would have been more difficult to implement. School 3 stated that due to the study, the year group participating went into the dining hall slightly early. Children queued for their vegetables first and then re-queued for their main meal.

Implementation factors. In both schools, all staff were enthusiastic to implement the study. Staff from school 3 were particularly eager to encourage vegetable intake since the school is in a deprived area and many of the children had not eaten vegetables before. Staff reported following the protocol exactly, with no adaptations needed. Staff in schools described the Phunky foods EDC as helpful to keep the schools on track with the study, but both schools reported becoming familiar with the procedures very quickly. Both schools stated that the lessons fit well with the curriculum and there was little to no extra burden on staff during the study. The only difficulty in school 3 was the timing of lunch slots for all children (different year groups access the dining hall in intervals).

With regards to the materials, school 3 liked the “Veg first” dinner plates as they were colourful and separate from the usual meal. The videos were fun to watch and all materials were appropriate and pitched at the right age. The materials were similar to regular classroom activities, as children are used to being involved with singing and watching YouTube. School 4 reported that the song and video were played in the dining hall.

Potential mechanisms of action. School 3 reported that many of their children had never tried vegetables before this study. Most children were therefore trying the vegetables and then deciding whether they liked them or not and how much to eat. The school reported that the study procedures were different from the usual mealtime and fun to participate in, which may have facilitated trying the vegetables. Children were continuing to sing the song on non-study days, however, teachers suggest that the novelty of serving vegetables first may have worn off after two weeks. Teachers noted that the video had a variety of vegetables and the study did not. More variety may have encouraged further vegetable intake, with one teacher suggesting that monotony may have been more important than liking of vegetables.

Teachers in school 3 reported an unexpected consequence as children did not view the vegetables as part of the meal. The teacher suggested that some children may not have understood that the vegetables were a starter and that they would get the rest of their meal afterwards. For this reason, some children ate their vegetables very quickly in order to get to their main meal, but then after the second week, some children would wait for their main meal. The teacher further reported that they thought the children ate more of their main meal when vegetables were served first. The teacher from school 4 further stated that the study was easier to manage than they thought it would be and they were happy that parents were supportive of the study.

7.3.3 Discussion of study 2

Study 2 explored the use of serving-vegetables-first and experiential learning techniques on children's intake of vegetables at school lunchtimes. Generally there was a higher percentage of children eating larger proportions of vegetables during the intervention weeks (weeks 2, 3 and 4) compared with the baseline week (week 1).

The findings suggest that in week 2, children were more likely to eat larger proportions of vegetables served. Although the novelty effect is often portrayed as a negative effect, with consumption decreasing at following eating occasions (e.g. Horne et al., 2009; Just & Price, 2013; Kessler, 2016), the idea of novelty is central to experiential learning theory. This suggests that any new activity that has not been encountered before can be considered as an experience (Kolb, 2014). The first week of intervention may therefore be interpreted as when the novelty of the experience has its largest effect. After this, for the intervention to remain effective will depend on the support provided by staff and children's level of engagement with the activities. However, it is important to note that whilst some experiential learning activities were delivered in this study, hands-on sensory experiences (sensory learning such as learning through touch, smell, etc.) are an aspect of experiential learning that could not be tested under COVID-19 restrictions. Embedding these activities into the intervention could improve children's willingness to try vegetables and consequently consume them after repeated exposures.

The results also show that children from different schools had very different eating profiles. The culture and context of lunchtimes in each school has effects on children's eating behaviours and how malleable they are to change. Schools have different rules at lunchtimes, which may affect whether children will eat vegetables first. However, it is not clear how specific lunchtime environments and rules may have affected what children ate across the study, or what children's attitudes were to lunchtime changes.

Lastly, as weighed intake was not feasible in the fast-paced school cafeterias, ratings of the proportion of vegetables eaten were measured. This means that the experimental procedures could have had smaller effects on individual children's eating than could be detected. In schools where children were fussier, willingness to taste or try may have improved, but this is unlikely to have been recorded. In school 3, teachers reported that they observed children trying the vegetables, but not all children liked them.

7.4 General discussion

The studies presented illustrate that serving vegetables first (study 1) combined with experiential learning (study 2) has the potential to increase vegetable intake by children. Both studies found a positive effect of the intervention on the first exposure (novelty effect). Eating vegetables may decrease after the first intervention session, but this first experience could be built on to become lunchtime habit. Differences between children from different schools were also found. These findings highlight the potential for vegetable feeding strategies to increase vegetable intake at school lunchtimes, but this is contingent on school management, lunchtime culture and context.

Birch, McPhee, Shoba, Pirok, and Steinberg (1987) suggested that to improve children's preferences for healthy food items, strategies and experiences are needed to increase exposure and accessibility to healthy foods. However, providing an intervention with these characteristics alone may not increase children's habitual vegetable intake. The GENIUS network in the UK recommends a systems approach to make changes to school food intake by children. This includes examining food policies and standards, procurement and provision of foods, the environment at lunchtimes and healthy eating interventions (Woodside, Adamson, Spence, Baker, & McKinley, 2021).

The success of future interventions may therefore be determined by their interaction with the school environment at lunchtimes. Unless sensory play is combined with vegetables-served-first, children might not understand the healthy eating message with provision alone (study 2, process evaluation). Interventions may also be successful when eating environments are positive and engaging, children have more time and space to eat (no overcrowding), age appropriate cutlery and plates, fewer social constraints (e.g. segregating children eating school dinners and packed lunches) and when eating lunch does not compete with play time (Moore, Murphy, Tapper, & Moore, 2010). These aspects of school culture and context could explain the differences observed between schools and why the intervention activities may have worked better in some schools than others. Without considering or changing these aspects of the eating environment, successful school lunchtime interventions may not be possible. This may be most pronounced for fussy eaters. Although food fussiness was measured for some children (study 1), it could not be included in the analysis as a variable. There is some evidence from study 1 that suggests fussy eaters try more vegetables (eat a few grams more) when they are served first. However, this needs to be tested with a larger sample of fussy eaters to determine whether the intervention effects will generalise for this population. It may be that for benefits of the intervention to generalise to fussy eaters eating larger or adequate sized portions, consistent provision of vegetables, experiential learning techniques and a positive environment in which to experience them is needed.

Many interventions and strategies successfully encourage children's healthy eating at lunchtimes (Cohen et al., 2021). However, interventions must be delivered within the school system and have commitment from school staff. The current studies recruited schools with staff that agreed with the importance of children consuming vegetables. This is important as enthusiasm from teachers can affect both the adherence to the intervention implementation and children's responses (Griffin et al., 2015; Kafatos, Peponaras, Linardakis, & Kafatos, 2004). An ecological model similar to Davison and Birch (2001) might suggest that eating interventions conducted within schools are embedded within the context of the wider school system. Consuming vegetables can only work when schools have good procurement policies and provision of vegetables, a positive eating environment and commitment from stakeholders. Children's eating behaviour whilst at school may be embedded within these school contexts and therefore future research must consider all aspects of school culture and contexts surrounding children's eating.

7.5 Future research

Future research using protocols from the current studies may examine how these types of intervention (serving-vegetables-first or experiential learning) may be built into the daily school lunchtime. More intense interventions that occur more frequently may see a larger effect in consuming vegetables before the rest of the meal. Other related studies may examine how different experiences of eating vegetables at lunchtimes can be learnt through further activities reflecting on and thinking about the experiences in the intervention.

Further research studies utilising this framework will be required to recruit many more schools to account for large differences between schools. To address the systems based approach, this will also include co-creation with schools and Head teachers to design healthy eating interventions around the culture and context of the school lunchtime and Head teacher ideologies around eating.

7.6 Conclusion

Study 1 found that serving vegetables first at school lunchtimes increased children's intake of vegetables. Study 2 found that whilst serving vegetables first increased vegetable intake on the first exposure, the effects of the intervention were largely dependent on the differences between schools. Due to between-school differences, it was not possible to determine whether experiential learning activities added benefit to serving vegetables first. These findings highlight the need for interventions to be designed alongside teachers to address not only the intervention itself, but also the eating environment, provision of vegetables and the delivery of interventions to children.

Chapter 8

General discussion

Chapter 8 General discussion

Large scale population studies indicate that children in the UK and across many other countries consume fewer vegetables than is recommended by the World Health Organisation. This means that, globally, many children do not benefit from potentially healthful effects that vegetables and their phytonutrients confer. Addressing the problem of children's (2-6 years) low vegetable consumption is both complex and multi-faceted. Factors shaping this problem vary from biopsychosocial and environmental, to wider societal systems (e.g. family and school). Addressing these factors either individually or together requires involvement from stakeholders, including parents/caregivers and schools, to make changes to eating occasions and encourage exposure to and intake of vegetables. Multiple theories can help to address specific problems with low vegetable consumption, whether focusing on children's learning (e.g. experiential learning theory) or parental intentions to make changes to feeding behaviours (e.g. Theory of Planned Behaviour). This chapter aims to provide a synthesis of findings from chapters 3-7, discussing the main themes in relation to current literature and theory. Implications of these studies for future practice and research are also considered.

8.1 Recap of main findings

The first aim of this thesis was to better understand the problem of eating vegetables from the existing literature (**Chapter 3**) and from nationally representative data on vegetable intake by children in the UK (**Chapter 4**). Children's online vegetable choices within the mealtime context were then examined (**Chapter 5**) along with self-reported parental responses to the implementation of different vegetable feeding strategies at mealtimes (**Chapter 6**). Finally, an in-person experiment to change children's vegetable consumption was tested to increase intake of vegetables at school mealtimes (**Chapter 7**). The key findings from each chapter in this thesis are summarised in the following sections and Figure 8.1.

8.1.1 Chapter 3: Synthesising existing evidence from the vegetable eating literature and highlighting areas for future research.

This narrative review (Chawner & Hetherington, 2021) highlighted the current literature on children's learning to eat vegetables. Research highlighting the impacts of specific developmental, biological, social and environmental factors on learning was synthesised. Three main proposals were identified for future vegetable eating studies and interventions. The first was to consider ecological validity in studies of vegetable serving, ensuring that vegetables are being served and eaten in research studies in similar ways to which they are eaten normally by children. The second suggestion concerns potential additive effects of interventions. Building complex interventions with different evidence-based elements may work well together to improve vegetable intake, compared with single strategies alone. Thirdly, individual differences of children should be taken into account when developing interventions. Children vary in temperament, fussiness and willingness to try new foods and so interventions may need to be adapted in content and intensity for different children to improve their vegetable intake.

8.1.2 Chapter 4: Determining how vegetables are commonly eaten by children in the UK.

Exploration of secondary data from the National Diet and Nutrition Survey (NDNS) (Chawner et al., 2021) found that children's (1.5-18 years) daily vegetable intake (g) increased with age, depended on the ethnicity of the child and was larger if a wider variety of vegetables was served to the child. When vegetables were eaten by children, a median of one portion was eaten (cumulatively of all vegetables) per day. This suggests that vegetables are typically eaten in smaller than recommended portion sizes. Most commonly, vegetables were eaten at home, with family members and at mealtimes. Vegetables were also more likely to be eaten alongside foods consisting mostly of carbohydrates and proteins, but not foods that are High in Fats, Sugar and Salt (HFSS). Outside of the home, vegetables were eaten at school and again in smaller portions than recommended.

8.1.3 Chapter 5: Exploring aspects of children’s food choice to select vegetables at mealtimes.

In an online experimental study (Chawner et al., 2022a), children were asked to select either a vegetable or a competitor food (protein or carbohydrate) to accompany a meal. Children selected vegetables more frequently in the context of a meal than with no meal. Children were more likely to choose vegetables when the vegetable option added nutritional variety to the meal, even if the vegetable was less liked than the competing option. Although, when vegetables were much less liked than the competing option, they were not chosen even if they added variety. Furthermore, children that scored higher on traits of food fussiness were always less likely to select the vegetable option.

8.1.4 Chapter 6: Parental intentions to implement vegetable feeding strategies with their child.

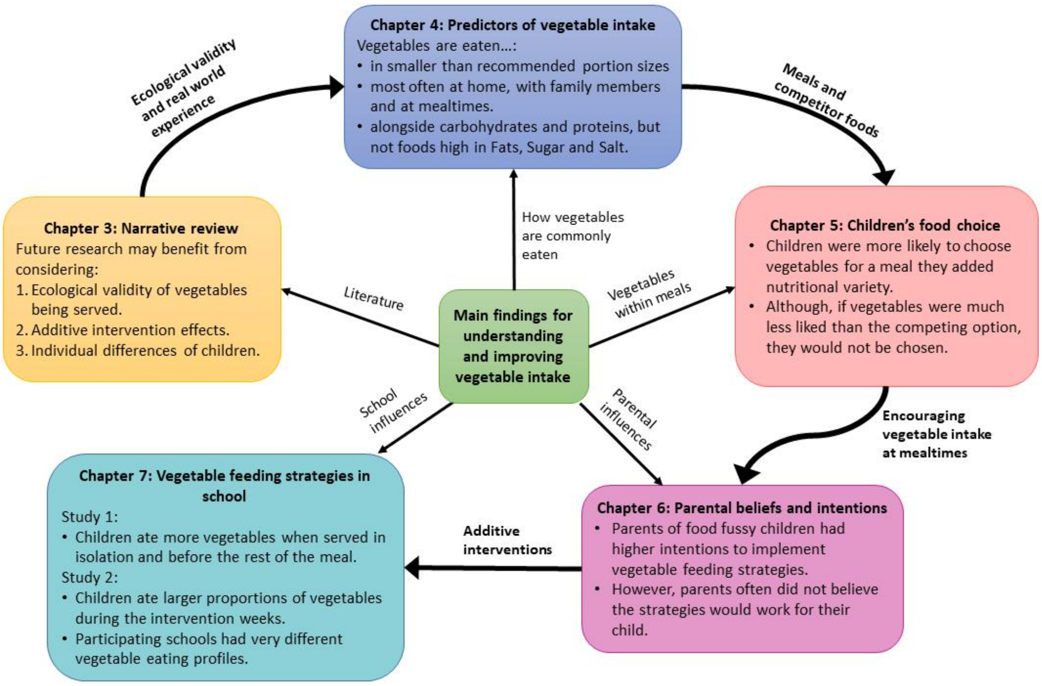
Parents were asked via online survey (Chawner et al., 2022b) about their intentions to implement vegetable feeding strategies (strategies to encourage vegetable intake) and their beliefs regarding whether these strategies would work for their child. Parents who rated their children as more food fussy had higher intentions to implement vegetable feeding strategies. However, this effect was competitively mediated by parental beliefs, as parents often did not believe the strategies would work for their child. Findings from written parental responses indicated that some parents disliked the idea of experiential learning strategies because play conflicted with their mealtime goals and what was perceived to be appropriate mealtime behaviour. Yet, other parents liked these strategies because play had the potential to make meals more enjoyable. Meal service strategies were disliked by some parents due to the potential for extra food waste and costs, but liked by others as they were perceived to be easy to implement and often parents believed their child would eat more simply because more vegetables would be served.

8.1.5 Chapter 7: Serving vegetables first and experiential learning to encourage children to eat vegetables within meals.

Two experimental pilot studies in children’s schools and nurseries examined the effect of serving vegetables as a starter to children at mealtimes.

Study 1 found that children ate larger portions of vegetables when served in isolation and before the rest of the meal. A portion size effect also indicated that the larger the portion sizes of vegetables and competitor foods served, the more of that food the child ate. Study 2 utilised experiential learning strategies (songs, videos, nutrition education) alongside serving vegetables first. Here, a higher percentage of children ate larger proportions of vegetables during the intervention weeks. However, participating schools had very different vegetable eating profiles (children in some schools typically ate larger amounts of vegetables, whereas others had higher refusal of vegetables), meaning that it was not possible to separate the effects of the intervention techniques from the effects of individual schools and their contexts.

Figure 8.1. An overview of the main findings from each chapter of this thesis and how each study developed from the findings of the previous studies.



8.2 Synthesis of findings

Three important themes are prominent across the chapters of this thesis. These are real world experience and competitor foods; individual differences that affect children's vegetable eating behaviour; and the importance of stakeholder engagement. Each of these themes will be discussed in the following sections.

8.2.1 Real world experience and competitor foods

Vegetables were served to children most commonly at mealtimes and alongside other foods, yet they were not eaten in large enough portions to meet intake recommendations (**Chapter 4**). Although focusing on mealtimes may miss opportunities to increase vegetable intake throughout the day (e.g. snacks or breakfast; McLeod, Haycraft, & Daley, 2022), there is the potential to increase portion sizes eaten and enhance children's learning about vegetables when they are already available (**Chapter 4**). However, a barrier to eating larger portions of vegetables within a meal is the presence of more palatable, "competitor" foods. Children were more likely to select a vegetable to be part of a meal, rather than a competitor food, if the vegetable added nutritional variety and if it was sufficiently well liked (**Chapter 5**). Liking and variety are important in children's intake of vegetables, as they are for adults. Children do not eat foods that they dislike (Keller et al., 2022) and variety increases intake (Roe et al., 2013). However, the independent and additive roles of liking and variety on children's food choices have not been systematically studied within meals. Importantly, these elements of a meal could interact to inhibit children eating vegetables.

The barrier of competitor foods has rarely been considered in the literature because often experimental studies of repeated exposures focus on a target (single) vegetable (Nekitsing, Blundell-Birtill, et al., 2018). Exposure techniques increase familiarity, liking and willingness to try vegetables (Appleton et al., 2018), however for children aged 2-6 years old, exposure to a single vegetable (or snack) is rare at school (Hubbard, Must, Eliasziw, Folta, & Goldberg, 2014) and at home (Draxten, Fulkerson, Friend, Flattum, & Schow, 2014). On the one hand, offering vegetables as snacks can enhance intake, but if they are most often eaten in the context of meals (often cooked vegetables), then there is a potential contrast effect with single item snacks (which are often raw vegetables, **Chapter 4**). This could make learning to eat vegetables within a meal difficult, especially if children are familiar with a particular vegetable in a particular context or presentation (Zeinstra, Koelen, et al., 2010). Consequently, children would likely require further learning to transfer familiarity effects from snack exposures to the mealtime context (Barends et al., 2013; Hetherington et al., 2015).

Serving vegetables first is one way to bridge the learning gap between exposure to vegetables in isolation and learning to eat vegetables as part of a meal (Spill et al., 2010) (**Chapter 7**). However, when foods are served together, children must show response inhibition to eat the vegetables first, before competitor foods. This may need to be learnt during mealtimes, because more palatable foods available can impair children's inhibitory control (Adise, White, Roberts, Geier, & Keller, 2021), resulting in children eating the most palatable foods first. Children vary in their ability to learn this response inhibition and the extent to which they already have this capacity. Therefore, to incorporate new vegetables into children's repertoire, the challenge is to ensure optimal context (e.g. meals), minimal contrast (e.g. cooked not raw vegetables) and adequate support to the child to eat vegetables (e.g. using vegetable feeding strategies). Children can then assimilate new ideas into their previously existing schemas about how vegetables are usually eaten.

