The Influence of Perceptual and Cognitive Factors in the Development of Food Preferences

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Thesis submitted for the award of Doctor of Philosophy

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Acknowledgements

I would like to thank firstly my PhD supervisors Dr Nicola J. Pitchford and Dr Ellen Townsend for their excellent support and guidance over the last few years. They have pushed me to produce the highest quality work I can; to question and to think about things from different perspectives. They have always been available to discuss things when necessary and have consistently helped me to clarify or to understand things, and have encouraged me to keep going. I would also like to thank each and every one of the children and families who made this work possible by participating in each of my experiments. All of the families registered on the Nottingham Toddler Lab database for giving up their time so generously to volunteer to take part; and to all the parents, staff and pupils from Dunston Primary School, in Chesterfield who welcomed me back time after time to work with them. With special thanks to their Head Teacher, Mrs Sharon Davison, who was always willing to allow me to spend time in her school on several occasions for the purposes of my PhD. I would also like to thank my friends and peers Eleanor Limback and Emma Davis for the many hours spent discussing aspects of our work and sharing our concerns and issues; but mostly for being there as friends who understood and were able to empathise in ways others were unable to. I would specially like to thank my parents, Debbie and Barry Pybis who have always been there for me, have always encouraged me and believed in my ability to succeed and have never doubted me. Finally I would like to thank my fiancé Tim Davison who has been there for me throughout the last 10 years, always there to make me smile, to take my mind off things and to consistently make me feel that everything is ok. He has supported, encouraged and believed in me and most importantly he has understood. Thank you so much, I couldn't have done it without you.

Abstract

Despite a considerable amount of research investigating factors that influence the development of food preferences, there is very little research considering factors associated with food items themselves and the cognitive processes used by children to determine acceptance or rejection of a novel food. When offered a new food, children will see what colour, size and shape it is and may be able to determine its texture. In addition, they will be able to smell the food and may even be informed of what the food is called by their parents labelling it. Hence children will have a significant amount of knowledge of what the food they are being offered is like. It may therefore be reasonable to suggest children will use this knowledge and make comparisons to prior experience with 'similar' foods. This thesis presents three experimental chapters which aim to explore the role of perceptual (e.g. colour, texture and size) and cognitive (categorisation) factors on the development of food preferences. Chapter 2 presents an Explicit Preference Task, which enables children to self-report on their food preferences, complemented by parental report Food Preference and Frequency questionnaires. Chapter 3 presents a Longitudinal Food Diary method exploring the relationship between preference and exposure. Finally in Chapter 4 using a series of match-to-sample experiments to consider if children use colour as a basis for categorisation of food objects, a comparison is made against non-food objects. Results indicated children to dislike food colours particularly associated with vegetables more so than other food colours. This was found to be related to the amount of exposure they had to those foods and specifically results indicated children to use food colour as a basis for rejection of novel foods. It was also observed that whilst children use shape as a basis for categorisation of non-food objects, they are more inclined to categorise foods on the basis of colour.

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Chapter 1: General Introduction

1.1. The link between perceptual and cognitive factors

There is little previous research considering which features of food are attended to and how these may relate to developing preferences. However, there is evidence that salient features differ dependent on the context. For example, it has been observed that adults show preference for familiar objects when looking at faces whereas they prefer novel objects when looking at natural scenes (Parka, Shimojoa & Shimojoa, 2010); findings such as this indicate that context and object function may play a role in the salient features of objects that are attended to. It has been consistently reported that children prefer to match objects on the basis of colour prior to a switch to shape at around 3- to 4-years of age (Baldwin, 1989; Brian & Goodenough, 1929; Pitchford & Mullen, 2001; Suchman & Trabasso, 1966). It has been observed that for some objects, such as food and canonically coloured objects (e.g. fire engines), colour may have more predictive validity than shape or other perceptual attributes (Macario, 1991).

The initial use of colour to categorise objects is not surprising as colour is perceptually salient to young children, and can be discriminated from as young as 4 months of age (Bornstein, Kessen, & Weiskopf, 1976). However, it is likely the switch to categorising on the basis of shape over colour comes as children realise that for the majority of objects shape is more informative of object function than colour. For example, a car can vary in colour yet shape remains constant (e.g., a box with four wheels), and it is the shape that is informative of the object's function (e.g., transports people from A to B), whereas colour provides no indication of a car's function.

Where previous research has indicated shape to be informative of class membership for the majority of objects, this may not be the case for food objects. The basis of categorisation for food items may differ, as for the majority of food items shape will have little predictive validity of taste. For example, round foods, such as peas, bread rolls, and certain sweets, differ greatly in taste, so grouping these objects on the basis of shape would not be predictive of taste. However, colour may be a reliable predictor of food taste. For example, most green foods have a bitter taste. In a series of experiments, Macario (1991) found that 3- and 4-year-old children were able to select the appropriate colour when given the label of an object that has a characteristic colour (e.g., red for strawberries). Similarly they could use colour cues to select labels for objects that have characteristic colours (e.g., given a red stick and asked what they could eat that is this colour they identified strawberries). Furthermore, children categorised novel objects on the basis of colour when they were told that the objects were something to eat whereas they categorised the same objects on the basis of shape when they were told that the objects were toys.

Although there has been little research considering the categorisation of food on the basis of colour in human children, there is evidence of a colour bias for categorisation of food objects in non-human primates. Santos, Hauser and Spelke (2001) conducted a series of experiments comparing the basis of categorisation in Rhesus Macaques using novel objects that were portrayed to be either foods or non-foods. For example, in one experiment monkeys were shown two objects simultaneously, varying in shape and colour (e.g., a green ring and a pink cylinder), one of which the experimenter pretended to eat. Both objects were then removed and replaced with two identical objects. Responses were based on which of the two objects the monkey approached after the experimenter walked away. It was observed that 12 out of 15 monkeys approached the item that was the same colour as the one the experimenter had pretended to eat, whereas when the experimenter used the item as a non-food object (e.g., twirled on finger) monkeys were more inclined to approach the object that differed in both shape and colour. Furthermore when replicated with objects being used as tools (e.g., to scratch the experimenter's ear) less than half of the monkey's approached the matching object; indicating monkeys to associate different perceptual properties with objects used in different ways.

A recent study by Shutts, Condry, Santos and Spelke (2009) built on the findings of Santos et al., (2001) to consider the use of shape and colour in categorisation by non-human primates and human infants. In a series of experiments Shutts et al. considered the role of shape and colour in the categorisation of stimuli identified as food and non-food objects. The first experiment, using a looking time paradigm, considered how non-human primates categorised objects (pink or purple clay sticks) which were indicated to be foods (by the experimenter pretending to eat). Target objects were then removed and a novel object, of either the same colour or shape, was placed on a platform and looking time was recorded. Results indicated looking time to be significantly longer when the object differed in colour to the target, than to when the object differed in shape. This suggests primates to associate colour, and not shape, with a change in an object depicted as food.

Shutts et al., (2009) extended this further to consider how human infants categorise food compared to non-food objects. A series of experiments were conducted with 8- and 9-month-old human infants. These experiments aimed to investigate perception of the unity and boundaries of natural food objects. In the first condition, infants were presented with two food objects (e.g., ginger and miniature pumpkin), one on top of the other, which differed in shape, colour and texture; whilst in the second condition infants were presented with just a single object. In both conditions a hand appeared and either the top half of the display moved alone (e.g., first condition: the top object moves separately to the bottom; second condition: the single item breaks in half and the top moves away from the bottom); or the whole stimuli moved as one (both objects move together, the single object moves as a whole). Looking time was recorded and a comparison was made between infants who had received prior exposure to these outcomes (experimental group) and those who had not (baseline group).

It was hypothesised that if human infants perceive natural food objects in the same manner as adult monkeys, then they should look longer when the two objects move as a whole, and should look equally long whether the single object is broken in half and the top half moves alone, or the single object moves as a whole. Interestingly results did not support these hypotheses. In the first condition, where two objects were placed one on top of the other and moved either separately or as a whole, infants looked equally long at each outcome. In contrast, in the second condition, when a single object either moved as a whole or broke apart, infants looked significantly longer when the object broke apart. These results imply human infants do not associate food colour as an informative basis for categorisation.

It is possible that the process of categorising food on the basis of colour, as opposed to shape, is a learned mechanism that has not developed by 8 months of age. The authors suggested this may be a plausible explanation of the results, particularly as human infants have a long period of nursing and as such are not actively engaged in their own food selection, therefore the need to develop informative measures of food selection may not develop until later. This theory is supported by the work of Paul Rozin and colleagues who have shown infants and toddlers are willing to put a variety of objects into their mouths, irrespective of whether the item may be 'disgusting' or harmful (e.g., Rozin & Vollmecke, 1986). Similarly, food neophobia (the rejection of new foods) does not emerge until around 18 months of age, suggesting children may not acquire the process of categorising foods on the basis of perceptual features until much later than the infants tested by Shutts et al. (2009). Thus further research is required to consider the role of perceptual attributes in children's categorisation of food and how this may relate to developing food preferences.

Perceptual categorisation and naming

In a series of studies, Horne, Lowe and Hughes (various combinations) have demonstrated the importance of naming in categorisation of object function. For example, Lowe, Horne and Hughes (2005) taught children ambiguous names ('zog', 'vek') for arbitrary stimuli (green wooden shapes) which were associated with one of two actions (clapping or waving). Following this, when naming other stimuli as 'zog' or 'vek', although not trained to do so, children went on to do the action (clapping or waving) that they had associated with the name previously. Furthermore, in a follow-up study, Horne, Hughes and Lowe (2006) found naming to be particularly important in categorisation. Not all of the children who participated named the objects, however, only those children who had learned common names of objects went on to categorise the stimuli; in contrast those who did not name, did not categorise. The primary function of food is taste and nutrition, therefore if children use naming in categorisation of object function, it is possible they associate the name of a food with its taste. Although there is no previous research linking naming, categorisation and food preference, it is possible similar principles apply in this domain.

Pitchford and Mullen (2005) have reported a link between colour preference, naming and exposure. They found that pre-school children (2- to 5-years) were less able to name colours that they had lower preference for. In addition, they reported that the least preferred colours (brown and grey) appeared less frequently in both pre-school texts and in mothers' speech than other colours. It is possible that a similar system operates in the domain of food; however previous research has not addressed this. In a series of experiments Landau, Smith and Jones (1988) found that 2- and 3-year-old children and adults displayed a preference for categorising non-food objects on the basis of shape rather than texture or size, although this was more distinct for 3-year-olds than 2-year-olds. They also noted that when objects were named categorisation on the basis of shape was more frequent than when objects were not named, indicating that labels increase awareness of category information. Landau et al. (1988) suggest that the shape bias develops with language acquisition, as children become aware that shape has high predictive validity for the majority of objects, specifically for objects depicted by nouns.

Nazzi and Gopnik (2001) have provided evidence that early in development children may use object labels to categorise novel objects. Three objects were presented to 16- and 20-month old infants in succession, two of which were identical. Each of the objects was given a novel label, with two objects being given the same name. The experimenter picked up one of the objects and asked the infant to give them the object that went with the one they had selected. Results indicated the 20-month-old infants to use naming information to categorise novel objects, whereas 16-month-old infants relied on visual similarities based on shape, colour and texture.

Further evidence for the importance of category labels comes from Gelman and Markman (1987) who found that when provided with category labels 5-year-olds use this information, and ignore perceptual similarities (such as shape), to categorise novel objects. For instance, when provided with category labels 5-year-olds were more inclined to generalise properties to a bat-like bird from a flamingo rather than from a bat. Furthermore, when no label information was provided children would categorise objects on the basis of perceptual attributes, such as shape. It has been suggested that perhaps when given label information children use this as a perceptual feature rather than a category marker (Sloutsky & Fisher, 2004). If two objects have the same name they become, in the child's mind, more similar. For instance when children generalise from a flamingo to a blackbird, common labels (e.g. bird) may simply increase the two birds' perceptual similarity. Smith, Jones and Landau (1996) have suggested that children's novel word interpretation is characterised by context specific selective attention to object properties. When a label is known children will most likely use this to help form their categories, however when it is not known they will use what they have available, in terms of perceptual attributes to help group objects together. Smith, Jones and Landau (1992) have suggested that perhaps there is no specific shape bias but rather that children categorise on the basis of the most salient feature. They found that when provided with labels children interpreted novel count nouns to refer to objects of similar shape. In comparison, children who were not provided with label information tended to group objects together on the most salient attribute (e.g., colour), and not always on the basis of shape. For the majority of objects, shape has more predictive validity than other perceptual attributes such as colour. Hence, when learning how to use language children are more inclined to categorise objects on the basis of shape than colour.

An object's label is generally representative of its shape, whereas a food label may be less so. Foods of similar shape are unlikely to always belong to the same category, for instance a round food could be an apple, a bread roll, or a type of sweet. To group these objects together on the basis of shape would not be very predictive of an object's function in terms of taste. Prior to having learned the basic level labels for various foods and understanding how these items can be grouped together, children may find that colour has more predictive validity than other perceptual features (e.g., green foods generally have a bitter taste).

Categorisation of food compared to non-food objects

Some previous research has used both food and non-food objects when comparing categorisation on the basis of either perceptual (e.g., colour) or conceptual (e.g., function) attributes. However, these studies have not differentiated the basis of perceptual categorisations. For example, Liu, Golinkoff and Sak (2001) used a series of match-to-sample experiments to investigate if 3- to 5-year-old children could extend novel words at the superordinate (e.g., 'fruits') level. In the first experiment, children were presented with two target objects from the same superordinate category (e.g., an orange and a banana), followed by four alternative matches; a thematic match (e.g., fruit bowl), a taxonomic match (e.g., a bunch of grapes) and two perceptual matches (e.g., a crescent moon and a basketball). When targets were given a novel superordinate label (e.g., chams for fruits) 4- and 5-year-olds chose the taxonomic match more than would be expected by chance (70%). When no label was provided 4- and 5-year olds made mostly perceptual matches (65%), although this did not differ from chance. In contrast, 3-year-olds performed at chance in both conditions. As it was not clear which of the two target items children were basing perceptual matches on, a second experiment was conducted that used only one target object (e.g., orange), followed by a perceptual match (e.g., basketball), a taxonomic match (e.g., grapes) and an unrelated match (e.g., crescent moon). When given a novel superordinate label, children aged 4- to 6-years selected the perceptual match more than would be expected by chance (54% where chance of 33%). However, it is unclear from this study if children used shape or colour to form perceptual category judgements for food items, as these two attributes were sometimes confounded (e.g., an orange and basketball are both round and orange).

Another study that used food and non-food items examined the influence of shape whilst controlling for colour in making perceptual category judgements. Imai, Gentner and Uchida (1994) used a match-to-sample design in which children, aged 3-and 5-years, were presented with a target object (e.g., apple), followed by a taxonomic match (e.g., grapes), perceptual shape match (e.g., balloon) and a thematic match (e.g., knife). The target object was presented either with or without a novel label. When given a novel label, 3- and 5-year-olds made significantly more perceptual shape-based matches than conceptual (taxonomic or thematic) matches (3-years-olds made 68% and 5-year-olds made 56% shape-based matches), but when no label was given the thematic match was chosen significantly more frequently than the perceptual and taxonomic alternatives (3-year-olds made 44% and 5-year-olds made 50% thematic based matches). These findings further support the link between shape and labels in categorisation that occurs around 3- or 4-years of age. However, as the role of colour was not considered in this study, it remains to be seen if children find colour to be more salient than shape when making perceptual categorical judgements about food.

Similarly, Lavin & Hall (2002) reported that 3–year-olds were more likely to extend a novel label to an item matched for shape rather than colour, texture or smell, if the item was described as a toy rather than a food. In addition, Matheson, Spranger and Saxe (2002) found colour to be more salient than shape and food class in pre-schoolers' perception of foods. They presented 5- and 6-year-olds with an array of four food items and asked them to identify one that was different from the others and to say why they had made that response.

The most frequent reason children gave was that the food they had chosen differed in colour to the other foods (26% of total responses). Explanations based on differences in shape (13% of total responses) and food class (11% of total responses) were less frequent. These studies suggest that food colour may be particularly important in young children's categorisation of food, but this needs to be firmly established. With research suggesting food to be categorised differently to non-food objects, and evidence to imply a link between perceptual attributes and preference, it is thus timely to consider the role of perceptual (colour, texture and size) and cognitive (naming, categorisation) factors in the development of food preferences.

1.2. Aims and hypotheses

This thesis has several aims. First in order to determine the role of perceptual attributes in children's food preferences it is necessary to develop an objective measure of preference allowing self-report from young children across a range of foods. Unlike typical methods to assess food preferences (e.g., food preference questionnaires) this measure must allow for the influence of perceptual and cognitive factors to be tested experimentally. Therefore, chapter 2 develops a novel methodology using high quality food photographs which is able to be completed by children as young as 20-months, complemented by a food preference and frequency questionnaire. A similar method was utilised in a recent study by Vereecken, Vandervorst, Nicklas, Covents and Maes (2010), however the method incorporated a four point rating scale and as the youngest children participating were 4 years old, this method may have been unsuitable for younger children.

The benefits of the methodology used in this thesis are two-fold; not only does it allow the assessment of food preferences for a wide range of items, but the use of high quality coloured photographs allows the influence of perceptual factors (colour, texture and size) to be considered alongside other factors traditionally explored in previous literature (e.g., innate taste preferences, heritability and exposure). Chapter 2 has three specific aims. First, to develop an objective measure of food preference allowing self-report from very young children, this will then be tested for reliability and validity. Second, using this methodology the influence of perceptual attributes (colour, texture and size) on children's food preferences will be explored with consideration of individual differences across body mass index (BMI) and socio-economic status (SES). Finally, the association between the influence of perceptual attributes and exposure on food preferences will be investigated.

It is well established that exposure influences developing food preferences (e.g., Birch & Marlin, 1982; Cooke & Wardle, 2005); thus a second aim of this thesis is to explore the relationship between preference, perceptual attributes and exposure. Using a longitudinal food diary method chapter 3 has three specific aims; first, to validate the use of the Food Frequency Questionnaire used in chapter 2; second, to further explore the relationship between food colour and exposure; and third, to investigate differences in the food colours children are exposed to at different times of year, considering how this relates to preference and exposure.

In addition, anecdotal reports from parents have indicated children to use perceptual attributes of food to reject novel foods that are similar in appearance. Moreover, children have been found to be more accepting of a novel food if it is the same colour as a food an adult is eating (Addessi, Galloway, Visalberghi & Birch, 2005). Thus, it is reasonable to suggest children may be using perceptual attributes as a basis for categorising foods. The specific role of perceptual attributes in children's food preferences is determined in chapter 2 and chapter 4 builds on this to establish if any perceptual attributes found to be influential in chapter 2 are utilised by children when categorising food, considering how this differs from categorisation of non-food objects.

1.3. Definition of food preference

To fully explore factors that influence the development of food preferences it must first be clear what is meant by the term 'preference'. Although similar in meaning the terms 'preference' and 'liking' are not synonymous. As Mela (2000) points out, whilst preference refers to a relative judgement, liking is absolute. For example, one could prefer a food item to another, yet like or dislike neither. Similarly, one could like or dislike two food items equally, thus exhibiting no marked preference for either. Despite this clear distinction, most previous research on the development of food preferences does not differentiate between liking and preference. This thesis uses methods to address liking and preference as separate entities. However, in reviewing previous literature preference and liking are used interchangeably, unless otherwise stated explicitly.

1.4. The Influence of Perceptual Attributes

Various factors can influence the development of food preferences in pre-school children, ranging from genetic determinants through to the level of parental control demonstrated. Prior to this, it is possible that other factors, relating to the appearance of foods, may influence the development of food preferences, specifically in terms of acceptance and rejection of foods. Perceptual factors are known to influence preferences for other sensory stimuli, such as colour (e.g., Pitchford & Mullen, 2005). However to date, very few studies have considered how perceptual factors may shape the emergence of food preferences in childhood and those that have are limited in considering a small number of food items (e.g., Walsh et al., 1990).

The colour, texture, and size of a food are all perceptual features that may be influential to children when forming their early food preferences. Children are known to use these perceptual features when categorising other objects, such as animals or toys (Gilmore, 1990) hence it is possible that they utilise a similar system of classification for foods. It is the influence of these factors that are the primary concern of chapters 2 and 3.

1.4.1. Colour.

In food selection, colour discrimination serves a valuable purpose as it can inform, for example, of when meat is cooked, or when fruit is ripe. In addition food colour can remain stable even when the food has changed shape or form (e.g., a carrot remains orange when raw and also when cooked, Macario, 1991). As children can discriminate colours from four months of age (Bornstein, Kessen, & Weiskopf, 1976) colour could help children to identify the food they are eating in conjunction with other perceptual features, such as smell, taste and texture. In addition, adults are known to be sensitive to food colour when assessing taste and aroma. Christensen (1983) found that adults who could see the food they were assessing reported that foods with a more intense and appropriate colour would taste and smell better than those with no or inappropriate colours. In contrast, participants who could not see the food they were assessing did not make these judgements. This suggests that adults incorporate their knowledge of food colour into their conceptual representations of food, and that these expectations influence their perceptual judgements. It would be interesting to establish when perceptual features of food become conceptually entrenched by investigating this developmentally. For example, children may make decisions about the food they are presented with based on food colour prior to tasting, although this has yet to be tested explicitly. Using an objective measure chapter 2 explores the influence of food colour on children's food preferences.

There is evidence for children to overgeneralise foods on the basis of colour when determining acceptance or rejection. Addessi et al., (2005) examined how changing the colour of food, so that it was either the same as or different to the food an adult was eating, influenced children's acceptance of novel foods. Twenty-seven children, aged 2- to 5-years participated in this study. Children were more likely to eat a novel food when it was the same compared to when it was a different colour as the adult's food. This study shows awareness of perceptual characteristics of foods in children as young as two-years, and a direct relationship between colour and food acceptance. However, only three novel foods were used and each was a variation of the same product (semolina with different colours and flavouring) therefore this study does not provide evidence for how children may use food colour to determine food preferences and choice in a naturalistic setting across a range of food items. For instance, this study may simply indicate that when presented with a food, within the same category, children will show awareness of colour and use this to determine acceptance or rejection of a novel food. However, this may not be generalised to other foods or across food categories (e.g., acceptance of a green apple may not indicate acceptance of other green foods). Explicit investigation of the role of food colour is thus needed to determine if colour is utilised by children when determining their food preferences. In addition, it would be helpful to establish whether children typically have higher preferences for some food colours over others, and the impact this may have on developing food preferences.

Shortcomings in the designs employed in research investigating the influence of colour on children's food preferences limit the generalisability of findings to a wider range of foods. For instance, Walsh et al., (1990) investigated the effects of food colour on the food choices of 120 5- to 9-year old children. Although a main effect of colour was found, with the most preferred colour being red, only candies were used rather than a range of food items, therefore this cannot be taken as an indicator of children's preference for red foods. Candies and other sweets generally differ in colour (e.g., red, green and blue Smarties) but very rarely in shape or size (e.g., Smarties are always round), therefore this finding is more likely to be a preference for the colour red, as opposed to the other colours examined (green, orange and yellow), rather than a display of preference for red foods. When considering the role of colour in the development of food preferences it is important to be mindful of the difference between foods with naturally occurring colours (e.g., fruits, vegetables) and man-made foods which can be manufactured to be any colour (e.g., snack foods). If colour is used by children as an indication of flavour this may differ for natural compared to man-made foods.

In a further study, Marshall, Stuart and Bell (2006) examined the relationship between product package colour and product selection in pre-school children (aged 3- to 5-years). Mock product packages of cereals, biscuits, and fizzy drinks, in a variety of colours, were used and participants were asked to select their favourite. The colour of the food model chosen was then compared to the colour previously identified by participants as their favourite. Results revealed that a child's favourite colour is closely related to their choice of colour for packaging of a food item. The most favourite colour found in this study was pink, and pre-school girls typically exhibit a strong preference for pink (Pitchford & Mullen, 2005). These results may have been influenced by a sample bias, as there were more female (n = 36) than male (n = 7) participants in the study. As such, the results of this study could be accounted for purely on the basis of participants' gender rather than a specific effect that colour has on packaging preference. However, it confirms previous research that shows how colour drives object choice in pre-school children (Pitchford & Mullen, 2005).

There has been a limited amount of research on the influence of colour in food preferences; various studies have however looked at preference for colour in beverages as opposed to food. Findings have suggested that adults are influenced by the colour of orange juice, preferring juice of an appropriate colour to that with a slight green shade (Tepper, 1993). Similarly, Stillman (1993) asked 310 adults to judge the flavour of either orange or raspberry beverages that had either been coloured red, orange or green, or were uncoloured. Colour was found to have a significant influence on the identification of both types of beverage, being enhanced when the beverage was of appropriate colour (e.g., red for raspberry) compared to when it was uncoloured, or of inappropriate colour. A similar method has been used with children aged 2- to 18-years (Oram et al., 1995). This study involved asking participants to taste four drinks that differed in colour and flavour. Each drink had either a-typical colour-flavour pairings (e.g., brown-pineapple) or typical pairings (e.g., brown-chocolate). Participants were required to taste each drink and identify the correct flavour name. When a-typical pairings were used, participants were more inclined to select colour-associated names than flavour associated names which decreased with age. However, for the typical pairings, the correct flavour name was selected for more than 80% across all ages. Children, aged between 2- and 7-years, made more colour associated pairings (55%) than flavour associated (21%), whereas from the age of 10-years children selected flavour associated pairings (49%) more than colour associated pairings (28%). These results indicate the importance of colour in recognition of beverages for children up to the age of 7-years. In addition, it is possible, with development and greater exposure to different types of food, beverages and flavours, that children may learn that flavour is more important than colour in determining the correct identification of a beverage. However, this study did not investigate the influence of colour in children's food preferences, therefore research is needed that explores the potential influence of colour and the manner in which that influence is administered in shaping children's emerging food preferences.

Although not objective, anecdotal reports from parents and caregivers indicate that colour may bias children's food choice and preferences. Children may choose a yogurt based on its packaging colour (e.g., 'I want the pink one') rather than asking for its flavour (e.g., 'I want the strawberry one'). Parents of selective eaters have also suggested that their children categorise foods they dislike based on colour, for example 'they dislike one green vegetable and refuse to try anything else of the same colour'. These reports are interesting as they suggest a link between product colour and children's willingness to try foods. There is, however, a noticeable gap in research investigating the effect that perceptual factors may have on the development of food preferences. Yet such studies could be important in helping to understand why children develop preferences for particular foods and what may be done to modify their preferences.

1.4.2. Texture.

Very few studies have investigated how food texture may influence food preference in children. However, as texture was found to be a factor for food rejection in children aged 4- to 17-years (Koivisto & Sjoden, 1996), it is likely that the texture of food could be influential in forming preferences. The authors gave no indication however of the kind of texture which was disliked, or if there was a trend for certain textures to be disliked by most of the participants. It has been reported that children will refuse a food 'on sight' on the basis of texture (e.g., a yogurt that has 'bits' in, Harris, 2008), indicating that texture is something children are aware of and may be sensitive to.

An effect of texture on preference has been demonstrated in a recent study by Blossfeld, Collins, Kiely and Delahunty (2007). They investigated texture preferences of 70 infants aged 12-months. Infants were fed carrots, either pureed or chopped, at regular meal times over a 20-month period. All participants were fed both textures of carrots and the amount ingested was recorded. Infants were found to consume significantly more pureed carrots than chopped carrots, suggesting that texture has an influence on preference. However, these were very young infants who had probably not had much exposure to a wide variety of textures, therefore preference may have been based on exposure (i.e. infants will have had more exposure to pureed/blended food than 'solid' food).

One of the few studies that have assessed texture preference of real food in children has found differences in the importance of texture to children of different ages (Rose, Laing, Oram & Hutchinson, 2004). Three meat products were used to assess the sensory preferences of 104 children. Approximately half were aged between 6- and 7-years and half were aged between 10- and 11-years. Children were required to taste each of the three meats and to describe their preference. Preference was indicated using a 'hand separation scale' in which the children stated whether they liked or disliked an item and then separated their hands to show how much they liked or disliked it (wider apart indicates a greater degree of preference). Participants rated their preference for each of the modalities that the authors were interested in (appearance, smell, taste, texture/mouthfeel, aftertaste and afterfeel). Results indicated that taste was the most important attribute for 10- to 11-year-olds, whereas for 6- to 7-year-olds texture was more important. Once again, this study used a limited number of food items, all from the same food category (meats). Further research is needed before a comprehensive understanding is reached as to how texture may mould food preferences. However, it is striking that the age at which the perceptual attribute considered here (texture) is important to children corroborates the findings of Oram et al., (1995) presented earlier when looking at the influence of food colour. These results suggest that children may be influenced by perceptual attributes, such as colour and texture, prior to the age of 7 years, after which other factors (e.g., taste, food class) may become more important. The relative influence of perceptual attributes compared to other factors and to each other is systematically explored in this thesis.