8.2.2 Individual differences that affect children's vegetable eating behaviour

Individual differences affect vegetable eating by children and the ways in which parents feed their child vegetables (**Chapter 5, 6**). When choosing foods for a meal, children that scored higher on food fussiness were less likely to select vegetables (**Chapter 5**). Other studies also show that fussy eaters eat fewer vegetables and have less variety of foods in their diet than non-fussy eaters (Cardona Cano et al., 2015; Mallan, Fildes, Magarey, & Daniels, 2016; Taylor, Wernimont, Northstone, & Emmett, 2015). Food fussiness affects what is eaten through children's food choices, which in turn depend on preferences (or dislikes) for particular foods (Mascola, Bryson, & Agras, 2010). Therefore, the impact of offering competitor foods may be more detrimental to some children's intake than to others.

Food fussiness was also related to lower parental beliefs that vegetable feeding strategies would work for their child (**Chapter 6**), which in turn led to reduced parental intentions to implement such strategies. Parents of fussy eaters commonly use techniques that involve pressure to eat, hiding vegetables, rewards and compromising, than parents of non-fussy children (Holley, Haycraft, & Farrow, 2018). These findings are important as food fussiness also impacts eating behaviours indirectly through parental feeding strategies. Studies therefore suggest a bi-directional relationship between child food fussiness and parental feeding strategies (Jansen et al., 2017; Wolstenholme, Kelly, Hennessy, & Heary, 2020). This means that whilst children's fussiness may influence their own vegetable eating behaviours (**Chapter 5**), perceived fussiness by the parent may also influence the feeding strategies that they use (**Chapter 6**). Such strategies could reinforce children's fussy eating behaviours in certain circumstances (Searle et al., 2020), or potentially encourage vegetable intake in others (e.g. using strategies based on positive encouragement and enjoyment of eating vegetables, **Chapter 3**).

In addition to fussy eating, other appetitive traits (Russell & Worsley, 2016; Vilela, Hetherington, Oliveira, & Lopes, 2018) and demographic factors (**Chapter 4**) (Dubois, Farmer, Girard, Burnier, & Porcherie, 2011) may be important in determining food preferences generally, and vegetable eating specifically, for individuals. These factors could also extend within community systems to affect eating. For example, children from the same school ate similar proportions of vegetables than children from different schools (**Chapter 7**: study 2). School level estimates of intra-cluster correlations for nutrition interventions range from 0.1 to 0.26, which means that children attending the same school are moderately similar to each other (Gerritsen et al., 2019; Juras, 2016). However, this is a complex issue as variables such as the food culture within the school, modelling and other social effects could impact how much children eat. Therefore, whilst relatively stable traits of food fussiness may influence eating vegetables directly (food choice) and indirectly (parental feeding practices), demographic and community variables may have further impacts beyond individual differences and family practices on children eating vegetables.

8.2.3 The importance of stakeholder engagement at home and in school

8.2.3.1 At home

Whilst parents may serve vegetables at mealtimes in the home (**Chapter 4**), this does not necessarily equate to intake. Parents can make vegetables available, encourage and model their intake to improve children's vegetable consumption (Couch, Glanz, Zhou, Sallis, & Saelens, 2014; Edelson, Mokdad,

& Martin, 2016; Vollmer & Baietto, 2017; Yee et al., 2017), yet these are not sufficient to increase intake for some children. Parents may hold health beliefs including healthy eating goals, which then influence feeding practices (Kiefner-Burmeister et al., 2014), yet some parents may not be open to trying new strategies to improve their child's vegetable consumption, especially if the parent does not believe the strategy will have the desired effect (**Chapter 6**). Raising awareness about the efficacy of some feeding practices and the counterproductive effect of others (e.g. use of pressure to eat) (Haß & Hartmann, 2018) may result in improved intake.

To utilise new feeding strategies, parental involvement and motivation is important (Overcash et al., 2018). In a cooking skills program, parents were asked to implement a new strategy each week for six weeks (Overcash et al., 2019). The habit strength for using each strategy was initially good during the intervention but then decreased, suggesting an intention-behaviour gap. This suggests a burden on parents to implement too many new strategies, therefore parents require further support when delivering vegetable feeding strategies to their child (Haycraft, Witcomb, & Farrow, 2020). Few studies consider which strategies parents find acceptable and which they would like to implement with their child. This may depend on parental beliefs, attitudes and whether strategies are consistent with existing parental feeding beliefs and goals (**Chapter 6**). Which strategies parents find acceptable may be the strategies that are closest to their normal feeding styles and strategies (real world experience) (**Chapter 6**), or strategies that parents perceive as feasible (Vandeweghe, Moens, et al., 2016). Therefore, co-creation of interventions may help to bridge the intention-behaviour gap, as although parents may want their child to eat vegetables, they may not wish to implement interventions that they do not believe will work for them and their family.

8.2.3.2 In school

Parents did not believe that some vegetable feeding strategies would work for their child (**Chapter 6**), so it is important to test these strategies outside of the home (**Chapter 7**). According to findings from the NDNS, the location and time of day vegetables were next most commonly eaten was in schools and at lunchtimes (**Chapter 4**), meaning that schools can be important places to deliver both nutrition education and vegetable feeding interventions to larger groups of children. As **Chapter 5** found that children were more likely to select protein and carbohydrate foods to eat together with a meal, rather than a vegetable, removing the competition between foods by serving vegetables first is a simple method to encourage vegetable intake at school lunchtimes (**Chapter 7**).

For vegetable feeding strategies to be effective, school staff are required to be committed, motivated, enthusiastic (Griffin et al., 2015) and have the necessary resources (e.g. staff, time, food provision, lesson plans). As with parents implementing feeding interventions, school staff also require support to encourage vegetable intake. This is because vegetable feeding strategies are different from commonly used feeding practices in schools. Schools often rely on practices that include pressure to eat (e.g. ensuring that children have eaten “enough”) and rewards, which may have counterproductive effects for children eating vegetables (Moore, Tapper, & Murphy, 2010b). These practices may be a result of the school environment, which may not facilitate vegetable intake. Many school lunchtimes are time constrained, the dining area is physically constrained (e.g. limited seating arrangements) and eating leads into play, which also competes with eating (Moore, Murphy, et al., 2010). It is possible that for vegetable feeding strategies to have an optimal effect, the environment within schools may need to be altered to make messaging around health benefits and social importance of lunchtime for children more prominent (Daniel & Gustafsson, 2010). However, it is important to note that the studies in **Chapter 7** were conducted post-Covid-19 pandemic and during this time, constraints in the school dining environment were worse than usual.

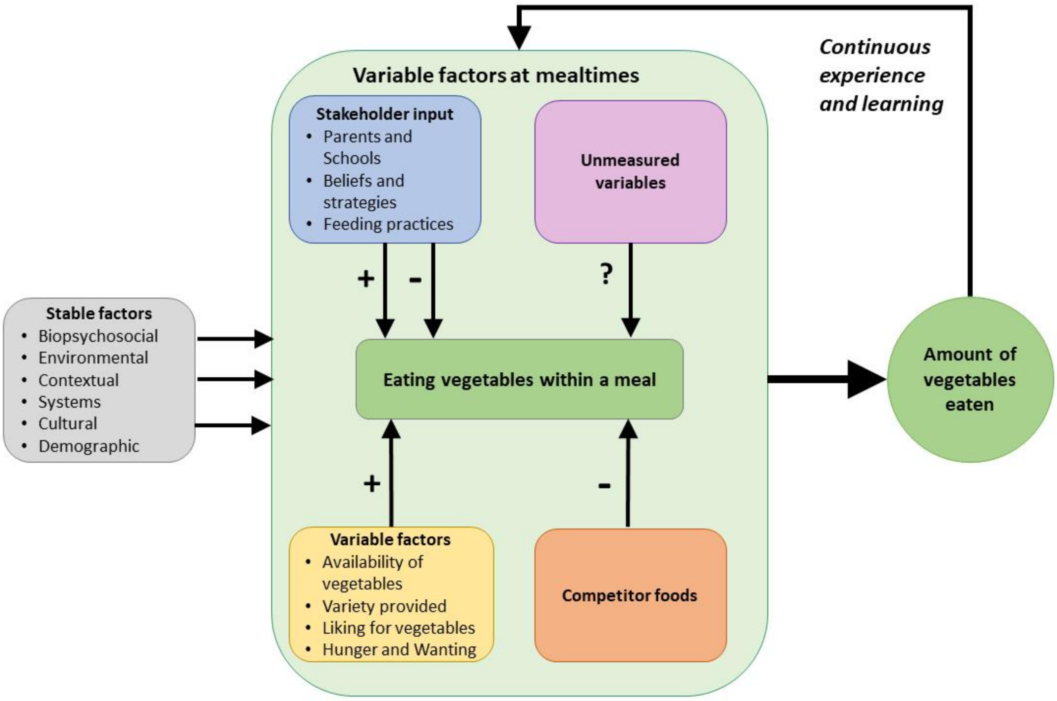
Engagement from schools is important because serving vegetables first increased vegetable intake by ~10g (**Chapter 7**). To increase intake of larger portions may require further learning within the classroom (reinforcement) and then practice at lunchtimes. Delivering different strategies that offer a variety of experiences to children when eating and outside of mealtimes could create both enjoyable lunchtimes and consolidate learning (Laureati, Bergamaschi, & Pagliarini, 2014). This could help to transition from experience to habit.

8.2.4 The difficulty of encouraging children to eat vegetables

The challenges of promoting vegetable intake are demonstrated across a number of published reviews. A systematic review with meta-analysis by Appleton et al. (2018) reports small effect sizes for exposure techniques, equating to an increase of ~10g vegetables eaten. Although exposure techniques usually do not include eating at mealtimes, serving vegetables first (before a meal) increased vegetable intake by ~10g (**Chapter 7**, study 1). Small to medium size effects were similarly reported for home based parental interventions (Touyz et al., 2018) and feeding interventions with 3-5 year old children (Nekitsing, Blundell-Birtill, et al., 2018). However, teaching approaches within schools (e.g. curriculum, experiential learning including gardening and cooking) have less clear outcomes on vegetable intake, again with small and variable effect sizes (Dudley, Cotton, & Peralta, 2015). Whilst each literature review showcases vegetable feeding strategies, the general consensus is that these have relatively small effects on vegetable intake. Therefore, liking, willingness to try and reducing food fussiness may be more achievable outcomes (Appleton et al., 2018) than increasing vegetable intake, as interventions to increase consumption achieve only around a quarter of a portion for the average child. Outcomes of interventions are even less successful for those that are fussy eaters (Holley et al., 2016).

The chapters in this thesis highlight some of the complexity of children's vegetable consumption that may explain small effect sizes of interventions. Not only are there multiple and varied factors that influence whether children will eat, or learn to eat, vegetables (**Chapter 3**), but there are also varied contextual and systems effects operating at each eating occasion. Therefore, a biopsychosocial and environmental approach is essential to address the complexities, with input from stakeholders (often parents and schools) to encourage vegetable consumption. Whilst this thesis addresses a limited selection of these factors (**Chapter 3**), the findings highlight the importance of vegetable availability at home, school and at mealtimes (**Chapter 4**). However, when vegetables are available, competitor foods within the meal may be preferred over vegetables, therefore inhibiting vegetables from being selected and potentially eaten (**Chapter 5**). Additionally, parents may not implement vegetable feeding strategies to address these complications at mealtimes if they do not believe their child's vegetable intake will improve as a result of using the strategy (**Chapter 6**). Alternatively, schools may be an appropriate place to deliver vegetable feeding strategies, yet school ethos, culture and environments vary widely (**Chapter 7**). These chapters illustrate only some of the difficulties and complexities in improving children's vegetable intake, and there are other factors which were not measured, but may still affect children's vegetable eating. These un-measured variables may contribute to explaining the error variance in these studies. Figure 8.2 illustrates these complexities for eating vegetables at mealtimes, highlighting some factors that are stable (not highly influenced by learning and experience at mealtimes) and others that are variable at different mealtimes or as a result of learning.

Figure 8.2. The complexity of factors that affect eating vegetables within a meal and how much is eaten. Stable factors are illustrated as always present, but not easily affected by learning or experience. Variable factors may change at different mealtimes or as a direct result of learning. + = positive effect on eating vegetables, - = negative effect, ? = unknown effect.



8.3 Strengths and limitations of the thesis

8.3.1 Strengths

The chapters of this thesis used a variety of different methodological designs and types of data analysis to address the research questions (**Chapter 1, 2**). These designs included larger scale analyses of national data (**Chapter**

4), as well as online experiments with children (**Chapter 5**), online surveys with parents (**Chapter 6**), and smaller scale in person experiments in nurseries and schools (**Chapter 7**). Together, these chapters captured some of the complexity of children eating vegetables, whilst addressing important gaps in the literature (**Chapter 3**). However, importantly, findings from each chapter complement each other and are compatible despite the wide differences in methodologies used. This suggests that we can be confident in the findings obtained between the chapters and between the methods used.

The chapters also offer novel findings by examining eating vegetables at mealtimes and how other available foods might inhibit vegetable intake. Examining different participants (children, parents), stakeholders (parents, school teachers) and environments (home, school) of children's vegetable eating allowed for multiple perspectives and theoretical considerations to be used within this thesis. This includes using experiential learning theory to encourage children to eat vegetables at school (with songs, nutrition education and meal service strategies, **Chapter 7**) and using the Theory of Planned Behaviour to identify why parents might intend to use some vegetable feeding strategies in the home, but not others (**Chapter 6**). As eating vegetables at mealtimes alongside competitor foods has not been studied previously, these studies offer a foundation that indicates the importance of the mealtime context and how other foods and environmental factors may inhibit vegetable intake. **Chapters 6** and **7** further provide insight into factors that were not measured directly in the studies, yet could affect eating vegetables, by utilising both quantitative and qualitative methods.

8.3.2 Limitations

Despite the strengths of using multiple methods, the sample recruitment was very different between studies. Within the NDNS, ages of children ranged between 1.5-19 years (**Chapter 4**). Recruiting for online studies involved children between 8-11 years (**Chapter 5**) and parents of children 4-7 years (**Chapter 6**). Lastly, studies from nursery and school experiments (**Chapter 7**) recruited children aged 3-7 years (across studies 1 and 2). This is a potential limitation as children's eating behaviour changes over their development and also across different settings, as well as certain cognitive abilities such as inhibition, which relates to which foods children may choose to eat first. Food neophobia and fussiness is highest between 2-6 years (Dovey et al., 2008) and it is transient (Cardona Cano et al., 2015), meaning that by 11 years, findings may not be comparable to 3-7 year olds. The recruitment of varied age groups was partly a result of practical limitations due to the Covid-19 pandemic and the resulting transition to conducting studies using online tools. In particular, younger children may not have been able to read and understand an online experiment as well as older children (**Chapter 5**). However, the findings of vegetable food choice may be similar in younger children, especially when selecting foods that are most liked and offer variety. Furthermore, recruiting parents online via Prolific has limitations, as only a subset of the parental population are subscribed to receive surveys to complete (**Chapter 6**). This effect was mitigated by recruiting from specific populations of parents. Lastly, school recruitment was difficult due to Covid-19 and issues of staffing and changes to school day procedures. This resulted in fewer schools willing to participate in mealtime experiments (**Chapter 7**), which reduced the statistical power to detect effects in this study.

Another limitation was that learning could not be measured or adequately addressed in this thesis. The aim of improving children's vegetable intake at mealtimes was based on children learning to eat vegetables within a meal through exposure and experiential learning strategies. Whilst **Chapters 4-6** set a foundation for **Chapter 7** to address this aim, learning could not be explored in detail. In **Chapter 7** (study 2), children ate larger proportions of vegetables in the first intervention week and then gradually decreased the amount eaten in some schools. This could be evidence of no learning occurring, or insufficient learning, however the findings could also indicate that learning needs to be further scaffolded in order to promote vegetable eating habits. This means that further research is necessary to identify what learning occurs, or does not occur, over time and how this influences children's eating throughout and after intervention. Viewing learning as a process, rather than an outcome of a portion eaten, may also take longer than 5 weeks (**Chapter 7**), and outcomes may need to be shifted from larger intakes of vegetables to specific learning outcomes after experiencing activities during a period of learning to eat vegetables.

8.4 Implications

Few studies have previously examined how the context of foods within a meal may affect children's consumption of vegetables. Therefore, this thesis presents novel insights into the effects of competitor foods. This could have implications for feeding practices by parents and schools. Serving vegetables first to encourage children to eat more vegetables is easy and limits the impact of competitor foods. This may be further supported by creating a positive, engaging dining environment, and classroom learning within which children can learn about vegetables and their benefits, as well as to enjoy eating vegetables. However, in order to achieve these outcomes, learning to consume more vegetables should be viewed as a longer term process, as eating larger portions is more difficult to achieve than learning to try vegetables. Since vegetable eating is complex, parents and schools are likely to require ongoing support and guidance to implement new feeding strategies and to be confident in their ability to positively affect vegetable eating behaviours by their children.

Within schools, this support has the potential to be largely influenced by policy. Currently, Head teachers or school cooks are the source for serving healthier foods and changing the eating environment. These changes start at a local level and result in inequality between schools. However, the national food strategy makes multiple recommendations to improve the food culture within schools (Dimbleby, 2021). This includes extending the eligibility of free school meals and introducing an “Eat and learn” initiative in schools. Policy that influences pedagogy with experiential learning (e.g. sensory education, food preparation skills), whilst also targeting inequality between schools, could create a positive school ethos surrounding food. Large scale changes in the curriculum could assign larger importance to eating and nutrition education for children. In addition to dedicating more time in the school day to improving diets and learning food skills, funding schools directly would mean that staff become invested in the procurement and delivery of vegetables to children. This could foster a whole school approach where eating, and eating healthily, is not only important for educational performance, but is an important part of daily life. These policy changes would also potentially better link schools to the wider food system, which would mean healthy children are linked to healthy communities.

Consequently, children would be encouraged throughout different contexts and environments to eat more vegetables.

The findings from this thesis also have implications for learning theory application to eating behaviour. Pairing a vegetable with other stimuli (e.g. a liked food, flavour-flavour learning) may not work within a meal as children might only eat the liked foods. Although reinforcement may encourage children to try foods, it too may not stimulate eating large portions of vegetables. Therefore experiences become much more important throughout the process of learning. Experiences need to be varied, many and frequent for the child. This has the potential to increase generalisability of learning from one eating context to another, using learned experiences. Enjoyable eating experiences may further be associated with vegetable liking. Therefore, over longer periods of learning with multiple and different experiences, learning could turn into habit which may result in healthier eating practices and larger vegetable intake at mealtimes.

8.5 Future research

Repeated exposure techniques have been well documented to increase children's willingness to try and liking of a single vegetable (Appleton et al., 2018). However, studies within this thesis illustrate that eating a vegetable alongside other foods within a meal may be very different experience. Therefore, research could focus on the eating context to examine whether children find it acceptable or not to eat vegetables in certain contexts and why. This may inform how children view vegetables within meals as part of their already developed schemas and may provide insight into how these could be changed.

Further studies may then focus on learning to eat vegetables over longer periods of time. This could include reinforcing learning (e.g. healthy eating messages such as eating vegetables first) and habits both at and outside of mealtimes, as well as scaffolding learning by bridging the gap between exposure to single vegetables and eating large portions within a meal. This could start from early childhood at the transition between complementary feeding and experiencing tastes of the vegetable alone, to tasting the vegetable with other foods and learning to eat portions of vegetables within meals.