1.4.3. Size.

When reviewing the literature on the influence of perceptual attributes on the development of food preferences, there appears to be no previous research that has considered the role of food size in shaping children's food preferences. However, the size of a food could be influential, particularly when children progress from being spoon fed to beginning to pick up foods in order to feed themselves. When first presented with solid food, foods which are easy to pick up, without the need for utensils (e.g., chips, carrot sticks, small pieces of fruit) may be preferable to toddlers as they will be able to gain some independence in their feeding, rather than relying on an adult to help them. Baby-Led weaning is a concept developed by parents and championed by Rapley and Murkett (2005) who suggest that by 6-months of age infants have the motor skills to pick up food to feed themselves, and ought to be encouraged to do so (Brown & Lee, 2011; Sachs, 2011; Wright, Cameron, Tsiaki & Parkinson, 2010). There is however, no evidence to my knowledge, of the influence this may have on developing food preferences, or if this is a desirable trait for young children. As the influence of food size has not been considered in the food preference literature, it is an aim of this thesis to consider if this is an important attribute to young children and one they consider when forming their early food preferences. This is considered using an objective measure of food preference in chapter 2, alongside the relative role of colour and texture.

1.5. Food preferences of children and adults

Despite the lack of research considering the role of perceptual and cognitive factors in the development of food preferences, there has been a body of research considering the types of foods liked and disliked by children. Next, research into the evolutionary development of innate taste preferences, in particular the innate preference for sweet foods (e.g., Desor, Maller & Turner, 1973) and dislike of bitter foods seen in newborn infants (e.g., Anliker, Bartoshuk, Ferris, & Hooks, 1991) is discussed. Consideration is given to how innate taste preference may relate to the potential influence of perceptual and cognitive factors addressed in this thesis. In addition, research into the specific food preferences of children and adults will also be discussed to determine if the types of foods reported as liked and disliked map onto these innate taste preferences.

1.5.1. Innate taste preferences.

Humans, and most other mammals, can detect five types of taste: sweet, salt, sour, bitter, and umami (monosodium glutamate). It is believed this was particularly important for our ancestors as it gave guidance as to the nutrient content of the foods they were consuming and provided awareness of toxic foods best to be avoided (Reed, Tanaka & McDaniel, 2006). Research into genetic influences on the development of food preferences has found evidence for particular flavour preferences in infancy each of which is discussed below.

Sweet preferences in infancy

A preference for sugar and sweet foods is thought to have a genetic basis as sweet foods contain energy and nutrients (see Birch, 1999 for more details) which would have been sought out by our ancestors. Newborn infants have been shown to prefer sugar (using different levels of sucrose concentration) compared to water (Desor et al., 1973). Desor et al, (1973) measured the volume of each solution ingested by infants to determine preference. A preference was found for higher levels of sucrose concentration to lower levels, and any concentration of sucrose solution was preferred to water. However, the infants that participated in this study had already been exposed to milk, and as milk is sweeter than the water solution used, the results of this study may have arisen from exposure to sweetness, reflecting a mere exposure effect, rather than an innate preference for sugar, although there is evidence for sweet taste preferences to be partly inherited (Keskitalo et al., 2007).

Similarly, Schwartz, Issanchou and Nicklaus (2009) assessed the acceptance of each of the five tastes (sweet, salt, bitter, sour & umami) in 45 3-, 6- and 12-month-old infants by observing ingestion. Infants were found to show higher preferences (based on amount ingested) for sweet solutions compared to all other flavours, however, a slight decrease in the preference for the sweet solution was observed at 12-months. It is extremely difficult to establish whether preference for a food item is innate or not, as many variables can influence preference, even of newborns. For example, food intake of the mother during pregnancy may influence taste preference of newborns. Mennella, Jagnow and Beauchamp (2001) demonstrated that exposure to flavours can occur in utero via the amniotic fluid. This raises the possibility that newborn infants may have prior experience of certain tastes before birth, perhaps influencing the emergence of early food preferences.

Irrespective of whether or not a preference for sweet foods is innate, any influence of taste can only be apparent after a food has been accepted. Prior to the food being placed in the mouth a child will have been exposed to various sensory stimuli. They will have observed the colour, shape and size of the food and may have made associations to other foods they have previously tried that are perceptually similar to the new food they are being offered. In addition, the parent may name the food as they offer it to their child and dependent on the label given the child may associate that label with previously tried foods. For example when offering banana the parent may label the item as 'banana' or may label it as 'fruit' or even as 'dessert'. There is much research into early word learning indicating overextensions to occur, particularly on the basis of perceptual attributes (e.g., Gelman & Markman, 1987). Thus, a child may be offered a yellow fruit (e.g., a slice of melon'), which perceptually is very similar to banana in terms of colour, shape and size. Parent's may label both banana and melon as 'fruit' or may have labelled one and not the other. It is possible therefore that associations in terms of perceptual attributes and the previous experience of consuming 'banana' is made when offered 'melon', which may be further entrenched through labelling. Whether 'banana' had been liked or disliked may thus determine acceptance or rejection of 'melon'. The association between perceptual attributes, food labelling and food preferences have not been considered in previous research. These factors may however be considered by a child prior to tasting a food.

Aversion to bitter taste in infancy

In addition to an innate preference for sweet foods, previous studies have suggested that humans have an innate preference against bitter foods (see Birch, 1999 for a review). Bitter tastes are quite complex with some being stronger or more acceptable than others. For example, Cowart, Yokomukai and Beauchamp (1993) found a decline in the sensitivity to quinine with age in adults but comparable sensitivity to the bitterness of urea in the same sample of participants. Similarly, Yokomukai, Cowart and Beauchamp (1993) found individual differences in the perceived bitterness of quinine and urea.

A bio-chemical basis may determine dislike of bitter foods. Some humans show sensitivity to the bitter tastant 6-n-propylthiouracil (PROP), which is linked to a disliking for bitter foods (Anliker et al., 1991). There is great variation in this sensitivity and approximately 30% of individuals are insensitive to the bitterness of PROP (Prescott & Tepper, 2004). Infants, 14- to 180-days-old, have been shown to exhibit negative facial expressions to bitter tastes, as measured by depression of the mouth (Kajiura, Cowart & Beauchamp, 1992). Anliker et al., (1991) assessed threshold levels for PROP of pre-school children (aged 3- to 5-years) using a tasting exercise in which participants were given differing concentrations of PROP to determine the lowest concentration they could taste. Food preferences of each participant were measured in three different ways. Participants tasted eight food items and ranked these items in order of which they liked best. Also, a hedonic rating scale was used in which children were asked to place a ball into boxes, containing a smiling, neutral, or frowning face in front, to represent their liking. This was complemented by a food preference questionnaire, which was answered verbally by the children. Results indicated that sensitivity to PROP bears relation to food preferences in that children classified as PROP tasters, placed bitter tasting foods later in their ranking selection than non-tasters. A more recent study by Keller, Steinmann, Nurse and Tepper (2002) found similar results.

Genetic variation in the sensitivity to PROP is thought to play a role in the acceptance of bitter tasting vegetables in 3 – 5 year old children (Bell & Tepper, 2006). This study assessed the threshold levels of PROP for each of 65 child participants; 24 were identified as tasters, and 41 as non-tasters of PROP. Non-tasters consumed more vegetables than the tasters when invited to consume as many vegetables as they liked from a choice of five in a free-choice intake test. Sensitivity to PROP has also been shown in adults (Drewnowski, Henderson & Barratt-Fornell, 1998), suggesting an innate taste preference that continues throughout life. However, to test this prediction systematically a longitudinal investigation is needed to determine if only children with sensitivity to PROP continue to express this sensitivity into adulthood. Sensitivity to PROP is not explicitly examined within this thesis; however a dislike of bitter tastes is considered when examining the types of food children like and dislike and the association between taste preferences and any preferences observed for perceptual factors (e.g., colour). Many bitter tasting foods are vegetables, and similarly many vegetables are green, thus there may be an association made between dislike of bitter foods and colour.

Salt

The preferences for sweet and against bitter foods are thought to be innate, although these could be influenced by very early exposure as discussed. Previous research suggests that infants are not born with a predetermined preference for salt but learn to like it through exposure (Dahl, 1972). To demonstrate this Beauchamp, Cowart and Moran (1986) measured the ingested amount of sodium chloride solution compared with water in infants under 4-months and in infants aged between 4- and 24-months. The youngest infants (under 4-months) ingested equal quantities of the sodium chloride solution to water, whereas infants aged between 4- and 24-months of age exhibited higher preference for the saline solution compared to water. It is thought that this change in acceptance is a result of exposure; for instance, infants who consumed more salty than plain soup also ingested more salty than plain carrots (Beauchamp, Gary & Moran, 1984). However, salt consumption and salt usage, as reported by parents, was unrelated to individual responsiveness in taste tests of children. Further to this, Harris, Thomas and Booth (1990) tested the salt preference for the first food fed to 12 breastfed infants aged 16- to 25-weeks. Results showed a decline in preference with age, indicating that the longer infants were breastfed the lower their preference for salt; it is thought this is as a result of breast-milk being low in sodium. This study adds further evidence for the link between exposure and preference for salt in infants.

Sour

With the growing concern over fruit and vegetable consumption in children some research has examined the acceptance of sour foods and the impact of this on developing food preferences, particularly for fruits. Like salt, preference for sour foods appears to result from exposure rather than having any genetic influence. Liem and Mennella (2002) investigated the sweet and sour preferences of 83 4- to 7-year-old children in relation to the type of formula they were fed during infancy. They found that the children who were fed formulas with a distinctive sour and bitter taste preferred higher levels of citric acid in juice. Similarly, Liem, Westerbeek, Wolterink, Kok and de Graaf (2004) asked 89 children, aged 7- to 12-years, to rank-order their preference for four gelatins and four yellow cards that differed in brightness. Each participant was also measured on their willingness to try a novel candy. More than half of the children (58%) preferred one of the sourest gelatins indicating children to have preferences for sour tastes; these children also preferred the brightest colour card and were more willing to try the novel candy without knowing its flavour than the other children.

It is difficult to establish from this study the impact of a sour taste preference for real foods. Similarly, the authors did not control for the potential influence of exposure to sour foods (e.g., fruits). There may have been marked differences in the amount of fruits consumed by the children who preferred the sour gelatins compared to those who did not. Despite this it could be inferred from this study that children associated flavours with colours, as preference for sour foods positively correlated with preference for bright colours. One study that has controlled for intake and exposure found a relationship between acceptance of sour tastes and fruit intake in very young children (Blossfeld, Collins, Boland, Baixauli, Kiely & Delahunty, 2007). The preference for varying sour solutions was measured in 53 6-, 12- and 18-month-old children and was found to differ across individuals. However, the infants who accepted the more sour solutions were found to have significantly higher fruit intake and fruit variety than the infants who rejected the highly sour taste. Similarly, Liem, Bogers, Dagnelie and de Graaf (2006) found a positive correlation between boys, but not girls, preference of sour taste and consumption of fruit.

Umami

The final flavour that humans are thought to be able to detect is umami, which refers to the energy density of food. Research into the preference for umami in young children has suggested that children prefer more energy dense foods (Beachamp & Pearson, 1991; Nicklaus, Boggio & Issanchou, 2005; Prescott, 2001). Interestingly, in contrast to other flavour preferences, where infants have shown preference for a flavoured solution compared to water (e.g., sweet and salt), monosodium-glutamate (MSG, which signals the energy density of food) has been shown to be rejected compared with water (Beauchamp & Pearson, 1991). However comparison of these findings to a group of twelve infants (aged 3- to 24-months) has indicated soup with MSG added was preferred to soup without any additives ($t = 3.99$, $p < .01$) (Beauchamp & Pearson, 1991).

Beauchamp and Pearson (1991) suggest perhaps MSG enhances the flavour of soup by adding a slight saltiness or by disguising any unpleasant flavours, although neither of these explanations is able to be fully supported. It has been suggested that the flavour of umami may reflect a signal for protein or for energy (Prescott, 2001), but there is no conclusive evidence for the role of umami in the development of food preferences. Despite the lack of evidence for infants possibly having a preference for umami when added to food, recent research has indicated that children, aged 2- to 3-years, choose starchy foods more often than other types (Nicklaus et al., 2005). Further research is needed to determine if the increase in choosing energy dense foods is related to a preference for umami or is a result of more familiarity with these kinds of foods (e.g., energy dense foods typically belong to the superordinate category 'carbohydrates' which are often limited in colour (brown, cream) and texture (soft)).

1.5.2. The food preferences of children.

There is some evidence for a genetic influence for certain flavour preferences (e.g., sweet and bitter) however, others may be influenced by exposure (e.g., salt and sour). Whether a flavour preference is learned or innate, it is important to determine how these map on to preferences for actual foods. In order to understand how food preferences may be modified it must first be established which foods children like to eat and why they like those foods over others.

Previous research has shown that the foods most liked by children fall into the categories of desserts, breads, snack foods and meats (Cooke & Wardle, 2005; Nicklaus, Boggio, Chabanet & Issanchou, 2004; Skinner, Carruth, Bounds & Ziegler, 2002). For example, Cooke & Wardle (2005) assessed the food preferences of children aged 4- to 16-years using a food preference questionnaire. Results indicated that the most liked foods were chocolate, pizza, ice cream, pasta and biscuits, and the least liked foods included several vegetables. It is interesting that preferred foods are typically brown or cream in colour, whereas disliked foods incorporate a larger range of colours that may map more directly to specific flavour preferences (e.g., bitter). Cooke & Wardle (2005) proposed that children like these foods because of an innate preference for foods high in saturated fat and sugar. Likewise, they proposed that children's disliking for vegetables stems from these foods being generally low in fat and sugar content and having a bitter taste. The relationship between colour and flavour preferences requires further consideration.

Despite food preference questionnaires having been tested for reliability and validity (Pliner & Pelchat, 1986) there are still difficulties in relying solely on this form of measurement when establishing food preferences. Food preference questionnaires do not enable specific attributes of foods to be tested experimentally, for example comparing preference for green apples to red apples, or to consider how preference for certain foods relates to acceptance or rejection of perceptually similar novel foods. Furthermore, although the food preference questionnaire utilised by Cooke and Wardle (2005) was completed by children themselves, rather than relying on parental report, children completed the questionnaires during class. The authors do not stipulate if participants were able to confer with each other; as such there is potential for these results to be influenced by participant bias. For example, individuals may state that they like similar foods to those of their peers, which may or may not reflect true food preferences.

Similarly, children aged 4- to 7-years were required to complete the questionnaire at home with the help of their parents. It is possible that parents actually completed this questionnaire on behalf of their children, and as a result may not be a true indication of their child's food preferences. Answers may be influenced by parents beliefs about what their child likes, their expectations of the purpose of the questionnaire (e.g., to see which kinds of foods they offer their child) or even influenced by their own preferences. Furthermore a study comparing the reliability of children's self-report preference for fruits and vegetables to parental report of children's preferences across the same items reported agreement to be rather low to moderate (Vereecken et al., 2010). Therefore there is a need for new methods to be established which do not rely on the use of questionnaires and parental report. Vereecken et al., (2010) have recently demonstrated the use of pictorial stimuli to assess food preferences in 4- to 6-year-old children. However, to my knowledge there is no previous research utilising a self-report method with children under the age of 4 years, across a range of food items. This thesis addresses these issues by developing an objective measure of food preference allowing self-report from very young children, which allows the aims of this thesis to be systematically explored. This is presented in chapter 2.

Food preferences can change from childhood into adulthood, which may indicate that innate taste preferences alone cannot solely account for food choice and intake. In a prospective study, in which food choices were recorded in a group of 2- to 3-year-old children and then again when they were adults, Nicklaus et al., (2004) found that vegetables were ranked as very much disliked in early childhood but were rated more favourably in adulthood. This shows that biological predispositions towards particular tastes do not only determine which foods are liked and disliked, as preferences are not stable across time. It is possible that taste preference change developmentally, however it is also possible that young children may make flavour associations based on perceptual (e.g., colour) or cognitive (e.g., categorisation) attributes until they reach an age where they realise these factors may not be a reliable indicator of taste. In order to understand how food choice and intake may be modified, more careful consideration is needed of how different factors interact to bring about a change in food preferences as children mature into adults. As it is possible that flavour preferences, or understanding of cues to taste, develop as a result of exposure, the next section looks at the similarities and differences in the food preferences of children as compared with their parents and siblings, particularly in twin studies.

1.6. Heritability of Food Preferences

A meta-analysis of parent and children's food preferences has found a small but significant relationship between the preferences of the parent and child (Borah-Giddens & Falciglia, 1993). This could either be due to environmental or genetic factors, however, it is most likely that both factors contribute to this familial relationship. If parents have a preference for certain types of food they may be more likely to buy the type of food they prefer and give this to their children. In addition, any food labels children acquire at home are likely to correspond to the foods they are offered, and hence relate to their parents' food preferences. If children are only exposed to foods their parents like, and acquire the names of these foods prior to other foods, through exposure children may develop the food preferences of their parents. It is difficult to distinguish if similarities in the food preferences of parents and their children have a genetic basis or are merely a result of a shared environment. Twin studies are much more informative of this distinction.

Breen et al., (2006) investigated the heritability of food preferences in 4- to 5-year-old children with a sample of monozygotic (MZ) (n = 103) and dyzygotic (DZ) (n = 111) twin pairs. They hypothesised that genetic factors would exert an influence on food preferences, predicting there would be a stronger correlation of likes and dislikes amongst MZ than DZ twins. Mothers of the children participating in the study completed a food preference questionnaire in order to rate their children's food preferences. As predicted, correlation coefficients were higher for MZ ($r = 0.76$) than DZ ($r = 0.56$) twins for 72 out of the 77 foods tested. The results of this recent study corroborate those of a previous study by Falciglia and Norton (1994) who assessed the food preferences of 14 monozygotic twin pairs and 21 dyzygotic twin pairs aged 9- to 18-years.

These studies may provide support for the heritability of food preferences. However, it is possible that parents of monozygotic twins may treat them more similarly than DZ twins, and MZ twins may conform to the likes and dislikes of the other twin to a greater extent than DZ twins. These slight environmental differences in attitude may account for the increased similarity between MZ food preferences compared to DZ. The methodology used by Breen et al., (2006) may also have influenced results, in that parental ratings on questionnaires may not be a true indication of children's food preferences but rather the parent's perceptions of the foods their children like and dislike. To disentangle these factors, studies are needed in which children state explicitly whether they like or dislike various foods, rather than relying purely on parental reports. This is addressed in chapter 2.

Food preferences have been seen to change with age, therefore it is possible that there is a strong environmental component in the development of food preferences that works alongside genetic influences (such as innate taste preferences). If children have similar food preferences to their parents and siblings, it is possible that this is as a result of modelling their behaviour. Theories of social development, such as Bandura's (1977) Social Learning Theory, suggest that young children without obvious reinforcement are inclined to copy, or model, the behaviours they observe in adults around them. Social learning may also apply to food. The role of modelling on children's food preferences is discussed next.

1.7. The Influence of Adult and Peer Modelling

Research into the influence of parental modelling on developing food preferences has shown if a child observes a food they currently dislike being eaten by their parents or significant others then they have a higher chance of increasing their acceptance of that food (Birch, 1999). Similarly, Harper and Sanders (1975) found that toddlers (aged 2- to 4-years) were more likely to try unfamiliar foods if adults, particularly their parents, ate the foods with the children. More recently, Hendy and Raudenbush (2000) found that teachers of pre-school children reported modelling to be a more effective way of encouraging children to sample new foods compared to other methods, such as offering a choice of foods, insisting that they try the new food, offering a reward for tasting the new food, or simple exposure to the new food.

Children not only model the behaviour of their parents but also, and to some extent more so, that of their peers and siblings. A study with pre-schoolers investigated the influence of peer modelling on the selection of a disliked vegetable (Birch, 1980). After assessing the preference for various vegetables for 39 pre-school children, a target child was sat at lunchtime with 3 or 4 peers who had opposite preferences to them for a particular vegetable. Both the preferred and non-preferred vegetables were served together and the target child was asked to choose one. On the first day of the study the target child chose first, whilst on days 2, 3 and 4 the peers chose first. Results revealed a significant shift in the choice made by the target child from their preferred vegetable on day-1 to their non-preferred vegetable by day-4. In addition, the majority (12 out of 17) of the target children increased their preference for the non-preferred vegetable. This study indicates children's awareness of foods being eaten by significant others around them. The authors do not indicate if the vegetables offered differed perceptually, however it would be interesting to determine if children would be more willing to accept a perceptually similar or perceptually dissimilar vegetable to their preferred choice.

A more recent similar study presented three novel foods to 38 pre-school children during five meals. Sixteen of the children were trained as peer models for one of the foods, and the remaining children were observed for food bites during baseline and modelled meals. Food acceptance was found to increase for the novel foods during modelled meals compared with baseline; however this effect had dissipated by a follow up one month later (Hendy, 2002). It is possible that the association may be made on the basis of perceptual factors (e.g., colour), although this needs to be explicitly investigated. If children's food choices and preferences are influenced by the foods consumed by their peers, then it is possible children may use the perceptual features of those foods to extend to other foods that are similar in appearance. For instance, they may see a peer eating broccoli, and may extend this to other green foods, thus increasing their willingness to try green foods. This thesis explicitly investigates the influence of perceptual factors on the development of food preferences (chapter 2) and how these may be used by children to categorise foods (chapter 4).

Peer models have been successfully used to increase physical activity in 9- to 11-year old children (Horne, Hardman, Lowe and Rowlands, 2009). The intervention reported in this study involved children receiving a personalised letter from fictional role models, the Fit 'n' Fun Dudes, outlining their daily step target, along with a copy of the Fit 'n' Fun Dudes song and a home-pack including a picture of the Fit 'n' Fun Dudes. Participants needed to have reached or exceeded their step target each day, monitored by pedometers, in order to qualify for a reward (e.g., balls and Frisbees). Children who had not reached their targets were encouraged to keep trying. The intervention resulted in increases in children's physical activity which was maintained over a 12-week period in girls.

Peer models have also been effective in increasing fruit and vegetable consumption in children (Lowe, Horne, Tapper, Bowdery & Egerton, 2004). Again the peer models were fictional characters (The Food Dudes) who enjoyed eating fruit and vegetables and received rewards for eating these foods. The intervention began with an 8- to 12-day baseline phase followed by a 16-day intervention phase. At snack-time during the school day 403 4- to 11-year-old children throughout both baseline and intervention phases, were presented with a 'snackpack' that contained two 20 gram portions of either fruit or raw vegetables. The fruit or vegetable given was counterbalanced across all participants, schools and days to ensure all participants received the same exposure to each of the fruits and vegetables used. Again at lunch time, children were presented with either a whole piece of fruit (approximately 80 grams) or a 60 gram portion of vegetables on alternate days.

During the intervention phase children watched 6-minute videos of the 'Food Dudes', a group of 12- to 13-year-old children who battle against the evil 'Junk Punks'. To arm themselves for battle the 'Food Dudes' eat, and appear to enjoy a variety of fruits and vegetables. Small rewards (e.g., a sticker) were given when children consumed some of their fruit or vegetables, and larger rewards (e.g., a pen, pencil case) when they ate a full portion. Consumption of fruits and vegetables was found to be significantly higher during the intervention than at baseline, and children's liking of fruit and vegetables increased significantly. Similar results have been reported by Horne, Tapper, Lowe, Hardman, Jackson and Woolner (2004) in 703 5- to 7-year-old children from inner city schools in London. These studies have clearly indicated the ability to encourage children to consume more fruits and vegetables, however the particular influences on these choices are less clear. For instance, children may consume more fruits and vegetables because they are being influenced by the peer models (the Fit 'n' Fun dudes), or because they receive a reward for consuming these foods (e.g., a pencil case), or as a result of receiving greater exposure to fruits and vegetables. To determine which of these three influential environmental factors (modelling, reward and exposure) are modifying children's food consumption, comparisons would have to be made between an intervention and a control group, where only the intervention group received encouragement from the peer models but both the intervention and control groups received rewards for consuming fruit and vegetables.

The influence of peer modelling can be both positive and negative as shown by Greenhalgh, Dowey, Horne, Lowe, Griffiths and Whitaker (2009). They investigated the effects of peer modelling on children's consumption of a novel blue food in 35 5- to 7-year old children in Study 1 and 44 3-4 year olds in Study 2. Children were assigned into three groups, one group received positive peer modelling, one received negative peer modelling and one received no peer modelling. Results revealed that negative peer modelling inhibited the consumption of the novel food, more so the effects of negative peer modelling were difficult to reverse in younger children. It is important to note that it is not the primary concern of this thesis to examine the role of modelling in the development of food preferences, but to show an awareness of this as a mediating factor alongside other factors which are explicitly measured (e.g., perceptual factors, exposure).

1.8. The Role of Exposure

Although there is evidence for an innate preference for certain flavours, children's food preferences are not stable across time. They may be altered by environmental influences, such as modelling the behaviour of significant others, or via exposure to certain flavours in utero (Mennella & Beauchamp, 1996). Interestingly, Sullivan and Birch (1990) found that 4- to 5-year-olds experience with added salt or sugar to foods increased their preference for those foods, compared with alternative flavours (e.g., the same food without added flavouring). It could be implied from this that food preferences may change as a result of exposure. This section discusses research into the effect that increasing exposure has on the development of food preferences.

Birch and Marlin (1982) investigated the effects of exposure on food preferences in 2-year-olds. This study comprised of two separate experiments with different participants ($n = 6$ children in experiment 1, $n = 8$ children in experiment 2). Experiment 1 involved offering children five varieties of cheese, on 26 separate occasions, and manipulating the degree of exposure to each variety of cheese given to the children over a six-week period. Experiment 2 used the same method but with five varieties of fruit. After exposure to the food items, children were asked to choose which of the five varieties that they wanted to 'eat more of'. Results showed that children wanted to eat more of the foods they had been more exposed to ($r = 0.95$, $r = 0.97$ for Experiments 1 and 2 respectively), suggesting that they preferred that item. Similarly, it has been reported that feeding infants a novel food once a day over a 10-day period can increase their acceptance of that food (Birch, 1998), measured by the amount ingested. This study also found that exposure to a target food doubled the acceptance of similar foods (e.g., if the target food was a fruit infants were more inclined to consume other novel fruits). This finding has implications for the influence of perceptual and cognitive factors on children's food preferences. It is possible, although yet to be explicitly investigated, that children develop an early semantic construct of a food, based on like/dislike and may use perceptual (e.g., colour) or conceptual (e.g., taxonomic class) attributes to overgeneralise that preference to other similar foods. This hypothesis is explored in chapters 2 and 4.

Although Birch and Marlin's (1982) findings indicate an influence of exposure on food preferences, only two varieties (cheese and fruits) of food were used. Previous research has indicated children to quite like foods that are high in fat (e.g., cheese), and fruits have not been found to be a disliked food (Cooke and Wardle, 2005). Research has shown the ability of increased exposure to increase acceptance of vegetables, which are typically a disliked food in children. Wardle, Cooke, Gibson, Sapochnik, Sheiham & Lawson (2003) have shown the effectiveness of a home-based, parent-led intervention to increase the acceptance of vegetables in 2- to 6-year olds. They found that exposure to a previously disliked vegetable, once a day over a two-week period, increased preference and consumption of the target vegetable. Similarly, a more recent study found that infants, at the start of weaning, increased their acceptance and consumption of a previously disliked vegetable puree if their mothers continued to offer it over an eight-day exposure. This study also found this acceptance to last in more than half (63%) of infants up to nine months later (Maier, Chabanet, Schaal, Issanchou & Leathwood, 2007). It has not been considered in previous research however, how this may impact on the acceptance of perceptually similar food items, for example, if acceptance of a disliked vegetable increases acceptance of other vegetables of the same colour.

A more extensive study, incorporating a wider range of foods is needed to establish the influence of exposure across different types of food. Furthermore, exploration is needed as to the basis of children's extension of food preferences. For instance, are young children aware of, and do they use, conceptual taxonomic class (e.g., fruits, vegetables, meats) and/or perceptual (e.g., colour, shape and size) factors to extend their emerging constructs of which foods are similar to each other (e.g., liked or disliked, familiar or unfamiliar). This thesis explores these issues systematically, by not only determining if perceptual factors have an influence on developing food preferences (chapter 2), but also if children use perceptual over conceptual factors to categorise foods (chapter 4).