Studies are also needed that specifically focus on fussy eaters at mealtimes and to what extra interventional activities may be required to achieve appropriate levels of vegetable acceptance for these children.

In schools, future research should focus on cultural changes, such as placing higher importance on positive mealtime environments and healthy eating. Eating lunch could be viewed as equally important as curriculum time because of the social benefits of eating, as well as the positive relationships children could build with food. Making environmental changes within schools, such as play time not competing with eating time, may further benefit the implementation of vegetable feeding interventions. Cultural changes with regards to vegetable growing and cooking with community involvement also show promise for better vegetable intake (Christian, Evans, Nykjaer, Hancock, & Cade, 2014). However, these types of changes must be developed within the complex food system approach, which requires cooperation between top level management and school staff to agree what is feasible and desirable for specific schools.

At home, research could be conducted to investigate how parents can be most appropriately supported to try new feeding strategies. This may include examining what resources, knowledge (Haycraft et al., 2020) or encouragement is needed by parents to provide them with the self-efficacy to implement feeding strategies and to believe that the strategies they deliver will have a positive effect on their child’s eating.

8.6 Conclusions

This thesis used a variety of methods and perspectives to examine children eating vegetables and factors that influence vegetable eating behaviours at mealtimes. If vegetables are served first at mealtimes, in isolation and without competitor foods available, children can be encouraged to eat around 10g more vegetables. However, there are caveats to this finding. Firstly, vegetables need to be somewhat liked (either similarly or better liked than competitor foods available) to be selected or eaten. Secondly, some children (e.g. those that are food fussy) may be less likely to eat or choose vegetables than others. Thirdly, parents may be less likely to encourage vegetable consumption with feeding strategies if they do not believe that the strategy will work for their child. Taken together, the findings from this thesis indicate that increasing vegetable intake in children is possible. However, it demonstrates the need for greater ecological validity in future research and sensitivity to individual child needs. It has also highlighted the importance of harnessing whole school food approaches to enable more children to learn about (experientially and pedagogically) and benefit from a greater intake of vegetables.

References

References

Adise, S., White, C., Roberts, N., Geier, C., & Keller, K. (2021). Children's inhibitory control abilities in the presence of rewards are related to weight status and eating in the absence of hunger. *Appetite, 167*, 105610.

Afshin, A., Penalvo, J., Del Gobbo, L., Kashaf, M., Micha, R., Morrish, K., . . . Smith, J. D. (2015). CVD prevention through policy: a review of mass media, food/menu labeling, taxation/subsidies, built environment, school procurement, worksite wellness, and marketing standards to improve diet. *Current Cardiology Reports, 17*(11), 1-12.

Agudo, A. (2005). *Measuring intake of fruit and vegetables [electronic resource]*: World Health Organization.

Ahern, S. M., Caton, S. J., Blundell, P., & Hetherington, M. M. (2014). The root of the problem: increasing root vegetable intake in preschool children by repeated exposure and flavour flavour learning. *Appetite, 80*, 154-160.

Ahern, S. M., Caton, S. J., Bouhlal, S., Hausner, H., Olsen, A., Nicklaus, S., . . . Hetherington, M. M. (2013). Eating a rainbow. Introducing vegetables in the first years of life in 3 European countries. *Appetite, 71*, 48-56.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Akobeng, A. K. (2005). Understanding randomised controlled trials. *Archives of Disease in Childhood, 90*(8), 840-844.

Alruwaily, A., Mangold, C., Greene, T., Arshonsky, J., Cassidy, O., Pomeranz, J. L., & Bragg, M. (2020). Child social media influencers and unhealthy food product placement. *Pediatrics, 146*(5).

Amao, I. (2018). Health benefits of fruits and vegetables: Review from Sub-Saharan Africa. *Vegetables: Importance of Quality Vegetables to Human Health*, 33-53.

Anzman-Frasca, S., Savage, J. S., Marini, M. E., Fisher, J. O., & Birch, L. L. (2012). Repeated exposure and associative conditioning promote preschool children's liking of vegetables. *Appetite, 58*(2), 543-553.

Anzman-Frasca, S., Ventura, A. K., Ehrenberg, S., & Myers, K. P. (2018). Promoting healthy food preferences from the start: a narrative review of food preference learning from the prenatal period through early childhood. *Obesity Reviews, 19*(4), 576-604.

Appleton, K. M., Hemingway, A., Rajska, J., & Hartwell, H. (2018). Repeated exposure and conditioning strategies for increasing vegetable liking and intake: systematic review and meta-analyses of the published literature. *The American Journal of Clinical Nutrition, 108*(4), 842-856.

Appleton, K. M., Hemingway, A., Saulais, L., Dinnella, C., Monteleone, E., Depezay, L., . . . Hartwell, H. (2016). Increasing vegetable intakes: rationale and systematic review of published interventions. *European Journal of Nutrition, 55*(3), 869-896.

Arlinghaus, K. R., Hernandez, D. C., Eagleton, S. G., Chen, T.-A., Power, T. G., & Hughes, S. O. (2019). Exploratory factor analysis of The Comprehensive Feeding Practices Questionnaire (CFPQ) in a low-income hispanic sample of preschool aged children. *Appetite, 140*, 82-90.

Atkins, L., & Michie, S. (2013). Changing eating behaviour: What can we learn from behavioural science? *Nutrition Bulletin, 38*(1), 30-35.

Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., . . . Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—a systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology, 46*(3), 1029-1056.

Avery, A., Anderson, C., & McCullough, F. (2017). Associations between children's diet quality and watching television during meal or snack consumption: A systematic review. *Maternal and Child Nutrition, 13*(4), e12428.

Bachmanov, A. A., & Beauchamp, G. K. (2007). Taste receptor genes. *Annual Review of Nutrition, 27*, 389.

Bandura, A. (1971). *Social learning theory*. New York: General Learning Press.

Barab, S., Arici, A., & Jackson, C. (2005). Eat your vegetables and do your homework: A design-based investigation of enjoyment and meaning in learning. *Educational Technology*, 15-21.

Barends, C., de Vries, J., Mojet, J., & de Graaf, C. (2013). Effects of repeated exposure to either vegetables or fruits on infant's vegetable and fruit acceptance at the beginning of weaning. *Food Quality and Preference, 29*(2), 157-165.

Barends, C., de Vries, J. H., Mojet, J., & de Graaf, C. (2014). Effects of starting weaning exclusively with vegetables on vegetable intake at the age of 12 and 23 months. *Appetite, 81*, 193-199.

Barron, A. B., Hebets, E. A., Cleland, T. A., Fitzpatrick, C. L., Hauber, M. E., & Stevens, J. R. (2015). Embracing multiple definitions of learning. *Trends in Neurosciences, 38*(7), 405-407.

Bassul, C., Corish, C., & Kearney, J. (2020). Associations between the home environment, feeding practices and children's intakes of fruit, vegetables and confectionary/sugar-sweetened beverages. *International Journal of Environmental Research and Public Health, 17*(13), 4837.

Beauchamp, G. K., & Mennella, J. A. (2009). Early flavor learning and its impact on later feeding behavior. *Journal of Pediatric Gastroenterology and Nutrition, 48*, S25-S30.

Beauchamp, G. K., & Mennella, J. A. (2011). Flavor perception in human infants: development and functional significance. *Digestion, 83*(Suppl. 1), 1-6.

Beckerman, J. P., Slade, E., & Ventura, A. K. (2020). Maternal diet during lactation and breast-feeding practices have synergistic association with child diet at 6 years. *Public Health Nutrition, 23*(2), 286-294.

Bell, K. I., & Tepper, B. J. (2006). Short-term vegetable intake by young children classified by 6-n-propylthoiuracil bitter-taste phenotype. *The American Journal of Clinical Nutrition, 84*(1), 245-251.

Bell, L. K., Gardner, C., Tian, E. J., Cochet-Broch, M. O., Poelman, A. A., Cox, D. N., . . . Kumar, S. (2021). Supporting strategies for enhancing vegetable liking in the early years of life: an umbrella review of systematic reviews. *The American Journal of Clinical Nutrition, 113*(5), 1282-1300.

Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience. *Physiology and Behavior, 81*(2), 179-209.

Betoko, A., Charles, M.-A., Hankard, R., Forhan, A., Bonet, M., Saurel-Cubizolles, M.-J., . . . de Lauzon-Guillain, B. (2013). Infant feeding patterns over the first year of life: influence of family characteristics. *European Journal of Clinical Nutrition, 67*(6), 631-637.

Birch, L. L. (1999). Development of food preferences. *Annual Review of Nutrition, 19*(1), 41-62.
Birch, L. L., & Anzman, S. L. (2010). Learning to eat in an obesogenic environment: a developmental systems perspective on childhood obesity. *Child Development Perspectives, 4*(2), 138-143.
Birch, L. L., Birch, D., Marlin, D. W., & Kramer, L. (1982). Effects of instrumental consumption on children's food preference. *Appetite, 3*(2), 125-134.
Birch, L. L., Fisher, J. O., Grimm-Thomas, K., Markey, C. N., Sawyer, R., & Johnson, S. L. (2001). Confirmatory factor analysis of the Child Feeding Questionnaire: a measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. *Appetite, 36*(3), 201-210.
Birch, L. L., Gunder, L., Grimm-Thomas, K., & Laing, D. G. (1998). Infants' consumption of a new food enhances acceptance of similar foods. *Appetite, 30*(3), 283-295.
Birch, L. L., & Marlin, D. W. (1982). I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. *Appetite, 3*(4), 353-360.
Birch, L. L., McPhee, L., Shoba, B., Pirok, E., & Steinberg, L. (1987). What kind of exposure reduces children's food neophobia?: Looking vs. tasting. *Appetite, 9*(3), 171-178.
Blechert, J., Meule, A., Busch, N. A., & Ohla, K. (2014). Food-pics: an image database for experimental research on eating and appetite. *Frontiers in Psychology, 5*, 617.
Blekkenhorst, L. C., Sim, M., Bondonno, C. P., Bondonno, N. P., Ward, N. C., Prince, R. L., . . . Hodgson, J. M. (2018). Cardiovascular health benefits of specific vegetable types: a narrative review. *Nutrients, 10*(5), 595.
Blissett, J. (2011). Relationships between parenting style, feeding style and feeding practices and fruit and vegetable consumption in early childhood. *Appetite, 57*(3), 826-831.
Blundell-Birtill, P., & Hetherington, M. M. (2019). Determinants of Portion Size in Children and Adolescents: Insights from the UK National Diet and Nutrition Survey Rolling Programme (2008–2016). *Nutrients, 11*(12), 2957.
Boeing, H., Bechthold, A., Bub, A., Ellinger, S., Haller, D., Kroke, A., . . . Schulze, M. (2012). Critical review: vegetables and fruit in the prevention of chronic diseases. *European Journal of Nutrition, 51*(6), 637-663.
Bouhlal, S., Issanchou, S., Chabanet, C., & Nicklaus, S. (2014). 'Just a pinch of salt'. An experimental comparison of the effect of repeated exposure and flavor-flavor learning with salt or spice on vegetable acceptance in toddlers. *Appetite, 83*, 209-217.
Bouton, M. E. (2010). The multiple forms of "context" in associative learning theory. In *B. Mesquita, L. F. Barrett, & E. R. Smith (Eds.), The mind in context (pp. 233–258).* Guilford Press.
Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22*(6), 723.
Bucher, T., Siegrist, M., & Van der Horst, K. (2014). Vegetable variety: an effective strategy to increase vegetable choice in children. *Public Health Nutrition, 17*(6), 1232-1236.
Burnett, A. J., Lamb, K. E., McCann, J., Worsley, A., & Lacy, K. E. (2020). Parenting styles and the dietary intake of pre-school children: a systematic review. *Psychology and Health, 35*(11), 1326-1345.

Capaldi-Phillips, E. D., & Wadhera, D. (2014). Associative conditioning can increase liking for and consumption of brussels sprouts in children aged 3 to 5 years. *Journal of the Academy of Nutrition and Dietetics, 114*(8), 1236-1241.

Cardona Cano, S., Tiemeier, H., Van Hoeken, D., Tharner, A., Jaddoe, V. W., Hofman, A., . . . Hoek, H. W. (2015). Trajectories of picky eating during childhood: a general population study. *International Journal of Eating Disorders, 48*(6), 570-579.

Carnell, S., Cooke, L., Cheng, R., Robbins, A., & Wardle, J. (2011). Parental feeding behaviours and motivations. A qualitative study in mothers of UK pre-schoolers. *Appetite, 57*(3), 665-673.

Carnell, S., & Wardle, J. (2007). Measuring behavioural susceptibility to obesity: validation of the child eating behaviour questionnaire. *Appetite, 48*(1), 104-113.

Carney, E. M., Stein, W. M., Reigh, N. A., Gater, F. M., Bakke, A. J., Hayes, J. E., & Keller, K. L. (2018). Increasing flavor variety with herbs and spices improves relative vegetable intake in children who are propylthiouracil (PROP) tasters relative to nontasters. *Physiology and Behavior, 188*, 48-57.

Carstairs, S. A., Caton, S. J., Blundell-Birtill, P., Rolls, B. J., Hetherington, M. M., & Cecil, J. E. (2018). Can reduced intake associated with downsizing a high energy dense meal item be offset by increased vegetable variety in 3–5-year-old children? *Nutrients, 10*(12), 1879.

Carter, P., Gray, L. J., Troughton, J., Khunti, K., & Davies, M. J. (2010). Fruit and vegetable intake and incidence of type 2 diabetes mellitus: systematic review and meta-analysis. *British Medical Journal, 341*.

Caton, S. J., Ahern, S. M., & Hetherington, M. M. (2011). Vegetables by stealth. An exploratory study investigating the introduction of vegetables in the weaning period. *Appetite, 57*(3), 816-825.

Caton, S. J., Ahern, S. M., Remy, E., Nicklaus, S., Blundell, P., & Hetherington, M. M. (2013). Repetition counts: repeated exposure increases intake of a novel vegetable in UK pre-school children compared to flavour–flavour and flavour–nutrient learning. *British Journal of Nutrition, 109*(11), 2089-2097.

Caton, S. J., Blundell, P., Ahern, S. M., Nekitsing, C., Olsen, A., Møller, P., . . . Chabanet, C. (2014). Learning to eat vegetables in early life: the role of timing, age and individual eating traits. *PloS One, 9*(5), e97609.

Charbonnier, L., van Meer, F., Johnstone, A., Crabtree, D., Buosi, W., Manios, Y., . . . Smeets, P. A. (2018). Effects of hunger state on the brain responses to food cues across the life span. *Neuroimage, 171*, 246-255.

Chawner, L. R., Blundell-Birtill, P., & Hetherington, M. (2019). Interventions for increasing acceptance of new foods among children and adults with developmental disorders: a systematic review. *Journal of Autism and Developmental Disorders, 49*(9), 3504-3525.

Chawner, L. R., Blundell-Birtill, P., & Hetherington, M. (2022a). An online study examining children's selection of vegetables at mealtimes: The role of meal contexts, variety and liking. *Appetite, 169*, 105803.

Chawner, L. R., Blundell-Birtill, P., & Hetherington, M. (2022b). Parental intentions to implement vegetable feeding strategies at home: A cross sectional study. *Appetite*, 106387.

Chawner, L. R., Blundell-Birtill, P., & Hetherington, M. M. (2021). Predictors of vegetable consumption in children and adolescents: Analyses of the UK

National Diet and Nutrition Survey (2008–2017). *British Journal of Nutrition, 126*(2), 295-306.

Chawner, L. R., & Hetherington, M. (2021). Utilising an integrated approach to developing liking for and consumption of vegetables in children. *Physiology and Behavior, 238*, 113493.

Cheung, G. W., & Lau, R. S. (2008). Testing mediation and suppression effects of latent variables: Bootstrapping with structural equation models. *Organizational Research Methods, 11*(2), 296-325.

Christian, M. S., Evans, C. E., Nykjaer, C., Hancock, N., & Cade, J. E. (2014). Evaluation of the impact of a school gardening intervention on children's fruit and vegetable intake: a randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 1-15.

Coates, A. E., Hardman, C. A., Halford, J. C., Christiansen, P., & Boyland, E. J. (2019). Social media influencer marketing and children's food intake: a randomized trial. *Pediatrics, 143*(4).

Cohen, J. F., Hecht, A. A., Hager, E. R., Turner, L., Burkholder, K., & Schwartz, M. B. (2021). Strategies to improve school meal consumption: A systematic review. *Nutrients, 13*(10), 3520.

Colapinto, C. K., Fitzgerald, A., Taper, L. J., & Veugelers, P. J. (2007). Children's preference for large portions: prevalence, determinants, and consequences. *Journal of the American Dietetic Association, 107*(7), 1183-1190.

Cook, L. T., O'Reilly, G. A., DeRosa, C. J., Rohrbach, L. A., & Spruijt-Metz, D. (2015). Association between home availability and vegetable consumption in youth: a review. *Public Health Nutrition, 18*(4), 640-648.

Cooke, L., Chambers, L. C., Añez, E. V., Croker, H. A., Boniface, D., Yeomans, M. R., & Wardle, J. (2011). Eating for pleasure or profit: the effect of incentives on children's enjoyment of vegetables. *Psychological Science, 22*(2), 190-196.

Cooke, L., Chambers, L. C., Añez, E. V., & Wardle, J. (2011). Facilitating or undermining? The effect of reward on food acceptance. A narrative review. *Appetite, 57*(2), 493-497.

Cooke, L., Wardle, J., & Gibson, E. (2003). Relationship between parental report of food neophobia and everyday food consumption in 2–6-year-old children. *Appetite, 41*(2), 205-206.

Cooke, L., Wardle, J., Gibson, E., Sapochnik, M., Sheiham, A., & Lawson, M. (2004). Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutrition, 7*(2), 295-302.

Correia, D. C., O'Connell, M., Irwin, M. L., & Henderson, K. E. (2014). Pairing vegetables with a liked food and visually appealing presentation: promising strategies for increasing vegetable consumption among preschoolers. *Childhood Obesity, 10*(1), 72-76.

Corsini, N., Slater, A., Harrison, A., Cooke, L., & Cox, D. N. (2013). Rewards can be used effectively with repeated exposure to increase liking of vegetables in 4–6-year-old children. *Public Health Nutrition, 16*(5), 942-951.

Couch, S. C., Glanz, K., Zhou, C., Sallis, J. F., & Saelens, B. E. (2014). Home food environment in relation to children's diet quality and weight status. *Journal of the Academy of Nutrition and Dietetics, 114*(10), 1569-1579. e1561.

Coulthard, H., & Ahmed, S. (2017). Non taste exposure techniques to increase fruit and vegetable acceptance in children: Effects of task and stimulus type. *Food Quality and Preference, 61*, 50-54.

Coulthard, H., Harris, G., & Emmett, P. (2009). Delayed introduction of lumpy foods to children during the complementary feeding period affects child's food acceptance and feeding at 7 years of age. *Maternal and Child Nutrition, 5*(1), 75-85.

Coulthard, H., Harris, G., & Fogel, A. (2016). Association between tactile over-responsivity and vegetable consumption early in the introduction of solid foods and its variation with age. *Maternal and Child Nutrition, 12*(4), 848-859.

Coulthard, H., & Sealy, A. (2017). Play with your food! Sensory play is associated with tasting of fruits and vegetables in preschool children. *Appetite, 113*, 84-90.