Increasing exposure to novel foods appears to have significant effects on infants developing food preferences, as outlined above. In modern western society where child obesity levels are at a worrying level, interventions to modify the food choices, preferences and consumption of young children are essential. Wardle et al., (2001) have investigated the influence of exposure on the food preferences of 4- to 5-year-old children. Mothers were asked to indicate, using a food preference questionnaire, the extent to which their child liked each of the foods listed. Results indicated that foods children had tried less often tended to be less liked ($r = 0.61$, $p < .001$). Likewise, using a food preference questionnaire, Cooke and Wardle (2005) found an effect of exposure on food preferences in children, aged 4- to 16-years ($r = 0.68$, $p < .001$). Despite these convincing results for the importance of exposure, it is important to remember that this study relied purely on parental report. Parents not only reported their children's food preferences, but also how often their child was offered each food.

Particularly in the pre-school years children's food consumption is mostly influenced by the foods their parents provide, however, children may also have tried and liked foods outside of the family home that their parents may not be aware of (e.g., food tried at nursery or at a friend's house). Similarly, there may be social desirability effects in terms of parents reporting how often their children are offered various food items. For example, parents may not wish to admit their children receive high-fat high-sugar foods as frequently as they actually do, or they may wish to portray their children as being offered fruits and vegetables more frequently. Therefore it is essential to develop new measures for determining children's food preferences and for measuring exposure. It is important that children themselves are asked about the foods they like and dislike, which can then be compared to parental report via questionnaires. In addition, longitudinal food diary studies can be utilised to establish how often children are exposed to different types of food and how this may impact on their developing food preferences. These methods are developed and utilised in this thesis to explore the role of perceptual and cognitive factors on children's food preferences.

Further evidence for the effect of exposure in the development of food preferences is provided by Wardle, Herrera, Cooke and Gibson (2003). They randomly assigned 49 children, aged 5- to 7-years to one of three experimental groups: exposure, reward, or control. Over a two-week period, all groups completed pre- and post-treatment assessments on day 1 and day 10. These consisted of children being invited to eat as much red pepper as they liked. During the treatment phase (days 2 to 9), the exposure group were allowed to eat as much of the novel food item (sweet red pepper) as they desired and the amount eaten each day was recorded. Participants in the reward group were offered a sticker for eating the red pepper and then told they could eat as much as they wanted to. Participants in the control group received no intervention. Preference for the red pepper was measured after consumption using a five-point 'faces' scale, ranging from 'I like it a lot' to 'I dislike it a lot'. Pre-treatment liking for sweet red pepper was lower in the exposure group than in either of the other two groups, although this difference was not significant. However, at post-treatment, the increase in preference for sweet red pepper was significantly higher for the exposure group compared to controls. There was a significant increase in liking in the reward group between pre- and post treatment.

This study demonstrates that, at least in the short term, repeated exposure to a novel food item can significantly increase preference for that item. It would be interesting to establish how lasting these effects are by investigating if this effect continues several months after initial exposure. Furthermore, although a novel item was used, consideration of whether the same effect of exposure would be observed for colours that may be associated with disliked foods (e.g., green vegetables) would be interesting. This thesis aims to determine if children associate colour with preference, with consideration of the relationship between colour, preference and exposure and also categorisation of preference on the basis of colour.

Previously it has been suggested that for exposure to be most effective a child needs to taste rather than just be visually exposed to a food (Birch, 1999). Recent research into the effects of visual exposure to pictures of fruits and vegetables, in 21- to 24-month-old children, found that children were less neophobic (avoidance of new foods) towards unfamiliar foods they had been exposed to pictures of compared to foods they hadn't. However, this same study found that exposure decreased a child's willingness to try a familiar vegetable (Wilcoxon $Z = 2.46$, $p = .014$) but increased their willingness to try unfamiliar fruits ($Z = .45$, $p = .66$) (Houston-Price, Butler & Shiba, 2009). In relation to this another recent study has demonstrated that the more fruit and vegetables a parent purchases, the more willing pre-school children are to try fruits and vegetables ($p < .01$) (Busick, Brooks, Pernecky, Dawson & Petzoldt, 2008). Furthermore it has recently been reported that exposure to sensory information of novel foods can increase willingness to try those foods (Mustonen and Tuorila, 2010). These studies indicate a significant role of perceptual attributes in the acceptance of novel foods which has not been considered in earlier food preference research.

The role of exposure in the development of food preferences appears to be considerable. However, new methods are needed to consider the role of exposure in relation to preference with consideration of the potential role of perceptual and cognitive factors. Next, other ways in which parents can influence children's food preferences, particularly looking at research into pressure to eat, restriction of certain foods and the use of food as a reward are considered.

1.9. Parental Control

Typically, parents have the most significant influence in early childhood on what their children may and may not eat. Parents can influence children's food preferences in a variety of ways, they can restrict foods they believe to be 'bad' and offer foods they believe to be 'good' for their child. Parents may keep foods out of their child's reach, and only offer their children certain foods as a 'treat', or allow their children to eat a particular food after eating a food they deem to be 'good for you'. Studies suggest that restricting children's consumption of certain foods may serve to increase preference and consumption of those foods when the child reaches an age where they take control of their food intake (Fisher & Birch, 1999; Galloway, Fiorito, Francis & Birch, 2006). Parental food preferences have also been shown to be influential in shaping food preferences in childhood.

If a parent dislikes a food they will most likely not introduce that food to their child. Skinner et al., (2002) demonstrated this using a food preference questionnaire, in which food preferences of children (aged 2- to 8-years) were assessed on a scale of 'Likes', 'Dislikes' and 'Never Tasted' by their parents. Many of the foods reported as never tasted by the children were also disliked by their mothers. Once again this study relied on a food preference questionnaire completed by parents. It is possible that parents own food preferences influenced which foods they believed their child liked. However, this study does demonstrate the influence parents have on their children's emerging food preferences. If parents reduce exposure to foods they themselves dislike this may have an impact on their children's food preferences. There is not enough scope within this thesis to explicitly examine the important role that parents may play in shaping their children's food preferences. However, it is important to consider previous research into these issues alongside other factors that are examined within this thesis.

1.9.1. Pressure to eat and restriction.

Parental control of food intake can have lasting consequences on later feeding habits. Parental control can emerge in two very distinct ways, pressure to eat and restriction (Scaglioni, Salvioni & Galimberti, 2008). Batsell, Brown, Ansfield and Paschall (2002) suggest that many common food dislikes can be traced back to children's experiences of being pressured to eat certain foods. Batsell et al., (2002) interviewed 407 adult participants (aged 16- to 46-years) and found that 70% recalled being forced to eat during childhood. Interestingly, these participants reported to be significantly more selective eaters than participants who did not recall being forced to eat in childhood. Similarly, Carper, Fisher and Birch (2000) found that 5-year-old girls who reported parental pressure to eat were three times more likely to report dietary restraint than girls who were not pressured by their parents to eat.

In recent years, Galloway et al., (2006) investigated the effect of pressuring children to eat soup. They hypothesised that this would have negative consequences for food consumption. All children (n = 27, aged 3- to 5-years) were attending full day care programs at the Pennsylvania State University and were told that they would be visiting the eating lab for an appetizer prior to having their normal lunch. Children were given various flavours of soup at different stages of the study. The volume of soup consumed, and comments made at the time of consumption, were recorded. During the 'pressure' condition, the research assistant repeated 'finish your soup please' four times within the five minutes allowed for finishing consumption. Results found no significant difference in the amount of soup consumed during the 'pressure' compared to 'no pressure' condition. The interesting result from this study was in the comments made by the children. During the pressure condition comments were overwhelmingly negative (157 negative comments), compared to the no-pressure condition (30 negative comments). This study suggests that whilst pressuring children to eat does not affect immediate food intake it could result in negative feelings towards the food product consumed, which may lead to negative food preferences for that food. This may be expressed only when children reach an age where they have control over their food intake.

Ogden, Reynolds and Smith (2006) have commented on the inconsistency of results in the literature looking at parental control. Some suggest control to be detrimental, as discussed above, whereas others suggest control can be useful in encouraging healthy feeding behaviour. For example Wardle, Sanderson, Guthrie, Rapoport and Plomin (2002), reported parents of obese children to be more neglectful in their feeding styles which may be connected to a lack of control. To tackle this inconsistency, Ogden et al., (2006) differentiated between different types of control, which they term 'overt' and 'covert' control. Overt control involves limiting a child's intake of foods in a way that can be perceived by the child, for example having unhealthy snack foods in the home but only allowing the child to eat a certain amount, or pressuring a child to eat. Covert control on the other hand may be out of the awareness of the child, for instance the parent simply does not buy unhealthy snack foods.

To investigate the differences between overt and covert control, a new measure assessing these factors was constructed and questionnaires were completed by 247 parents of children aged 4- to 11-years. Parents were required to rate the extent to which they participated in each control practice. Questions on overt control contained items such as 'How often are you firm about when your child should eat?', whereas covert control items were more subtle, such as 'How often do you avoid going to cafe's or restaurants with your children which sell unhealthy foods?' Results indicated overt and covert control to be conceptually distinct constructs, and to differ from existing measures of control.

Brown, Ogden, Vogele, and Gibson (2008) carried out an extension of the Ogden et al., (2006) study to investigate differences in the types of parents who used differing control practices. Parents of 518 4- to 7-year-old children completed self-report questionnaires (the questionnaires used were existing measures previously used by Ogden et al., 2006 and the Child Feeding Questionnaire see Birch, Fisher, Grimm-Thomas, Markey, Sawyer and Johnson, 2001 for full details). Results indicated no relation between intake of healthy snack foods and parental control practices. However, children consumed more unhealthy snacks if their parents reported lower levels of covert control over snack foods and high levels of pressure to eat.

Fisher and Birch (1999) investigated the effects of food restriction, and the consequences this has on young children when given free access to various snack foods. Seventy children (30 girls, 40 boys) aged 3- to 6-years participated in this study. Parents were questioned as to the extent to which they restricted their child's access to certain snack foods. Children were left alone in the lab, where they were given free access to various snack foods for 10 minutes, whilst being observed using a one-way mirror by the experimenter. They were informed by the experimenter that they could eat the snacks if they wanted to. Results showed that parental restriction of children's access to snack foods positively correlated with girls' consumption of the snacks when given free access, however this effect was not found for boys.

Similarly, Liem, Mars and De Graaf (2004) investigated parental restriction of foods containing high amounts of mono- and di-saccharides (MDS). Forty-four 5-year-old children performed a rank order preference taste test for five concentrations of orangeade. Results showed that a child whose eating was most restricted by their parents preferred the higher concentrations of MDS, whereas this effect was not found for children with less parental restriction. Thus, there is evidence to suggest that restricting children's access to certain foods increases preference for those foods, whilst pressuring children to eat particular foods can induce negative feelings towards certain foods. This suggests that parental control of food intake can shape the development of food preferences in young children.

More recently, Jansen, Mulksen and Jansen (2007) have provided further evidence for restriction to increase preference. They investigated the influence of restriction on the desire and consumption of sweet/snack foods for 74 5- and 6-year-old children. Children were assigned to either a prohibition group (where they were prohibited to eat red foods) or a no prohibition group (where they could eat as much of whichever foods they wished). There were two phases to the experiment. In the first phase, the prohibition group were told not to eat the red foods whilst the experimenter left the room for 5 minutes, the no-prohibition group were informed that they could eat whatever foods they wanted. In the second phase, both groups were able to eat any foods they wanted whilst the experimenter left the room. Measurements of each child's desire to eat each kind of food were assessed and the bowls of food were weighed after each phase. It was found that the desire to eat certain foods significantly increased for the prohibition group ($t(35) = 2.24$, $p < .05$), but not for the control group. Similarly the prohibition group consumed a larger proportion of red snacks ($M = .061$, $SD = .18$) than the control group ($M = .05$, $SD = .19$). This suggests that restriction of particular foods has a negative impact on children's food consumption patterns when given free access. Once children reach an age where they take control over their own food intake, those who were restricted from eating certain foods in childhood may consume more of those foods in adulthood. It is possible perceptual attributes of food may further enhance the impact of restriction through generalisation. For example, if children have restricted access to a particular item (e.g., a red food), they may have increased desire to consume other perceptually similar foods when given free access.

1.9.2. Reward.

The use of rewards in eliciting certain behaviours has been well documented, ever since the work Thorndike (1901) and his instrumental conditioning theory of learning. Parents may use food as a reward for eliciting certain behaviours from their children. For example, a young child throwing a tantrum because s/he wants to go out and play may be offered food by her/his parents as an incentive and/or reward for sitting quietly and playing indoors. This would operate in accordance with Thorndike's (1927) 'law of effect', which states that an action is more likely to be repeated if it leads to a reward. Research demonstrates that the context in which food is used as a reward is important in establishing food preferences. When food is used to reward a particular behaviour (for example 'you've been really good, you can have some chocolate'), preference for that food increases (see Birch 1999). However, when children are offered non-food rewards for eating foods (e.g. 'eat your carrots and we will go out and play') then children's preference for that food decreases (Birch, Marlin & Rotter, 1984).

The context in which rewards were offered in these studies may explain the results. If a child has behaved well parents will more likely reward using a food they know their child likes. In contrast, a reward for eating a food is most likely to be used for foods children dislike, which parents want to encourage consumption of. This is illustrated in a study discussed earlier by Wardle at al., (2003); offering a reward of a sticker to children before consuming sweet red pepper led to an increase in preference but not significantly so. As the amount of red pepper consumed by the children in the reward group was greater than the amount needed to gain the reward, the reward alone could not be the only reason for consumption. In addition, the target food was a novel food item to the children participating in this study and they had no previous liking or disliking for the food. Again it is possible, through categorisation, that perceptual attributes have an influence here. If children are found to use perceptual attributes for example as a colour-favour association, this information may be informative to parents.

In contrast, Birch et al., (1984) assessed the use of different rewards for food consumption in 3- to 5-year-old children. The rewards compared were verbal praise and a tangible reward (a movie ticket), given for consuming a specific amount of a chosen beverage. The beverage chosen for each child was rated neutral on a food preference assessment conducted prior to the experimental task. In both reward conditions, except for control groups, a negative shift in preference was observed, indicating that when a reward is given for consumption of various foods, preference for that food item decreases. In a further study, Birch, Zimmerman and Hind (1980) assessed preferences for eight snack foods and then gave a neutral food (one that was neither strongly liked or disliked by each child) to children aged 3- to 5-years, as a reward for performing certain behaviours (for example, performing an activity adequately or responding to a verbal request). In this instance, preference for the neutral food item was seen to increase, suggesting that context plays an important role in the use of reward and food preference.

A recent study has found evidence for the role of modelling and rewards in increasing fruit and vegetable consumption in pre-school children (Horne et al., 2011). A repeated measures design was used to target children's consumption of 8 fruit and 8 vegetables with a modelling and rewards intervention. Food were presented as 4 different food sets, each comprising 2 fruit and 2 vegetables. Over a 16 day baseline phase children received a different food set daily, first as snack time and then at lunch. Consumption was not rewarded suring the baseline phase. During the fruit intervention period (32-days) food sets 2 and 3 were presented on alternate days with rewards offered at snack time only for consumption of the fruit component of the food set. Following further baselines phases the intervention targeted snack consumption of the vegetable components. During the intervention phases children received hierarchical rewards for consumption of the fruit and vegetables. If they consumed 1-3 pieces they received a sticker, if they consumed 4 – 7 pieces they received a sticker and a badge, and if they consumed all eight pieces they received a sticker, a badge and a toy brick that could be used to make a toy (children were shown a picture of the toy they could make with the bricks). The amount of food consumed was measured visually by independent researchers who rated the amount consumed on a 5-point scale. Results revealed no difference between the items at baseline. However, following the intervention phase there was found to be a three-fold increase in the amount of both fruit and vegetables consumed which was maintained at a 6 month follow up. Furthermore, the increase in consumption of these items generalised to lunch time and children increased consumption not only for the items used in the intervention period but to all 16 items used throughout the study. This study provides support for the role of rewards in increasing pre-school children's willingness to consume fruit and vegetables.

In addition, a cluster randomised trial explored the use of exposure and reward on children's consumption of a disliked vegetable (Cooke et al., 2010). Over days 1 and 2 of the study, 422 children aged 4 – 6 years were presented with 6 vegetables, and asked to taste a little and rate their preference for each vegetable. They were then asked to rank order the items and the 4th item listed was selected as the target vegetable. There were four conditions to this study, 1) exposure paired with a tangible reward (a sticker), 2) exposure paired with a social reward (verbal praise), 3) exposure alone and 4) a control group. On days 3 – 14 children were seen individually and presented with their target vegetable. The experimenter asked them to try a small piece and depending on the condition they were in they were given a sticker for consumption, verbal praise or no reward. The amount of the target vegetable consumed was seen to increase in each condition, however a larger effect was seen for the tangible reward only and the effects on consumption were maintained for the reward conditions only and not for the exposure condition.

These studies show how exposure and rewards can lead to increased preference and consumption of previously disliked foods. This thesis does not investigate the use of reward in the development of food preferences however this is another factor which may be influential and needs to be considered when examining other influential factors (e.g., perceptual and cognitive factors).

1.10. Food preferences in relation to childhood obesity

It is important to consider not only the theoretical implications of the role of perceptual and cognitive factors on the development of food preferences, but also the potential applied implications. Obesity refers to a significantly higher amount of body fat than is recommended for a person's height, resulting in possible health problems. It is estimated that 7% of the entire world's population is classified as obese (Benton, 2004) affecting one billion people worldwide with two to three times that many being overweight (Malecka-Tendera & Mazur, 2006). The rising incidence of obesity not only affects the adult population, there are also reports of 22 million children under the age of five being overweight or obese (Deitel, 2002). The extent of childhood adiposity is so great that it has overtaken rates of child malnutrition (Martorell, Khan, Hughes & Grummer-Strawn, 2000). This large scale 'epidemic' is a relatively new phenomenon, between 1974 and 1984 obesity levels remained relatively stable in British children (aged 4-11 years) at about 9% of the population (Chinn & Rona, 2001). However, between 1984 and 1994 obesity levels rose significantly for British boys (3.6% increase) and girls (4.1% increase for English and 5.4% increase for Scottish girls), (Chinn & Rona, 2001). Similarly, Jebb, Rennie and Cole (2003) reported that 15.5% of British boys and 20.7% of British girls, aged 4- to 6-years, were overweight or obese in 1997. More recent estimates from the Centers for Disease Control and Prevention suggest 10% of 2- to 5-year-old American children are overweight relative to their age and gender (Connor, 2006).

A recent national study into child obesity trends and socioeconomic status (SES) has suggested a relationship between a child's body mass index (BMI) and SES. Although levels of childhood overweight and obesity appear to have stabilised this has not been observed for children from lower SES (Stamatakis, Wardle & Cole, 2010). In this study children aged between 2- and 15-years (N = 15271) were measured for height and weight in order to calculate child BMI adjusted for age and gender. Socioeconomic status was determined by parental education. When looking at trends in childhood obesity between 1997 and 2007, Stamatakis et al., (2010) have demonstrated an apparent levelling off after 2003. Similar findings have been reported in France (Lioret et al., 2009; Peneau, Saanave, Rolland-Cachera, Castetbon & Hercberg, 2008), Switzerland (Aeberli, Amman, Knabenhans & Zimmerman, 2008), and Sweden (Sjoberg, Lissner, Albertsson-Wikland & Marild, 2008). However, for children from lower SES obesity levels have continued to rise in comparison to those from higher SES. The reasons for this discrepancy are currently unclear. When considering influences on children's food preferences, this thesis therefore explores differences in the food preferences of (chapter 2), and the portion sizes offered to and consumed by (chapter 3), children belonging to different BMI and SES classifications.

The most prominent cause for concern, with regards to obesity in children, is the associated health risks. Obesity can lead to Type II Diabetes, which has been found to be on the increase in western children. In 1992 Type II diabetes was rarely reported in children, however by 1999 the incidence of Type II diabetes in American children ranged from 8% up to 45%, depending on geographical location (American Diabetes Association, 2000). It is thought that the increase in Type II diabetes in American children between 1992 and 1999 may have been correlated with higher prevalence of obesity in children at this time.

Interventions to ease the prevalence, and reduce the increasing incidence, of childhood obesity need to be established. A number of school based intervention programs have been trialled with varying success. Using a multi-component intervention for three consecutive years Caballero et al., (2003) targeted 8- to 11-year-old American Indian children across 41 schools. The intervention consisted of four components; firstly, a change in dietary intake, secondly, an increase in physical activity, thirdly, a classroom curriculum focussed on healthy eating and lifestyle and finally, a family involvement program. Despite the use of a multi-component model the intervention failed to produce significant reduction in percentage body fat Another intervention, in 8- to 11-year-old school age children, aimed to improve physical fitness and ease obesity levels (Donnelly et al., 1996). The intervention group received enhanced physical activity, nutrition education and a lower fat and sodium lunch program, whereas the control group continued with regular lunches and physical activity. Although improvements in the nutritional content of school lunches, and an increase in the amount of physical activity in the classroom, were observed, there were no differences in body weight and fat between the control and intervention groups at the end of the program. Various other studies have tried similar intervention programs with little success (e.g., Baranowski et al, 2003; Neumark-Sztainer, Story, Hannan & Rex, 2003; Pangrazi, Beighle, Vehige & Vack, 2003; Sahota, Rudolf, Dixey, Hill, Barth & Cade, 2001; and Warren, Henry, Lightowler, Bradshaw & Perwaiz, 2003).

Despite this apparent lack of success some intervention studies have achieved reductions in child body mass index. Robinson (1999) aimed to reduce the amount of television viewing, video watching and video game playing in 8-year-old children. The children were divided into an intervention group, who received an 18-lesson classroom curriculum over six months, and a control group who received no intervention. Compared with controls, the intervention group had a significant reduction in body mass index ($p < .005$). Similarly, Flores (1995) conducted a small scale trial, with 110 10- to 13-year-old children, to determine the effectiveness of an intervention program, 'Dance for Health'. The intervention group received health education lessons twice a week and a dance oriented physical education class, whereas the control group received normal school physical activities consisting mainly of playground activities. This intervention was successful in significantly lowering the body mass index of girls in the intervention group (pre intervention BMI = 22.9, post intervention BMI = 22.1), compared with the control group (pre intervention BMI = 22.2, post intervention BMI = 22.5).

The studies reported above demonstrate interventions trialled in school age children have been inconsistent in their effectiveness in lowering body mass index and body fat. It has recently been reported that nearly 10% of 2- to 5-year-old children in the United States were classified as being overweight in 2007-2008 (Ogden, Carroll, Curtin, Lamb & Flegal, 2010), similarly in 2003-2004 26% of 2- to 5-year-old children were either at risk of becoming overweight or were overweight (Ogden, Carroll, Curtin, McDowell, Tabak & Flegal, 2006). With such high prevalence of overweight in pre-school children it has been suggested that perhaps intervening before children reach school age could help tackle the rising levels of obesity (Birch & Ventura, 2009). As Birch (1999) discusses, during the pre-school years children learn more about food and eating than during any other developmental period. By the time children begin to attend school they will have tried a wide variety of different foods, will have distinguished between what can and cannot be eaten, and will have developed preferences for certain foods and dislike of others. Therefore, it seems reasonable to suggest that implementing obesity interventions at a pre-school level may be more effective than school based interventions.

To date, there have only been a few obesity intervention studies that have specifically targeted pre-school children, each of which has found encouraging results. One example targeted the overweight parents of 43 2-year-old Native American children (Harvey-Berino & Rourke, 2003). Parents were assigned to either, 16-weeks obesity prevention and parenting support, or parenting support alone. The intervention was delivered on a one-to-one basis at the child's home. Results for the intervention group showed a decrease in child weight-for-height scores and a reduction in energy intake both of which were towards significance ($p = .06$). Another example is that of Williams, Strobino, Bollella and Brotanek (2004) who evaluated the impact of a multi-component cardiovascular health intervention on a pre-school population. Results found a significant decrease in total serum cholesterol in the intervention group compared with controls ($p = .02$). Other intervention studies targeted at pre-school children have also been found to be successful, such as that of Mo-suwan, Pongprapai, Junjana, & Puetpaiboon (1998).

Success rates for interventions that were aimed at pre-school children appear to be higher than school-based interventions. It could be implied that food knowledge, choices and preferences developed at a pre-school age could impact on later feeding behaviour. Moreover, a strong link between body mass index in childhood and that in adulthood has been reported (Guo, Roche, Chumlea, Gardner and Siervogel, 1994). In addition, Whitaker, Wright, Peper, Seidel and Dietz (1997) conducted a study to predict obesity in young adulthood from childhood and parental obesity. Results indicated childhood obesity to be predictive of adult obesity for children over the age of 3-years. Furthermore, having an obese parent more than doubled the risk of adult obesity in both obese and non-obese children under the age of 10 years.

Children's food preferences are strongly associated with their consumption patterns; in essence children eat foods that they like (Domel, Thompson, Davis, Baranowski, Leonard & Baranowski, 1996; Drewnowski, 1997; Gibson, Wardle & Watts, 1998; and Resnicow et al, 1997). As children eat foods that they like it is vital to understand the factors that influence the development of food preferences in order to help improve the nutritional value and quality of their diets (Birch, 1998). One possible way to help tackle the obesity epidemic is to understand more about the food choices of young children and what drives and influences their food preferences. Gaining insight into these issues could inform parents and health practitioners of possible ways to influence choices and developing food preferences. Diets high in fruit and vegetables are thought to reduce the risk of chronic diseases such as diabetes (McCrory et al., 1999). Yet, very few adults and children are eating the recommended daily five portions of fruit and vegetables, as advised by the World Health Organisation (WHO). Cooke, Wardle, Gibson, Sapochnik, Sheiham and Lawson (2004) found that British 2- to 6-year-olds consume fruits and vegetables less frequently than recommended: 30% were reported to eat fruit and more than 40% to eat vegetables less than once a day.

Fruits and vegetables differ considerably from other food types in that they contain a range of naturally occurring vivid colours and a spectrum of flavours, textures and sizes, with some fruits and vegetables being sweet (strawberries, carrots), sour (grapefruit) bitter (cabbage), firm (pear, pepper), soft (peach, mushrooms), large (pineapple, aubergine) and small (blueberries, peas). Other types of food within the same superordinate level (e.g., the level at which objects share only a few common attributes, 'carbohydrates', 'fruit'; Rosch, Mervis, Gray, Johnson and Boyes-Braem, 1976) typically do not vary in colour, texture or flavour. For example, meat and fish tend to be brown, white or pink and carbohydrates tend to be brown or white. An exception to this is sweet and snack foods which are generally artificially produced to contain a variety of colours, textures, sizes and flavours.

As fruits and vegetables differ from other food classes in terms of perceptual attributes and are a primary concern of parents and health practitioners, it is important to consider the influence these perceptual differences may have on the development of food preferences. To my knowledge, no previous research has considered the influence of food colour, texture and size on children's food preferences across a wide range of food items.

1.11. The development of food preferences with age

Thus far, it has been seen how intervening at a pre-school level may be more effective in tackling childhood obesity than school based interventions. This may be due to food preferences and feeding behaviours established at a young age continuing into adulthood. A recent longitudinal study, assessing the food preferences of almost 200 girls, from the age of 5- to 11-years, for 10 snack foods, has indicated food preferences to remain relatively stable in childhood (Rollins, Loken & Birch, 2010). However, the generalisability of these kinds of foods to other food items is unclear. Skinner et al., (2002) conducted a longitudinal study, across a larger range of food items, investigating the relationship between food preferences in childhood and those in adulthood. Data were collected using a food preference questionnaire, which has been extensively used in studies of both adult and children's food preferences (Breen, Plomin & Wardle, 2006; Cooke & Wardle, 2005; Nicklaus et al., 2004; Wardle, Sanderson, Gibson & Rapoport, 2001). The same children were assessed at 2- to 3-years, 4-years, and 8-years. Results showed the number of foods liked increased by only 3.7% between the first and third assessment, whereas the number of foods disliked increased by 5.5%. Also, the number of foods never tasted decreased slightly over this period, suggesting that children were trying more new foods as they got older. Skinner and colleagues found that foods introduced after the age of four years were more likely to be disliked than liked, perhaps reflecting an increase in levels of neophobia between 4- and 8-years.

Further support for the finding that children try more foods as they get older is provided by Cooke and Wardle (2005) who also used a food preference questionnaire. Interestingly however, Cooke and Wardle (2005) reported that the number of foods liked decreased with age when co-varied with the number of foods tried. This suggests that food preferences become more specific with increasing age. Perhaps the more foods tried the more foods an individual can find to dislike. In contrast, Nicklaus et al., (2004) conducted a cross-longitudinal study of food preferences in childhood. They followed children longitudinally from ages 2- to 3-years through to early adulthood, at 17- to 22-years, with the aim of establishing whether early food preferences impact on later food preferences. Various cohorts were assessed between 1982 and 1999. Children were then contacted in 2001-2002 at various 'current' ages. Nicklaus et al. used a food preference questionnaire for all ages, except for the very young children (aged 2- to 3-years) whose food preferences were measured via observation of food selection at lunch over a specific time period. A food preference questionnaire was then used to assess current food preferences in comparison to those previously recorded. In contrast to Skinner et al's., (2002) study, results indicated stability of food preferences gradually decreasing with age group, and becoming non-significant after puberty. Hence favourite food choices at 2- to 3-years were not significantly correlated with food preferences later in early adulthood.