Craigie, A. M., Lake, A. A., Kelly, S. A., Adamson, A. J., & Mathers, J. C. (2011). Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas, 70*(3), 266-284.

Cravener, T. L., Schlechter, H., Loeb, K. L., Radnitz, C., Schwartz, M., Zucker, N., . . . Keller, K. L. (2015). Feeding strategies derived from behavioral economics and psychology can increase vegetable intake in children as part of a home-based intervention: results of a pilot study. *Journal of the Academy of Nutrition and Dietetics, 115*(11), 1798-1807.

Dai, J., Cone, J., & Moher, J. (2020). Perceptual salience influences food choices independently of health and taste preferences. *Cognitive Research: Principles and Implications, 5*(1), 1-13.

Daniel, P., & Gustafsson, U. (2010). School lunches: children's services or children's spaces? *Children's Geographies, 8*(3), 265-274.

Davison, K. K., & Birch, L. L. (2001). Childhood overweight: a contextual model and recommendations for future research. *Obesity Reviews, 2*(3), 159-171.

de Droog, S. M., Buijzen, M., & Valkenburg, P. M. (2014). Enhancing children’s vegetable consumption using vegetable-promoting picture books. The impact of interactive shared reading and character–product congruence. *Appetite, 73*, 73-80.

de Droog, S. M., van Nee, R., Govers, M., & Buijzen, M. (2017). Promoting toddlers’ vegetable consumption through interactive reading and puppetry. *Appetite, 116*, 75-81.

de Wild, V. W., de Graaf, C., Boshuizen, H. C., & Jager, G. (2015). Influence of choice on vegetable intake in children: an in-home study. *Appetite, 91*, 1-6.

de Wild, V. W., de Graaf, C., & Jager, G. (2013). Effectiveness of flavour nutrient learning and mere exposure as mechanisms to increase toddler’s intake and preference for green vegetables. *Appetite, 64*, 89-96.

De Wit, J. B., Stok, F. M., Smolenski, D. J., de Ridder, D. D., de Vet, E., Gaspar, T., . . . Luszczynska, A. (2015). Food culture in the home environment: Family meal practices and values can support healthy eating and self-regulation in young people in four European countries. *Applied Psychology: Health and Well-Being, 7*(1), 22-40.

Deci, E. L. (1971). Effects of externally mediated rewards on intrinsic motivation. *Journal of Personality and Social Psychology, 18*(1), 105-115.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125*(6), 627.

Department of Health (DOH), & Food Standards Agency (FSA). (2011). *Diet and Nutrition Survey of Infants and Young Children, 2011*.

Dhandevi, P., & Jeewon, R. (2015). Fruit and vegetable intake: Benefits and progress of nutrition education interventions-narrative review article. *Iranian Journal of Public Health, 44*(10), 1309.

Dhurandhar, N. V., Schoeller, D., Brown, A. W., Heymsfield, S. B., Thomas, D., Sørensen, T. I., . . . Allison, D. B. (2015). Energy balance measurement: when something is not better than nothing. *International Journal of Obesity, 39*(7), 1109-1113.

Diederichs, T., Perrar, I., Roßbach, S., Alexy, U., & Buyken, A. E. (2018). In adolescence a higher 'eveningness in energy intake'is associated with higher total daily energy intake. *Appetite, 128*, 159-166.

Diktas, H., Roe, L., Keller, K., Sanchez, C., & Rolls, B. (2021). Promoting vegetable intake in preschool children: independent and combined effects of portion size and flavor enhancement. *Appetite, 4*, 105250.

Dimbleby, H. (2021). *National Food Strategy: Independent review*. Retrieved from: https://www.nationalfoodstrategy.org/the-report/. Accessed on 07/12/2022.

Domínguez, P. R., Gámiz, F., Gil, M., Moreno, H., Zamora, R. M., Gallo, M., & de Brugada, I. (2013). Providing choice increases children's vegetable intake. *Food Quality and Preference, 30*(2), 108-113.

Domoff, S. E., Miller, A. L., Kaciroti, N., & Lumeng, J. C. (2015). Validation of the Children's Eating Behaviour Questionnaire in a low-income preschool-aged sample in the United States. *Appetite, 95*, 415-420.

Dovey, T. M., Staples, P. A., Gibson, E. L., & Halford, J. C. (2008). Food neophobia and 'picky/fussy'eating in children: a review. *Appetite, 50*(2-3), 181-193.

Draxten, M., Fulkerson, J. A., Friend, S., Flattum, C. F., & Schow, R. (2014). Parental role modeling of fruits and vegetables at meals and snacks is associated with children's adequate consumption. *Appetite, 78*, 1-7.

Dubois, L., Farmer, A., Girard, M., Burnier, D., & Porcherie, M. (2011). Demographic and socio-economic factors related to food intake and adherence to nutritional recommendations in a cohort of pre-school children. *Public Health Nutrition, 14*(6), 1096-1104.

Dudley, D. A., Cotton, W. G., & Peralta, L. R. (2015). Teaching approaches and strategies that promote healthy eating in primary school children: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 1-26.

Duffy, E. W., Kay, M. C., Jacquier, E. F., Catellier, D., Hampton, J., Anater, A. S., & Story, M. (2019). Trends in food consumption patterns of US infants and toddlers from Feeding Infants and Toddlers Studies (FITS) in 2002, 2008, 2016. *Nutrients, 11*(11), 2807.

Dulay, K. M., Masento, N., Harvey, K., Messer, D. J., & Houston-Price, C. (2020). Me and my veggies: The use of interactive, personalised picture books in healthy eating interventions. *Nutrition Bulletin, 45*(1), 51-58.

Duncanson, K., Burrows, T., Holman, B., & Collins, C. (2013). Parents' perceptions of child feeding: a qualitative study based on the theory of planned behavior. *Journal of Developmental and Behavioral Pediatrics, 34*(4), 227-236.

Earl, L., & Lalli, G. S. (2020). Healthy meals, better learners? Debating the focus of school food policy in England. *British Journal of Sociology of Education, 41*(4), 476-489.

Echelbarger, M., Maimaran, M., & Gelman, S. A. (2020). Children's Variety Seeking in Food Choices. *Journal of the Association for Consumer Research, 5*(3), 000-000.

Edelson, L. R., Mokdad, C., & Martin, N. (2016). Prompts to eat novel and familiar fruits and vegetables in families with 1–3 year-old children: relationships with food acceptance and intake. *Appetite, 99*, 138-148.

Edwards, K. L., Thomas, J. M., Higgs, S., & Blissett, J. (2022). Exposure to models' positive facial expressions whilst eating a raw vegetable increases children's acceptance and consumption of the modelled vegetable. *Appetite, 168*, 105779.

Ehrenberg, S., Leone, L., Sharpe, B., Reardon, K., & Anzman-Frasca, S. (2019). Using repeated exposure through hands-on cooking to increase children's preferences for fruits and vegetables. *Appetite, 142*, 104347.

Eldridge, A. L., Catellier, D. J., Hampton, J. C., Dwyer, J. T., & Bailey, R. L. (2019). Trends in mean nutrient intakes of US infants, toddlers, and young children from 3 Feeding Infants and Toddlers Studies (FITS). *The Journal of Nutrition, 149*(7), 1230-1237.

Elsbernd, S., Reicks, M., Mann, T., Redden, J., Mykerezi, E., & Vickers, Z. (2016). Serving vegetables first: A strategy to increase vegetable consumption in elementary school cafeterias. *Appetite, 96*, 111-115.

Emmett, P. M., Hays, N. P., & Taylor, C. M. (2018). Antecedents of picky eating behaviour in young children. *Appetite, 130*, 163-173.

Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. *African Journal of Emergency Medicine, 7*(3), 93-99.

Evans, C., Christian, M. S., Cleghorn, C. L., Greenwood, D. C., & Cade, J. E. (2012). Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 y. *The American Journal of Clinical Nutrition, 96*(4), 889-901.

Evans, C., Greenwood, D., Thomas, J., & Cade, J. (2010). A cross-sectional survey of children's packed lunches in the UK: food-and nutrient-based results. *Journal of Epidemiology and Community Health, 64*(11), 977-983.

Farrow, C., Belcher, E., Coulthard, H., Thomas, J. M., Lumsden, J., Hakobyan, L., & Haycraft, E. (2019). Using repeated visual exposure, rewards and modelling in a mobile application to increase vegetable acceptance in children. *Appetite, 141*, 104327.

Farrow, C., & Coulthard, H. (2018). Multisensory evaluation and the neophobic food response. In *Food neophobia* (pp. 219-236): Elsevier.

Feeney, E., O'brien, S., Scannell, A., Markey, A., & Gibney, E. (2011). Genetic variation in taste perception: does it have a role in healthy eating? *Proceedings of the Nutrition Society, 70*(1), 135-143.

Fildes, A., van Jaarsveld, C. H., Cooke, L., Wardle, J., & Llewellyn, C. H. (2016). Common genetic architecture underlying young children's food fussiness and liking for vegetables and fruit. *The American Journal of Clinical Nutrition, 103*(4), 1099-1104.

Fildes, A., van Jaarsveld, C. H., Llewellyn, C. H., Fisher, A., Cooke, L., & Wardle, J. (2014). Nature and nurture in children's food preferences. *The American Journal of Clinical Nutrition, 99*(4), 911-917.

Fildes, A., van Jaarsveld, C. H., Wardle, J., & Cooke, L. (2014). Parent-administered exposure to increase children's vegetable acceptance: a randomized controlled trial. *Journal of the Academy of Nutrition and Dietetics, 114*(6), 881-888.

Finnane, J. M., Jansen, E., Mallan, K. M., & Daniels, L. A. (2017). Mealtime structure and responsive feeding practices are associated with less food fussiness and more food enjoyment in children. *Journal of Nutrition Education and Behavior, 49*(1), 11-18. e11.

Finney, S. J., & DiStefano, C. (2013). Nonnormal and categorical data in structural equation modeling. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course (2nd ed., pp. 439–492).* Charlotte, NC: Information Age Publishing.

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. *Philosophy Rhetoric, 10*(2).

Fisher, J. O., & Birch, L. L. (1999). Restricting access to foods and children's eating. *Appetite, 32*(3), 405-419.

Fisher, J. O., Mennella, J. A., Hughes, S. O., Liu, Y., Mendoza, P. M., & Patrick, H. (2012). Offering “dip” promotes intake of a moderately-liked raw vegetable among preschoolers with genetic sensitivity to bitterness. *Journal of the Academy of Nutrition and Dietetics, 112*(2), 235-245.

Fitt, E., Cole, D., Ziauddeen, N., Pell, D., Stickley, E., Harvey, A., & Stephen, A. M. (2015). DINO (Diet In Nutrients Out)–an integrated dietary assessment system. *Public Health Nutrition, 18*(2), 234-241.

Flora, D. B., & Curran, P. J. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychological Methods, 9*(4), 466.

Folkvord, F., Naderer, B., Coates, A., & Boyland, E. (2021). Promoting Fruit and Vegetable Consumption for Childhood Obesity Prevention. *Nutrients, 14*(1), 157.

Foster, E., Hawkins, A., & Adamson, A. (2010). Young Person's Food Atlas - Primary. *Food Standards Agency: London*.

Foster, E., Hawkins, A., Barton, K. L., Stamp, E., Matthews, J. N., & Adamson, A. J. (2017). Development of food photographs for use with children aged 18 months to 16 years: comparison against weighed food diaries–The Young Person’s Food Atlas (UK). *PloS One, 12*(2).

Fritts, J. R., Bermudez, M. A., Hargrove, R. L., Alla, L., Fort, C., Liang, Q., . . . Keller, K. L. (2019). Using Herbs and Spices to Increase Vegetable Intake Among Rural Adolescents. *Journal of Nutrition Education and Behavior, 51*(7), 806-816. e801.

Galloway, A. T., Fiorito, L., Lee, Y., & Birch, L. L. (2005). Parental pressure, dietary patterns, and weight status among girls who are “picky eaters”. *Journal of the American Dietetic Association, 105*(4), 541-548.

Gardner, B., & Rebar, A. L. (2019). Habit formation and behavior change. In *Oxford Research Encyclopedia of Psychology*.

Gerritsen, S., Renker-Darby, A., Harré, S., Rees, D., Raroa, D. A., Eickstaedt, M., . . . Waterlander, W. E. (2019). Improving low fruit and vegetable intake in children: Findings from a system dynamics, community group model building study. *PloS One, 14*(8), e0221107.

Gibson, E., & Wardle, J. (2003). Energy density predicts preferences for fruit and vegetables in 4-year-old children. *Appetite, 41*(1), 97-98.

Gillman, M. W., Rifas-Shiman, S. L., Frazier, A. L., Rockett, H. R., Camargo Jr, C. A., Field, A. E., . . . Colditz, G. A. J. A. o. f. m. (2000). Family dinner

and diet quality among older children and adolescents. *Archives of Family Medicine, 9*(3), 235.
Giskes, K., Avendaňo, M., Brug, J., & Kunst, A. (2010). A systematic review of studies on socioeconomic inequalities in dietary intakes associated with weight gain and overweight/obesity conducted among European adults. *Obesity Reviews, 11*(6), 413-429.
Glasson, C., Chapman, K., & James, E. (2011). Fruit and vegetables should be targeted separately in health promotion programmes: differences in consumption levels, barriers, knowledge and stages of readiness for change. *Public Health Nutrition, 14*(4), 694-701.
Gosling, S. D., & Mason, W. (2015). Internet research in psychology. *Annual Review of Psychology, 66*, 877-902.
Gregory, J., Lowe, S., Bates, C., Prentice, A., Jackson, L., Smithers, G., . . . Farron, M. (2000). *National Diet and Nutrition Survey: Young people aged 4 to 18 years. Volume 1: Report of the diet and nutrition survey*. London: The Stationery Office
Gregory, J., Paxton, S. J., & Brozovic, A. M. (2011). Maternal feeding practices predict fruit and vegetable consumption in young children. Results of a 12-month longitudinal study. *Appetite, 57*(1), 167-172.
Griffin, T. L., Clarke, J. L., Lancashire, E. R., Pallan, M. J., Passmore, S., & Adab, P. (2015). Teacher experiences of delivering an obesity prevention programme (The WAVES study intervention) in a primary school setting. *Health Education Journal, 74*(6), 655-667.
Ha, O.-R., Bruce, A. S., Pruitt, S. W., Cherry, J. B. C., Smith, T. R., Burkart, D., . . . Lim, S.-L. (2016). Healthy eating decisions require efficient dietary self-control in children: a mouse-tracking food decision study. *Appetite, 105*, 575-581.
Hammond, J., Nelson, M., Chinn, S., & Rona, R. (1993). Validation of a food frequency questionnaire for assessing dietary intake in a study of coronary heart disease risk factors in children. *European Journal of Clinical Nutrition, 47*(4), 242-250.
Harnack, L. J., Oakes, J. M., French, S. A., Rydell, S. A., Farah, F. M., & Taylor, G. L. (2012). Results from an experimental trial at a Head Start center to evaluate two meal service approaches to increase fruit and vegetable intake of preschool aged children. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 51.
Haroun, D., Harper, C., Wood, L., & Nelson, M. (2011). The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in primary schools in England. *Public Health Nutrition, 14*(2), 209-218.
Harris, G., & Mason, S. (2017). Are there sensitive periods for food acceptance in infancy? *Current Nutrition Reports, 6*(2), 190-196.
Harris, H. A., Ria-Searle, B., Jansen, E., & Thorpe, K. (2018). What's the fuss about? Parent presentations of fussy eating to a parenting support helpline. *Public Health Nutrition, 21*(8), 1520-1528.
Hartley, L., Igbinedion, E., Holmes, J., Flowers, N., Thorogood, M., Clarke, A., . . . Rees, K. (2013). Increased consumption of fruit and vegetables for the primary prevention of cardiovascular diseases. *Cochrane Database of Systematic Reviews*(6).
Haß, J., & Hartmann, M. (2018). What determines the fruit and vegetables intake of primary school children?-An analysis of personal and social determinants. *Appetite, 120*, 82-91.

Haszard, J. J., Skidmore, P. M., Williams, S. M., & Taylor, R. W. (2015). Associations between parental feeding practices, problem food behaviours and dietary intake in New Zealand overweight children aged 4–8 years. *Public Health Nutrition, 18*(6), 1036-1043.

Hausner, H., Bredie, W. L., Mølgaard, C., Petersen, M. A., & Møller, P. (2008). Differential transfer of dietary flavour compounds into human breast milk. *Physiology and Behavior, 95*(1-2), 118-124.

Hausner, H., Olsen, A., & Møller, P. (2012). Mere exposure and flavour–flavour learning increase 2–3 year-old children's acceptance of a novel vegetable. *Appetite, 58*(3), 1152-1159.

Havermans, R. C., & Jansen, A. (2007). Increasing children's liking of vegetables through flavour–flavour learning. *Appetite, 48*(2), 259-262.

Haycraft, E., Witcomb, G., & Farrow, C. (2020). The Child Feeding Guide: A digital health intervention for reducing controlling child feeding practices and maternal anxiety over time. *Nutrition Bulletin, 45*(4), 474-482.

Hayes, J. E. (2020). Influence of Sensation and Liking on Eating and Drinking. In *Handbook of Eating and Drinking: Interdisciplinary Perspectives* (pp. 131-155).

Haymond, M., Kappelgaard, A.-M., Czernichow, P., Biller, B. M., Takano, K., & Kiess, W. (2013). Early recognition of growth abnormalities permitting early intervention. *Acta Paediatrica, 102*(8), 787-796.

Hayter, A. K., Draper, A. K., Ohly, H. R., Rees, G. A., Pettinger, C., McGlone, P., & Watt, R. G. (2015). A qualitative study exploring parental accounts of feeding pre-school children in two low-income populations in the UK. *Maternal and Child Nutrition, 11*(3), 371-384.

Heath, P., Houston-Price, C., & Kennedy, O. B. (2011). Increasing food familiarity without the tears. A role for visual exposure? *Appetite, 57*(3), 832-838.

Hendy, H., Harclerode, W., & Williams, K. E. (2016). The Parent Mealtime Action Scale revised (PMAS-R): Psychometric characteristics and associations with variables of clinical interest. *Appetite, 105*, 283-290.

Hendy, H., Williams, K. E., Camise, T. S., Eckman, N., & Hedemann, A. (2009). The Parent Mealtime Action Scale (PMAS). Development and association with children's diet and weight. *Appetite, 52*(2), 328-339.

Hepper, P. G. (1996). Fetal memory: does it exist? What does it do? *Acta Paediatrica, 85*, 16-20.

Hetherington, M. M., Schwartz, C., Madrelle, J., Croden, F., Nekitsing, C., Vereijken, C. M., & Weenen, H. (2015). A step-by-step introduction to vegetables at the beginning of complementary feeding. The effects of early and repeated exposure. *Appetite, 84*, 280-290.

Hingle, M., Beltran, A., O'Connor, T., Thompson, D., Baranowski, J., & Baranowski, T. (2012). A model of goal directed vegetable parenting practices. *Appetite, 58*(2), 444-449.

Hoffmann, D. A., Marx, J. M., Kiefner-Burmeister, A., & Musher-Eizenman, D. R. (2016). Influence of maternal feeding goals and practices on children's eating behaviors. *Appetite, 107*, 21-27.