The contradictory findings of Skinner et al., and Nicklaus et al., may arise due to methodological differences between studies. For example, the study by Nicklaus et al., (2004) was a cross-longitudinal study and the participants varied within different age groups. This made data collection easier than following a large sample throughout different time periods; it may however compromise the reliability of their results. It is interesting that Skinner's study suggests the majority of food preferences are established prior to school age and have not altered dramatically by the age of eight. Nicklaus's study however, suggests that by early adulthood there is much variability in individual food preferences and that they differ greatly from early childhood. This may reflect the role of environmental factors on determining food choice; as we get older the environment may have higher impact than genetics on food choice.

Again, methodological factors may also have influenced results as Nicklaus et al., collected data for the early years (2- to 3-years) via observation whereas in adulthood data were collected via a food preference questionnaire. These methods may not correlate well and may produce differing results. Whether early food preferences remain stable into adulthood is not well established within the current literature. Although it is not within the scope of this thesis to follow the food preferences of young children into adulthood, it will be considered in chapter 2 how food preferences develop in the pre-school years comparatively with the food preferences of adults, alongside other factors (e.g., exposure) that may influence the development of food preferences.

1.12. Changes in food preferences with body mass index (BMI)

As outlined previously, food preferences may impact on child obesity, however how food preferences vary across children of different body mass indices are still to be considered. Body mass index (BMI) is a calculation that compares weight and height providing an estimate of whether a person is overweight for their height (calculated by dividing a person's weight in kilograms (kg) by their height in metres squared (m2)). An adult is classified as being 'underweight' if they have a BMI less than 18.5; a healthy 'normal weight' adult would have a BMI of between 18.5 and 24.99; an 'overweight' adult would have a BMI that is greater than or equal to 25; and a BMI of over 30 indicates a person to be 'obese'. A BMI calculation can also be used for children. The calculation for child BMI is the same as that for adults but takes into account the child's age and gender in relation to their weight and height. Child BMI is mapped onto growth charts for age and gender and transformed into a percentile providing an indication of whether the child is of a healthy weight relative to their age, gender and height (Ogden et al., 2002). A child is classified as 'underweight' if their BMI is equal to or less than the 5^{th} percentile; a healthy 'normal weight' is classified if the BMI falls between the 6^{th} and 85^{th} percentiles; a child is seen to be 'at risk of overweight' if their BMI falls between the 86^{th} and 95^{th} percentile; and are classified as 'overweight' if their BMI is greater than the 95^{th} percentile.

A number of studies have investigated the relationship between child BMI and food preferences. Specifically, research has considered BMI in relation to the preference for high-fat foods, the choices made by parents and the portion sizes consumed by children of varying BMI classifications. Using hedonic rating scales, after tasting four familiar snack foods, Ricketts (1997) reported a significant positive correlation between child BMI and preference for high-fat foods in children aged 9- to 12-years ($n = 85$, $r = .46$, $p < .05$). In addition, through examination of 3-day dietary records the same study found that preference for high-fat snack foods was also correlated with dietary intake of these foods ($r = .57$, $p < .05$). However, using a three day dietary record cannot allow consideration of changes in the preferences and consumption of different foods at different times of the year. For example, it may be coincidental that the children with higher BMI's in this study consumed more high-fat snack foods during the three days recorded. To determine if children with higher BMI's consume more high-fat foods generally, a longitudinal food diary study would need to be conducted. This issue is addressed in this thesis in chapter 3 where a longitudinal food diary method is implemented.

In addition, Ricketts' (1997) study was conducted with children from the age of 9-years, by which time food preferences and feeding behaviours may have been well established. In order to understand the factors that drive children's emerging food preferences and consumption, studies need to be conducted in much younger populations of children. Fisher and Birch (1995) examined the differences in preference for high-fat foods among 3- to 5-year-old children. Although all children in this study were offered the same menu children's dietary fat intake ranged from 25% to 42%. The children who had the highest fat preference also had the highest fat intakes ($r = 0.54$, $p < .05$), and these children also had parents with higher BMI's ($r = .67$, $p < .01$). This study provides some insight into the link between child BMI, food preference and consumption of high-fat foods. However this is not a naturalistic study as participants were provided with food in a laboratory setting, therefore the ecological validity may be compromised.

Despite this, studies using more naturalistic methods have reported similar findings. Diet quality and quantity across BMI classifications for 8- to 13-year-old Mohawk children was investigated using 24-hour recalls (Receveur, Morou, Gray-Donald & Macaulay, 2008). A comparison of the most frequently consumed food items revealed that children classified as 'overweight' consumed slightly more portions of French fries than children of 'normal weight', which the authors conclude compromised diet quality. Furthermore, a study investigating the association between 9- to 10-year-old children's preferences for fruits and vegetables relative to their BMI percentile found a negative correlation ($r = -.026$, $p < .01$) (Lakkakula, Zanovec, Silverman, Murphy & Tuuri, 2008). These findings indicate children with higher BMI's may prefer foods higher in fat, and consume more of these foods, and similarly to have lower preferences for fruits and vegetables. However, they do not provide an indication of the causal relationship; namely whether children consume more of these foods because they have higher preferences for them, or if they have higher preferences for these foods as a result of exposure. The role of exposure in the development of food preferences will be discussed in detail later in this chapter and examined in chapters 2 and 3.

Attitudes can have a bearing on behaviour, for example if a child has a negative attitude towards a specific type of food, it may result in them consuming that item less frequently than other foods. It is possible that the attitudes towards food differ across children based on BMI classification. It has been reported that there is a difference between 'explicit' and 'implicit' attitudes (Fazio, 1990). Fazio (1990) proposed 'explicit attitudes' may guide ones behaviour in a conscious and deliberate manner whereas 'implicit attitudes' may also guide ones behaviour but in a more spontaneous manner. Craeynest, Crombez, De Houwer, Deforche, Tanghe, and De Bourdeaudhuij (2005) investigated the explicit and implicit attitudes of children classified as obese compared with a matched control group, to food and physical activity. They predicted that the explicit attitudes of both groups (obese and control) would be to prefer healthy food, and moderate and high intense physical activity, compared with unhealthy food and sedentary activities. In comparison, it was expected that implicit attitudes would differ between children classified as obese compared with controls; with children classified as obese preferring unhealthy food and sedentary activities. Explicit attitudes were measured using self-report and implicit attitudes were measured using a modified version of the Implicit Association Task (IAT, Greenwald, McGhee, & Schwartz, 1998), the Extrinsic Affective Simon Task (EAST, De Houwer, 2003). Participants were asked to provide words for physical activities or foods prior to the task that he/she really liked/disliked. There were 9 preselected words for physical activity, divided into sedentary, moderate and high intensity, and 6 preselected words for foods, divided into unhealthy and healthy, determined by the results of a previous study. In the first practice block participants were presented with these words, in white, and asked to classify the words according to whether they like or do not like to do or to eat that word. Whether their response was positive or negative corresponded with a particular key on the keyboard, thus participants learnt an association between positive and negative and the key they pressed. In the second practice block participants were to respond to the colour of the word (either blue or green) using the same keys. In the experimental block words were presented in white, blue or green. It has been shown that task performance is better when the response for the colour is compatible with the positive/negative response to the word.

Results indicated whilst explicit attitudes did not differ between children classified as obese and controls, children with obesity had a more pronounced positive implicit attitude towards sedentary activities, and a more pronounced negative implicit attitude towards physical activities. In addition they had a more positive implicit attitude towards healthy and unhealthy food, which was not present in the control group. The authors suggest that this pattern of results may indicate children classified as obese not to prefer unhealthy food but to prefer eating. Similar findings have been reported with adults (Roefs and Jansen, 2002). Therefore when considering influences on children's food preferences it is important to develop methods that enable causal mechanisms to be considered, as children classified as obese/overweight may have different eating styles, and consume different foods, to children classified as normal weight, but they may actually have similar preferences for foods. Thus, there may be factors other than preference, for example parental control, that may account for some of the variability in children's BMI.

The relationship between food consumption patterns in childhood and BMI has been examined using a longitudinal method. DeHeeger, Akrout, Bellisle, Rossignol and Rolland-Cachera (1996) investigated the food intake patterns across 112 children at the age of 10-months, and then at 2-, 4-, 6- and 8-years. Mothers were interviewed about the typical eating habits of their child and estimates of portion sizes were recorded alongside a 24-hour recall. Despite almost half of the children being in the same BMI category at 8-years as they were at 10-months, energy intake between the ages of 4- and 6-years was found to increase more for children who were classified as overweight at 8-years. This emphasises the importance of understanding the development of food preferences and early feeding behaviour at a pre-school level. Again, it must be considered that this study consisted only of a 'snapshot' of the food intake of these children. Despite being a longitudinal study only a 24-hour recall was recorded. There may be a number of reasons why children who were overweight at 8-years were found to consume more high-energy foods between 4- and 6-years. This study did not explore the relationship between food preferences and feeding behaviour. As stated earlier, children tend to eat foods that they like, therefore food preferences and factors that influence their development are essential in understanding the feeding behaviour of children.

1.13. Methods for Assessing Food Preferences

There are various different methods available when investigating the development of food preferences. Outlined below are some of the methods used in previous research (e.g., questionnaires, tasting tests etc.) as discussed in the preceding sections, as well as suggestions for alternative methods (e.g., longitudinal diary studies, use of explicit stimuli).

1.13.1. Questionnaires.

The most prominent method used to assess the development of food preferences, particularly in pre-school children, has been the food preference questionnaire. Food preference questionnaires are often completed by the mothers of children participating in studies (Breen et al., 2006, Cooke & Wardle, 2005, Nicklaus et al., 2004, Wardle et al., 2001, Skinner et al., 2002). A typical food preference questionnaire consists of approximately 100 common food items and a likert-type scale to assess the extent to which each food is liked by the child (ranging from 'hates it' to 'loves it' and also including 'never tried it'). Pliner and Pelchat (1986) analysed the reliability of food preference questionnaires using a shortened 26 item version and found high correlations between mothers' responses and children's actual food preferences as measured by presenting children with food photographs of the 26 food items and asking if they liked it.

Food preference questionnaires are a useful tool as they allow information to be gathered from large samples of participants, across a large number of items. However alternative methods may be more useful and reliable when considering the role of perceptual and cognitive factors on the development of food preferences. A food preference questionnaire will not enable an experimental investigation into the influence of specific perceptual attributes of a food. In addition, relying on mothers' reports can only be accurate to a certain extent as they may be unaware of foods their child has eaten outside the family home. It is also possible that certain food items (e.g., vegetables) can have their flavour disguised by other items (e.g., gravy). Parents may therefore report their child eats a certain vegetable when they may not actually like that vegetable but will eat it when disguised by other flavours. Alternatively, parents may be influenced by their own food preferences when reporting those of their children. Young children are unable to complete questionnaires regarding their likes and dislikes, however, other methods may be used to assess food preferences in very young children that may provide a more direct measure of childhood preferences than is obtained using parental reports. Chapter 2 utilises a simple objective experimental measure to gain self-report across a wide variety of food items in children as young as 20 months.

1.13.2. Photographs and models.

More recent research has explored the use of explicit stimuli such as photographs or food models. Explicit measures using food stimuli may be a more accurate method than food preference questionnaires in assessing food preferences in childhood. This typically requires showing children food stimuli and asking them to express their preference for the different foods tested. Responses may involve sorting stimuli into 'I like' and 'I dislike' categories using smiley or sad faces. Food preferences can be assessed using a variety of different stimuli. Real food items can be used for tasting tests, although this is limited due to the number of foods that can be tasted in a specific time period. Other possible stimuli include food photographs, line drawings, and food models.

Guthrie, Rapoport and Wardle (2000) assessed three different types of food stimuli (food tasting, food photographs, and food models) to investigate how effective they were for investigating childhood preferences. Seven different food items were presented to 96 pre-school children, each of whom had been assigned to one of the three different experimental groups. Participants were required to name each food item and to select an appropriate face, on a 5-point rating scale, to indicate their preference, ranging from 'yummy' to 'yucky'. All participants were tested on two separate occasions so as to determine the reliability and repeatability of the different methods used. Results showed that food photographs were almost as reliable (r = 0.75) as food tasting (r = 0.81) for assessing children's food preferences. Using food photographs rather than tasting tests, allows a wider range of food items to be assessed at any one time. Food models were found to be relatively unreliable (r = 0.52), which may be because food models are considered to be unrealistic and they may appear to be more like toys to children than actual food items. Within this thesis food photographs are used alongside questionnaire measures to enable evaluation of children's direct responses to food items in comparison with parental report.

A recent study has tested the reliability of using food photographs to determine food preferences of fruits and vegetables in 4- to 6-year old children. Vereecken et al., (2010) used a computerised task in which children were presented with individual photographs of 23 fruits and 23 vegetables and asked to indicate their preference for each item by selecting one of four animated figures. The animated figures expressed different food preferences (yummy; not yummy, not yucky, but ok; yucky; and never tried). Reliability was determined using a test-retest paradigm, in which children completed the same task following a one week interval. Children were found to be consistent in their responses in the test and retest preference scores, thus providing further support for the use of this measure with pre-school children. However, the youngest children participating in this study were 4-years old, thus it remains to be seen if food photographs could be used reliably to determine food preferences of children younger than 4-years. As research has shown food preferences developed by the age of 4-years relate to food preferences in adulthood (Skinner et al., 2002), it is important to develop measures to assess preference at a younger age in order to be informed of appropriate techniques to modify developing preferences. Hence, within this thesis an objective measure of food preference is developed, utilising food photographs, that can be used with children as young as 20 months.

A benefit of using food photographs over questionnaires is the ability to consider perceptual attributes whilst keeping all other attributes constant. For instance, a comparison can be made as to the preference for a 'red pepper' compared to a 'green pepper', where both items are identical in all attributes with the exception of colour. Questionnaires do not usually distinguish items to this level, and if they did parents may not be aware of subtle differences in preferences and may indicate children to like 'red pepper' equally to 'green pepper'. If differences in preference across colours exist the use of food photographs is a method that can be used to determine this.

1.13.3. Tasting tests.

Of course when investigating food preferences it would seem apparent that the gold standard ought to be the use of tasting tests. However, research that has used this method has been limited in the variety and extent of items that can be assessed at any one time. Studies that have used tasting tests to measure food preferences in childhood have either asked children to provide hedonic categorisation of their likes and dislikes (Wardle et al., 2003) or to complete a rank order preference test (Birch et al., 1980, Birch, 1981, Leon, Couronne, Marcuz & Koster, 1999). These methods are limited to assessing food preferences for a very small number of food items, generally from a specific food category, as only a few foods can be consumed within an experimental setting with young children. Order of presentation could also influence subsequent food tasting and this may be difficult to control, especially with very young children.

1.13.4. Diary studies.

To assess the amount of and type of food consumed by children there are a few methods that have been commonly used in the literature, from food frequency questionnaires, to 24-hour recalls, to the use of food diaries. The most common method used has been that of the food diary, although even this has been used in a number of different ways. Some researchers have asked participants to keep a weighed record of all the food they are consuming over a period of time, whereas other studies have not used weighed records. More recent studies have investigated the effectiveness of pre-coded food diaries to allow information to be gathered from larger samples whilst maintaining ease of use (Lillegaard, Lokken & Anderson, 2007). Others have avoided the use of weighed records by using photographs to estimate portion size.

Although there are differences in the approaches used by different studies, the majority of research using this method has implemented a food diary that has not been completed for more than 7-days. Furthermore, in the majority of studies it has been completed for only three- or four-days (e.g., Belderson, Harvey, Kimbell, O'Neill, Russel & Barker, 2003; Cade, Frear & Greenwood, 2006; Johnson, Hackett, Roundfield & Coufopoulos, 2001; Lanigan, Wells, Lawson & Lucas, 2001; Lillegaard et al., 2007; Macdiarmid, Loe, Craig, Masson, Holmes & McNeil, 2009; Moore, Tapper, Dennehy & Cooper, 2005; Vereecken, Rossil, Giacchi & Maes, 2008). When diaries have been completed for a longer period of time there appears to be only one type of food that participants are asked to keep a record of (e.g., Albertson, Anderson, Crockett & Goebel, 2003).

With careful consideration of the format and ease of use of a food diary it may be possible to gain accurate and reliable information on the foods offered to and consumed by children over a longer period of time. A longitudinal food diary study is used within this thesis (chapter 3), alongside the use of food photographs and questionnaires (chapter 2), to ensure a more complete indication of factors that influence children's food preferences and consumption. The use of a longitudinal approach also allows an examination of the differences in the foods offered and consumed at different times of year. This may be important as if significant differences are observed cross-sectional studies may be inaccurate in their conclusions over typical diets of children. For example, children may consume fewer fruits and vegetables in winter than in summer, however this may be balanced out during the summer months in terms of nutritional quality of diets throughout the year.

1.14. Summary of Introduction

Through careful consideration of previous research into the development of food preferences, it is apparent there is a lack of research considering the potential influence of perceptual and cognitive factors. It is important to consider how any attributes found to be influential fit with previous literature in this area and how they may impact on child obesity levels. Chapter 2 presents an Explicit Preference Task alongside a Food Preference Questionnaire and a Food Frequency Questionnaire, designed to investigate the role of colour, texture and size on the development of food preferences in relation to exposure, whilst considering differences across BMI and SES. Through these methods chapter 2 has three distinct aims; 1) to develop an objective measure of food preference allowing self-report from very young children, which will be tested for reliability and validity; 2) using this methodology to investigate if perceptual attributes (colour, texture and size) influence children's food preferences, with consideration of individual differences across BMI and SES; and 3) examine the association between the influence of perceptual attributes of food preferences and exposure.

Following this, chapter 3 further explores the relationship between perceptual attributes and exposure. Using a longitudinal food diary method, chapter 3 has three specific aims; 1) to validate the use of the Food Frequency Questionnaire used in chapter 2; 2) to further explore the relationship between food colour and exposure; and 3) to investigate differences in the food colours children are exposed to at different times of year, considering how this relates to preference and exposure.

In addition, anecdotal reports from parents have indicated children to use perceptual attributes of food to reject novel foods that are similar in appearance. Moreover, children have been found to be more accepting of a novel food if it is the same colour as a food an adult is eating. Thus, it is reasonable to suggest children may be using perceptual attributes as a basis for categorising foods. Chapter 4 builds on the findings of chapter 2 to establish if any perceptual attributes found to be influential in chapter 2 are utilised by children when categorising food, considering how this differs from categorisation on non-food objects.

Chapter 2: An Explicit Investigation into the Influence of Perceptual Factors on Children's Food Preferences

2.1. Introduction

Prior to investigating how perceptual and cognitive factors may interact in shaping developing food preferences, it must first be established *if* perceptual attributes influence children's food preferences. As outlined in the general introduction, colour, texture and size are all salient perceptual attributes that could be used by young children when determining acceptance or rejection of a food. However, the precise mechanism by which these attributes may influence food preferences has not been systematically considered in previous research.

Colour is known to be perceptually salient to young children, and is used to categorise non-food objects (Baldwin, 1989; Brian & Goodenough, 1929; Pitchford & Mullen, 2001; Suchman & Trabasso, 1966). Colour may also be informative of taste, for example the majority of green foods are vegetables (with the exception of a few fruits) and many vegetables have a bitter taste. Similarly, texture has been found to be a reason for food rejection in children (Koivisto & Sjoden, 1996), and children have been reported to prefer smooth textures to firm/lumpy textures (Blossfeld et al., 2007). In addition, advocates of Baby-Led weaning would argue that small foods, which can be easily picked up by a child in order to feed themselves, would be preferred to larger items or foods that require the use of utensils. As no previous research has systematically explored the influence of these factors on children's food preferences, it is unclear how these attributes may exert an influence. Thus this chapter aims to establish if and how these perceptual attributes influence children's food preferences.

In order to experimentally investigate the role of these factors, it is necessary to develop a reliable and valid measure of food preference enabling self-report from young children across a range of food items. Although parental report through questionnaire can be reliable and valid (Pliner & Pelchat, 1986), a measure such as this does not enable the specific influence of perceptual attributes to be considered. In addition, the influence of perceptual attributes, in terms of acceptance or rejection of perceptually similar novel foods, could not be established through parental report questionnaire. Furthermore, very young children may find difficulty in rating their preferences on a typical likert scale across a large number of items, for instance deciding the extent to which they 'like' a banana (if they 'like' or 'love' it). Therefore a more simplistic scale needs to be administered whereby children can clearly distinguish between the categories they are to choose between, for example 'likes' and 'dislikes'.

With research indicating food photographs to be almost as reliable as tasting tests (Guthrie et al., 2000), and having been used successfully with 4- to 6-year old children (Vereecken et al., 2010), this chapter presents a novel objective measure of food preference using high quality coloured photographs of food. This measure will thus enable comparisons in children's food preferences across items that differ in one or more perceptual attributes (e.g., preference for a green apple compared to a red apple). This chapter presents the first large scale study, to my knowledge, using an objective measure of children's food preferences across a wide range of food items, with children younger than 3 years. The measure must of course be seen to be reliable and valid. Although parental report through questionnaire has some drawbacks, it has been found to be both reliable and valid, thus the use of a Food Preference Questionnaire, completed by parents on behalf of their children, allows some indication of the validity of the novel objective measure[1]. Alongside this a test re-test paradigm enables reliability to be determined. Thus, the first aim of this chapter is to develop an objective measure, which can be utilised with very young children, enabling self-report. This will be assessed for reliability and validity.

Further to this, no previous research to my knowledge has indicated the role of perceptual attributes to differ dependent on a child's body mass index (BMI) or socio-economic status (SES). However, a negative correlation between child BMI and preference for fruit and vegetables has been reported (Craeynest et al., 2005); and as fruits and vegetables typically vary in terms of perceptual attributes, it is necessary to consider child BMI as a factor when investigating preference across perceptual attributes.

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1 It must be noted that parental report on a rating scale may not be comparable to child self-report on a dichotomous scale. However, it was not appropriate in this study to test validity through asking children to taste and rate a number of food items. As food preference questionnaires have previously been tested for reliability and validity this was the next best instrument for testing the validity of the novel measure.

Furthermore, recent research has reported that although increasing rates of child BMI appear to have levelled off in recent years, this has not been the case for children from lower SES (Stamatakis et al., 2010). As such, this chapter will also consider factors that may be bearing an influence on differences in child BMI, also in relation to SES.

With much previous research indicating exposure to exert an influence on developing food preferences, when considering the influence of perceptual attributes, it is necessary to also consider the interplay between these factors and exposure. It is a primary concern of parents and health practitioners that children are not consuming the quantity of fruits and vegetables recommended by the World Health Organisation (WHO) (Cooke et al., 2004). Therefore if an effect of food colour is found on children's food preferences, for example liking green foods significantly less than other colours, this may be attributable to children being exposed to green foods less often than other food colours, as a result of consuming vegetables less frequently. In addition, as research has shown 'overweight' children to consume more high-fat, high-sugar foods, it might be expected that they are more exposed to these foods.

Using a measure of exposure (e.g., a Food Frequency Questionnaire), alongside the objective measure of preference, enables the relationship between preference and exposure to be explored. There is some evidence that children may use food colour to accept and/or reject novel foods 'on sight'. Addessi et al., (2005) reported children were more inclined to accept a novel food if it was the same colour as a food a significant adult was eating. It could be implied from this that children use food colour to categorise novel foods, determining acceptance or rejection on this basis. Recent research has suggested that children being reluctant to try a new food may result in barriers against familiarisation (Tuorila and Mustonen, 2010), which has been shown to be important in developing food preferences. Thus if children use food colour to categorise new foods on the basis of taste, they may refuse to try novel foods which are perceptually similar; this may then impact on developing preference.

To summarise, this chapter has three specific aims; first, to develop an objective measure of food preference allowing self-report from very young children, which will be tested for reliability and validity; then, using this methodology to investigate if perceptual attributes (colour, texture and size) influence the development of food preferences, and finally, to examine the association between the influence of perceptual attributes of food preferences and exposure.

3.2. Methodology

Three tasks were developed to investigate the specific aims of this chapter: an Explicit Preference Task; a Food Preference Questionnaire; and a Food Frequency Questionnaire. The Explicit Preference Task is an objective measure of food preference allowing self-report from children as young as 20-months, as to whether a food is 'liked' or 'disliked'. High quality coloured photographs of food are used enabling the influence of perceptual factors to be fully explored alongside other factors (e.g., exposure and food class) that have previously been shown to influence children's food preferences. The Food Preference Questionnaire, completed by parents, was used to assess the validity of the Explicit Preference Task, whilst the Food Frequency Questionnaire, also completed by parents, provided further information as to any foods children had never tried and the frequency with which children are exposed to each item. This was used to examine if there is a relationship between exposure and the influence of perceptual factors on children's food preferences.

3.2.1. Participants.

To investigate the influence of perceptual factors on children's food preferences, 160 typically developing English speaking children were recruited from the University of Nottingham databases and from Dunston Primary School, Derbyshire. The gender and age distribution of participants is shown in Table 1.

Table 1. Gender and Mean (SD) age of participants

	Male	Female	Total	Mean (SD) age
Under 24 months	3	6	9	22.9 (1.45)
25 – 36 months	29	17	46	30.46 (3.29)
37 – 48 months	28	18	46	43.17 (3.11)
49 – 60 months	18	18	36	54.7 (3.23)
61 – 72 months	8	10	18	64.7 (3.83)
Over 73 months	2	3	5	75.6 (1.35)

Prior consent was obtained from parents or guardians. The parent who was mainly responsible for their child's feeding was also recruited (n = 160, 5 male, 155 female). Height (cm) and weight (kg) were measured for all participants and BMI was calculated as detailed in the general introduction (p 46 height in m2/weight in kg: adjusted for age and gender in children, this is achieved using the 'BMI for age' percentile ranges developed by the Center for Disease Control and Prevention). There were 4 'underweight' (2 male, 2 female), 121 'normal weight' (65 male, 56 female), 18 'at risk' (8 male, 10 female) and 17 'overweight' (13 male, 4 female) children. The distribution of child BMI across parent BMI can be seen in Table 2. Socioeconomic status (SES) was calculated using the 2007 Indices of Deprivation, which were derived from each child's home postcode. Postcodes were uploaded to the GeoConvert application hosted by MIMAS at the University of Nottingham to obtain deprivation scores and ranks. Indices of Multiple Deprivation (IMD) scores were ranked from 1 to 5 with 1 being the most deprived (IMD score 2757 – 8652) and 5 being the least deprived (IMD score 26341 – 32236). The majority (72.5%) of participants were from middle-to-high SES (Table 2) and of White British heritage (n = 156, 97.5%), of the remaining four participants two were of Greek heritage, one of Asian heritage and one of Chinese heritage. The distribution of participants across BMI percentile classifications and SES rankings can be seen in Table 2.

As the primary objective of the Explicit Preference Task was to investigate the influence of perceptual attributes, including colour, on children's food preferences it was important to assess all participants for colour vision. The Matsubura (1957) colour test for infants was given to all participants, as it is particularly suitable for young children. The test involves displaying a series of pictures to each participant requiring them to trace the outline of the picture with their finger to show they can see the image or to correctly label the image. All participants were found to have normal colour vision.

Parents were asked to complete the food preference and frequency questionnaires on behalf of their children in the same testing session. Thirteen parents failed to complete the questionnaires resulting in a total sample of 147. In order to assess social desirability in parents' responses to the Explicit Preference Task, and also in the ratings of their child's food preferences in the Food Preference Questionnaire, a shortened version of the Marlow-Crowne Social Desirability Scale (Strahan and Gerbasi, 1972) was administered to parents. This version has been found to be of similar internal consistency to the original version and was administered as it would take less time to complete than the original.

2.2.2. Apparatus and Materials.

<u>Explicit Preference Task</u>

The Explicit Preference Task was designed to gain an objective measure of food preference from very young children using self-report, rather than relying purely on parental report through questionnaire. A simple two alternative forced choice design was implemented, as opposed to a rating scale, as this allowed information to be gathered across a large range of food items whilst minimising fatigue. Previous research that has used rating scales with pre-school children has been limited in the range of items that have been able to be explored (e.g., Birch & Marlin, 1982, Walsh et al., 1990), sometimes only using a few items within one food category. This is typically a result of using tasting tests rather than photographic stimuli.