Holaday, B., Turner-Henson, A., & Swan, J. (1991). Stability of School-age Children's Survey Responses. *Image: Journal of Nursing Scholarship, 23*(2), 109-114.

Holley, C. E., Farrow, C., & Haycraft, E. (2016). Investigating the role of parent and child characteristics in healthy eating intervention outcomes. *Appetite, 105*, 291-297.

Holley, C. E., Farrow, C., & Haycraft, E. (2017a). Investigating offering of vegetables by caregivers of preschool age children. *Child: Care, Health and Development, 43*(2), 240-249.

Holley, C. E., Farrow, C., & Haycraft, E. (2017b). A systematic review of methods for increasing vegetable consumption in early childhood. *Current Nutrition Reports, 6*(2), 157-170.

Holley, C. E., Haycraft, E., & Farrow, C. (2015). 'Why don't you try it again?'A comparison of parent led, home based interventions aimed at increasing children's consumption of a disliked vegetable. *Appetite, 87*, 215-222.

Holley, C. E., Haycraft, E., & Farrow, C. (2018). Predicting children's fussiness with vegetables: The role of feeding practices. *Maternal Child Nutrition, 14*(1), e12442.

Holley, C. E., Haycraft, E., & Farrow, C. (2020). Unpacking the relationships between positive feeding practices and children's eating behaviours: The moderating role of child temperament. *Appetite, 147*, 104548.

Hoppu, U., Puputti, S., & Sandell, M. (2021). Factors related to sensory properties and consumer acceptance of vegetables. *Critical Reviews in Food Science and Nutrition, 61*(10), 1751-1761.

Horne, P. J., Greenhalgh, J., Erjavec, M., Lowe, C. F., Viktor, S., & Whitaker, C. J. (2011). Increasing pre-school children's consumption of fruit and vegetables. A modelling and rewards intervention. *Appetite, 56*(2), 375-385.

Horne, P. J., Hardman, C. A., Lowe, C. F., Tapper, K., Le Noury, J., Madden, P., . . . Doody, M. (2009). Increasing parental provision and children's consumption of lunchbox fruit and vegetables in Ireland: the Food Dudes intervention. *European Journal of Clinical Nutrition, 63*(5), 613-618.

Houston-Price, C., Butler, L., & Shiba, P. (2009). Visual exposure impacts on toddlers' willingness to taste fruits and vegetables. *Appetite, 53*(3), 450-453.

Houston-Price, C., Owen, L. H., Kennedy, O. B., & Hill, C. (2019). Parents' experiences of introducing toddlers to fruits and vegetables through repeated exposure, with and without prior visual familiarization to foods: Evidence from daily diaries. *Food Quality and Preference, 71*, 291-300.

Hovdenak, I. M., Stea, T. H., Twisk, J., Te Velde, S. J., Klepp, K.-I., & Bere, E. (2019). Tracking of fruit, vegetables and unhealthy snacks consumption from childhood to adulthood (15 year period): does exposure to a free school fruit programme modify the observed tracking? *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 1-10.

Howden, J., Chong, Y., Leung, S., Rabuco, L., Sakamoto, M., Tchai, B., . . . Yap, M. (1993). Breakfast practices in the Asian region. *Asia Pac J Clin Nutr, 2*(2), 77-84.

Hubbard, K. L., Must, A., Eliasziw, M., Folta, S. C., & Goldberg, J. (2014). What's in children's backpacks: Foods brought from home. *Journal of the Academy of Nutrition and Dietetics, 114*(9), 1424-1431.

Hughes, F. P. (2009). *Children, play, and development*: Sage.

Image by rawpixel.com. https://www.freepik.com/free-vector/hand-drawn-batch-vegetables_2782910.htm#page=3&query=vegetables&position=49&from_view=search&track=sph

Irwin, J., O'callaghan, F., & Glendon, A. I. (2018). Predicting parental intentions to enrol their children in swimming lessons using an extended Theory of Planned Behaviour. *Australian Psychologist, 53*(3), 263-270.

Ishdorj, A., Capps Jr, O., Storey, M., & Murano, P. S. (2015). Investigating the relationship between food pairings and plate waste from elementary school lunches. *Food and Nutrition Sciences, 6*, 1029-1044.

Jansen, P. W., de Barse, L. M., Jaddoe, V. W., Verhulst, F. C., Franco, O. H., & Tiemeier, H. (2017). Bi-directional associations between child fussy eating and parents' pressure to eat: Who influences whom? *Physiology and Behavior, 176*, 101-106.

Jarvis, J. W., Harrington, D. W., & Manson, H. (2017). Exploring parent-reported barriers to supporting their child's health behaviors: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 1-10.

Johnson, S. (2016). Developmental and environmental influences on young children's vegetable preferences and consumption. *Advances in Nutrition, 7*(1), 220S-231S.

Johnson, S., McPhee, L., & Birch, L. (1991). Conditioned preferences: young children prefer flavors associated with high dietary fat. *Physiology and Behavior, 50*(6), 1245-1251.

Johnston, M. P. (2014). Secondary data analysis: A method of which the time has come. *Qualitative and Quantitative Methods in Libraries, 3*(3), 619-626.

Jones, L. R., Steer, C. D., Rogers, I. S., & Emmett, P. M. (2010). Influences on child fruit and vegetable intake: sociodemographic, parental and child factors in a longitudinal cohort study. *Public Health Nutrition, 13*(7), 1122-1130.

Jønsson, S. R., Angka, S., Olsen, K., Tolver, A., & Olsen, A. (2019). Repeated exposure to vegetable-enriched snack bars may increase children's liking for the bars-but not for the vegetables. *Appetite, 140*, 1-9.

Juras, R. (2016). Estimates of intraclass correlation coefficients and other design parameters for studies of school-based nutritional interventions. *Evaluation Review, 40*(4), 314-333.

Just, D., & Price, J. (2013). Default options, incentives and food choices: evidence from elementary-school children. *Public Health Nutrition, 16*(12), 2281-2288.

Kaar, J. L., Shapiro, A. L., Fell, D. M., & Johnson, S. L. (2016). Parental feeding practices, food neophobia, and child food preferences: What combination of factors results in children eating a variety of foods? *Food Quality and Preference, 50*, 57-64.

Kafatos, I., Peponaras, A., Linardakis, M., & Kafatos, A. (2004). Nutrition education and Mediterranean diet: exploring the teaching process of a school-based nutrition and media education project in Cretan primary schools. *Public Health Nutrition, 7*(7), 969-975.

Kaukonen, R., Lehto, E., Ray, C., Vepsäläinen, H., Nissinen, K., Korkalo, L., . . . Roos, E. (2019). A cross-sectional study of children's temperament, food consumption and the role of food-related parenting practices. *Appetite, 138*, 136-145.

Keller, K. L., & Adise, S. (2016). Variation in the ability to taste bitter thiourea compounds: implications for food acceptance, dietary intake, and obesity risk in children. *Annual Review of Nutrition, 36*, 157-182.

Keller, K. L., Shehan, C., Cravener, T., Schlechter, H., & Hayes, J. E. (2022). Do children really eat what they like? Relationships between liking and intake across laboratory test-meals. *Appetite, 172*, 105946.

Kern, D. L., McPhee, L., Fisher, J., Johnson, S., & Birch, L. L. (1993). The postingestive consequences of fat condition preferences for flavors associated with high dietary fat. *Physiology and Behavior, 54*(1), 71-76.

Kessler, H. S. (2016). Simple interventions to improve healthy eating behaviors in the school cafeteria. *Nutrition Reviews, 74*(3), 198-209.

Kidwell, K. M., Kozikowski, C., Roth, T., Lundahl, A., & Nelson, T. D. (2018). Concurrent and longitudinal associations among temperament, parental feeding styles, and selective eating in a preschool sample. *Journal of Pediatric Psychology, 43*(5), 572-583.

Kiefner-Burmeister, A. E., Hoffmann, D. A., Meers, M. R., Koball, A. M., & Musher-Eizenman, D. R. (2014). Food consumption by young children: a function of parental feeding goals and practices. *Appetite, 74*, 6-11.

Kim, S. A., Moore, L. V., Galuska, D., Wright, A. P., Harris, D., Grummer-Strawn, L. M., . . . Rhodes, D. G. (2014). Vital signs: fruit and vegetable intake among children—United States, 2003–2010. *Morbidity Mortality Weekly Report, 63*(31), 671.

Kininmonth, A. R., Schrempft, S., Smith, A., Dye, L., Lawton, C., Fisher, A., . . . Fildes, A. (2021). The Home Environment Interview and associations with energy balance behaviours and body weight in school-aged children–a feasibility, reliability, and validity study. *International Journal of Behavioral Nutrition and Physical Activity, 18*(1), 1-14.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*: FT press.

Kral, T. V., Kabay, A. C., Roe, L. S., & Rolls, B. J. (2010). Effects of doubling the portion size of fruit and vegetable side dishes on children's intake at a meal. *Obesity, 18*(3), 521-527.

Kraut, R., Olson, J., Banaji, M., Bruckman, A., Cohen, J., & Couper, M. (2004). Psychological research online: report of Board of Scientific Affairs' Advisory Group on the Conduct of Research on the Internet. *American Psychologist, 59*(2), 105.

Krølner, R., Rasmussen, M., Brug, J., Klepp, K.-I., Wind, M., & Due, P. (2011). Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part II: qualitative studies. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 112.

Lafraire, J., Rioux, C., Giboreau, A., & Picard, D. (2016). Food rejections in children: Cognitive and social/environmental factors involved in food neophobia and picky/fussy eating behavior. *Appetite, 96*, 347-357.

Laureati, M., Bergamaschi, V., & Pagliarini, E. (2014). School-based intervention with children. Peer-modeling, reward and repeated exposure reduce food neophobia and increase liking of fruits and vegetables. *Appetite, 83*, 26-32.

Leahy, K. E., Birch, L. L., Fisher, J. O., & Rolls, B. J. (2008). Reductions in entree energy density increase children's vegetable intake and reduce energy intake. *Obesity, 16*(7), 1559-1565.

Leak, T. M., Swenson, A., Rendahl, A., Vickers, Z., Mykerezi, E., Redden, J. P., . . . Reicks, M. (2017). Examining the feasibility of implementing behavioural economics strategies that encourage home dinner vegetable intake among low-income children. *Public Health Nutrition, 20*(8), 1388-1392.

Ledford, J. R., & Gast, D. L. (2006). Feeding problems in children with autism spectrum disorders: A review. *Focus on Autism and Other Developmental Disabilities, 21*(3), 153-166.

Lee, J., Shin, A., Oh, J. H., & Kim, J. (2017). Colors of vegetables and fruits and the risks of colorectal cancer. *World Journal of Gastroenterology, 23*(14), 2527.

Lewinsohn, P. M., Holm-Denoma, J. M., Gau, J. M., Joiner Jr, T. E., Striegel-Moore, R., Bear, P., & Lamoureux, B. (2005). Problematic eating and feeding behaviors of 36-month-old children. *International Journal of Eating Disorders, 38*(3), 208-219.

Ling, J., Robbins, L., & Hines-Martin, V. (2016). Perceived parental barriers to and strategies for supporting physical activity and healthy eating among head start children. *Journal of Community Health, 41*(3), 593-602.

Liu, R. H. (2003). Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. *The American Journal of Clinical Nutrition, 78*(3), 517S-520S.

Llewellyn, C. H., & Fildes, A. (2017). Behavioural susceptibility theory: Professor Jane Wardle and the role of appetite in genetic risk of obesity. *Current Obesity Reports, 6*(1), 38-45.

Lowe, C. F., Horne, P. J., Tapper, K., Bowdery, M., & Egerton, C. (2004). Effects of a peer modelling and rewards-based intervention to increase fruit and vegetable consumption in children. *European Journal of Clinical Nutrition, 58*(3), 510-522.

Lynch, C., Kristjansdottir, A. G., Te Velde, S. J., Lien, N., Roos, E., Thorsdottir, I., . . . Ribic, C. H. (2014). Fruit and vegetable consumption in a sample of 11-year-old children in ten European countries–the PRO GREENS cross-sectional survey. *Public Health Nutrition, 17*(11), 2436-2444.

Maguire, E. R., & Monsivais, P. (2015). Socio-economic dietary inequalities in UK adults: an updated picture of key food groups and nutrients from national surveillance data. *British Journal of Nutrition*, *113*(1), 181-189.

Maier, A. S., Chabanet, C., Schaal, B., Issanchou, S., & Leathwood, P. (2007). Effects of repeated exposure on acceptance of initially disliked vegetables in 7-month old infants. *Food Quality and Preference, 18*(8), 1023-1032.

Mak, T. N., Prynne, C. J., Cole, D., Fitt, E., Roberts, C., Bates, B., & Stephen, A. M. (2012). Assessing eating context and fruit and vegetable consumption in children: new methods using food diaries in the UK National Diet and Nutrition Survey Rolling Programme. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 126.

Mallan, K. M., Fildes, A., Magarey, A. M., & Daniels, L. A. (2016). The relationship between number of fruits, vegetables, and noncore foods tried at age 14 months and food preferences, dietary intake patterns, fussy eating behavior, and weight status at age 3.7 years. *Journal of the Academy of Nutrition and Dietetics, 116*(4), 630-637.

Maratos, F. A., & Staples, P. (2015). Attentional biases towards familiar and unfamiliar foods in children. The role of food neophobia. *Appetite, 91*, 220-225.

Marlette, M. A., Templeton, S. B., & Panemangalore, M. (2005). Food type, food preparation, and competitive food purchases impact school lunch plate waste by sixth-grade students. *Journal of the American Dietetic Association, 105*(11), 1779-1782.

Martin, I., & Levey, A. B. (1978). Evaluative conditioning. *Advances in Behaviour Research and Therapy, 1*(2), 57-101.

Martins, M. L., Rodrigues, S. S., Cunha, L. M., & Rocha, A. (2020). Factors influencing food waste during lunch of fourth-grade school children. *Waste Management, 113*, 439-446.

Marty, L., Miguet, M., Bournez, M., Nicklaus, S., Chambaron, S., & Monnery-Patris, S. (2017). Do hedonic-versus nutrition-based attitudes toward food predict food choices? A cross-sectional study of 6-to 11-year-olds. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 162.

Mascola, A. J., Bryson, S. W., & Agras, W. S. (2010). Picky eating during childhood: a longitudinal study to age 11 years. *Eating Behaviors, 11*(4), 253-257.

Mathias, K. C., Rolls, B. J., Birch, L. L., Kral, T. V., Hanna, E. L., Davey, A., & Fisher, J. O. (2012). Serving larger portions of fruits and vegetables together at dinner promotes intake of both foods among young children. *Journal of the Academy of Nutrition and Dietetics, 112*(2), 266-270.

McCance, R. A., & Widdowson, E. M. (2021). *McCance and Widdowson's the Composition of Foods Integrated Dataset 2021*: Public Health England.

McGowan, L., Cooke, L. J., Gardner, B., Beeken, R. J., Croker, H., & Wardle, J. (2013). Healthy feeding habits: efficacy results from a cluster-randomized, controlled exploratory trial of a novel, habit-based intervention with parents. *The American Journal of Clinical Nutrition, 98*(3), 769-777.

McLeod, C. J., Haycraft, E., & Daley, A. J. (2022). Would offering vegetables to children for breakfast increase their total daily vegetable intake? *Public Health Nutrition*, 1-5.

Meinert, L., Frøst, M. B., Bejerholm, C., & Aaslyng, M. D. (2011). Enhancing the sensory quality of vegetables by decreasing some less-desired sensory properties with low-fat pork gravy. *Journal of Culinary Science and Technology, 9*(2), 113-131.

Mennella, J. A., & Bobowski, N. K. (2015). The sweetness and bitterness of childhood: Insights from basic research on taste preferences. *Physiology and Behavior, 152*, 502-507.

Mennella, J. A., Jagnow, C. P., & Beauchamp, G. K. (2001). Prenatal and postnatal flavor learning by human infants. *Pediatrics, 107*(6), e88-e88.

Mennella, J. A., Johnson, A., & Beauchamp, G. K. (1995). Garlic ingestion by pregnant women alters the odor of amniotic fluid. *Chemical Senses, 20*(2), 207-209.

Menozzi, D., Sogari, G., Veneziani, M., Simoni, E., & Mora, C. (2017). Eating novel foods: An application of the Theory of Planned Behaviour to predict the consumption of an insect-based product. *Food Quality and Preference, 59*, 27-34.

Miller, N., & Dollard, J. (1941). *Social learning and imitation*. New Haven: Yale University Press.

Miller, N., Reicks, M., Redden, J. P., Mann, T., Mykerezi, E., & Vickers, Z. (2015). Increasing portion sizes of fruits and vegetables in an elementary school lunch program can increase fruit and vegetable consumption. *Appetite, 91*, 426-430.

Mitchell, G. L., Farrow, C., Haycraft, E., & Meyer, C. (2013). Parental influences on children’s eating behaviour and characteristics of successful parent-focussed interventions. *Appetite, 60*, 85-94.

Moding, K. J., Bellows, L. L., Grimm, K. J., & Johnson, S. L. (2020). A longitudinal examination of the role of sensory exploratory behaviors in young children's acceptance of new foods. *Physiology and Behavior, 218*, 112821.

Monsivais, P., Aggarwal, A., & Drewnowski, A. (2014). Time spent on home food preparation and indicators of healthy eating. *American Journal of Preventive Medicine, 47*(6), 796-802.

Moore, S., Murphy, S., Tapper, K., & Moore, L. (2010). The social, physical and temporal characteristics of primary school dining halls and their implications for children's eating behaviours. *Health Education*.

Moore, S., Tapper, K., & Murphy, S. (2010a). Feeding goals sought by mothers of 3–5-year-old children. *British Journal of Health Psychology, 15*(1), 185-196.

Moore, S., Tapper, K., & Murphy, S. (2010b). Feeding strategies used by primary school meal staff and their impact on children's eating. *Journal of Human Nutrition and Dietetics, 23*(1), 78-84.

Morrill, B. A., Madden, G. J., Wengreen, H. J., Fargo, J. D., & Aguilar, S. S. (2016). A randomized controlled trial of the Food Dudes program: tangible rewards are more effective than social rewards for increasing short-and long-term fruit and vegetable consumption. *Journal of the Academy of Nutrition and Dietetics, 116*(4), 618-629.

Morrison, T. G., Morrison, M. A., & McCutcheon, J. M. (2017). Best practice recommendations for using structural equation modelling in psychological research. *Psychology, 8*(09), 1326.

Moss, K. M., Dobson, A. J., Tooth, L., & Mishra, G. D. (2020). Associations between feeding practices in infancy and fruit and vegetable consumption in childhood. *British Journal of Nutrition, 124*(12), 1320-1328.

Mura Paroche, M., Caton, S. J., Vereijken, C. M., Weenen, H., & Houston-Price, C. (2017). How infants and young children learn about food: A systematic review. *Frontiers in Psychology, 8*, 1046.

Musher-Eizenman, D., & Holub, S. (2007). Comprehensive feeding practices questionnaire: validation of a new measure of parental feeding practices. *Journal of Pediatric Psychology, 32*(8), 960-972.

Mustonen, S., & Tuorila, H. (2010). Sensory education decreases food neophobia score and encourages trying unfamiliar foods in 8–12-year-old children. *Food Quality and Preference, 21*(4), 353-360.