The Explicit Preference Task was carefully formulated to enable completion by both children and adults. This allowed direct comparisons to be made between the likes and dislikes of children and their parents. In addition, where information regarding the use of perceptual attributes to categorise novel foods is unable to be gained from either the objective measure or questionnaires alone, administering the Explicit Preference Task alongside a Food Frequency Questionnaire (in which parents indicated foods their child had never tried) provided the opportunity to consider this hypothesis.

Stimuli were high quality coloured photographs of individual food items presented on a white background that were prepared specifically for this task. Items selected were taken from those used by Cooke and Wardle (2005) in their Food Preference Questionnaire. All items used by Cooke and Wardle were included in this task alongside additional items selected from the Food Standard Agency's publication 'The composition of foods' (McCance and Widdowson, 2002). Additional items were selected to cover a wider range of foods than selected by Cooke and Wardle, the purpose of which was to ensure there were a sufficient variety of items within each category across various perceptual attributes (e.g., biscuits that differed in size and colour), thus enabling consideration of the influence of colour, texture and size on children's food preferences.

Table 2. Participant characteristics in relation to child body mass index (BMI).

	Child BMI classification				
	Underweight	Normal weight	At risk	Overweight	Total
N *(%)*	4 (2.5)	121(75.6)	18 (11.3)	17 (10.6)	160 (100)
SES, n (%)					
Lowest	1 (9.1)	8 (72.7)	2 (18.2)	0	11 (6.9)
Low	1 (3)	25 (75.8)	3 (9.1)	4 (12.1)	33 (20.6)
Middle	0	20 (71.43)	4 (14.3)	4 (14.3)	28 (17.5)
High	1 (2.4)	33 (80.5)	3 (7.3)	4 (9.8)	41(25.6)
Highest	1 (2.1)	35 (74.5)	6 (12.8)	5 (10.6)	47 (29.4)
Female, *n (%)*	2 (2.8)	56 (77.8)	10 (13.9)	4 (5.5)	72 (45)
Parental BMI					
Underweight, *n (%)*	0	5 (100)	0	0	5 (3.1)
Normal weight, *n (%)*	4 (4.3)	71 (75.5)	12 (12.8)	7 (7.4)	94 (58.8)
Overweight, *n (%)*	0	34 (73.9)	5 (10.9)	7 (15.2)	46 (28.8)
Obese, *n (%)*	0	11 (73.3)	1 (6.7)	3 (20)	15 (9.4)
Age in months *(mean, SD)*	47.8 (10.5)	44.7 (14.9)	42.72 (9.7)	43.3 (11.4)	
BMI percentile rank *(mean, SD)*	1.8 (1.5)	49.2 (23.1)	87.4 (5.4)	96.5 (3.6)	

In order to consider the role of perceptual attributes on children's food preferences it was necessary to include photographs of some items presented in a multitude of ways. For example, 'carrot' was included as a whole carrot but also diced and chopped, similarly 'pepper' was presented in each available colour (red, green, yellow and orange pepper). In total there were 230 photographs administered in this task. Alongside this each item was classified on the basis of colour, texture and size by 10 independent adult raters. Each rater was provided with a list of eight colour categories: 'brown', 'red', 'orange', 'yellow', 'green', 'purple', 'pink' and 'cream/white'; three texture categories: 'firm', 'soft' and 'liquid'; and three size categories: 'small', 'medium' and 'large' and asked to tick the appropriate box indicating which colour, texture and size they believed each of the 230 items belonged to. Every item received at least 80% agreement amongst raters as to each of these attributes, which was deemed to be acceptable for inclusion in the task.

In addition to ratings of perceptual attributes, items were classified based on their taxonomic food class membership. Food class membership was concordant with the Food Standard Agency's publication 'The composition of foods' with the following exceptions; potatoes were deemed to be 'carbohydrates' rather than 'vegetable' as it was felt preference for potatoes may mask understanding of children's vegetable preferences. This is as a result of potatoes traditionally being consumed as a carbohydrate rather than a vegetable. In addition potatoes are not included in the World Health Recommendations for 5-a-day[2]. Each of the 230 items was classified into one of seven food class memberships: 'fruit', 'vegetable', 'meat & fish', 'sweet & snack', 'carbohydrates', 'eggs & dairy' and 'mixed & miscellaneous'. The distribution of items across each perceptual (colour, texture, size) and taxonomic (class) category can be seen in Table 3. It can clearly be seen in Table 3 that the distribution of items across the class, colour, texture and size classifications is not equivalent. It was necessary to take this approach in order for an experimental study to be conducted across a range of food items. With no prior research indicating specific perceptual attributes to influence food preferences of children it was important that a wide variety of items were able to be included in this study. This does create difficulties in analysing the data succinctly, thus a number of post hoc analyses are likely to be required on the data to fully explore the

[2] www.eatwell.gov.uk

influence of the various factors on children's food preferences. Of course this raises the Type 1 error rate therefore, following this study, it would be important for a more controlled experiment to be conducted to further explore any of the factors found to influential here, however, this is beyond the scope of this thesis. A complete list (including the photographic image used) of all the items and the class, colour, texture and size classifications can be found in Appendix 1.

Food Preference Questionnaire

The Food Preference Questionnaire is the most frequently used method for assessing children's food preferences. The questionnaire used in the present study was based on Cooke and Wardle's (2005) Food Preference Questionnaire. This questionnaire was originally based on one used by Wardle et al., (2001) in a study of 4 – 5 year olds and was tested for reliability and validity when completed by parents (Pliner & Pelchat, 1986).

For the purposes of the present study, it was necessary to modify Cooke and Wardle's questionnaire to ensure items were the same as those used in the Explicit Preference Task, thus enabling a direct comparison to be made between the foods children indicate they like and their parents understanding of their children's food preferences. All food items used in Cooke and Wardle's questionnaire were included in the present study. However, to focus this study on food and beverages, items listed as 'condiments' (e.g., jam) in the Cooke and Wardle questionnaire, were not included here.

Of course parental ratings on the Food Preference Questionnaire cannot fully validate children's ratings on the Explicit Preference Task, and as this questionnaire was a modification of a previous questionnaire, which similarly has been modified from Wardle et al's (2001) original, caution must be taken in stating the validity of this measure. However, within the confines of this task it was not possible to determine validity by presenting children with real food items and asking which they would like to eat.

Unlike the Explicit Preference Task where some items were included more than once in different presentation (e.g., 'whole carrot', 'chopped carrot') each item was only listed once in the Food Preference Questionnaire (e.g., 'carrot'), resulting in a total of 152 items. It must therefore be noted that when comparing these measures the preference rating obtained for 'carrot' on the Food Preference Questionnaire was used against each depiction of 'carrot' in the Explicit Preference Task. There is a conflict here, however it was important to ensure the questionnaire was not longer than necessary therefore it was not appropriate to state each variation of each item in the Food Preference Questionnaire. The same class, colour, texture and size ratings were attributed to each item as in the Explicit Preference Task. The questionnaire consisted of a 5-point likert scale: 'loves its', 'likes it', 'it's ok', 'dislikes it', and 'hates it' (Appendix 2).

Food Frequency Questionnaire

Previous research has indicated a relationship between food preferences and exposure, therefore, the Food Frequency Questionnaire was used alongside the Explicit Preference Task to explore this relationship further. In addition it allowed information regarding foods children had never tried to be considered. The questionnaire consisted of an 8-point likert scale: 'never tried', 'more than once a day', 'once a day', 'more than once a week', 'once a week', 'more than once a month', 'once a month', 'less than once a month' (Appendix 2). Parents were asked to tick the appropriate box indicating how often their child was typically offered each item, and instructed not to consult with their child about their responses. Children were engaged in other activities whilst their parent completed the questionnaire.

Table 3. The distribution of food items across each perceptual (colour, texture, size) and taxonomic (class) category

	Fruit	Vegetable	Carbohydrate	Meat/fish	Eggs/dairy	Sweet/snack	Mixed	Total
N *(%)*	34 (14.8)	51 (22.2)	49 (21.3)	20 (8.7)	12 (5.2)	40 (17.4)	24 (10.4)	230 (100)
Colour, n (%)								
Red	6 (33.3)	4 (22.2)	1 (5.6)	0	0	3 (16.7)	4 (22.2)	18 (7.8)
Brown	1 (1.7)	4 (6.7)	23 (38.3)	7 (11.7)	0	15 (25)	10 (16.6)	60 (26)
Yellow	9 (20)	4 (8.9)	14 (31.1)	1 (2.2)	6 (13.3)	10 (22.2)	1 (2.2)	45 (19.5)
Orange	3 (15.8)	8 (42.1)	1 (5.3)	2 (10.5)	0	1 (5.3)	4 (21)	19 (8.2)
Green	8 (26.7)	21 (70)	0	0	0	0	1 (3.3)	30 (13)
Purple	5 (41.7)	6 (50)	0	0	0	0	1 (8.3)	12 (5.2)
Pink	0	0	0	7 (43.8)	2 (12.4)	7 (43.8)	0	16 (6.9)
Cream/white	2 (6.8)	4 (13.3)	10 (33.3)	3 (10)	4 (13.3)	4 (13.3)	3 (10)	30 (13)
Texture, n (%)								
Firm	17 (15.6)	38 (34.9)	19 (17.4)	6 (5.5)	6 (5.5)	17 (15.6)	6 (5.5)	109 (47.4)
Soft	17 (15.7)	13 (12)	30 (27.8)	14 (13)	3 (2.8)	20 (18.5)	11 (10.2)	108 (47)
Liquid	0	0	0	0	3 (23.1)	3 (23.1)	7 (53.8)	13 (5.6)
Size, *n (%)*								
Small	17 (15.2)	25 (22.3)	25 (22.3)	8 (7.1)	7 (6.3)	26 (23.2)	4 (13.6)	112 (48.7)
Medium	13 (13.5)	18 (18.7)	21 (21.9)	11 (11.5)	5 (5.2)	11 (11.5)	17 (17.7)	96 (41.7)
Large	4 (18.2)	8 (36.4)	3 (13.6)	1 (4.5)	0	3 (13.6)	3 (13.6)	22 (9.5)

2.2.3. Procedure.

Participants from the University of Nottingham databases were tested in a laboratory at the University of Nottingham specifically designed for children and families. Participants from Dunston Primary School were tested in a quiet area of the school. Parent-child pairs were invited to attend the testing session together however the task was completed individually.

Each participant was presented with the same stack of 230 photographs of food items in a random order (randomised by shuffling between participants). Two response boxes were used to collect the photographs, one represented 'yum yum' foods where the participant was required to insert any photographs of foods they liked, the other represented 'yuk yuk' foods where the participant was required to insert any photographs of foods they disliked (Appendix 3).

Instructions were given to parents prior to the child being invited to the other end of the room to play a game. Parents were instructed to look at each photograph and to place any foods they felt they liked into the 'yum yum' box and any foods they disliked into the 'yuk yuk' box. If there were any photographs they were unsure of what the item was or had never tried they were instructed to decide based purely on the photograph if they felt this was a food they would like or dislike. In the mean-time, children were invited to play a game in which they were to look at an identical set of 230 food photographs to that of their parents and to sort these into 'all the yummy foods that you like' and 'all the yucky foods that you don't like'. The child sat on a chair or on a rug facing the experimenter with the two boxes directly in front of them at reaching distance. The experimenter pointed to the 'yum yum' box and said 'see this face here, this is the 'yum yum' face and is where all the yummy, tasty foods that you like should go'. The experimenter then pointed to the 'yuk yuk' box and said 'see this one here, this is the 'yuk yuk' face and is where all the yucky, foods that you don't like should go. Do you understand?'[3]

Once children had indicated that they understood which box was for liked foods and which was for disliked foods a practice trial was administered in which the experimenter

3 The order of presentation of the 'yum yum' and 'yuk yuk' boxes was counterbalanced across participants.

showed the child one of the food stimuli photographs selected at random and said 'see this (name of food), do you like (name of food)?'. If the child answered 'yes' the experimenter would say 'ok, so you like (name of food), which box should we put it in?' This was to ensure that each child understood the aim of the task. The practice trial was removed from all data analysis, resulting in 229 responses for each participant. For all other food stimuli the experimenter did not label the item. Each food stimuli photograph was individually shown to the child and they were asked 'is this 'yum yum' or 'yuk yuk'?' (counterbalanced across items) and asked to put it in or point to the box that matched their preference.

The questionnaires were completed by parents on behalf of their child during the same testing session. Each participant was asked to tick the appropriate box indicating the extent to which their child liked each item, and how often it was offered, or if it had never been tried. Parents were requested not to consult with their child, but rather to base responses on their own understanding of their child's food preferences. This was due to children completing the Explicit Preference Task during the same testing session which may have confounded their responses.

In order to assess the Explicit Preference Task for reliability, a test re-test assessment was utilised for the first 40 child-parent pairings. As children's food preferences can rapidly change through development, it was important to conduct the re-test on the same day as the original testing session. Due to the task taking a fairly long time to complete it was not possible for all children to be re-tested on all of the items, therefore 20 items from the full set of 230 were repeated for both children and adults.

2.2.4. Data analysis.

Data were analysed using SPSS version 16. First the reliability and validity of the novel experimental measure were assessed using chi-square analyses, comparing consistency of test re-test responses (reliability) and parental report on the Food Preference Questionnaire to child self-report on the Explicit Preference Task (validity).

A simple two alternative forced choice design was implemented, as opposed to a rating scale, as this allowed information to be gathered across a large range of food items whilst minimising fatigue. Previous research that has used rating scales with pre-school children has been limited in the range of items that have been able to be explored (e.g., Birch & Marlin, 1982, Walsh et al., 1990). However, in order to investigate the influence of perceptual attributes on the development of food preferences from the Explicit Preference Task data needed to be transformed from dichotomous categorical data (i.e., 'like' or 'dislike') to continuous data (i.e., a preference score, how much is a food liked). This allowed more sensitive statistical analyses to be conducted. Prior to transformation of the data a Mokken scaling analysis was conducted to determine if all of the items could be included in one scale.

Mokken scaling is a hierarchical scaling method for dichotomous data and assumes the existence of an underlying latent attribute. An individual's score on the scale is simply the rank of the highest item in the hierarchy that they endorse, or is their total number of positive responses (Andries van der Ark, 2007). In this instance the 'individual' is the food item, therefore the rank of an item relates to the number of children who liked that item.

Each individual food item ($n = 230$) was entered as the independent variable and each child's preference (like, dislike) for each item was entered as the dependent variable ($n = 160$). Results indicated all of the 230 items to fit into one scale in terms of the number of children who liked each item and the number of items a child liked (scale coefficient $H = 0.35$, range = 0.23 – 0.52), indicating little variability amongst items. In essence, the foods which are disliked tend to be disliked by the majority of children.

Next, logistic regression analyses were conducted on each item ($n = 230$) with child preference (either 1 or 0) as the dependent variable and the predicted probability residual was saved. This allowed for the removal of the influence of the number of children who like a food and the number of foods a child liked from the preference score. To create the new continuous dependent variable the residual was subtracted from 1, creating a range of preference scores for each participant for each item. Due to the manner in which data were transformed the preference score refers to preference against an item, as such the higher the preference score the lower an individual's preference for an item. Data could thus be analysed using a wider range of available methods (e.g., Analysis of Variance). Throughout the results section both the original dichotomous data and the transformed continuous data have been used for different analyses, which has been used is clearly stated where appropriate. Using the new dependent variable data were checked for normality prior to the use of parametric statistical analyses being conducted.

2.2.5. Summary of methods.

Three methods were developed to examine the specific aims of this chapter outlined in the introduction. Data were collected in a format to ensure reliability of results with very young children and statistical methods were used to transform data enabling a broader range of statistical analyses. Each of the three aims of this chapter is considered next and results reported accordingly.

2.3. Results

To explore the aims of this chapter, first using a test re-test method the novel objective measure will be tested for reliability, then validity will be assessed by comparing children's responses using the objective measure to parental report on the Food Preference Questionnaire. Next, using the novel method the influence of colour, texture and size on food preferences will be explored, with further consideration of differences across BMI and SES. Then, the role of exposure in relation to any perceptual attributes found to be influential will be explored.

2.3.1. Aim1: Develop an objective measure of food preferences allowing self-report of very young children, testing for reliability and validity.

To examine the test re-test reliability of the Explicit Preference Task 2 x 2 chi-square analyses were conducted to determine the consistency of preference from the first presentation of each item to the second. Original dichotomous ('like', 'dislike') data were used rather than correlating the transformed preference score at time 1 and time 2. This was due to the transformed data resulting from a Mokken scaling analysis across the whole group of participants ($n = 160$), whereas only a sub-sample of participants ($n = 40$) completed the test re-test assessment.

The first 40 parent-child pairings participating in the study were re-tested on 20 items during the same testing session. Two 2 x 2 chi-square analyses were conducted to determine the consistency of likes and dislikes at time 1 and time 2, significant associations were observed for both children ($\chi2$ = 440.9 , $p < .001$) and adults ($\chi2$ = 800, $p < .001$) (Table 4 and 5). Post-hoc Bonferroni corrected one group chi-square analyses (significant at $p < .025$) were conducted to explore these associations. Children liked a higher proportion of foods consistently at time 2 as they did at time 1 (observed frequency of foods liked at both time 1 and time 2 = 509, expected frequency = 382.3, $\chi2$ = 134.9, $p < .001$). Similarly, they disliked more foods consistently at time 2 as they did at time 1 (observed frequency of foods disliked at both time 1 and time 2 = 203, expected frequency = 76.3, $\chi2$ = 305.9, $p < .001$). Adults were found to be 100% consistent in their responses, with all foods liked at time 1 also liked at time 2 and all foods disliked at time 1 also disliked at time 2 (observed frequency of foods liked at both time 1 and time 2 = 644, expected frequency = 518.4, $\chi2$ = 156 , $p < .001$).

Table 4. Observed and Expected values at Time 1 and Time 2 (children).

			Time 2		
			Like	Dislike	Total
Time 1	Like	Observed	509	46	555
		Expected	382.3	172.7	
	Dislike	Observed	42	203	245
		Expected	168.7	76.3	
		Total	551	249	800

Table 5. Observed and Expected values at Time 1 and Time 2 (adults).

			Time 2		
			Like	Dislike	Total
Time 1	Like	Observed	644	0	644
		Expected	518.4	125.6	
	Dislike	Observed	0	156	156
		Expected	125.6	30.4	
		Total	644	156	800

Parental report on the Food Preference Questionnaire was used to determine the validity of the Explicit Preference Task. To match parental responses to child self-report on the Explicit Preference Task all items for which parents indicated their child 'loves' or 'likes' were re-coded as 'likes', similarly all items for which parents indicated their child 'dislikes' or 'hates' were re-coded as 'dislikes' and directly compared with child self-report on the Explicit Preference Task. Items indicated by parents as 'neither likes nor dislikes' were removed for this analysis. As above, the original dichotomous ('like', 'dislike') value was used as opposed to the transformed continuous scale as this analysis considered consistency for each child-parent pairings, rather than preference determined as a result of a whole group.

A 2 x 2 chi-square analysis was conducted to compare the consistency of child self-report on the Explicit Preference Task with parental report on the Food Preference Questionnaire (Table 6). A significant association was found ($\chi 2 = 3319.2$, $p < .001$). It would be expected if the two measures are comparable, that there would be consistent likes and dislikes than inconsistent.

Post-hoc Bonferroni corrected one group chi-square analyses (significant at $p < .0125$) revealed significant agreement amongst children and their parents in terms of the items liked. Parents indicated children liked 15,529 items, of which 12,087 were indicated to be liked by their children ($\chi 2 = 857.4$, $p < .001$), similarly, children indicated they liked

13,979 items of which 12,087 were indicated to be liked by their parents ($\chi2$ = 1102.5, $p < .001$). However, children indicated greater disliking of foods than was indicated by their parents. Parents indicated children disliked 5408 items, of which 3516 were indicated to be disliked by their children ($\chi2$ = 2461.4, $p < .001$), and children indicated they disliked 6958 items, of which 3516 items were indicated to be disliked by their parents ($\chi2$ =2216.3, $p < .001$). These results suggest parents are more aware of foods their children like than of those they dislike. However, there were more consistent, and fewer inconsistent, likes and dislikes than expected by chance (Table 6).

Table 6. Comparison between child self-report and parental report of child preference.

			Explicit Preference Task		
			Likes	Dislikes	Total
Food Preference Questionnaire	Likes	Observed	12087	3442	15529
		Expected	10368.2	5160.8	
	Dislikes	Observed	1892	3516	5408
		Expected	3610	1797.2	
			13979	6958	20937

2.3.2. Aim 2: Investigate if perceptual attributes (colour, texture and size) influence children's food preferences.

The influence of perceptual attributes (colour, texture and size) on children's food preferences are first examined in relation to mean preference across all children for each of the 230 items tested using Analysis of Variance (ANOVA). Thus the between group variable is each individual food item and not each individual participant. As the participants are not the between group variable it is not appropriate to attempt to 'control for' differences between these groups using Analysis of Covariance (ANCOVA). However, with child BMI a primary concern in the literature and recent research showing child BMI to level off in recent years except for children from lower SES, if perceptual attributes are found to influence children's food preferences it may be helpful to further explore variances with BMI and SES. As such any perceptual attributes found to influence children's food preferences will be further explored post-hoc in relation to BMI and SES.

As shown in Table 2 some food colours are largely associated with specific taxonomic class categories. For example, the majority of 'green' foods are 'vegetables' or 'fruits' and previous research has shown children to dislike vegetables (Cooke & Wardle, 2005). Therefore, if food colour is found to influence food preference further analysis is required to determine if this could be attributable to the food class those items belong to. As texture and size are normally distributed across all taxonomic class categories (Table 2), if these factors are found to influence children's food preferences, further analyses in relation to food class will not be required.

<u>The influence of colour, texture and size on children's food preferences</u>

To investigate if perceptual attributes (colour, texture and size) influence children's food preferences an 8 x 3 x 3 between groups ANOVA[4] was conducted across each of the 230 items assessed, with colour (8 levels: 'brown', 'red', 'orange', 'yellow', 'green', 'purple', 'pink' and 'cream/white'), texture (3 levels: 'firm', 'soft' and 'liquid') and size (3 levels: 'small', 'medium' and 'large') as the independent variables and mean preference against each item (after Mokken scaling analysis, see page 70) across all children as the dependent variable. Significant main effects of colour ($F(7, 229) = 2.19$, $p = .037$) and size ($F(2, 229) = 5.23$, $p = .006$) were found. There was no main effect of texture ($F(2, 229) = .22$, $p = .801$) and no interaction effects were observed. Post hoc Bonferroni corrected analyses (significant at $p < .006$) revealed 'purple' and 'green' foods to be disliked significantly more than 'brown', 'pink' and 'yellow' foods (Table 7, Figure 1) and 'small' foods were found to be liked significantly more than 'medium'.

4 Levenes test has been violated ($F = 2.03$, $p < .001$). Due to the data for this task having been transformed from dichotomous to a continuous scale, it is not appropriate to transform the data further. Thus results must be interpreted with caution. However, with large sample sizes ANOVA is relatively robust to this violation particularly as the other assumptions of ANOVA have been met.

The influence of colour and size in relation to child BMI and SES

With 'purple' and 'green' foods primarily belonging to the taxonomic class categories of 'fruits' and 'vegetables' (Table 2) and with diets high in fruits and vegetables associated with a normal healthy lifestyle, it is possible that differences exist in relation to preference for 'purple' and 'green' items with child BMI. In addition, it might be expected that children from lower SES also have lower preferences for these foods. Therefore, it might be expected that as child BMI increases individual preference for fruits and vegetables decreases and conversely as SES increases it might be expected that preference also increases. Pearson correlation analyses indicated no relationship between either, child BMI or SES and their individual preference for 'purple' and 'green' foods ($r = .073$, $p = .91$, SES $r = .016$, $p = .20$, respectively). Thus children dislike 'purple' and 'green' foods significantly more than 'brown', 'pink' and 'yellow' foods irrespective of their BMI or SES. In addition Pearson correlation analyses were conducted between child preference for 'small' foods across BMI and SES. Results indicated no significant relationship between preference for 'small' foods and child BMI ($r = -.06$, $p = .59$), however there was a significant relationship with SES ($r = -.112$, $p < .001$). With a high SES score indicating low deprivation and a high preference score indicating low preference this suggests children from higher SES have higher preference for 'small' foods than children from lower SES.

Table 7. Mean (SD) child preference against each perceptual attribute[5]

Perceptual Attribute		Mean	SD
Colour	Red	.36	.13
	Brown	.36	.15
	Orange	.34	.13
	Purple	.49	.16
	Pink	.31	.15
	Green	.45	.13
	Yellow	.35	.14
	White	.35	.16
Texture	Soft	.35	.13
	Firm	.38	.17
	Liquid	.38	.14
Size	Small	.33	.14
	Medium	.39	.15
	Large	.46	.13

5 The lower the score the higher the preference for those types of foods

Figure 1. The main effect of food colour on child preference [6]

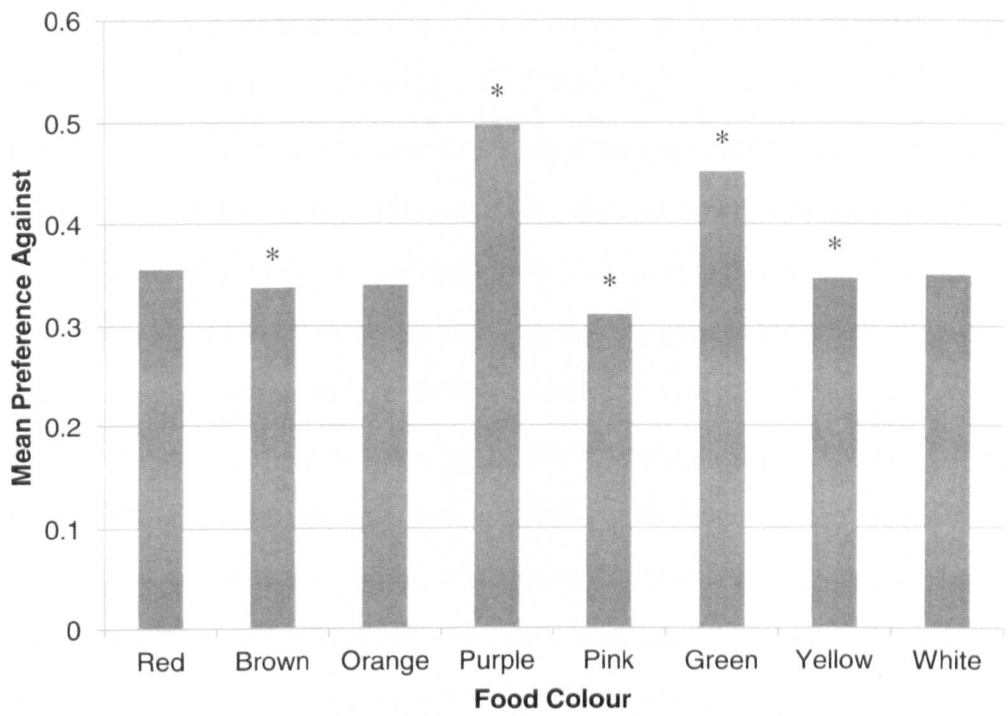
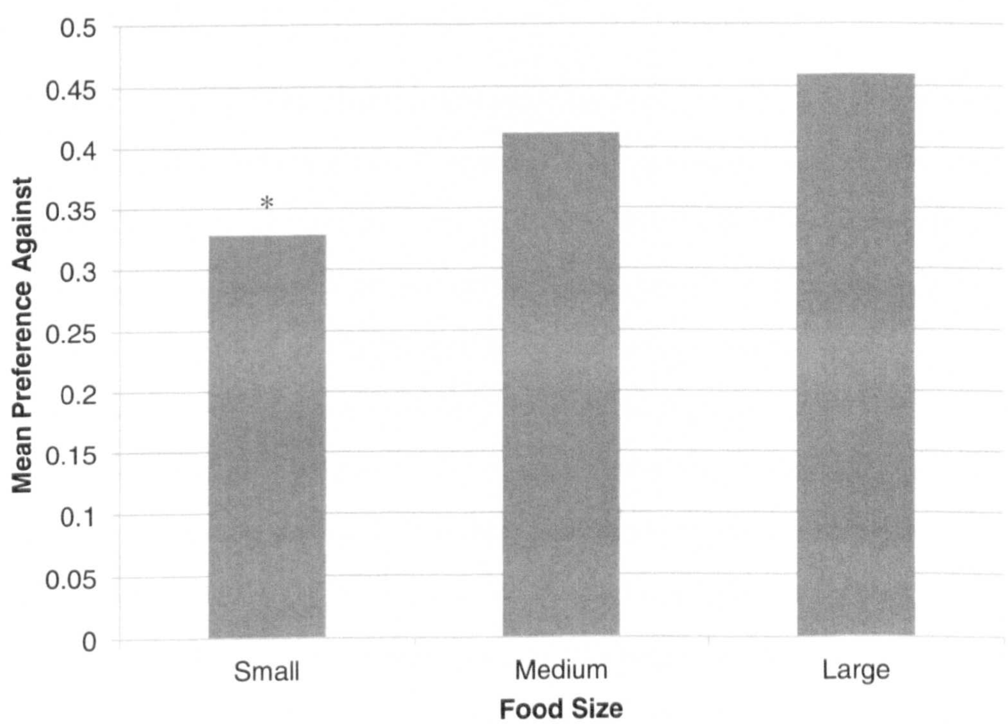


Figure 2. The main effect of food size on child preference



6 * = p < .006

Perceptual attributes and adult's food preferences

Colour is a perceptual attribute that is known to be salient to young children (Baldwin, 1989; Brian & Goodenough, 1929; Pitchford & Mullen, 2001; Suchman & Trabasso, 1966) but not to adults; therefore it would be unexpected for colour to influence adults' food preferences. Similarly although there was justification to suggest children may prefer small foods (e.g., Baby-Led weaning) there is no prior research to indicate food size should influence adult food preferences. However, it is important to determine if the effect of colour and size observed is unique to children or if these perceptual attributes also influence adult food preferences. To examine if colour or size influence the food preferences of adults an 8 x 3 between groups ANOVA[7] was conducted across each of the 230 food items assessed with colour (8 levels: 'brown', 'red', 'orange', 'yellow', 'green', 'purple', 'pink' and 'cream/white') and size (3 levels: 'small', 'medium', 'large') as the independent variables and mean adult preference as the dependent variable. Surprisingly a significant main effect of food colour was found ($F(2, 229) = 2.52$, $p = .016$). There was no effect of size ($F(2, 229) = .049$, $p = .952$) and no interaction between food colour and size ($F(13, 229) = 1.02$, $p = .438$).

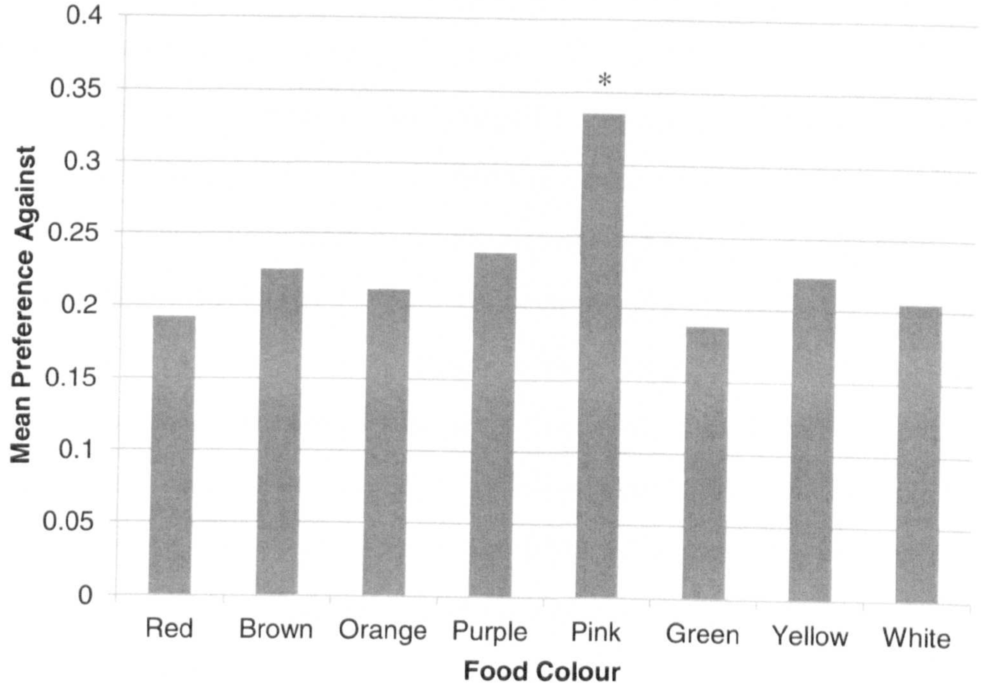
Post hoc Bonferroni corrected analyses (significant at $p < .006$) revealed adults to like pink foods significantly less than all other food colours (Table 8 and Figure 3). Within the data set only 16 out of the 230 items were pink and these primarily belonged to the taxonomic class categories of sweet/snack and meat/fish (7 sweet/snack, 7 meat/fish, 2 eggs/dairy). The dislike of pink foods could be related to social desirability effects with adults indicating they like sweet/snack foods or pink meat/fish items (including ham and bacon) less than they actually do. To examine this each parents score on the Marlow-Crowne social desirability scale (SDS) was correlated with their mean preference, a significant positive correlation was found ($r = .112$, $p < .001$). As the higher a preference score the lower the liking (due to transformation of the data) this suggests parents who score more highly on the Marlow-Crowne social desirability scale indicate lower liking of foods. Therefore the dislike of pink foods in adults could be a social desirability effect.

7 Levenes test was not violated ($F = 1.415$, $p = .109$).

Table 8. Mean (SD) adult preference against each food colour[8]

Food Colour	Mean	SD
Red	.21	.10
Brown	.23	.13
Orange	.19	.09
Purple	.21	.09
Green	.20	.09
Yellow	.22	.09
White	.21	.11
Pink	.36	.14

Figure 3. The main effect of food colour on adult food preferences[9]



8 The lower the score the higher the preference

9 * = p < .006

2.3.3. Aim 3: Examine if there is a relationship between preference and exposure.

BMI, SES and exposure

There is concern over children not consuming the appropriate amount of fruits and vegetables. Therefore, with the dislike of purple and green foods being related to a dislike of vegetables, it is possible this may be related to a lack of exposure to these kinds of foods. Previous research has indicated that children with higher BMI's consume fewer vegetables than other children (Cooke & Wardle, 2005). Therefore, although no difference in preference for purple and green foods was found with either BMI or SES it is possible that children with higher BMI's are exposed to these foods less frequently than other children; in contrast children from higher SES may be exposed to these foods more frequently. To explore the relationship between child BMI, SES and exposure to purple and green foods Pearson correlation analyses were conducted. Results indicated a positive correlation between exposure and BMI ($r = .017$, $p = .005$) and a negative correlation between exposure and SES ($r = -.034$, $p < .001$). However as both SES and exposure are negative scales this translates to indicate exposure decreases with increasing BMI, and similarly exposure increases with increasing SES.

Thus children with higher BMI's appear to be exposed to 'purple' and 'green' foods less frequently than children with lower BMI's and children from higher SES are exposed to 'purple' and 'green' foods more frequently than children from lower SES. However, as no relationship between either BMI or SES on preference for purple and green foods was found (Aim 2) these relationships do not appear to be related to the preference for purple and green foods. This corroborates findings of Craeynest et al. (2005) who reported that although there were differences in the implicit attitudes of children classified as 'obese' compared with a control group, as explicit attitudes did not differ between groups the difference in implicit attitudes may be attributable to a preference for eating rather than a preference for specific foods.

Perceptual attributes and exposure

The observed effects of 'colour' and 'size' on preference could be attributed to the amount of exposure children have to these foods. Previous research has suggested children prefer foods they have had more exposure to (e.g., Birch and Marlin, 1982). Therefore, if the effect of colour and size on children's food preferences is related to exposure it would be expected children have been less exposed to disliked 'purple' and 'green' foods and similarly more exposed to liked 'small' foods. First, to validate the novel methodology and determine if results corroborate those of previous research a Pearson correlation was conducted indicating a small but significant positive correlation between frequency of exposure (as reported by parents on the food frequency questionnaire) and preference ($r = .26$, $p < .001$).

Dislike of 'purple' and 'green' foods and exposure

The dislike of 'purple' and 'green' foods may be a result of less exposure to these items. To investigate if children are exposed to 'purple' and 'green' foods significantly less than other food colours all food items were divided into two groups on the basis of colour ('purple and green foods', 'all other food colours') and a between groups t-test was conducted on the mean frequency of exposure, determined by parental report on the Food Frequency Questionnaire. No significant effect of colour was found ($t\ (193) = -.408$, $p = .684$), indicating children are exposed to 'purple and green foods' as frequently as 'all other food colours'. However, as it was seen there may be a social desirability bias in parent's responses (Aim 2) it was important to correlate parents scores on the SDS with their responses on the Food Frequency Questionnaire. A significant positive correlation was found. Again the higher the score the less exposure parents indicate their children have to a food, suggesting parents who score highly on the SDS indicate their children have less overall exposure to foods. This finding suggests that parents may be indicating their children to have less exposure to sweet/snack foods and carbohydrates than they actually do, resulting in it appearing that children are exposed to other foods (e.g., fruits and vegetables, hence 'purple' and 'green') equally as often. More robust methods, such as a longitudinal diary study, may be more suitable for assessing the frequency with which children are exposed to specific foods. This approach is taken in chapter 3.

The use of colour to categorise novel foods

As indicated in chapter 1, parents have provided anecdotal evidence that children overgeneralise on the basis of colour and reject novel foods that belong to the same colour category as a previously tried and disliked food. This has been supported by the findings of Addessi et al., (2005) who reported children were more inclined to accept a novel food if it was the same colour as a food a significant adult was eating. Therefore the dislike of 'purple' and 'green' foods established in Aim 2 could be related to familiarity and exposure in terms of children using food colour as a basis to accept or reject novel foods. Children typically consume 'fruits' and 'vegetables' less often than recommended by the World Health Organisation (WHO). In addition, 'vegetables' are typically disliked. Therefore it is possible many of the 'purple' and 'green' items in the data set were unfamiliar to the children. As such, it is possible when determining preference in terms of 'like' or 'dislike' children used their previous experience of 'purple' and 'green' foods they have tried, and possibly disliked, as a basis for categorisation of novel purple and green foods, perhaps presuming that colour represents flavour (bitter) or taxonomic class (vegetable).

To determine if children use perceptual attributes to reject novel foods on sight two 2 x 2 chi-square analyses were conducted using the original dichotomous ('like', 'dislike') data. For both 'purple and green' foods and 'all other food colours' the total number of 'liked' and 'disliked' choices, across both 'familiar' and 'novel' foods was compared to the expected frequency based on chance. It would be expected that if children are using food colour as a basis to reject 'disliked' foods on sight then significantly more 'purple and green' novel foods will be disliked than expected by chance. This effect is not expected for 'all other food colours'. Results revealed significant differences for both groups; 'purple and green foods' ($\chi2 = 55.35$, $p < .001$; Table 9) 'all other food colours' ($\chi2 = 6.78$, $p = .009$, Table 8). Post-hoc Bonferroni corrected one group chi-square analyses (significant at $p < .025$) were conducted to explore these associations. These indicated children to like more familiar 'purple and green' foods than expected by chance (observed frequency = 2643, expected frequency = 3592, $\chi2$ = 16.77, p < .001). Similarly, children disliked a higher proportion of novel foods than expected by chance (observed frequency of disliked novel foods = 1088, expected frequency = 948.2, $\chi2$ = 38.56, p < .001). In contrast there was no significant difference between the proportion of novel foods from 'all other food colours' that were disliked than expected by chance (observed frequency = 3756, expected frequency = 3653.4, $\chi2$ = 4.38, p = .04, Table 10). Similarly, there was no significant difference between the proportion of familiar foods that were liked than expected by chance (observed frequency = 12866, expected frequency = 12763.4, $\chi2$ = 2.41, p = .12).

Table 9. Association between 'familiarity' and 'preference' of purple and green foods

			Preference		
			Likes	Dislikes	Total
Familiarity	Novel	Observed	949	1088	2037
		Expected	1088.8	948.2	
	Familiar	Observed	2643	2040	4683
		Expected	2503.2	2179.8	
			3592	3128	6720

Table 10. Association between 'familiarity' and 'preference' of 'all other food colours'

			Preference		
			Likes	Dislikes	Total
Familiarity	Novel	Observed	6930	3756	10686
		Expected	7032.6	3653.4	
	Familiar	Observed	12866	6528	19394
		Expected	12763.4	6630.6	
			19796	10284	30080

As the dislike of 'purple and green' foods appears to be attributable to 'novel' and not 'familiar' foods it is possible that it is the categorisation of novel foods on the basis of colour that is driving the dislike of purple and green foods observed earlier. To explore this hypothesis further all novel foods for each child were removed from the data set and the same 8 x 3 x 3 between groups ANOVA[10] between colour, texture and size with mean preference for each item across all children as the dependent variable was conducted as in Aim 2. Interestingly, when novel foods were removed from the data set the effect of colour was no longer apparent ($F(7, 195) = 1.59$, $p = .142$). There was still no effect of texture ($F(2, 195) = 1.33$, $p = .269$) and an effect of size ($F(2, 195) = 6.55$, $p = .002$) with children preferring 'small' foods to 'medium'.

Thus far it has been seen that children dislike 'purple and green' 'novel' but not 'familiar' foods. It is possible that children have been exposed to fewer purple and green foods than other colours, and as a result of reduced exposure children presume dislike of these foods, whereas other food colours may be more familiar, hence presumed to be liked. However, no significant difference between the proportion of 'novel' 'purple and green' foods and 'all other colours' were observed. Within the data set 19.3% of items were purple or green, of which 13.8% were novel, whereas of the 80.7% of all other food colours 14.4% were novel, indicating that the proportion of novel foods across each colour category to not differ significantly. Therefore it appears the proportion of novel purple and green foods is equivalent to novel foods from other food colours, suggesting unfamiliarity of purple and green foods compared to other food colours to be unable to account for the dislike of novel purple and green foods.

As established elsewhere children generally dislike vegetables whereas fruits are comparatively well liked (Cooke and Wardle, 2005). Of the 19.3% of 'purple and green' foods in this data set 31% belong to the class of 'fruits', 64.3% belong to the class of 'vegetables' and 4.8% belong to the class of 'miscellaneous' (Table 2, p 65). Therefore, the majority of 'purple and green' foods belong to the disliked category of 'vegetables'. Hence, it is possible the dislike of 'novel' 'purple and green' foods observed could be attributable to

10 Levenes test was violated therefore results ought to be interpreted with caution ($F = 1.78$, $p = .007$)

the dislike of 'vegetables', as although children also dislike 'novel' 'purple and green' 'fruits' this may be due to categorisation on the basis of food class. For example, children may have learnt that many purple and green foods are vegetables and many vegetables are disliked, therefore to reject all novel purple and green foods on the basis of colour prior to tasting may prevent an experience of tasting a food they will most likely dislike.

To determine if children may use food class to categorise novel 'fruits' and 'vegetables' two 2 x 2 chi-square analyses were conducted. A comparison was made between preference ('like' or 'dislike') and familiarity ('novel' and 'familiar') in the categories of 'vegetables' and 'fruits' (Table 11 and 12). Results revealed significant differences for both groups, ('vegetables': $\chi 2 = 25.25$, $p < .001$, 'fruits'; $\chi 2 = 52.32$, $p < .001$).

Post hoc Bonferroni corrected one group chi-square tests (significant at $p < .0125$) were conducted to determine the nature of these effects. Results indicated children to like more familiar vegetables than novel ($\chi 2 = 12.63$, $p < .001$), to dislike more novel vegetables than chance ($\chi 2 = 12.6$, $p < .001$), to dislike more novel vegetables than familiar ($\chi 2 = 12.88$, $p < .001$), and to like more familiar vegetables than they dislike ($\chi 2 = 7.35$, $p < .01$) . In contrast children were found to like more familiar fruits than novel ($\chi 2 = 18.78$, $p < 001$), to dislike more familiar fruits than chance ($\chi 2 = 33.54$, $p < .001$), to dislike more novel fruits than chance ($\chi 2 = 41.32$, $p < 001$), and to like more novel fruits than they disliked ($\chi 2 = 11.0$, $p < 001$). These results suggest familiarity may play a key role in the influence of perceptual attributes on children's food preferences; particularly for disliked food categories.

Table 11. Association between 'familiarity' and 'preference' for vegetables

		Like	Dislike	Total
Novel	Observed	1085	1293	2378
	Expected	1188.1	1189.9	
Familiar	Observed	2992	2790	5782
	Expected	2888.9	2893.1	
		4077	4083	8160

Table 12. Association between 'familiarity' and 'preference' for fruits

		Like	Dislike	Total
Novel	Observed	629	515	1144
	Expected	733.3	410.7	
Familiar	Observed	2858	1438	4296
	Expected	2753.7	1542.3	
		3487	1953	5440

2.4. Discussion

This chapter has investigated the influence of food colour, texture and size, in relation to food class and exposure on children's food preferences. First, to develop an objective measure of food preference allowing self-report from very young children, this will then be tested for reliability and validity. Second, using this methodology the influence of perceptual attributes (colour, texture and size) on children's food preferences will be explored with consideration of individual differences across body mass index (BMI) and socio-economic status (SES). Finally, the association between the influence of perceptual attributes and exposure on food preferences will be investigated. These specific aims have been systematically investigated through three distinct tasks, a novel objective measure of preference using child self-report (the Explicit Preference Task), a parental report of child preference (the Food Preference Questionnaire) and an assessment of exposure (the Food Frequency Questionnaire).

Development of an objective measure of food preference

The Explicit Preference Task was developed using high quality coloured photographs of 230 food items across a range of food classes. This method had two distinct benefits for the aims of this thesis. First, the use of high quality coloured photographs of food enabled the influence of perceptual attributes to be considered in relation to children's food preferences. Methods typically used in previous research have been unable to consider these issues either as a result of relying on parental report through questionnaire or through administering tasting tests across a small number of food items, typically from the same food class (e.g., meats). However, recent research has provided support for the reliability of food photographs with pre-school children (Vereecken et al., 2010). Thus, through developing a dichotomous measure of food preference ('like' versus 'dislike') the Explicit Preference Task enabled very young children to self-report on their likes and dislikes across a range of food items, which has not been achieved in previous research.

As no previous research has considered the influence of perceptual factors on children's food preferences, when investigating the role of perceptual attributes it was essential to include a large number of food items, as a small number of items may not adequately reflect the role of colour, texture or size in children's food preferences. The use of a dichotomous measure is thus essential as very young children may be unable to rate their preference for a large number of items on a typical likert scale, such as that used by Vereecken et al., (2010). Furthermore a questionnaire measure typically lists each item only once (e.g., 'carrot' 'pepper'), whereas the use of photographs allowed individual items to be presented a number of times in different presentations. This allowed preferences for different colours and sizes to be systematically investigated (e.g., 'whole carrot' versus 'chopped carrot'; 'red pepper' versus 'green pepper'). Using a test re-test methodology the Explicit Preference Task was found to be reliable, with children being 80% consistent in their responses to the items. In addition, comparison with parental report on the Food Preference

Questionnaire suggested the Explicit Preference Task to be valid. However, the measure of validity ought to be interpreted with caution as the two measures may not be comparable, thus further research ought to be conducted comparing child-self report on the Explicit Preference Task to child self-report using a tasting test. Future research investigating children's food preferences ought to use objective measures as these may enable more complex associations between individual food items and preference to be systematically investigated.

The influence of perceptual attributes on children's food preferences

The Explicit Preference Task revealed colour and size, but not texture, may influence children's food preferences. Specifically, children were found to dislike 'purple' and 'green' foods more than 'brown', 'pink' and 'yellow' foods, irrespective of their BMI or SES. In addition they preferred small foods to medium and large.

Colour

For the first time this thesis has provided some evidence that children may have preference for certain food colours over others. With previous research indicating colour to increase acceptance of novel foods (Addessi et al., 2005) it was hypothesised colour preference might be used by children to categorise novel foods, thus rejecting foods belonging to disliked colour categories and accepting foods belonging to preferred colour categories.

There is widespread agreement in the literature for an association between food preference and exposure; moreover the effect of food colour observed here appears to be related to familiarity. Many studies have indicated children to prefer foods they have been more exposed to (e.g., Birch and Marlin, 1982; Wardle et al., 2003). Hence it was hypothesised that any dislike of foods would be related to lower exposure to those foods. Findings indicated that novel foods of disliked colour categories (purple and green), but not familiar foods, were more likely to be presumed to be disliked than expected by chance, whilst novel foods of 'all other colours' were more likely to be presumed to be liked. Further to this, removal of novel food items from the analysis led to the effect of colour also being removed. Thus it appears children may be using colour as a basis for categorisation to determine acceptance of novel foods. The Explicit Preference Task was unable to experimentally assess the use of colour as a basis for categorisation; however the specific role of colour in the categorisation of foods is explored systematically in chapter 4 to add further insight into the findings reported here.

The findings presented in this chapter have indicated children may be using food colour to categorise novel foods. Further research is needed to understand the process by which this may occur. For example, children may dislike specific colours as a result of an innate taste preference against certain flavours; novel foods that are perceptually similar in terms of colour may thus be rejected as the colour-taste association has been extended to all food items. If food colour is a mechanism by which children make decisions about whether to accept or reject a novel food, particularly vegetables, understanding the cognitive processes by which children may make this decision could help parents develop methods to persuade their children to try a broader range of vegetables. Ultimately food preferences are likely to be determined on the basis of taste. However, through combining knowledge of innate taste preference with the suggestion that children may use food colour to categorise foods it is possible for parents to encourage children to taste more vegetables. For example parents could provide green vegetables that are more likely to be accepted by their children due to a sweet taste (e.g., peas) prior to offering a bitter green vegetable (e.g., broccoli). It is unclear if overextension of the colour-flavour association will occur for disliked and liked foods, this needs to be tested experimentally.

Size

Alongside the effect of food colour there was also a significant effect of food size with children preferring ‘small’ foods to ‘medium’ and ‘large’. This supports the views of Baby-Led weaning (e.g., Brown and Lee, 2011; Rapley, 2005; Sachs, 2011; Wright et al., 2010), although there is no empirical evidence to suggest the ability to pick up food and feed one-self is a desirable trait for young children. It was the aim of this chapter to determine if the perceptual attributes of colour, texture and size influence food preferences and to consider how this may relate to food class and exposure. The effect of food size is unlikely to be related to taxonomic class due to items tested being normally distributed in terms of size across each class category. As such further research is required specifically investigating why small foods appear to be preferred and if this is related to children having a preference to be independent feeders from a young age. These issues cannot be addressed through the present study. Future research ought to specifically address this question by experimentally investigating if children show a preference for small foods over larger items. Despite this, the finding that children do prefer small foods is important and novel. No previous research to my knowledge has provided empirical support in this regard.

In addition to the role of colour, understanding the influence of food size on children's food preference could also help parents, health practitioners and food manufacturers to provide children with food they may be more accepting of. It is possible, if young children have a preference for foods they can pick up and feed to themselves, and parents respond to this preference, meal times may be more enjoyable for families. Parents may be able to sit down with their children and eat their own meal while their children feed themselves, rather than requiring their assistance.

Texture

Despite categories of texture in the present study being fairly broad ('firm', 'soft' and 'liquid') no effect of texture on children's food preferences was found in the present study. Previous research which has found an effect of texture on food preference (Harris, 2008) has typically used more refined categories; therefore it is surprising no effect was observed in the present study. A possible explanation for the lack of effect of texture is in terms of the methodology compared with previous research. The use of photographs as opposed to a tasting test may have masked the effect of texture. A photograph of a food item clearly demonstrates its colour and size but not necessarily its texture. For instance looking at a photograph of a 'pear' it is clearly green and would fit in your hand, and although colour may indicate ripeness, it may be unclear if, on biting into the pear, if it would be soft or firm. Although the findings of this chapter has suggested texture may be relatively less important than other perceptual attributes in the development of food preferences, further research would need to be conducted using a variety of methods, including tasting tests, to clarify the role of texture. It may be that colour and size are important in terms of food acceptance and rejection prior to tasting, whereas perhaps once a food has been accepted texture becomes important alongside taste in whether a preference for that item develops. Current research into this cannot provide a definitive answer as to the relative importance of colour, texture and size alongside each other in children's food preferences.

Implications of the role of perceptual attributes on children's food preferences

If children are presented with food that is more visually appealing and easy to consume without assistance, parents may not need to spend a lot of time persuading their children to eat. Research has shown children who are pressured to eat at a young age are more likely to develop into selective eaters (Batsell et al., 2002), which may also have the potential to lead onto food related disorders in adulthood (e.g., eating disorders). Although the finding that children prefer small foods cannot inform if using this information could prevent future feeding problems, it is important for future research to investigate this issue as this finding has not been reported elsewhere.

Future research into children's food preferences ought to consider the role of perceptual attributes, particularly when considering acceptance and/or rejection of novel foods. Colour and size are both salient perceptual attributes that may be easily used by children when determining acceptance of novel foods. With research indicating the importance of tasting, rather than looking, for exposure to influence preference (e.g., Birch and Marlin, 1982), gaining information on how to encourage children to taste new foods could help to modify developing food preferences. Although an effect of colour was found for adults in this study the dislike of purple and green foods was not apparent in the adult sample, therefore it would be interesting for future research to consider the age at which children are no longer influenced by food colour, and use other methods (such as food class) to categorise novel foods. This is addressed in this thesis in chapter 4.

With some research suggesting foods introduced after the age of 4-years more likely to be rejected than accepted and food preferences established by the age of 8-years predicting food preferences in adulthood (Skinner et al, 2002) it is vital parents and health practitioners are fully aware of all factors that can influence preferences at an early age.

Exposure is known to influence preference therefore increasing exposure could also increase preference for particular foods. The importance of exposing children to purple and green foods more frequently becomes apparent when considering children with higher BMI's, despite not having lower preferences for purple and green items than other children, were found to be exposed to these items less frequently. As many purple and green foods belong to the categories of fruits and vegetables, less exposure may result in less consumption of fruits and vegetables. Chapter 3 thus explores further the relationship between food colour and exposure with consideration of BMI, using a longitudinal diary methodology.

2.5. Conclusion

Through the use of a novel experimental measure chapter 2 has provided new evidence for the potential role of colour and size in the development of food preferences. Despite BMI not being related to preference, results indicated exposure to disliked 'purple' and 'green' foods to decrease with increasing BMI. Chapter 3 considers the influence of food colour in relation to portion size and frequency of exposure through the use of a longitudinal food diary method, to gain further insight into the differences in the amount of food offered to and consumed by children differing in BMI and how this may relate to the dislike of purple and green foods.

Chapter 3: A Longitudinal Food Diary Study

3.1. Introduction

The Explicit Preference Task alongside the Food Frequency Questionnaire presented in chapter 2 have enabled exploration of the types of foods children like and dislike and some insight into the relationship between food colour, preference and exposure. However, when considering the role of exposure in children's food preferences, particularly when examining differences across child BMI, longitudinal methods may enable a more in depth understanding of the interplay between preference and exposure to be uncovered. Therefore this chapter presents a Longitudinal Food Diary Methodology, tracking the type and amount of food offered to and consumed by children over a period of time. Furthermore, it was observed in chapter 2 that there may have been a social desirability bias in parent's responses on the Food Frequency Questionnaire, perhaps underestimating the extent to which children are exposed to 'unhealthy' foods, such as sweet and snack items. Through completion by a sub-sample of participants from the previous chapter, the Longitudinal Food Diary aims to validate the use of the Food Frequency Questionnaire[11].

Food diary studies have been commonly used to measure children's food consumption patterns. However, the majority of previous food diary studies have been of fairly short duration, typically either a 24-hour recall or a 3-day diary, with the occasional diary being completed for 7-days (e.g., Belderson et al., 2003; Cade et al., 2006; Johnson et al., 2001; Lanigan et al., 2001; Lillegaard et al., 2007; Macdiarmid et al., 2009; Moore et al., 2005; Vereecken et al., 2008). Despite many benefits to the use of a longitudinal food diary methodology, to my knowledge no previous published study has used this method for more than a 7-day period. There are a number of methodological reasons for this, for example studies that require parents to weigh food pre- and post-consumption are unlikely to retain participants for a longitudinal study. Methods have been utilised to overcome this difficulty, for example photographs have been used to estimate portion size, which can replace the traditional approach of weighed food records.