NatCen Social Research, M. E. W. L. (2019). National Diet and Nutrition Survey Years 1-9, 2008/09-2016/17. [data collection]. 15th Edition. . *SN: 6533, UK Data Service.*

Nekitsing, C., Blundell-Birtill, P., Cockroft, J. E., Fildes, A., & Hetherington, M. M. (2019). Increasing intake of an unfamiliar vegetable in preschool children through learning using storybooks and sensory play: a cluster randomized trial. *Journal of the Academy of Nutrition and Dietetics, 119*(12), 2014-2027.

Nekitsing, C., Blundell-Birtill, P., Cockroft, J. E., & Hetherington, M. M. (2018). Systematic review and meta-analysis of strategies to increase vegetable consumption in preschool children aged 2–5 years. *Appetite, 127*, 138-154.

Nekitsing, C., Blundell-Birtill, P., Cockroft, J. E., & Hetherington, M. M. (2019). Taste exposure increases intake and nutrition education increases willingness to try an unfamiliar vegetable in preschool children: a cluster randomized trial. *Journal of the Academy of Nutrition and Dietetics, 119*(12), 2004-2013.

Nekitsing, C., Hetherington, M. M., & Blundell-Birtill, P. (2018). Developing healthy food preferences in preschool children through taste exposure, sensory learning, and nutrition education. *Current Obesity Reports, 7*(1), 60-67.

Nepper, M. J., & Chai, W. (2016). Parents' barriers and strategies to promote healthy eating among school-age children. *Appetite, 103*, 157-164.

Newman, J., & Taylor, A. (1992). Effect of a means-end contingency on young children's food preferences. *Journal of Experimental Child Psychology, 53*(2), 200-216.

Nezlek, J. B. (2008). An introduction to multilevel modeling for social and personality psychology. *Social and Personality Psychology Compass, 2*(2), 842-860.

Nguyen, B., Bauman, A., Gale, J., Banks, E., Kritharides, L., & Ding, D. (2016). Fruit and vegetable consumption and all-cause mortality: evidence from a large Australian cohort study. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), 1-10.

Nguyen, S. P. (2007). Cross-classification and category representation in children's concepts. *Developmental Psychology, 43*(3), 719.

Nguyen, S. P. (2008). Children's evaluative categories and inductive inferences within the domain of food. *Infant and Child Development: An International Journal of Research*

and Practice, 17(3), 285-299.

Nguyen, S. P., Girgis, H., & Robinson, J. (2015). Predictors of children’s food selection: the role of children’s perceptions of the health and taste of foods. *Food Quality and Preference, 40*, 106-109.

NHS-Digital. (2018). *Health Survey for England [NS]*. Available online: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2018 (accessed on 10 March 2020)

NHS-England. (2018). *School fruit and vegetable scheme.* Available online: https://www.nhs.uk/live-well/eat-well/school-fruit-and-vegetable-scheme/ (accessed on 20 March 2020)

NHS-UK. (2018). *Change4Life: 5 A Day*. Available online: https://www.nhs.uk/change4life/food-facts/five-a-day (accessed on 17 March 2020)

Nicklaus, S. (2016). The role of food experiences during early childhood in food pleasure learning. *Appetite, 104*, 3-9.

Nicklaus, S., Boggio, V., Chabanet, C., & Issanchou, S. (2005). A prospective study of food variety seeking in childhood, adolescence and early adult life. *Appetite, 44*(3), 289-297.

Nicklaus, S., & Remy, E. (2013). Early origins of overeating: tracking between early food habits and later eating patterns. *Current Obesity Reports, 2*(2), 179-184.

Niebylski, M. L., Lu, T., Campbell, N. R., Arcand, J., Schermel, A., Hua, D., . . . L’Abbé, M. R. (2014). Healthy food procurement policies and their impact. *International Journal of Environmental Research and Public Health, 11*(3), 2608-2627.

Nor, N. D. M., Houston-Price, C., Harvey, K., & Methven, L. (2018). The effects of taste sensitivity and repeated taste exposure on children's intake and

liking of turnip (Brassica rapa subsp. rapa); a bitter Brassica vegetable. *Appetite, 157*, 104991.
O'brien, M., Kiely, M., Galvin, M., & Flynn, A. (2003). The importance of composite foods for estimates of vegetable and fruit intakes. *Public Health Nutrition, 6*(7), 711-726.
O'Brien, S. A., Feeney, E. L., Scannell, A. G., Markey, A., & Gibney, E. R. (2013). Bitter taste perception and dietary intake patterns in irish children. *Lifestyle Genomics, 6*(1), 43-58.
O'Connell, M. L., Henderson, K. E., Luedicke, J., & Schwartz, M. B. (2012). Repeated exposure in a natural setting: A preschool intervention to increase vegetable consumption. *Journal of the Academy of Nutrition and Dietetics, 112*(2), 230-234.
Office for National Statistics (ONS). (2022). *Average household income, UK: financial year ending 2021, https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/bulletins/householddisposableincomeandinequality/financialyearending2021 (accessed September 2022)*.
Ohly, H., Gentry, S., Wigglesworth, R., Bethel, A., Lovell, R., & Garside, R. (2016). A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. *BMC Public Health, 16*(1), 286.
Olsen, A., Ritz, C., Hartvig, D. L., & Møller, P. (2011). Comparison of sensory specific satiety and sensory specific desires to eat in children and adults. *Appetite, 57*(1), 6-13.
Olsen, A., Ritz, C., Kraaij, L. W., & Møller, P. (2012). Children's liking and intake of vegetables: A school-based intervention study. *Food Quality and Preference, 23*(2), 90-98.
Osborne, C. L., & Forestell, C. A. (2012). Increasing children's consumption of fruit and vegetables: Does the type of exposure matter? *Physiology and Behavior, 106*(3), 362-368.
Overcash, F., Ritter, A., Mann, T., Mykerezi, E., Redden, J., Rendahl, A., . . . Reicks, M. (2018). Impacts of a vegetable cooking skills program among low-income parents and children. *Journal of Nutrition Education and Behavior, 50*(8), 795-802.
Overcash, F., Vickers, Z., Ritter, A. E., Mann, T., Mykerezi, E., Redden, J., . . . Reicks, M. (2019). An in-home intervention of parent-implemented strategies to increase child vegetable intake: results from a non-randomized cluster-allocated community trial. *BMC Public Health, 19*(1), 1-13.
Oyebode, O., Gordon-Dseagu, V., Walker, A., & Mindell, J. S. (2014). Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *Epidemiol Community Health, 68*(9), 856-862.
Pearce, A. L., Adise, S., Roberts, N. J., White, C., Geier, C. F., & Keller, K. L. (2020). Individual Differences in the Influence of Taste and Health Impact Successful Dietary Self-Control: A Mouse Tracking Food Choice Study in Children. *Physiology and Behavior*, 112990.
Pearce, J. M. (1987). A model for stimulus generalization in Pavlovian conditioning. *Psychological Review, 94*(1), 61.
Pearce, J. M. (1994). Similarity and discrimination: a selective review and a connectionist model. *Psychological Review, 101*(4), 587.

Pearson, N., Biddle, S. J., & Gorely, T. (2009). Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. *Public Health Nutrition, 12*(2), 267-283.
Pearson, N., Griffiths, P., Biddle, S. J., Johnston, J. P., & Haycraft, E. (2017). Individual, behavioural and home environmental factors associated with eating behaviours in young adolescents. *Appetite, 112*, 35-43.
Pedersen, S., Grønhøj, A., & Thøgersen, J. (2015). Following family or friends. Social norms in adolescent healthy eating. *Appetite, 86*, 54-60.
Pedersen, S., Grønhøj, A., & Thøgersen, J. (2016). Texting your way to healthier eating? Effects of participating in a feedback intervention using text messaging on adolescents' fruit and vegetable intake. *Health Education Research, 31*(2), 171-184.
Piaget, J. (1971). The theory of stages in cognitive development. In *D. Green, M. P. Ford, & G. B. Flamer (Eds.), Measurement and piaget (pp. 1e11)*. New York: McGraw-Hill.
Pliner, P. (1982). The effects of mere exposure on liking for edible substances. *Appetite, 3*(3), 283-290.
Pliner, P. (2008). Cognitive schemas: how can we use them to improve children's acceptance of diverse and unfamiliar foods? *British Journal of Nutrition, 99*(S1), S2-S6.
Pocock, M., Trivedi, D., Wills, W., Bunn, F., & Magnusson, J. (2010). Parental perceptions regarding healthy behaviours for preventing overweight and obesity in young children: a systematic review of qualitative studies. *Obesity Reviews, 11*(5), 338-353.
Poelman, A. A., Cochet-Broch, M., Wiggins, B., McCrea, R., Heffernan, J. E., Beelen, J., & Cox, D. N. (2020). Effect of experiential vegetable education program on mediating factors of vegetable consumption in Australian primary school students: a cluster-randomized controlled trial. *Nutrients, 12*(8), 2343.
Powell, F., Farrow, C., Meyer, C., & Haycraft, E. (2017). The importance of mealtime structure for reducing child food fussiness. *Journal of Maternal Child Nutrition, 13*(2), e12296.
Prynne, C. J., Handford, C., Dunn, V., Bamber, D., Goodyer, I. M., & Stephen, A. M. (2013). The quality of midday meals eaten at school by adolescents; school lunches compared with packed lunches and their contribution to total energy and nutrient intakes. *Public Health Nutrition, 16*(6), 1118-1125.
Public Health England (PHE). (2018a). *The Eatwell Guide: Helping you eat a healthy, balanced diet.* Available online: https://www.gov.uk/government/publications/the-eatwell-guide (accessed on 10 March 2020)
Public Health England (PHE). (2018b). *Food groups and portion sizes. https://campaignresources.phe.gov.uk/schools/resources/food-groups-portion-sizes (accessed April 2022).*
Public Health England (PHE),. & Food Standards Agency (FSA). (2021). *National Diet and Nutrition Survey: Diet, nutrition and physical activity in 2020*.
Rangel, A. (2013). Regulation of dietary choice by the decision-making circuitry. *Nature Neuroscience, 16*(12), 1717.
Ransley, J., Greenwood, D., Cade, J., Blenkinsop, S., Schagen, I., Teeman, D., . . . Schagen, S. (2007). Does the school fruit and vegetable scheme

improve children's diet? A non-randomised controlled trial. *Journal of Epidemiology and Community Health, 61*(8), 699-703.

Rasmussen, M., Krølner, R., Klepp, K.-I., Lytle, L., Brug, J., Bere, E., & Due, P. (2006). Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: quantitative studies. *International Journal of Behavioral Nutrition and Physical Activity, 3*(1), 22.

Rasmussen, M., Pedersen, T. P., Johnsen, N. F., Krølner, R. F., & Holstein, B. E. (2018). Persistent social inequality in low intake of vegetables among adolescents, 2002–2014. *Public Health Nutrition, 21*(9), 1649-1653.

Reale, S., Hamilton, J., Akparibo, R., Hetherington, M., Cecil, J., & Caton, S. (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.

Reale, S., Kearney, C. M., Hetherington, M. M., Croden, F., Cecil, J. E., Carstairs, S. A., . . . Caton, S. J. (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.

Redden, J. P., Mann, T., Vickers, Z., Mykerezi, E., Reicks, M., & Elsbernd, S. (2015). Serving first in isolation increases vegetable intake among elementary schoolchildren. *PloS One, 10*(4), e0121283.

Remington, A., Añez, E., Croker, H., Wardle, J., & Cooke, L. (2012). Increasing food acceptance in the home setting: a randomized controlled trial of parent-administered taste exposure with incentives. *The American Journal of Clinical Nutrition, 95*(1), 72-77.

Roe, L. S., Meengs, J. S., Birch, L. L., & Rolls, B. J. (2013). Serving a variety of vegetables and fruit as a snack increased intake in preschool children. *The American Journal of Clinical Nutrition, 98*(3), 693-699.

Roe, L. S., Sanchez, C. E., Smethers, A. D., Keller, K. L., & Rolls, B. J. (2021). Portion size can be used strategically to increase intake of vegetables and fruits in young children over multiple days: a cluster-randomized crossover trial. *The American Journal of Clinical Nutrition*.

Rozin, P., Hammer, L., Oster, H., Horowitz, T., & Marmora, V. (1986). The child's conception of food: Differentiation of categories of rejected substances in the 16 months to 5 year age range. *Appetite, 7*(2), 141-151.

Rubin, D. B. (2004). *Multiple imputation for nonresponse in surveys* (Vol. 81): John Wiley & Sons.

Russell, C. G., & Worsley, A. (2013). Why don't they like that? And can I do anything about it? The nature and correlates of parents' attributions and self-efficacy beliefs about preschool children's food preferences. *Appetite, 66*, 34-43.

Russell, C. G., Worsley, A., & Campbell, K. J. (2015). Strategies used by parents to influence their children's food preferences. *Appetite, 90*, 123-130.

Russell, C. G., Worsley, A., & Liem, D. G. (2015). Parents' food choice motives and their associations with children's food preferences. *Public Health Nutrition, 18*(6), 1018-1027.

Russell, C. G., & Worsley, T. (2016). Associations between appetitive traits and food preferences in preschool children. *Food Quality and Preference, 52*, 172-178.

Sanson, A., Hemphill, S. A., & Smart, D. (2004). Connections between temperament and social development: A review. *Social Development, 13*(1), 142-170.

Sausenthaler, S., Kompauer, I., Mielck, A., Borte, M., Herbarth, O., Schaaf, B., . . . Group, L. S. (2007). Impact of parental education and income inequality on children's food intake. *Public Health Nutrition, 10*(1), 24-33.

Savarino, G., Corsello, A., & Corsello, G. (2021). Macronutrient balance and micronutrient amounts through growth and development. *Italian Journal of Pediatrics, 47*(1), 1-14.

Schomaker, J., Vriens, M., & Jarva, H. (2022). Healthy or not: influencing attention to bias food choices. *Food Quality and Preference, 96*, 104384.

Schrempft, S., van Jaarsveld, C. H., Fisher, A., & Wardle, J. (2015). The obesogenic quality of the home environment: associations with diet, physical activity, TV viewing, and BMI in preschool children. *PloS One, 10*(8), e0134490.

Schulte-Mecklenbeck, M., Sohn, M., de Bellis, E., Martin, N., & Hertwig, R. (2013). A lack of appetite for information and computation. Simple heuristics in food choice. *Appetite, 71*, 242-251.

Schuster, R. C., Szpak, M., Klein, E., Sklar, K., & Dickin, K. L. (2019). “I try, I do”: Child feeding practices of motivated, low-income parents reflect trade-offs between psychosocial-and nutrition-oriented goals. *Appetite, 136*, 114-123.

Schwartz, C., Chabanet, C., Lange, C., Issanchou, S., & Nicklaus, S. (2011). The role of taste in food acceptance at the beginning of complementary feeding. *Physiology and Behavior, 104*(4), 646-652.

Searle, B.-R. E., Harris, H. A., Thorpe, K., & Jansen, E. (2020). What children bring to the table: The association of temperament and child fussy eating with maternal and paternal mealtime structure. *Appetite, 151*, 104680.

Seiverling, L., Towle, P., Hendy, H. M., & Pantelides, J. (2018). Prevalence of feeding problems in young children with and without autism spectrum disorder: A chart review study. *Journal of Early Intervention, 40*(4), 335-346.

Sharp, W. G., & Postorino, V. (2017). Food selectivity in autism spectrum disorder. In *Clinical handbook of complex and atypical eating disorders* (pp. 126-148): Oxford University Press Oxford.

Sharps, M., Hetherington, M. M., Blundell-Birtill, P., Rolls, B. J., & Evans, C. E. (2019). The effectiveness of a social media intervention for reducing portion sizes in young adults and adolescents. *Digital Health, 5*, 2055207619878076.

Sharps, M., & Robinson, E. (2015). Perceived eating norms and vegetable consumption in children. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 135.

Sharps, M., & Robinson, E. (2017). Perceived eating norms and children's eating behaviour: An informational social influence account. *Appetite, 113*, 41-50.

Sharps, M., Thomas, E., & Blissett, J. M. (2020). Using pictorial nudges of fruit and vegetables on tableware to increase children's fruit and vegetable consumption. *Appetite, 144*, 104457.

Shim, J. E., Kim, J., Lee, Y., Harrison, K., Bost, K., McBride, B., . . . Wiley, A. J. J. o. n. e. (2016). Fruit and vegetable intakes of preschool children are associated with feeding practices facilitating internalization of extrinsic motivation. *Journal of Nutrition Education and Behavior, 48*(5), 311-317. e311.

Slavin, J. L., & Lloyd, B. (2012). Health benefits of fruits and vegetables. *Advances in Nutrition, 3*(4), 506-516.

Smethers, A. D., Roe, L. S., Sanchez, C. E., Zuraikat, F. M., Keller, K. L., Kling, S. M., & Rolls, B. J. (2019). Portion size has sustained effects over 5 days in preschool children: A randomized trial. *The American Journal of Clinical Nutrition, 109*(5), 1361-1372.

Smith, A. D., Herle, M., Fildes, A., Cooke, L., Steinsbekk, S., & Llewellyn, C. H. (2017). Food fussiness and food neophobia share a common etiology in early childhood. *Journal of Child Psychology and Psychiatry, 58*(2), 189-196.

Smith, A. M., Roux, S., Naidoo, N. R., & Venter, D. J. (2005). Food choices of tactile defensive children. *Nutrition, 21*(1), 14-19.

Smith, B., Rogers, S. L., Blissett, J., & Ludlow, A. K. (2020). The relationship between sensory sensitivity, food fussiness and food preferences in children with neurodevelopmental disorders. *Appetite*, 104643.

Spill, M. K., Birch, L. L., Roe, L. S., & Rolls, B. J. (2010). Eating vegetables first: the use of portion size to increase vegetable intake in preschool children. *The American Journal of Clinical Nutrition, 91*(5), 1237-1243.

Spill, M. K., Birch, L. L., Roe, L. S., & Rolls, B. J. (2011). Hiding vegetables to reduce energy density: an effective strategy to increase children's vegetable intake and reduce energy intake–. *The American Journal of Clinical Nutrition, 94*(3), 735-741.

Stage, V. C., Downing, C., Hegde, A. V., Dev, D. A., Peterson, A. D., & Goodell, L. S. (2019). Comparison of parent and child ratings of fruit and vegetable liking to assess parent accuracy as proxy reporters. *Ecology of Food Nutrition, 58*(2), 166-186.

Staiano, A. E., Marker, A. M., Frelier, J. M., Hsia, D. S., & Martin, C. K. (2016). Influence of screen-based peer modeling on preschool children's vegetable consumption and preferences. *Journal of Nutrition Education and Behavior, 48*(5), 331-335. e331.

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: the food choice questionnaire. *Appetite, 25*(3), 267-284.

Stifter, C. A., & Moding, K. J. (2019). Temperament in obesity-related research: Concepts, challenges, and considerations for future research. *Appetite, 141*, 104308.

Stone, R. A., Haycraft, E., Blissett, J., & Farrow, C. (2022). Preschool-aged children's food approach tendencies interact with food parenting practices and maternal emotional eating to predict children's emotional eating in a cross-sectional analysis. *Journal of the Academy of Nutrition and Dietetics*.