The use of photographs to estimate portion size has been found to be reliable and

11 It must be noted that as the Longitudinal Food Diary method is also a parental report methodology it may be no more valid that the Food Frequency Questionnaire developed in chapter 2.

valid. One study that has successfully used food photographs to estimate portion size in young children is that conducted by Øverby, Lillegaard, Johansson and Anderson (2004). They examined the sugar intake of 2561 4-, 9- and 13-year-old Norwegian children. Food intake was recorded using a pre-coded food diary over a four-day period, completed by parents of the 4-year-old children and with self-report for the 9- and 13-year-olds. Each participant received a photographic booklet consisting of 13 series of photographs, each with four different portion sizes ranging from small to large. To evaluate the effectiveness of this measure Lillegaard and Anderson (2005) presented 63 participants aged between 9- and 19-years with plates of food and asked them to compare the portion sizes to the foods depicted in the photographs. Overall participants correctly identified 60% of the portion sizes using the photographic booklet, suggesting that using photographs to help estimate portion sizes of a variety of foods is a useful tool to gain information into the amount of food children are offered and consuming without the need for weighing. Through making food diaries easier to complete parents may be more inclined to participate in these studies for a longer period of time. As such it may be possible to understand more fully the relationship between preference and exposure.

Lillegaard and Anderson (2005) have shown that with careful consideration over methodology the use of a longitudinal diary study could provide important insight into children's consumption patterns that cannot be accessed through other methods (e.g., objective measures, questionnaires) or diaries of shorter duration. This method enables the influence of colour observed in chapter 2 to be considered further in relation to exposure. Exposure can, however, be measured in two distinct ways, either through frequency of exposure, as in the Food Frequency Questionnaire (e.g., once a day, more than once a week etc.) or in terms of the quantity offered at any one time (e.g., two foods are offered three times a day but one of those foods is always offered in greater quantity than the other). Therefore, although children may be receiving purple and green foods as frequently as other foods it is possible smaller portions of purple and green foods are offered. This may account for the dislike observed. Therefore the composite measure of exposure (frequency + portion size) may be relatively small.

Another area of importance that previous research has not accounted for is the difference between visual exposure and exposure in terms of consumption. Until recently research has implied exposure to influence preference only when a food is consumed and not simply by visual exposure to that food (e.g., Birch & Marlin, 1982). With children showing dislike of purple and green foods and yet being exposed to these as frequently as other colours (chapter 2), it is possible children may receive purple and green foods as frequently as preferred foods and perhaps in equal quantity, however they may consume smaller amounts of these than other colours. The distinction between frequency and quantity of exposure and between the amount offered and that consumed has not been explored through previous research. The use of the novel Longitudinal Food Diary method in this chapter enables these differences to be assessed. Thus, further to considering differences in the amount of food offered across various food colours, analyses will be conducted to consider the difference between the amount offered and that consumed.

Furthermore, although the Explicit Preference Task revealed the effect of colour was found to exist across all BMI groups there was a significant relationship between BMI and exposure to disliked 'purple' and 'green' foods, with children with higher BMI's being exposed to these foods less frequently than children with lower BMI's. With the majority of purple and green foods belonging to the taxonomic class categories of fruits and vegetables, and consumption of fruits and vegetables being associated with a healthier lifestyle, it is important to further investigate the relationship between exposure and consumption of these foods in relation to child BMI. As exposure is known to influence preference, if food preferences bear any influence on child BMI it would be expected as BMI increases exposure to 'healthy' foods such as fruits and vegetables, and hence purple and green foods, would decrease, supporting the findings of the Explicit Preference Task (chapter 2).

Another factor able to be considered with a longitudinal diary method is any differences throughout the year in the kinds of foods consumed. Previous research has not addressed this. However, children may consume more colours associated with fruit and vegetables (e.g., purple, green, red, orange) in summer than in winter, and similarly it may be expected that more brown foods (carbohydrates, chocolate etc.) may be consumed in winter than summer. Therefore a study of food consumption patterns conducted in winter may indicate children not consuming enough fruit and vegetables, when this may be counteracted by the amount consumed in summer. This may be important as if differences in either the type or amount of food consumed are observed at different times of the year future research conducted over a shorter period of time would need to account for this. Therefore alongside an examination of the relationship between food colour and exposure, this chapter explores the food colours children are exposed to at different times of year, considering how this may relate to preference and exposure.

For the first time, this chapter presents a Longitudinal Food Diary Study aimed to explore differences in the foods offered to and consumed by children across a range of BMI percentiles, at different times of year. This allows further exploration of the relationship between food colour and exposure in relation to children's food preferences. This chapter has three specific aims relating to the relationship between food preference and exposure. First, the novel methodology will be used to validate the Food Frequency Questionnaire administered in chapter 2; next, the relationship between food colour and exposure is examined; and finally, consideration is given to any differences in the food colours children are exposed to at different times of year, considering how this may relate to preference and exposure.

3.2. Methodology

3.2.1. Participants.

To investigate the specific aims of this chapter a sub-sample of 16 participants (10 male, 6 female) were recruited from the Explicit Preference Task (see chapter 2), selected specifically across a range of child body mass index percentile ranks (M = 65th percentile, Min = 19, Max = 96, SD = 26.6). First, ten families were approached to participate in a one month pilot study aimed to validate the Food Frequency Questionnaire and to establish the effectiveness and feasibility of the diaries. Following this 25 families were contacted (including those who participated in the pilot study) to participate in a longitudinal study to complete the diaries for four months on a quarterly basis over the period of one year (September, December, March and June). A total of 23 parent-child pairs were recruited, 7 families chose to discontinue the study after the first month, the remaining 16 parent-child pairs completed the full four months. All participants were from middle to high socioeconomic status and were aged between 22 and 79 months (M = 48.3, Min = 22, Max = 79, SD = 17.8).

3.2.2. Apparatus and materials.

Participants were provided with four identical 28-day food diaries designed specifically for this study. For ease of use and to encourage accuracy of entries each day was divided into six four-hour time sections (Appendix 5). As it was important not only to gain information about the type but also the amount of food children were offered and consuming, a set of five photographs were included to allow estimates of portion size (small, medium and large) to be provided by parents (Appendix 4). This method of using food photographs to estimate portion sizes has been validated by previous research (e.g., Foster, Matthews, Nelson, Harris, Mathers & Adamson, 2006; Lillegaard et al., 2005; Nelson, Atkinson & Darbyshire, 1994; Turconi, Guarcello, Berzolari, Carolet, Bazzano & Roggi, 2005).

A modified version (modified to include a smaller number of sets of photographs and to be applicable to a British diet) of the photographic booklet used by Øverby et al., (2004; validated by Lillegaard et al., 2005) was included in the present study which allowed parents to make accurate estimates of the portion sizes offered to and consumed by their children. It must however be noted that the portion size photographs were not age adjusted in the present study therefore may not accurately reflect the relationship between exposure and preference due to the range of ages of the participants included in the sample. For instance a 'small' portion to a 6 year old may actually be a 'large' portion to a 2 year old. Therefore any observed relationship between exposure and preference must be interpreted with caution. To ensure accuracy of diary entries participants were provided with stamped addressed envelopes to return the completed diary at the end of each 24-hour period.

3.2.3. Procedure.

All participants were invited by letter to attend a half-day training session prior to beginning the study. The training session outlined the general purpose of the study, provided specific instructions on how the diary was to be completed and offered the opportunity for all participants to ask any questions that they may have. During the training session parents were provided with a Food Diary and stamped addressed envelopes for the first 28-day period (September) with instructions to begin completing the diary on the first day of the month. All participants were provided with a contact telephone number and email address and informed they could contact the experimenter at any time if they had any questions regarding the study. Similarly, all participants provided the experimenter with a contact mobile telephone number with permission to receive a text message once a day over the course of each month they were completing the diary, as a reminder to complete it and return it at the end of each day.

For each 28-day period parents were required to complete the diary on a daily basis including all food and beverages offered to and consumed by their child. For each item listed an estimate of portion size using the photographs provided was to be recorded and an indication of how many portions, of that size, their child was offered. In addition, parents were requested to record of the portions offered how many were consumed (an example is provided in Appendix 5).

Parents were instructed to be as specific as possible and to list every item individually rather than the label of the overall meal. For example, if the meal was 'spaghetti bolognaise' the diary should include 'spaghetti pasta', 'minced beef in tomato based sauce', and estimates of portion size for each of these. In addition, for items that could belong to more than one colour group (e.g., apples can be green, yellow or red) parents were to indicate which colour the item was. This allowed more accurate investigation into the portions of different food colours (e.g., pasta compared to meat, and cream compared with brown/red).

At the end of each day, in order to ensure diaries were completed on a daily basis and not using recall, parents were asked to return each day's diary using the stamped addressed envelope provided. At the end of each 28-day period once the full set of diary entries had been returned participants were sent thank you letters and vouchers[12] as reimbursement for their time. The value of the vouchers increased each month (£10 at the end of month 1, £20 at the end of month 2, £30 at the end of month 3 and £40 at the end of month 4) to help encourage participants to continue completing the diaries for the full four

12 Cow and Gate Vouchers were kindly donated by Danone Babyfood Nutrition to be exchanged for a variety of their products. High street gift vouchers were also used in addition.

months required. For those who completed the entirety of the study a total of £100 worth of vouchers was received.

3.2.4. Data analysis.

Data were analysed using SPSS version 16. Throughout this chapter the independent variable relates to the number of food items rather than the number of participants. Only full data sets (each of the four months) were included in any analysis. First, pilot data (n = 10; collected prior to the first month of the full study and not included in the full analysis) was analysed separately to assess reliability of the Food Frequency Questionnaire. The number of times an item had been offered over the 28-day period was calculated and converted to relate to the scale used in the Food Frequency Questionnaire (e.g., cucumber was offered in total 4 times over 28-days, which is equivalent to once a week). To investigate exposure in terms of frequency and portion size a composite measure of exposure was calculated by first calculating the frequency of times each item was offered for small, medium and large portions. Then the number of times a food was offered across each month was multiplied by its portion size (small = 1, medium = 2, large = 3), the sum of these resulted in a composite measure of exposure for each item accounting for both frequency and portion size. For example, a small portion of cereal may have been offered 10 times, and a medium portion 5 times; the number of small portions would be multiplied by 1 (small = 10*1 portions = 10) and the number of medium portions by 2 (medium = 5*2 portions = 10), thus the total quantity for small portions of cereal would be 10, and for medium portions would also be 10, as such the composite measure for exposure to cereal would be 20 portions. Data were checked for normality prior to using parametric statistical analyses.

3.3. Results

Data were collated and analysed in line with the specific aims of this chapter. First the validity of the Food Frequency Questionnaire was assessed, then the relationship between food colour and exposure was examined, and finally differences in food colours offered throughout the year were considered in relation to preference and exposure.

3.3.1. *Aim1: Validation of the Food Frequency Questionnaire*

One month pilot data (n = 10) was analysed to assess the validity of the Food Frequency Questionnaire[13]. The number of times an item had been offered to each participant over the 28-day period was calculated and a Pearson correlation analysis was conducted to determine the relationship between how often each food is actually offered and how often parents indicated they are offering each item in the Food Frequency Questionnaire. There was found to be a significant positive correlation ($r = .79$, $p < .001$).

3.3.2. *Aim2: Further exploration of the relationship between food colour and exposure*

Chapter 2 indicated children to dislike purple and green foods more than brown, pink and yellow foods. This was associated with a dislike of vegetables. Although, using a food frequency questionnaire, no significant difference was observed in the frequency of exposure children have to purple and green foods compared with other colours, it is possible children receive less exposure in terms of quantity (portion size) rather than frequency.

Thus, to investigate further the dislike of purple and green foods over brown, pink and yellow established in chapter 2, the Longitudinal Food Diary study was analysed to explore the relationship between food colour and exposure, considering both frequency and quantity. All items were coded to represent the colours used in the Explicit Preference Task (chapter 2). Independent raters were not used for this task, however each item was carefully matched to a corresponding item in the Explicit Preference Task and parents were asked to indicate food colour for items that may be ambiguous in this regard (e.g., 'apple'; asked to specify if red, green or yellow). Using these codes food items were grouped into colours that were 'liked': brown, pink and yellow; 'disliked': purple and green; and 'neither liked nor disliked': red, orange, cream and mixed.

An ANCOVA was conducted with 'food colour' (3 levels; 'liked': brown, pink and yellow; 'disliked' green and purple; and 'neither liked nor disliked' red, orange, cream and mixed) as the independent variable and a composite measure of exposure (frequency and

13 It is a difficulty within the child food preference literature to develop methods that ensure reliability and validity. Often, as in this instance, parental report is used, thus validity may not be able to be accurately determined. The Food Frequency Questionnaire used in chapter 2 is a parental self-report measure, as is the Food Diary method used here. It would be very difficult to ensure validity when investigating exposure to and consumption of foods without the experimenter being present and recording the data directly, or video recording the child on a daily basis. These methods are not only difficult but do not fully eradicate the potential bias as parents will still be aware that the food they offer to their children is being observed and measured.

quantity) as the dependent variable, with BMI added as a covariate. To calculate the composite measure of exposure the mean number of portions offered for each individual colour was multiplied by the portion size, 'small' = 1, 'medium = 2, 'large' = 3. This composite measure enabled consideration of both frequency and quantity of portions.

A significant effect of food colour was found ($F(2, 47) = 57.41$, $p < .001$), there was no effect of child BMI ($F(1, 47) = 1.64$, $p = .206$). To explore the main effect of colour a one way between groups ANOVA[14] was conducted with food colour as the independent variable and the composite measure of exposure as the dependent variable. The composite mean (SD) number of portions offered for each food colour category is shown in Table 13. Post hoc Bonferroni corrected analyses (significant at $p < .0001$) revealed fewer portions of 'disliked' purple and green foods to be offered than both 'liked' brown, pink and yellow foods and 'neither liked nor disliked' food colours. There were no significant differences between 'liked' and 'neither liked nor disliked' food colours.

Table 13. The composite mean number of portions offered for each food colour category

	Mean	SD
'Liked' (brown, pink and yellow)	962.15	77.35
'Disliked' (green and purple)	217.1	29.84
'Neither liked or disliked' (red, orange, cream and mixed)	856.9	41.77

Previous research has suggested that for exposure to influence preference a child needs to consume a food rather than simply be visually exposed to it (Birch & Marlin, 1982). Therefore as children are offered fewer portions of 'disliked' purple and green foods than other colours it is expected that there will be a significant positive correlation between the amount offered and amount consumed, with the number of portions consumed increasing with the number of portions offered. A composite measure of the number of portions consumed was calculated as for the number of portions offered and a Pearson correlation

14 Levenes test was not violated ($F = .962$, $p = .390$).

analysis was conducted. Results revealed a significant positive correlation between the amount offered and that consumed ($r = .94$, $p < .001$), indicating that children are not only being offered, but are also consuming, fewer portions of purple and green foods.

It is unclear however the order by which this relationship presents itself. To clarify, parents may offer fewer portions of 'disliked' purple and green foods as a result of children disliking these kinds of foods. In contrast children may consume fewer portions of these foods as a result of being offered fewer portions, which in turn may impact on preference. If the latter is true it would be expected if the amount of 'disliked' purple and green foods offered increased then the amount of these foods consumed would also increase. To explore this hypothesis it is necessary to examine the relative difference between the amount offered to that consumed for 'liked', 'disliked' and 'neither liked nor disliked' food colours. Thus, the difference between the amount offered and consumed was calculated for each item to create a new dependent variable and a one way between groups ANOVA[15] was conducted with 'food colour' (3 levels, 'disliked', 'liked' and 'neither liked nor disliked') as the independent variable. There was no significant effect of 'food colour' on the difference between the amount offered and that consumed ($F(2, 47) = .44$, $p = .65$, 'disliked': $M = 56.96$, $SD = 156.16$; 'liked': $M = 47.35$, $SD = 121.73$; 'neither liked nor disliked' $M = 89.19$, $SD = 117.50$).

Thus far results have indicated children (across a range of BMI percentiles) to be exposed to 'disliked' food colours significantly less frequently than other coloured foods. Despite there being a significant positive relationship between the amount offered and that consumed, the lack of an effect of colour on the difference between these measures (offered and consumed) suggests that children are consuming similar proportions of the food they are offered irrespective of whether the food belongs to a 'liked', 'disliked' or 'neither liked nor disliked' category. This suggests that if the quantity of 'disliked' foods offered increased this may result in an increase in consumption of these foods, which could have a positive impact on preference. Further research is needed to explore this hypothesis.

15Levenes test was not violated ($F = 1.73$, $p = .188$)

3.3.3. *Aim 3: Examine differences in the food colours children are exposed to at different times of year*

A distinct benefit of the Longitudinal Food Diary Study is the ability to consider differences in the foods offered and consumed throughout the year. If differences exist future research using cross sectional methods need to account for the time of year the study is being undertaken as results may be influenced by this. With this aim being related to individual colours, rather than mediated by preference as in aim 2, the analysis considering the relationship between food colour and exposure throughout the year compares each individual colour to each other, rather than grouping on the basis of preference (e.g., 'liked', 'disliked etc.). A mixed ANOVA was conducted with month (4 level, 'September', 'December', 'March' and 'June) as the within subject variable and food colour (9 levels; 'Brown', 'Red', 'Orange', 'Green', 'Yellow', 'Purple', 'Pink', 'Cream', 'Mixed') as the between group variable and the composite measure of exposure (the sum of the number of portions offered multiplied by portion size: 1 = small, 2 = medium, 3 = large) as the dependent variable. Significant effects of month and food colour were found ('month': $F(3, 405) = 8.19$, $p < .001$; 'food colour': $F(8, 135) = 39.2$, $p < .001$) and there was a significant interaction ($F(24, 405) = 1.92$, $p = .006$).

To investigate the main effect of 'month' a series of paired samples t-tests were conducted. Significant differences were found between 'March' and each of the other months ('September': $t(143) = 3.74$, $M = 72.5$, $SD = 66.2$, 'December': $t(143) = 3.81$, $M = 71.9$, $SD = 61.2$, 'June': $t(143) = 3.83$, $M = 71.9$, $SD = 58.3$, $p < .001$) with fewer portions being offered in March ($M = 58.4$, $SD = 52.9$). There were no significant differences between any of the other months. Post hoc Bonferroni corrected analyses (significant at $p < .001$) were conducted to explore the main effect of food colour (Figure 5, Table 11) revealing significantly more portions of 'brown' food to be offered than all other colours except cream; and fewer potions of 'purple' and 'pink' foods than 'cream', 'orange' and 'yellow'. Other significant differences are shown in Table 14.

Figure 5. Mean composite exposure across each food colour

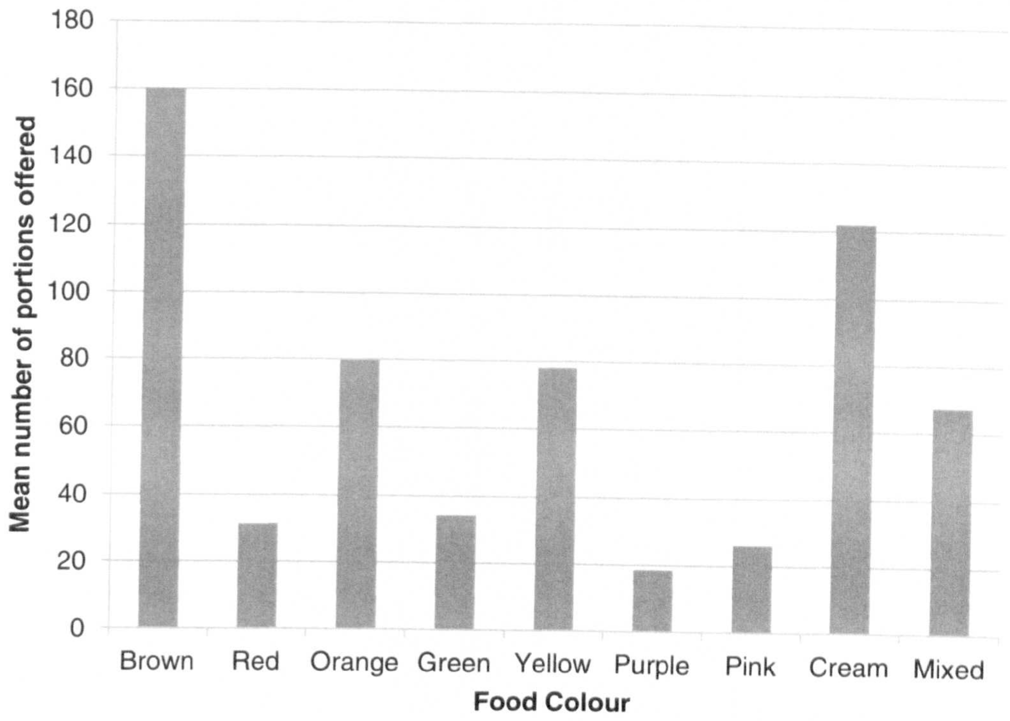


Table 14. Mean difference in the number of portions offered between each colour across all months.

	Red	Orange	Green	Yellow	Purple	Pink	Cream	Mixed
Brown	128.82*	80.46*	125.86*	82.07*	141.58*	133.91*	38.13	92.81*
Red		-48.36	-2.96	-46.76	12.76	5.09	-90.69*	-36.03
Orange			45.4	1.6	61.12*	53.45*	-42.33	12.34
Green				-43.81	15.72	8.05	-87.73*	-33.07
Yellow					59.51*	51.85*	-43.94	10.73
Purple						-7.66	-103.45*	-48.78*
Pink							-95.78*	-41.12
Cream								55.67

*p < .001

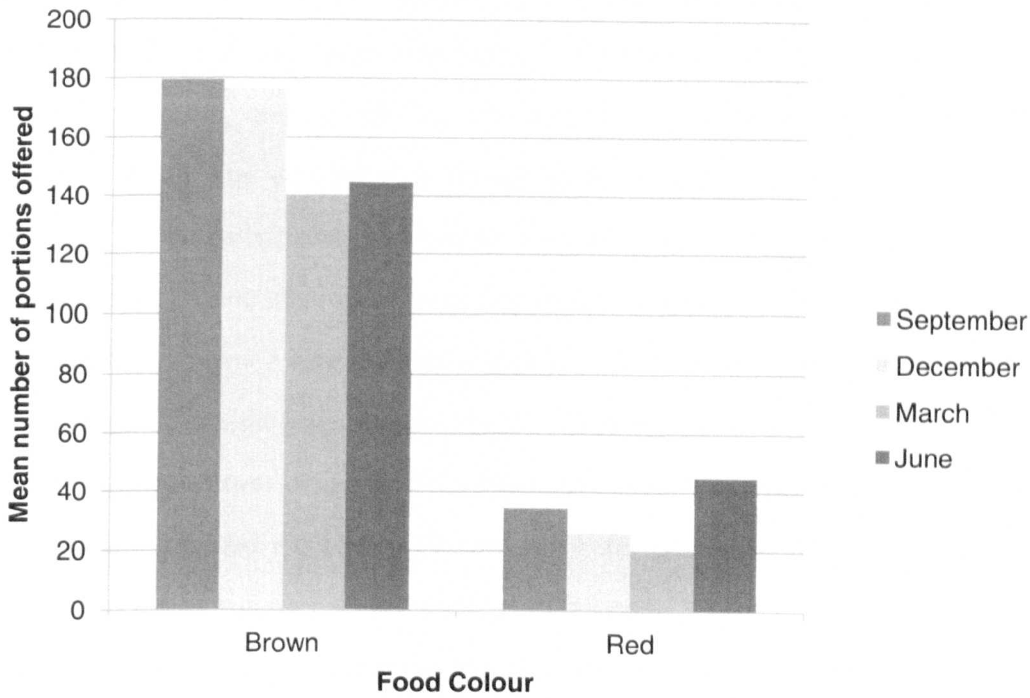
Next, to explore the significant interaction between 'month' and 'food colour' a series of nine repeated measures ANOVA's were conducted across each food colour with 'month' as the independent variable and the composite measure of exposure as the dependent variable revealing significant effects of month for 'brown' and 'red' foods ($F(3, 45) = 4.8$, $p = .005$, $F(3, 45) = 3.09$, $p = .037$, respectively), no significant effects of month were found for any other food colour (Table 15).

Table 15. The mean number of portions offered across each 'month' and 'food colour'

	September	December	March	June
Brown	179.45	176.5	140.29	144.54
Red	34.41	26.31	19.59	45.19
Orange	78.43	82.78	67.97	89.77
Green	32.88	31.28	34.69	38.5
Yellow	81.37	79.40	67.15	84.60
Purple	19.44	25.02	18.78	11.25
Pink	29.78	28.03	21.84	25.49
Cream	132.66	134.09	91.03	130.5
Mixed	64.48	63.28	64.21	77.63

To further explore the effect of month on brown and red foods six post hoc Bonferroni corrected (significant at $p < .008$) paired t-tests were conducted for both 'brown' and 'red' foods comparing each month to each other (September to December; September to March; September to June; December to March; December to June; and March to June). No significant differences were observed for 'brown' foods, however, for 'red' foods there was a significant difference in the number of portions between 'March' and 'June ($t(15) = -5.18$, $p < .001$). Figure 6 displays the mean number of portions offered for 'brown' and 'red' foods across each month.

Figure 6. The mean number of portions offered across each 'month' and 'food colour'.



It is possible that the effect of red foods between March and June is due to the overall phenomena on fewer portions being offered in March compared to all other months. However, if this were the case it would be expected this would be true for all months compared to March. An interpretation of these findings, alongside the other results reported in this chapter relating food colour, preference and exposure are discussed next.

3.4. Discussion

<u>The use of a Longitudinal Food Diary</u>

This chapter has demonstrated the feasibility of a Longitudinal Food Diary Study. Twenty five families successfully completed the diaries for a period of one month, and sixteen families continued to complete the diary for a total of four months on a quarterly basis over the period of one year. Other food diaries in the literature have been completed for a maximum of 7-days, and typically for only 3-days (e.g., Lillegaard et al., 2007, Macdiarmid et al., 2009). This demonstrates through careful consideration of methodology and close contact with participants' longitudinal food diaries are an appropriate and successful method for gaining information regarding children's food consumption patterns. The ability to collect data over a longer period of time than in previous studies is important as it allows a more naturalistic investigation into the foods offered to and consumed by children with consideration over differences in portion size. In addition, repeating the study on a quarterly basis enabled exploration of how the foods offered to children change seasonally and how this may impact on developing preferences.

The success of this method can be attributed to three factors; firstly, all participants had taken part in the Explicit Preference Task presented in chapter 2, and as a result the experimenter and the nature of the research was familiar which may aid in a greater retention of participants; secondly, the use of a modified version of the photographic booklet used by Øverby et al., (2004) to estimate portion sizes, enabled parents a quick and easy method for estimating portion size; and finally, the experimenter contacted parents every day as a reminder to complete the diaries and post them back each day. The contact with the experimenter was a vital aspect of ensuring this data was of high quality, complete and accurate, whilst also enabling a relationship to form between participants and the experimenter. The use of technology, such as palm pilots, could enable this kind of data to be collected on a larger scale in future research.

Food colour preference and exposure

The primary aim of this chapter was to further explore the relationship between food colour preference and exposure in relation to child BMI observed in chapter 2. The food diary methodology revealed all children, irrespective of their BMI, to receive 'disliked' purple and green foods less often than other coloured foods. Although contradictory to the findings presented in chapter 2, it has already been discussed how the diary method can account not only for frequency of exposure, but also quantity in terms of portion size. However it is unlikely children with higher BMI's receive purple and green foods less frequently but in greater quantity than other children. One possible explanation for the discrepancy between the Food Frequency Questionnaire and the Food Diary is in terms of the participants recruited. Children in the diary study were selected specifically to cover a range of BMI's, therefore more than the normal distribution of participants were either 'at risk of overweight' or 'overweight', whereas the participants in the Food Frequency Questionnaire were of a normal distribution with the majority being of 'normal weight'. In addition, parents who agreed to participate in the Diary study were from middle to high SES. Therefore, as there was less variability in participants in terms of BMI and SES in this study compared with the Food Frequency Questionnaire, this may account for the lack of an effect in terms of the amount of exposure to purple and green foods, and also vegetables. Further research using a longitudinal diary methodology on a more representative sample of participants is thus required to further explore the influence of exposure on preference in relation to BMI and SES.

A comparison of exposure to each individual colour indicated that in addition to purple and green foods, red and pink foods were offered significantly less than other colours, with brown and cream foods being offered significantly more. Consideration of the distribution of items in the Explicit Preference Task (chapter 2) indicates the majority of red items (13 out of 18, 72%) belong to the categories of fruit (n = 6), vegetables (n = 4) and sweet/snack (n = 3), and the majority of pink items (14 out of 16, 87.5%) belong to the categories of meat/fish and sweet/snack. Fruits, vegetables, sweet/snack and meat/fish items are often offered in smaller quantity than carbohydrates (brown and cream), therefore the additional measure of portion size (quantity), rather than just frequency, may account for red and pink foods being offered less than other colours and brown and cream being offered more.