Suggs, L. S., Della Bella, S., Rangelov, N., & Marques-Vidal, P. (2018). Is it better at home with my family? The effects of people and place on children's eating behavior. *Appetite, 121*, 111-118.

Sweetman, C., McGowan, L., Croker, H., & Cooke, L. (2011). Characteristics of family mealtimes affecting children's vegetable consumption and liking. *Journal of the American Dietetic Association, 111*(2), 269-273.

Tani, Y., Fujiwara, T., Ochi, M., Isumi, A., & Kato, T. (2018). Does eating vegetables at start of meal prevent childhood overweight in Japan? A-CHILD study. *Frontiers in Pediatrics, 6*, 134.

Tani, Y., Ochi, M., & Fujiwara, T. (2021). Association of Nursery School-Level Promotion of Vegetable Eating with Caregiver-Reported Vegetable Consumption Behaviours among Preschool Children: A Multilevel Analysis of Japanese Children. *Nutrients, 13*(7), 2236.
Taylor, C. M., Wernimont, S. M., Northstone, K., & Emmett, P. M. (2015). Picky/fussy eating in children: Review of definitions, assessment, prevalence and dietary intakes. *Appetite, 95*, 349-359.
te Velde, S. J., Twisk, J. W., & Brug, J. (2007). Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight. *British Journal of Nutrition, 98*(2), 431-438.
Tennant, D. R., Davidson, J., & Day, A. J. (2014). Phytonutrient intakes in relation to European fruit and vegetable consumption patterns observed in different food surveys. *British Journal of Nutrition, 112*(7), 1214-1225.
Tharner, A., Jansen, P. W., Kiefte-de Jong, J. C., Moll, H. A., van der Ende, J., Jaddoe, V. W., . . . Franco, O. H. (2014). Toward an operative diagnosis of fussy/picky eating: a latent profile approach in a population-based cohort. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 1-11.
Timberlake, W., & Allison, J. (1974). Response deprivation: An empirical approach to instrumental performance. *Psychological Review, 81*, 146-164.
Touyz, L. M., Wakefield, C. E., Grech, A. M., Quinn, V. F., Costa, D. S., Zhang, F. F., . . . Cohen, J. (2018). Parent-targeted home-based interventions for increasing fruit and vegetable intake in children: a systematic review and meta-analysis. *Nutrition Reviews, 76*(3), 154-173.
Trofholz, A. C., Tate, A. D., Draxten, M. L., Neumark-Sztainer, D., & Berge, J. M. (2016). Home food environment factors associated with the presence of fruit and vegetables at dinner: A direct observational study. *Appetite, 96*, 526-532.
Upton, D., Upton, P., & Taylor, C. (2013). Increasing children's lunchtime consumption of fruit and vegetables: an evaluation of the Food Dudes programme. *Public Health Nutrition, 16*(6), 1066-1072.
Vaillancourt, P. M. (1973). Stability of children's survey responses. *Public Opinion Quarterly, 37*(3), 373-387.
Van Cauwenberghe, E., Maes, L., Spittaels, H., Van Lenthe, F. J., Brug, J., Oppert, J.-M., & De Bourdeaudhuij, I. (2010). Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and ‘grey’literature. *British Journal of Nutrition, 103*(6), 781-797.
Van den Bosch, I., van Delft, J., de Wijk, R., de Graaf, C., & Boesveldt, S. (2015). Learning to (dis) like: the effect of evaluative conditioning with tastes and faces on odor valence assessed by implicit and explicit measurements. *Physiology and Behavior, 151*, 478-484.
Van der Horst, K. (2012). Overcoming picky eating. Eating enjoyment as a central aspect of children’s eating behaviors. *Appetite, 58*(2), 567-574.
Van der Horst, K., Deming, D. M., Lesniauskas, R., Carr, B. T., & Reidy, K. C. (2016). Picky eating: Associations with child eating characteristics and food intake. *Appetite, 103*, 286-293.
Van der Horst, K., Ferrage, A., & Rytz, A. (2014). Involving children in meal preparation. Effects on food intake. *Appetite, 79*, 18-24.
Van der Horst, K., Mathias, K. C., Patron, A. P., & Allirot, X. (2019). Art on a Plate: A Pilot Evaluation of an International Initiative Designed to

Promote Consumption of Fruits and Vegetables by Children. *Journal of Nutrition Education and Behavior, 51*(8), 919-925. e911.

Van Duyn, M. A. S., & Pivonka, E. (2000). Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: selected literature. *Journal of the American Dietetic Association, 100*(12), 1511-1521.

Vandeweghe, L., Moens, E., Braet, C., Van Lippevelde, W., Vervoort, L., & Verbeken, S. (2016). Perceived effective and feasible strategies to promote healthy eating in young children: focus groups with parents, family child care providers and daycare assistants. *BMC Public Health, 16*(1), 1-12.

Vandeweghe, L., Verbeken, S., Moens, E., Vervoort, L., & Braet, C. (2016). Strategies to improve the Willingness to Taste: The moderating role of children's Reward Sensitivity. *Appetite, 103*, 344-352.

Varman, S. D., Cliff, D. P., Jones, R. A., Hammersley, M. L., Zhang, Z., Charlton, K., & Kelly, B. (2021). Experiential Learning Interventions and Healthy Eating Outcomes in Children: A Systematic Literature Review. *International Journal of Environmental Research and Public Health, 18*(20), 10824.

Vaughn, A. E., Ward, D. S., Fisher, J. O., Faith, M. S., Hughes, S. O., Kremers, S. P., . . . Power, T. G. (2016). Fundamental constructs in food parenting practices: a content map to guide future research. *Nutrition Reviews, 74*(2), 98-117.

Ventura, A. K., & Birch, L. L. (2008). Does parenting affect children's eating and weight status? *International Journal of Behavioral Nutrition and Physical Activity, 5*(1), 1-12.

Ventura, A. K., & Worobey, J. (2013). Early influences on the development of food preferences. *Current Biology, 23*(9), R401-R408.

Verdonschot, A., De Vet, E., Van Rossum, J., Mesch, A., Collins, C. E., Bucher, T., & Haveman-Nies, A. (2020). Education or provision? A comparison of two school-based fruit and vegetable nutrition education programs in the netherlands. *Nutrients, 12*(11), 3280.

Vereecken, C., Rovner, A., & Maes, L. (2010). Associations of parenting styles, parental feeding practices and child characteristics with young children's fruit and vegetable consumption. *Appetite, 55*(3), 589-596.

Vereijken, C., Weenen, H., & Hetherington, M. (2011). Feeding infants and young children. From guidelines to practice-conclusions and future directions. *Appetite, 57*(3), 839-843.

Vilela, S., Hetherington, M. M., Oliveira, A., & Lopes, C. (2018). Tracking diet variety in childhood and its association with eating behaviours related to appetite: The generation XXI birth cohort. *Appetite, 123*, 241-248.

Vollmer, R. L., & Baietto, J. (2017). Practices and preferences: Exploring the relationships between food-related parenting practices and child food preferences for high fat and/or sugar foods, fruits, and vegetables. *Appetite, 113*, 134-140.

Vollrath, M. E., Stene-Larsen, K., Tonstad, S., Rothbart, M. K., & Hampson, S. E. (2012). Associations between temperament at age 1.5 years and obesogenic diet at ages 3 and 7 years. *Journal of Developmental and Behavioral Pediatrics, 33*(9), 721.

Wadhera, D., Phillips, E. D. C., & Wilkie, L. M. (2015). Teaching children to like and eat vegetables. *Appetite, 93*, 75-84.

Wang, X., Ouyang, Y., Liu, J., Zhu, M., Zhao, G., Bao, W., & Hu, F. B. (2014). Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. *BMJ, 349*.

Wardle, J., & Carnell, S. (2007). Parental feeding practices and children's weight. *Acta Paediatrica, 96*, 5-11.

Wardle, J., & Cooke, L. (2008). Genetic and environmental determinants of children's food preferences. *British Journal of Nutrition, 99*(S1), S15-S21.

Wardle, J., Guthrie, C. A., Sanderson, S., & Rapoport, L. (2001). Development of the children's eating behaviour questionnaire. *The Journal of Child Psychology, Psychiatry and Allied Disciplines, 42*(7), 963-970.

Wardle, J., Herrera, M. L., Cooke, L., & Gibson, E. L. (2003). Modifying children's food preferences: the effects of exposure and reward on acceptance of an unfamiliar vegetable. *European Journal of Clinical Nutrition, 57*(2), 341-348.

Warren, E., Parry, O., Lynch, R., & Murphy, S. (2008). ‘If I don't like it then I can choose what I want’: Welsh school children's accounts of preference for and control over food choice. *Health Promotion International, 23*(2), 144-151.

WHO. (2003). Promoting fruit and vegetable consumption around the world. *https://www.who.int/dietphysicalactivity/fruit/en/*, Accessed on 01/12/2020.

WHO. (2014). Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases. *https://www.who.int/elena/titles/bbc/fruit_vegetables_ncds/en/*, Accessed on 01/12/2020.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., . . . Wood, A. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet, 393*(10170), 447-492.

Wolstenholme, H., Kelly, C., Hennessy, M., & Heary, C. (2020). Childhood fussy/picky eating behaviours: A systematic review and synthesis of qualitative studies. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 1-22.

Woodside, J., Adamson, A., Spence, S., Baker, T., & McKinley, M. (2021). Opportunities for intervention and innovation in school food within UK schools. *Public Health Nutrition, 24*(8), 2313-2317.

Yang, J., Tani, Y., Tobias, D. K., Ochi, M., & Fujiwara, T. (2020). Eating Vegetables First at Start of Meal and Food Intake among Preschool Children in Japan. *Nutrients, 12*(6), 1762.

Yang, S., Zhang, X., Feng, P., Wu, T., Tian, R., Zhang, D., . . . He, F. (2021). Access to fruit and vegetable markets and childhood obesity: a systematic review. *Obesity Reviews, 22*, e12980.

Yang, Y., Zhang, D., Feng, N., Chen, G., Liu, J., Chen, G., & Zhu, Y. (2014). Increased intake of vegetables, but not fruit, reduces risk for hepatocellular carcinoma: a meta-analysis. *Gastroenterology, 147*(5), 1031-1042.

Yee, A. Z., Lwin, M. O., & Ho, S. S. (2017). The influence of parental practices on child promotive and preventive food consumption behaviors: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 1-14.

Yeomans, M. R. (2010). Understanding individual differences in acquired flavour liking in humans. *Chemosensory Perception, 3*(1), 34-41.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*(2p2), 1.

Zeinstra, G. G., Koelen, M., Kok, F., & De Graaf, C. (2010). The influence of preparation method on children's liking for vegetables. *Food Quality and Preference, 21*(8), 906-914.

Zeinstra, G. G., Kooijman, V., & Kremer, S. (2017). My idol eats carrots, so do I? The delayed effect of a classroom-based intervention on 4–6-year-old children's intake of a familiar vegetable. *Food Quality and Preference, 62*, 352-359.

Zeinstra, G. G., Renes, R. J., Koelen, M. A., Kok, F. J., & de Graaf, C. (2010). Offering choice and its effect on Dutch children's liking and consumption of vegetables: a randomized controlled trial. *The American Journal of Clinical Nutrition, 91*(2), 349-356.

Zeinstra, G. G., Vrijhof, M., & Kremer, S. (2018). Is repeated exposure the holy grail for increasing children's vegetable intake? Lessons learned from a Dutch childcare intervention using various vegetable preparations. *Appetite, 121*, 316-325.

Zellner, D. A., & Cobuzzi, J. L. (2016). Just dessert: Serving fruit as a separate "dessert" course increases vegetable consumption in a school lunch. *Food Quality & Preference, 48*, 195-198.

Zellner, D. A., Rozin, P., Aron, M., & Kulish, C. (1983). Conditioned enhancement of human's liking for flavor by pairing with sweetness. *Learning and Motivation, 14*(3), 338-350.

Zhao, X., Lynch Jr, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197-206.

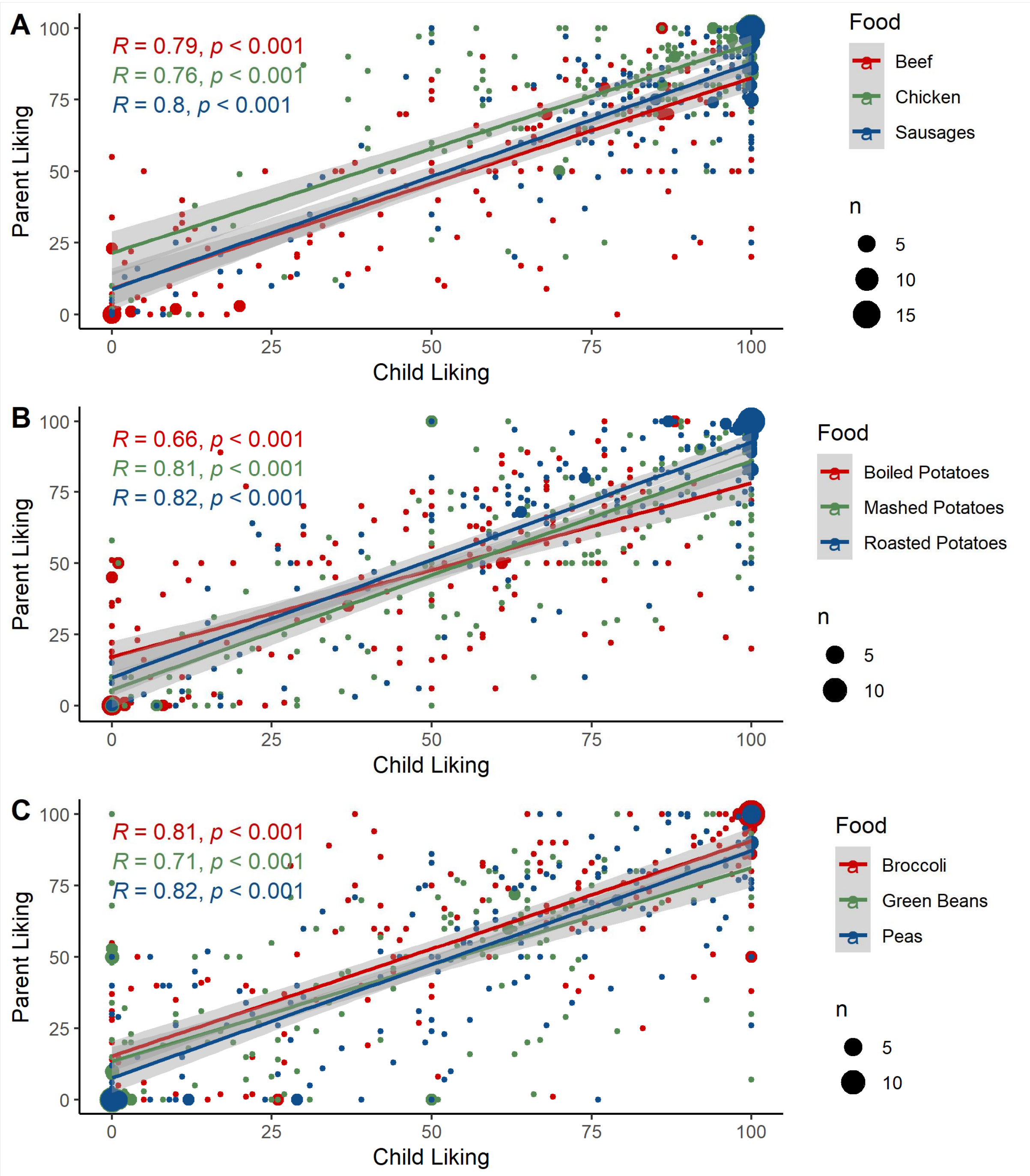
Ziauddeen, N., Almiron-Roig, E., Penney, T. L., Nicholson, S., Kirk, S. F., & Page, P. (2017). Eating at food outlets and "on the go" is associated with less healthy food choices in adults: cross-sectional data from the UK National Diet and Nutrition Survey Rolling Programme (2008–2014). *Nutrients, 9*(12), 1315.

Appendices

Appendices A: Chapter 5

Appendix A1: Correlations between parent and child food liking ratings

Pearson's correlations between child self-reported liking of foods and caregiver's perceived liking of foods by their child. Plot A shows ratings for protein foods, plot B for carbohydrate foods and plot C for vegetables. The shading around each regression line illustrates 95% confidence intervals for the fitted values.



Appendices B: Chapter 6

Appendix B1: Survey Questionnaires

Intention and beliefs questionnaires:

Parental intentions:

7 point Likert scale from Strongly disagree to strongly Agree

Scenario:

Imagine that you are informed from a reliable source that you could increase your child's vegetable intake at mealtimes by 1 portion (40g), by changing the way that the vegetables are served (e.g. serving larger portions of vegetables, serving a variety of vegetables, or serving vegetables before the rest of the meal). Given that information, over the next month to what extent would you try it? Reading the statements below, let us know whether you would agree or disagree with these statements.

Questions:

1. I would try it even if it involves some extra effort at mealtimes.
2. I would make an effort to try it.
3. I would insist on trying it once.
4. I would intend to try it for at least one meal per week.
5. I would like to try it even if it costs a little more to do.

Parental beliefs:

Scenario:

If the methods mentioned by the reliable source included the following, for each method, what effect would it have on your child's intake of vegetables?

7 point Likert scale – Response options:

(1) My child would eat fewer vegetables, (2) No change to the amount of vegetables my child eats, (3) My child would try them, but not eat more, (4) My child would eat a few bites more, (5) My child would eat up to half of the portion served, (6) My child would eat up to 3/4 of the portion served, (7) My child would eat the whole portion.

Questions:

1. Serve vegetables as a starter, before the rest of the meal.

2. Offer a taste of the vegetable at different mealtimes (on 5-15 separate occasions)
3. Involve your child in vegetable related games/songs at mealtimes
4. Serve a larger portion of vegetables
5. Offer a variety of vegetables at mealtimes so that there is more than one type of vegetable to eat
6. Involve your child in sensory play (e.g. smelling, touching, playing or tasting the vegetables).

Child eating and parent feeding questionnaires:

Child Eating Behaviour Questionnaire (CEBQ):

Reference - Wardle, J, Guthrie CA, Sanderson, S and Rapoport, L. Development of the Children's Eating Behaviour Questionnaire. Journal of Child Psychology and Psychiatry. 42, 2001, 963-970.

Subscales: Food fussiness, Satiety responsiveness, Slowness of eating.

Questions – 5 point Likert (Never-Always):

1. My child has a big appetite
2. My child takes more than 30 minutes to finish a meal
3. My child enjoys tasting new foods
4. My child enjoys a wide variety of foods
5. My child eats slowly
6. My child is difficult to please with meals
7. My child gets full up easily
8. My child is interested in tasting food s/he hasn't tasted before
9. My child decides that s/he doesn't like a food, even without tasting it
10. My child refuses new foods at first
11. My child finishes his/her meal quickly
12. My child gets full before his/her meal is finished
13. My child eats more and more slowly during the course of a meal
14. My child leaves food on his/her plate at the end of a meal
15. My child cannot eat a meal if s/he has had a snack just before

Comprehensive Feeding Practices Questionnaire (CFPQ):

Reference – Musher-Eizenman, D., & Holub, S. (2007). Comprehensive feeding practices questionnaire: validation of a new measure of parental feeding practices. Journal of pediatric psychology, 32(8), 960-972.

Subscales: Encouraging Balance and variety, Modelling, Child involvement, Pressure.

Questions – 5 point Likert scale (Never-Always):

1. Do you encourage this child to eat healthy foods before unhealthy ones?

5 point Likert (Disagree-Agree)

1. I encourage my child to try new foods.
2. I tell my child that healthy food tastes good.
3. I encourage my child to eat a variety of foods.
4. I model healthy eating for my child by eating healthy foods myself.
5. I try to eat healthy foods in front of my child, even if they are not my favourite.
6. I try to show enthusiasm about eating healthy foods.
7. I show my child how much I enjoy eating healthy foods.
8. I involve my child in planning family meals.
9. I allow my child to help prepare family meals.
10. I encourage my child to participate in grocery shopping.
11. My child should always eat all of the food on his/her plate.
12. If my child says, "I'm not hungry," I try to get him/her to eat anyway.
13. If my child eats only a small helping, I try to get him/her to eat more.
14. When he/she says he/she is finished eating, I try to get my child to eat one more (two more, etc.) bites of food.

Food Choice Questionnaire (FCQ):

Reference – Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: the food choice questionnaire. Appetite, 25(3), 267-284.

Subscales: Health, Natural content, Convenience

Questions – 5 point Likert scale (Disagree-Agree):

1. Contains a lot of vitamins and minerals
2. Keeps my child healthy
3. Is nutritious
4. Is high in protein
5. Is good for my child's skin/teeth/hair/nails etc
6. Is high in fibre and roughage
7. Contains no additives
8. Contains natural ingredients
9. Contains no artificial ingredients
10. Is easy to prepare
11. Is easily available in shops and supermarkets
12. Can be cooked very simply
13. Takes no time to prepare

14. Can be bought in shops close to where I live or work

Food Frequency Questionnaire:

Reference – Hammond, J., Nelson, M., Chinn, S., & Rona, R. J. (1993). Validation of a food frequency questionnaire for assessing dietary intake in a study of coronary heart disease risk factors in children. European Journal of Clinical Nutrition, 47(4), 242-250.

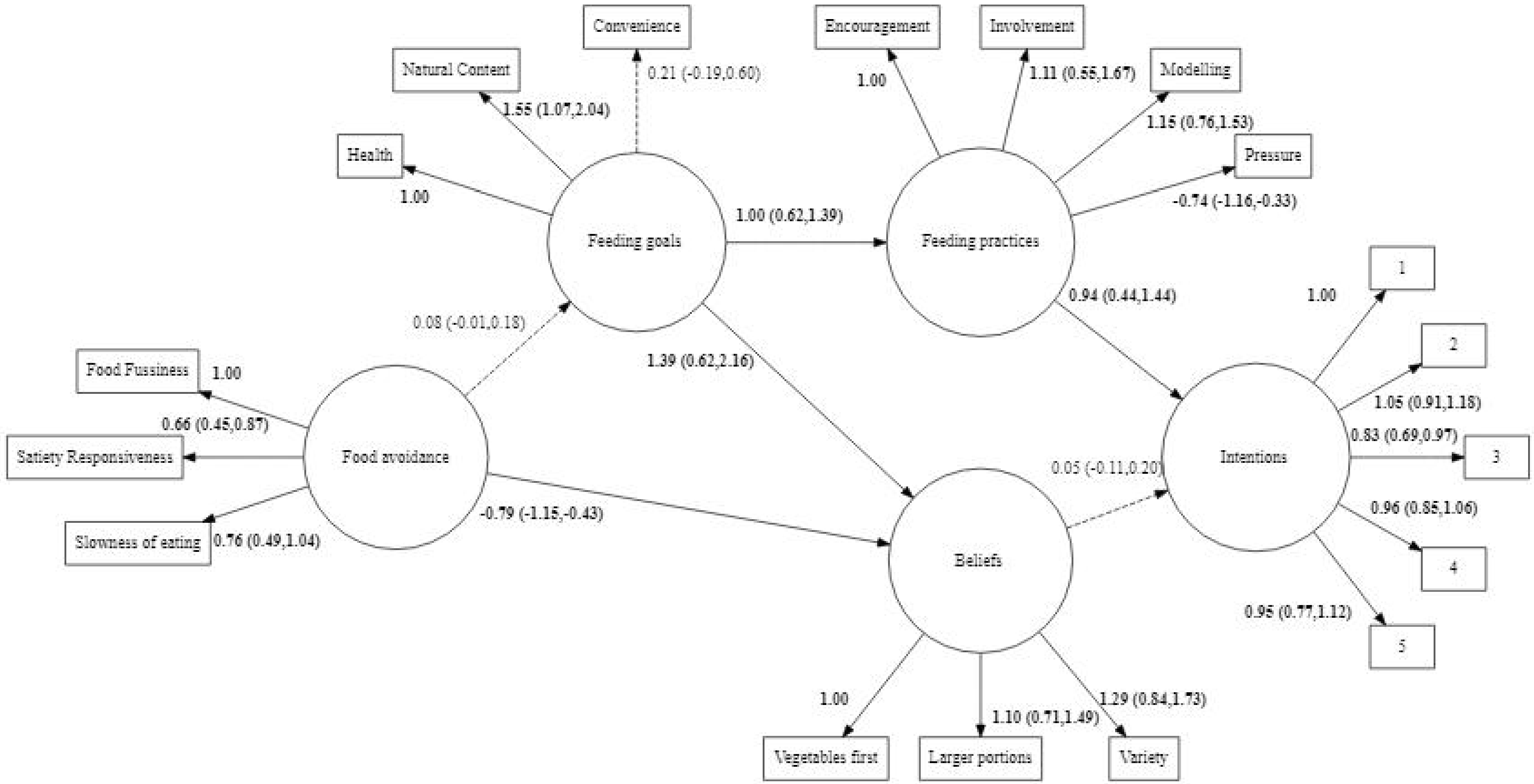
5 point frequency scale – Never, Once per month, Once per fortnight, Once per week, Daily.

Please check the box that best describes how often your child tends to eat EACH of the following food groups.

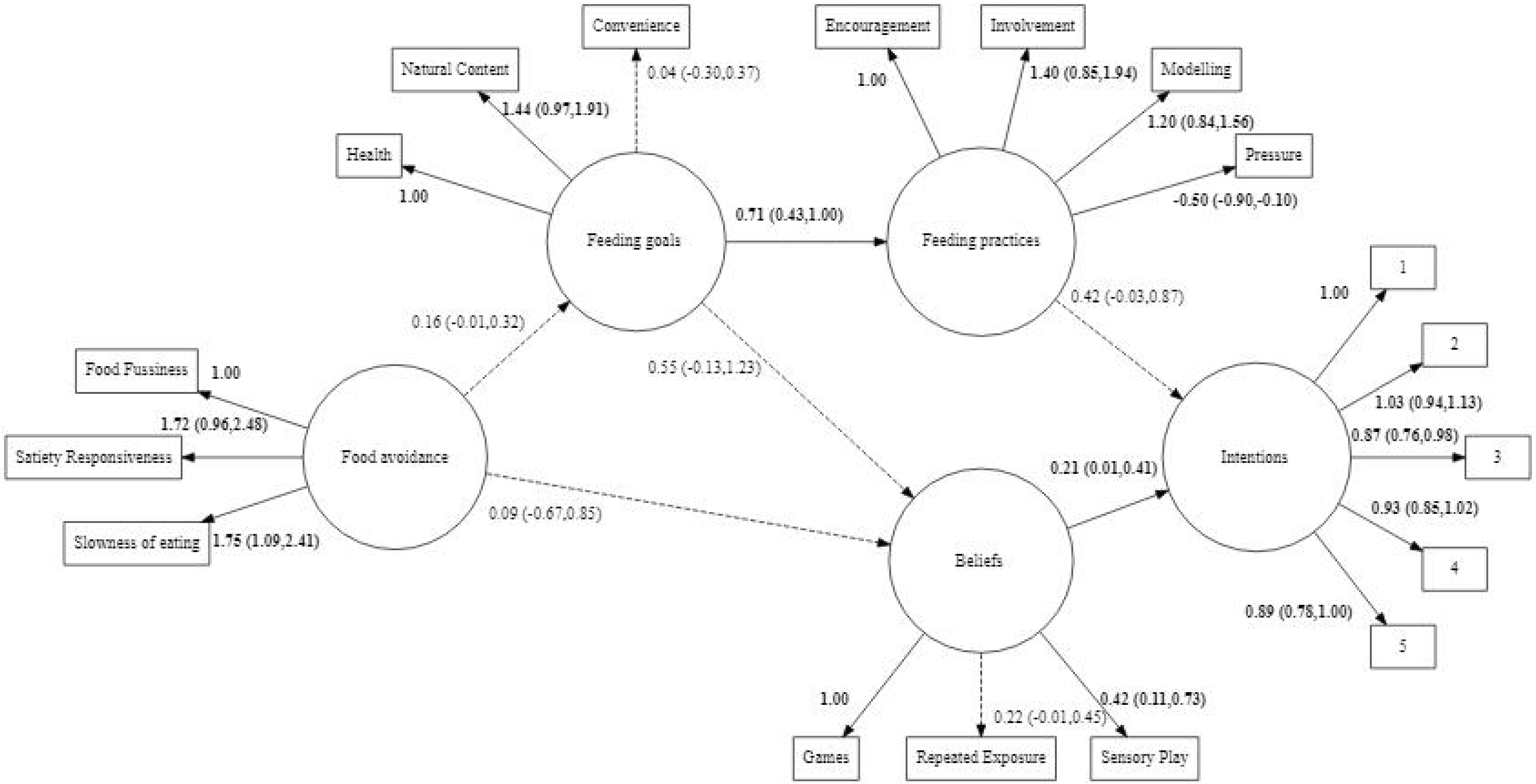
1. Baked beans, lentils, chick peas, kidney beans, soya mince.
2. Potatoes, yams, sweet potatoes, plantain
3. Green cooked vegetables (including cauliflower, peas, broccoli, aubergines, green beans, Brussels sprouts, cabbage)
4. Other cooked vegetables (carrots, turnip, onions, etc.)
5. Salads (tomatoes, lettuce, raw vegetables)

Appendix B2: Initial SEM models before respecification.

Initial Meal Service SEM model that was tested before respecification.



Initial Experiential Learning SEM model that was tested before respecification.



Appendices C: Chapter 7

Appendix C1: Participant Characteristics.

Participant characteristics from study 1 and descriptive statistics of questionnaires. 20 parents did not return the questionnaire, therefore percentages are of the parents that completed and returned the survey.

Participant Characteristics.	
Total Parents, Female (%)	18, 16 (89)
Total Children, Female (%)	18, 7 (39)
Parent Age, Mean (SD) [Range]	32 (7.8) [22,46]
Child Age, Mean (SD) [Range]	4 (0.8) [3,5]
Ethnicity of parent, N (%)	
White/White British	18 (100)
Household Income, N (%)	
Less than £25,000	4 (22)
£25,000 to £49,999	6 (33)
£50,000 to £74,999	2 (11)
above £75,000	2 (11)
prefer not to answer	4 (22)
Parental Education, N (%)	
Some High School or Less	2 (11)
Some college education	4 (22)
Associate Degree (AA) or vocational license	4 (22)
Bachelor's degree	4 (22)
Graduate or professional degree	1 (6)
Prefer not to answer	3 (17)
Descriptive statistics from questionnaires	M (SD) [mode]
CEBQ - Fussiness	3.2 (0.4) [“Sometimes”]
CEBQ – Enjoyment of food	3.9 (0.8) [“Often”]
CEBQ – Satiety responsiveness	2.9 (0.3) [“Sometimes”]
CEBQ – Food responsiveness	2.8 (0.9) [“Rarely”]
CEBQ – Slowness in eating	2.9 (0.4) [“Sometimes”]
PMAS – Positive persuasion	3.8 (0.8) [“Often”]
PMAS – Use of reward	2.9 (0.8) [“Sometimes”]
PMAS – Insistence on eating	2.2 (0.7) [“Rarely”]
PMAS – Child selected meals	3.4 (0.5) [“Often”]
Frequency and liking of study foods	M (SD) [mode]
Vegetable liking (100 point VAS)	63.8 (29.5)
Competitor food liking (100 point VAS)	52.1 (18.6)
Frequency child eats vegetables	3.3 (0.7) [“At least once a week”]
Frequency child eats competitor foods	2.8 (0.8) [“Twice a month”]

Appendix C2: Multi-level model – Competitor foods (study 1)

Results of a multi-level model predicting total amount of competitor foods (fish fingers and potato wedges) eaten (g) by children in each experimental condition.

	Total competitor foods eaten in g				
Predictors	*Estimates*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)	30.00	16.25	-2.41 – 62.41	1.85	0.069
School (reference level School 1)					
School 2	6.98	5.84	-4.67 – 18.64	1.20	0.236
Amount of competitor foods served (g)	0.49	0.14	0.22 – 0.76	3.61	**0.001**
Vegetable presentation (reference level served together)					
Vegetables-served-first	4.63	3.76	-2.87 – 12.13	1.23	0.222
Random Effects					
σ^2	238.74				
$\tau_{00\ Participant}$	184.62				
ICC	0.44				
$N_{Participant}$	38				
Observations	75				
Marginal R^2 / Conditional R^2	0.161 / 0.527				

Appendix C3: Multi-level model – Energy consumed (study 2)

Results of a multi-level model predicting total amount of energy consumed (kcal) by children in each experimental condition.

	Total energy consumed in kcal				
Predictors	*Estimates*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)	27.12	45.22	-63.12 – 117.36	0.60	0.551
School (reference level School 1)					
School 2	16.20	19.61	-22.92 – 55.33	0.83	0.411
Vegetables served energy (kcal)	0.98	0.80	-0.62 – 2.57	1.22	0.226
Competitor foods served energy (kcal)	0.56	0.13	0.30 – 0.82	4.33	**<0.001**
Vegetable presentation (reference level served together)					
Vegetables-served-first	14.17	6.77	0.65 – 27.68	2.09	**0.040**
Random Effects					
σ^2	730.35				
τ_{00} Participant	674.75				
ICC	0.48				
N Participant	38				
Observations	75				
Marginal R^2 / Conditional R^2	0.208 / 0.588				

Appendix C4: Phunky foods teaching resources

Veg First!

Dear teaching staff,

Welcome to Veg First! Thank you for taking part in this valuable research project to discover if presenting children with vegetables first, before the main component of their meal, will result in higher vegetable consumption at lunch time.

Please deliver the introductory session on the first day of the intervention and then the follow-up material, each day that the intervention is taking place. The input required is simple and should only take around 5 minutes to complete. It needs to be delivered just before lunch time, so that the input is fresh in the pupil's minds.

If children ask why they are being served vegetables on their own, please respond by saying that ***"we are trying a new way of serving lunch, eating a starter first before the main meal".*** Please try to keep any answers to this question as general as possible.

Thank you for your help.

Introductory Session:

Activity	**Input**
Read the welcome message to the pupils:	Welcome to Veg First! You are taking part in an important project because we are trying a new way of serving lunch, eating a starter before the main meal! On some school days, you will be given a special 'Veg First' plate and you will eat your vegetables first. After you've eaten them, you will then get the rest of your meal to eat. On the other days, you will eat your vegetables at the same time as the rest of your lunch. On the 'Veg First' days, you will also watch a short video about eating vegetables and sing a song.
Watch the Veg First video	Either as a class, or in groups if more convenient, watch the veg first video. An ideal time would be as the children are getting ready for lunch.

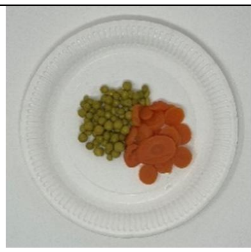
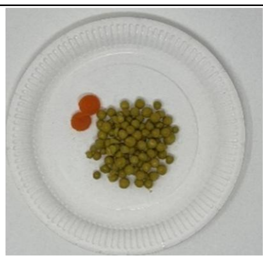
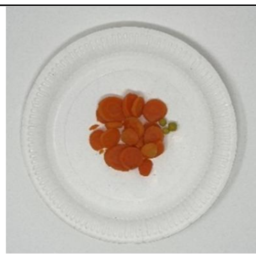
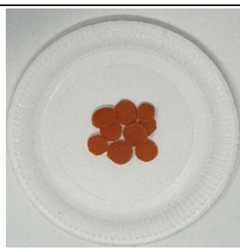
Sing the Veg First song	Explain to the class that now it's their turn to sing the song they heard on the video. Teach the following words to the tune of 'London Bridge is faking down': Vegetables are eaten first, eaten first, eaten first, Vegetables are eaten first, then my lunch.

<u>Follow-up Sessions:</u>

Activity	**Input**
Read the 3 top reasons why vegetables are good for us: (and/or ask the children why vegetables are good for them)	1. Vegetables have lots of lovely vitamins and minerals that help keep our whole bodies healthy 2. Vegetables help our tummies feel better because they contain something called fibre 3. Vegetables taste yummy!
Watch the Veg First video	Just before lunch time, watch the veg first video.
Sing the Veg First song	Sing the following words to the tune of 'London Bridge': Vegetables are eaten first, eaten first, eaten first, Vegetables are eaten first, then my lunch.

Appendix C5: Vegetable intake rating resource

Instructions for rating vegetable intake
Please record the closest portion size on the data collection sheet.

None Example – For this rating, the child may not have touched any of their vegetables, or maybe they have eaten only a few pieces of either (or both) vegetables.			
1/4 Example – It is clear that the child has eaten more than a few bites of their vegetables, but the majority of the portion still remains.			
1/2 Example – About half of the original portion of vegetables has been eaten by the child. It may be that the child has eaten all of one vegetable, but has left the other on the plate.			
3/4 Example – The child has eaten more than half of the portion, but there are still some remains of one or both vegetables on the plate.			
All Example - The child has eaten the entire portion of vegetables that was served to them. However, there may be a few scraps left on the plate.			

Appendix C6: Process evaluation interview guide

Interview guide

Contextual factors

1. Briefly in your own words, how do lunchtimes usually work?
    - How long do children get to eat
    - How big are the groups children sit with
    - do they choose some of their own foods
    - are desserts served with main meals
    - are children encouraged to eat their food
    - does lunch lead out into play, or does everybody wait

2. How did the study procedures affect the usual meal process? (time –staff and children, serving food, what was served)?

Implementation factors

1. How was the intervention delivered by staff?
    - Were staff on board with procedures and delivering intervention?
    - Do you think that the instructions/protocol were closely followed?
    - Were there any deviations from the procedure or did any adaptations have to be made?
    - Was it possible to serve vegetables first 3 times each week before the meal?
    - Did the procedures add any extra burden for staff?
    - Was the study easier to do when the EDC was present?
2. What are your thoughts on the teaching materials provided by Phunky foods (plates, song, video, lesson plan), was there anything that could have been done differently, anything that you particularly liked/disliked?

Potential mechanisms of action

1. What were children's responses to vegetables being served first, singing the song, watching the video?
2. Did children engage with the material? –why/why not?
3. Do you think that the strategies made lunchtimes more enjoyable for children?
4. Do you think that there were changes to the amount that was eaten by children?
5. Were there any unexpected consequences of any of the procedures?

Any other feedback?