This result may be attributable to the composite measure of exposure (frequency and portion size), rather than frequency alone or portion size alone. However it is interesting that children's dislike of red and pink foods is not equivalent to the dislike of purple and green foods, despite the amount these foods are offered being equivalent. Thus, the dislike of purple and green foods may not be mediated by exposure. However, a reduction in exposure may increase an existing dislike of these foods. As an example, previous research considering the use of rewards in food preferences has indicated if a reward is given for consumption of a disliked food, preference for that food is most likely to reduce further (Birch et al., 1984). Thus if purple and green foods are generally disliked, perhaps as a result of a colour-flavour association, then reducing the amount of exposure children have to these foods may serve to increase the dislike of these kinds of foods.

Similarly brown and cream foods were found to be offered more than other colours which correspond to the preferred food categories of 'sweet/snack' and 'carbohydrate'. Thus parents may be mediating children's preferences by increasing exposure to already liked colours and reducing exposure to disliked colours. Further research would need to determine if this is the case by establishing preference for novel foods and varying the amount of exposure to these foods experimentally with consideration of how exposure mediates preference.

Role of parents

In addition, the finding that pink foods were offered significantly less frequently than other colours is particularly interesting as pink foods were found to be a preferred food colour in the Explicit Preference Task for children; however it was the least preferred food colour for adults (chapter 2). Evidence for the influence of parental food preferences on children's consumption was provided by Skinner et al., (2002) who reported that many of the foods never tasted by children were disliked by their parents. Although it might be expected that parents may offer foods their children prefer more frequently, if foods of specific colours are disliked by parents these may be offered less frequently, despite children preferring them. The interplay between parental and child food preferences and consumption thus requires further investigation.

The findings presented here are important as they demonstrate the impact parents may have on their children's developing food preferences. Previous research has considered the role of parents in children's food preferences with reference to reward (e.g., Birch et al., 1984; Wardle et al., 2003), restriction (e.g., Fisher & Birch, 1999) and pressure to eat (e.g., Batsell et al., 2002; Galloway et al., 2006). To my knowledge no previous research has considered the more subtle influence parents may have on children's food preferences, by offering smaller quantities of certain foods. With results from the previous chapter suggesting children use food colour as a basis for categorisation and rejection of disliked foods, it is a significant finding that the exposure children have to 'disliked' foods appears to be significantly reduced.

There are various processes which may account for these findings. Parents may initially offer certain foods more frequently and/or in greater quantity, and through increased exposure children may develop preferences for these foods. Alternatively, children may develop preferences for these certain foods early in life, and as a result of preference they may ask for these foods, which in turn may increase exposure. As such exposure to foods may be mediated by naming as a result of preference. The role of naming in the development of food preferences has not to my knowledge been explored in previous research. However, outside the domain of foods, Pitchford and Mullen (2005) reported a link between colour preferences, exposure and naming, thus it is possible these factors may be related when considering children's food preferences.

There is a need for further research to understand more fully why parents do not offer purple and green foods, and indeed vegetables, in as great a quantity as other foods. A small change in the amount offered could impact on the amount consumed, which would increase exposure, and thus familiarity to these kinds of foods. The use of food colour to categorise foods is explored systematically in chapter 5, however if this is a process developed by children it is important parents have an awareness of this and adjust their feeding behaviours accordingly. By increasing children's exposure to a wide range of foods children may begin to learn earlier that foods belonging to the same colour category do not necessarily taste the same. With previous research suggesting that food preferences developed early continue into adulthood (Skinner et al., 2002), this knowledge could arm parents with the resources necessary to make a positive impact on their children's developing food preferences.

Food colours consumed throughout the year

The final aim of the Food Diary Study was to consider if differences exist in the colour of food offered at different times of the year in relation to food preferences and exposure. It was proposed that more brown and cream foods may be offered in the winter months (September and December), which may be related to an increase in sweet/snack foods and carbohydrates, whereas foods with more vivid colours (red, green, orange, yellow) may be offered in the summer months, possibly as a result of an increase in fruit and vegetable consumption. In addition by specifically selecting months to incorporate Christmas (December) and Easter (March) there may be an increase in brown and cream foods in these months due to the majority of the British population celebrating these events and consuming a larger quantity of chocolate and carbohydrates than at other times of the year.

Unexpectedly, significantly fewer portions overall were offered in March than any other month, the reason for which remains unclear. There is no justifiable explanation to expect fewer portions to be offered in March than September, December, or June, therefore further research ought to be conducted to determine if this was a chance finding. Despite there being differences in the amount of food offered between individual months and colours, the main interest here is the interaction between month and colour. The finding that more red foods are offered in June than in March is likely to be partly related to the general reduction in the amount of food offered in March compared with other months. However, if this was simply a result of the main effect of month then it would be expected that more red foods would also be consumed in September and December than March, and not only in June. The summer months bring about an increase in consumption of summer berries which are often red (e.g., strawberries and raspberries) which may account for the increase in red foods during June. However not significantly more red foods are consumed in June than

September or December, therefore this is partly related to the decrease overall in foods offered in March.

3.5. Conclusion

The use of a Longitudinal Food Diary method has been found to be an effective method for assessing the food consumption patterns of children. In contrast to cross sectional methods including food diaries of shorter duration, this method enables insight into foods children are being offered and are consuming on a regular basis, providing a more naturalistic investigation. Using photographs to estimate portion sizes has been found to be effective in previous research, and similarly this study has shown the ability to use this method over a period of time.

Chapter 4: Perceptual Categorisation of Food

4.1. Introduction

A body of research investigating the categorisation of non-food objects in young children has provided evidence for what has been termed the 'shape bias'. The shape bias is thought to be related to early word learning with young children often overextending object labels on the basis of shape, rather than other object properties, for example referring to all four legged animals as 'dog'. A number of theories have been put forward for the occurrence of the shape bias. The Attentional Learning Account (ALA) (Smith and Samuelson, 2006) suggests a child will attend to a word, for example 'ball', and extend this on the basis of shape as they learn that when people say the word ball they often point to things that are 'ball shaped', thus learning the association between label and shape (e.g., Landau, Smith, & Jones, 1988; Smith, Jones, Landau, Gershkoff-Stowe & Samuelson, 2002). An alternative theory is that shape is used as an indication of object kind for count nouns (e.g., Bloom, 2000; Diesendruck, Markson & Bloom, 2003). Following this approach a child would extend the word ball on the basis of shape as they are aware that ball is a count noun and shape is a reliable indicator of object shape. Although the precise mechanisms underpinning these theories differ they share the view that children will learn to categorise objects on the basis of shape over other perceptual attributes. It has been suggested that the shape bias occurs as early as 15-months with infants attending to shape over colour and texture in order to infer a non-obvious property in a novel object (e.g., Graham & Diesendruck, 2010; Graham & Poulin-Dubois, 1998). Whatever the age at which the shape bias occurs and whichever theory you adhere to, it is clear that categorisation on the basis of shape is likely to be learned; as such it is probable that children first categorise objects on the most salient perceptual property, which may differ in the domain of food to other objects.

Evidence has been presented in previous chapters for the potential role of perceptual (colour and size) and cognitive (categorisation) factors on children's food preferences. It has been suggested through the findings of chapter 2 that children may use food colour as a basis for categorisation to reject novel foods on sight. Although the role of categorisation in the development of food preferences can be inferred from the findings of previous chapters, it is important to systematically explore this hypothesis. The role of colour in the categorisation of foods could provide important insight into factors that influence the development of food preferences and may provide parents, health practitioners and food manufacturers with an understanding of how foods are perceived by young children. This understanding may enable more healthy foods to be marketed in a manner that is appealing to young children.

As presented in the general introduction (chapter 1) there has been a considerable amount of research considering children's categorisation of objects. As a result a general consensus has been established for a shape bias, with young children preferring to categorise objects on the basis of shape, rather than other perceptual attributes such as colour (e.g., Landau et al., 1988). There is some evidence to suggest that children first use colour as a basis for categorisation prior to a switch to shape around the same time as word learning develops (e.g., Pitchford and Mullen, 2001). It has been suggested that the principles by which children categorise food compared to non-food objects may differ, and specifically that colour may be more informative of object function, in terms of taste, for food, than shape would be (e.g., Macario, 1991). It has recently been reported that the principles by which primates categorise food compared with non-food objects differ, and specifically that there is a colour bias for food objects, compared to a shape bias for non-food objects (Santos et al., 2001; Shutts et al., 2009). Therefore it is now timely to systematically investigate the basis of categorisation for food, compared with non-food objects in young children.

In order to determine the principles by which young children categorise food it is important to select items for comparison at the same level of classification. In their seminal paper, Rosch et al., (1976) alluded to 'food' as a superordinate level category but as it "*cross-cut a large number of other taxonomic structures*" (pp 388) they considered instead 'fruits' and 'vegetables' to be examples of superordinate food categories. So as to be consistent with previous research, basic and superordinate level categories in this chapter are defined according to Rosch et al. (1976). Hence, 'basic' refers to the level at which categories carry the most information and are most differentiated from one another (e.g., 'apples', 'cars', and 'flowers') and 'superordinate' refers to the level of categorisation where objects share only a few common attributes (e.g., 'fruits', 'vehicles', and 'plants').

This chapter uses a series of match-to-sample experiments to systematically investigate the categorisation of food and non-food items at the basic and superordinate level for both children and adults. Most previous studies investigating the development of object categorisation have selected basic level items (as defined by Rosch et al., 1976) on which to form perceptual category judgements, as shape is most indicative of category membership at this level (e.g., 'apples'). However, at the superordinate level (e.g., 'fruits') shape varies across category items so is less predictive of category membership (e.g., apples and bananas are both fruits but differ in shape) than at the basic level (Rosch et al., 1976). Thus, at the superordinate level, a conceptual-based rather than perceptual-based method of categorisation may be adopted, such as taxonomic class (e.g., 'fruits'). It is predicted that across development young children will shift from making perceptual category judgements of food based on colour to categorising food conceptually by taxonomic class and this will differ from non-food objects where there is expected to be an early shape bias operating.

Here, for the first time, shape and colour are explicitly contrasted in forming perceptual category judgements at the basic level (Experiment 4.1) to see if the shape bias, shown to operate on non-food objects (e.g., 'cars' and 'motorbikes'), also extends to food items (e.g., 'apples' and 'melons'). Experiment 4.2 then examined if children use a perceptual (colour) or conceptual (taxonomic class) basis when categorising food (e.g., 'fruits' versus 'vegetables') and non-food (e.g., 'vehicles' and 'plants') items at the superordinate level where shape varies across category items. Experiment 4.3 investigated the influence of prior knowledge of superordinate food categories when making perceptual (colour) or conceptual (taxonomic class) based judgements of food items at the superordinate level. With research suggesting an important link between naming and categorisation (Horne et al., 2005; Lowe et al., 2006), Experiment 4.4 explored the influence of providing basic level, colour, and superordinate level labels (e.g., "banana", "yellow", and "fruit" respectively) when categorising food items at the superordinate level. Experiment 4.5 determined the age by which children categorise food items at the superordinate level on the basis of taxonomic class without labels being provided. Finally, Experiment 4.6 investigated if other perceptual attributes, i.e., texture and size, are used in preference to colour when categorising food.

4.2. Methods and Results

4.2.1. Experiment 4.1: Categorisation by shape or colour for basic level food and non-food items.

To clarify previous research by determining if shape or colour is more salient to young children when perceptually categorising food and non-food objects, three match-to-sample tasks were administered. Children (aged 3- to 6-years) were presented with basic level items from three different categories ('fruits': apples and melons, 'vehicles': cars and motorbikes and 'plants': flowers and trees) and required to match a target stimulus to a choice of alternatives based on perceptual similarity (colour or shape). As food and plants are biological categories and there is some evidence to suggest that biological objects are categorised differently from non-biological objects (e.g., Rosch et al., 1976), the comparison of these three sets of objects enabled the ability to differentiate the principles governing food categorisation from those of other biological or non-food categories.

Experiment 4.1: Method

Participants

A group of 81 typically developing English-speaking children (aged 36 – 82 months) were recruited from Dunston Primary School, Derbyshire. Most of the children in this school are from White British heritage and the school has an above average number of pupils eligible for free school meals, indicating a below average socio-economic status. Prior consent to participate was obtained from parents or guardians. To enable developmental differences in the categorisation of objects to be considered children were divided into four age groups (Table 16).

Table 16. Gender and Mean (SD) age of participants in Experiment 4.1

	N	Male	Female	Mean (SD) age months
3 years	20	10	10	41.65 (3.41)
4 years	20	9	11	55.45 (2.98)
5 years	21	9	12	66.86 (2.63)
6 years	20	10	10	77.4 (3.15)

Apparatus and Materials

For each of the three categories two basic level items were selected (apples and melons for 'fruits', trees and flowers for 'plants', and cars and motorbikes for 'vehicles') and for each basic level item there were two stimuli which differed in colour (e.g., a green apple and a yellow apple). Figure 8 shows the stimulus display and Appendix 6a lists the items used in each task. The selection of these items enabled colour and shape to vary systematically within each category (e.g., green and yellow apples – round shape versus green and yellow melons – crescent shape[16]).

Figure 8. Stimulus display of Experiment 4.1: Vehicle task

Colour versus shape

"See this, can you find another?"

Colour Shape

[16] Although melons do not naturally occur in 'crescent shape', it is common for children to be offered melon in this form

Food stimuli were high-resolution digital photographs of individual food items that were prepared specifically for the Explicit Preference Task (chapter 2). Food stimuli were selected from the larger set of 230 different food items, each of which received at least 80% agreement amongst 10 independent adult raters for colour. Non-food stimuli were also high-resolution digital photographic images sourced from various generic websites. To enhance ecological validity, the colour of the digital images was not altered so the precise shade of colour varied across items (e.g., the shade of yellow differed for the apple and melon) but all were clear examples of each colour. Stimuli were presented against a white background on a PC laptop computer (refresh rate of 60 Hz and resolution of 1280 x 800 pixels) with a 15" screen, under control of E-Prime (version 1.1)[17], which also recorded responses. Each stimulus subtended an area of 199 x 312 pixels and was viewed at an average distance of 30 cm.

Procedure

Each participant was tested in a quiet area within the primary school. Participants sat on a chair facing the monitor at a distance that enabled them to touch the screen easily. All participants completed all three tasks over three consecutive days (one task per day) and the order of task presentation was counterbalanced across participants. For each task the experimenter explained to the child that they were going to play a game on the computer that required them to select one of two alternative forced choices (e.g., a red apple and a yellow melon) to match to a target stimulus (e.g., red melon). Each of the two alternative choices was consistent with the target in either colour or shape only – see Figure 8. For each task, each of the four different stimuli was presented twice as a target stimulus, resulting in 8 trials in total, the order of which was randomised across participants.

At the start of each trial a target stimulus was presented for 5 seconds at the centre top of the screen, and the experimenter said, "See this, can you find another?" This question has been used in previous research (e.g., Baldwin, 1989; Pitchford and Mullen, 2001) and enabled children to match on either colour or taxonomic class. The target stimulus remained on the screen whilst the two alternative choices were presented, in random order, to the lower right and left of the screen. Participants were required to point to the stimulus they felt

[17]Psychology Software Tools Inc., Pittsburgh, PA.

was most similar to the target stimulus. All stimuli remained on the screen until the participant indicated their choice. Responses were recorded by the experimenter pressing a corresponding key on the keyboard.

Experiment 4.1: Results

The number of colour matches was calculated for each participant for each of the three tasks, and the mean number of colour choices for each task was calculated for each age group. Results are reported in Table 14. A 4 x 3 mixed ANOVA was conducted to investigate the effect of age and task on colour-based responses with age (3-years, 4-years, 5-years, 6-years) as the between-subjects variable and task ('fruits', 'vehicles', 'plants') as the within-subjects variable. Results revealed a significant main effect of age (F (3, 77) = 7.13, $p < .001$) and task (F (2, 154) = 69.46, $p < .001$) and the interaction between age and task was also significant (F (6, 154) = 7.51, $p < .001$). Post-hoc Bonferroni comparisons (significant at $p < .05$) revealed a significant effect of age for the 'fruits' task (F (3, 80) = 20.84, $p < .001$) as 6-year-olds made significantly less colour-based matches than all other age groups, but no effect of age for either the 'vehicles' (F (3, 80) = .77, $p > .05$) or 'plants' (F (3, 80) = 2.23, $p < .05$) task. In addition, post-hoc repeated measures ANOVA's (Bonferroni corrected for multiple comparisons, $p < .025$ at least) found a significant main effect of task for 3-, 4-, and 5-year-olds (3-years: F (2, 38) = 14.83, $p < .001$; 4-years: F (2, 38) = 44.68, $p < .001$; and 5-years: F (2, 40) = 45.67, $p < .001$) with each age group making significantly more colour-based matches on the 'fruits' compared to 'vehicles' and 'plants' task. In contrast, no significant effect of task was found for 6-year-olds (F (2, 38) = .29, p = .75).

Table 17. Mean (SD) of colour-based matches made by each age group across the food and non-food tasks in Experiment 4.1.

Age Group	Food (biological) task 'Fruit'	Non-food (biological) task 'Plants'	Non-food (non-biological) task 'Vehicles'
3-years	5.5 (1.31)	2.71 (2.51)	2.4 (2.37)
4-years	5.1 (1.89)	2.00 (2.27)	1.7 (2.0)
5-years	4.9 (2.55)	1.70 (2.2)	1.62 (1.94)
6-years	1.4 (1.39)	.95 (1.61)	1.45 (2.21)

Experiment 4.1: Discussion

Experiment 4.1 clearly demonstrates that children up to 6-years of age use different perceptual attributes to categorise food compared to non-food objects. Between the ages of 3- and 5-years, children showed a preference for matching food items on the basis of colour, whereas for non-food items perceptual category judgements were made according to shape, irrespective of whether the non-food items were drawn from biological or non-biological categories. Only when children reached 6-years of age did they categorise both food and non-food items on the basis of shape. Thus, this experiment confirms previous research by showing that for most objects, children show a shape bias when making perceptual category judgements, and thus serves to validate the methodology used. However, for the first time, it is shown that young children adopt a different principle for categorising food compared to non-food items, such that the shape bias does not appear to extend to food items until a much later age.

This supports the results of chapter 2 which indicated colour may be particularly salient for young children when categorising food. However, Experiment 4.1 has only compared perceptual attributes (colour and shape), and at the basic level shape and taxonomic class are confounded. Therefore, it is possible children may match food items differently when given the opportunity to match on taxonomic class. Thus, Experiment 4.2 contrasted perceptual and conceptual category judgements for food and non-food items at the superordinate level (e.g., 'fruits' versus 'vegetables') where shape varies (e.g., a pepper and sweetcorn - on cob are both vegetables but differ in shape) and thus cannot be used reliably for categorisation.

4.2.2. Experiment 4.2: Categorisation by colour or taxonomic class for food and non-food items at the superordinate level.

This experiment investigated if children use colour (a perceptual feature) or taxonomic class (a conceptual feature) to categorise food and non-food items at the superordinate level where shape is less predictive of category membership. Children were required to match either on the basis of colour or taxonomic class for food ('fruits' versus 'vegetables') and non-food items ('vehicles' versus 'plants').

Experiment 4.2: Method

A group of 80 typically developing English-speaking children (aged 36 – 82 months) were recruited from Dunston Primary School, Derbyshire. Most of the children in this school are from White British heritage and the school has an above average number of pupils eligible for free school meals, indicating a below average socio-economic status. Prior consent to participate was obtained from parents or guardians. To enable developmental differences in the categorisation of objects to be considered children were divided into four age groups, as shown in Table 18.

Table 18. Gender and Mean (SD) age of participants in Experiment 4.2

	N	Male	Female	Mean (SD) age
3 years	21	9	12	40.9 (2.62)
4 years	20	10	10	53.2 (2.63)
5 years	20	10	10	65.7 (2.87)
6 years	19	10	9	78.1 (2.91)

Two tasks were given to each child, one with food and another with non-food items. Task order was counterbalanced across children and each task was administered on a different day. Each task contrasted two superordinate categories (food task: 'fruits' and 'vegetables'; non-food task: 'vehicles' and 'plants'). For each superordinate category (e.g., 'fruits') two items were selected that varied in shape (e.g., apple and melon slice). Each of the two items from each of the four superordinate categories was coloured either green or yellow (e.g., a green apple and a yellow melon slice) to ensure consistency of colour-based categorisation. The same two colours were used for each superordinate category to ensure that any differences observed did not result from preference or bias for individual colours. Figure 9 illustrates the stimulus display used and Appendix 6b list the different items used per trial in each task. The apparatus and procedure were the same as that used in Experiment 4.1.

Figure 9. Experiment. 4.2: Superordinate level food items

Colour versus shape.

"See this, can you find another?"

Experiment 4.2: Results

For each of the two tasks the number of colour matches was calculated for each participant (out of 8) and the mean number of colour choices per task was calculated for each age group. Results are reported in Table 18. To investigate the effect of age and task on colour-based responses a 4 x 2 mixed ANOVA was conducted with age (3-years, 4-years, 5-years, 6-years) as the between-subjects variable and task (food and non-food) as the within-subjects variable. A significant main effect of task was found ($F(1, 76) = 130.7$, $p < .001$) as children made more colour matches in the food than non-food task. The main effect of age ($F(3, 76) = .892, p > .05$) and the interaction between age and task ($F(3, 76) = 1.05, p > .05$) was not significant.

Table 19. Mean (SD) of colour-based matches made for each age group across the food and non-food tasks in Experiment 4.2.

Age Group	Food task 'Fruits' and 'Vegetables	Non-food task 'Vehicles' and 'Plants'
3-years	6.48 (1.17)	2.80 (2)
4-years	5.95 (1.5)	2.90 (1.97)
5-years	6.40 (1.47)	3.70 (2.07)
6-years	6.80 (1.27)	2.74 (2.34)

Experiment 4.2: Discussion

These results confirm the findings from Experiment 4.1 and show that young children use colour to categorise food instead of shape or taxonomic class, which they use to categorise other non-food items. Furthermore, this preference for categorising food on the basis of colour extends over basic (Experiment 4.1) and superordinate (Experiment 4.2) level categories and clearly differs from the basis for categorisation of non-food items.

Whilst a preference for categorising food on the basis of colour over class was evident in Experiment 4.2, it is possible that the difference between the superordinate categories of food items tested ('fruits' and 'vegetables') was less familiar to children than the distinction between the superordinate non-food categories ('vehicles' and 'plants). As such children may be aware of the difference between a vehicle and a plant, but may not yet be aware of the conceptual difference between a fruit and a vegetable. Differences in category familiarity may thus have influenced the basis of categorisation for food and non-food items in this experiment. To explore this hypothesis further, Experiment 4.3 investigated the role of prior knowledge of superordinate food categories in making colour (perceptual) or taxonomic class (conceptual) category judgements.

4.2.3. *Experiment 4.3: Influence of prior knowledge of superordinate food categories on the categorisation of 'fruits' and 'vegetables' by colour and taxonomic class.*

This experiment investigated the influence of prior knowledge of superordinate food categories on the principles governing categorisation of 'fruits' and 'vegetables'. In particular, this experiment was conducted to determine if knowledge of food class results in a shift from a perceptual (colour) to conceptual (taxonomic class) basis for food categorisation.

<u>Experiment 4.3: Method</u>

Participants

A group of 41 children (12 male, 29 female) were recruited from Dunston Primary School, Derbyshire. Children ranged in age from 37 to 84 months (M = 62 months SD = 14.7 months).

Apparatus and materials

A set of 14 different food stimuli were selected from the larger set of 230 items (see the Explicit Preference Task, chapter 2). For both superordinate food categories, 'fruits' and 'vegetables', there were 7 items, one of each of the following colours: red (strawberry, pepper), orange (orange, carrot), yellow (melon, sweetcorn), white (banana (peeled), cauliflower), green (apple, broccoli), brown (kiwi, onion) and purple (blackberries, aubergine), which enabled categorisation of each of the colours considered in chapter 2 to be explored. The experimental apparatus and set-up was the same as in Experiment 4.1.

Procedure

The procedure was the same as in Experiment 4.1. Each of the two alternative choices was consistent with the target in only colour or taxonomic food class. Each of the 14 different stimuli was presented twice as a target stimulus, resulting in 28 trials in total. Figure 10 illustrates the stimulus display used. To assess prior knowledge of the superordinate food categories examined, after completion of the match-to-sample task, each of the 14 food items was presented individually, and the participant was asked, "Is this a fruit or vegetable?" Order of presentation of stimuli was randomised across participants and the order of inquiry about superordinate category (i.e., 'fruit' or 'vegetable') was counterbalanced within and across participants.

Figure 10. Experiment 4.3: Fruit and vegetables

Colour versus food class

"See this, can you find another?"

Class Colour

Experiment 4.3: Results

First, prior knowledge of the superordinate food categories ('fruits' and 'vegetables') was determined by comparing the number of items identified correctly compared to chance (50%). Across all items ('fruits' and 'vegetables') children correctly identified more items by taxonomic class than they failed to identify (observed frequency of items for which class was known = 450, observed frequency of items for which class was not known = 154, expected frequency = 287, $\chi 2 = 185.15$, $p < .001$).

Next, the basis of categorising 'fruits' and 'vegetables' was investigated by comparing the number of colour- and class-based matches made against the levels expected by chance (50%). Results showed that children matched significantly more on the basis of colour than class (observed frequency of colour matches = 761, observed frequency of class matches = 387, expected frequency = 574, $\chi 2 = 121.84$, $p < .001$).

Furthermore, although not more than chance, children made significantly more colour- than class-based matches to both items for which they knew the superordinate level category and for those they did not know (class known:, $\chi 2 = 260.32$, $p < .001$; class not known:, $\chi 2 = 132.96$, $p < .001$) (Table 20).

Table 20. Colour- and class-based matches for items known and not known.

		Class known	Class not known
Colour matches	Observed	603	292
	Expected	1055.8	536.9
Class matches	Observed	158	95
	Expected	298.5	151.8

Experiment 4.3: Discussion

These results show that 'fruits' and 'vegetables' are equally familiar to young children, and thus validate comparing the basis for categorisation across items drawn from these two superordinate level categories. Children used colour as a basis for categorisation irrespective of whether or not they knew which superordinate category the items belonged to. Although children could recognise the superordinate food category to which items belonged when asked (after performing a categorisation task), it appears they did not use this information in making category judgements. However, explicit labelling immediately prior to performing a categorical matching task has been shown to shift the criteria on which young children group together non-food items from colour to shape (e.g., Gelman & Markman, 1987; Landau et al., 1988; Nazzi & Gopnik, 2001; Smith, Jones & Landau, 1992), therefore it was next investigated if a similar principle operates for food.

4.2.4. *Experiment 4.4: Influence of explicit labelling on the categorisation of 'fruits' and 'vegetables' by colour and taxonomic class.*

Experiment 4.4 investigated the effects of providing labelling information to children when categorising 'fruits' and 'vegetables', specifically whether labelling information leads to a switch from categorising on the basis of colour to categorising on the basis of taxonomic class. In addition, as it was seen in chapter 2 that the influence of food colour differed for children and adults the principles by which adults categorise 'fruits' and 'vegetables' were determined to identify whether adults utilise a different method of categorisation than children.

Experiment 4.4: Method

A total of 84 typically developing English-speaking children (aged 36 – 82 months) were recruited from Dunston Primary School, Derbyshire. Prior consent was obtained from parents or guardians. Children were divided into four age groups in order to establish the basis by which adults categorise 'fruits' and 'vegetables' (Table 21).

Table 21. Gender and Mean (SD) age (Month) of participants in Experiment 4.4.

	N	Male	Female	Mean (SD) age months
3 years	20	9	11	41.25 (3.0)
4 years	22	12	10	53.22 (3.36)
5 years	22	12	10	64.8 (2.73)
6 years	20	10	10	76.9 (2.94)
Adult	22	10	12	19.8 (5.06) years

The same match-to-sample task was used as in Experiment 4.3. Participants completed the task on two separate occasions, six weeks apart. On the first administration of the task, the standard match-to-sample procedure used in Experiment 4.1 was followed. On the second administration, at the start of each trial the experimenter told the participant the name (basic level), colour, and taxonomic class (superordinate level) of the target item. For example, "This is a banana. It's yellow and it's a fruit". The basic name was always given first, but the order in which the colour and superordinate level information was provided was counterbalanced within and across participants. Trial order was randomised across participants and task administrations. Adult participants were given only one administration of the task using the standard match-to-sample procedure without labelling information.

Experiment 4.4: Results

The two administrations of the task are analysed individually due to adults participating in only the first administration. Results are shown in Table 22. First, the effect of age on the number of colour matches made on each administration of the task was investigated. For each participant the number of choices based on colour (out of 28) was determined and the mean number of colour matches was calculated per age group. Results showed that on the first administration of the task (without labelling) the number of colour matches was similar across each of the groups of children but was lower for adults. A one-way between-subjects ANOVA revealed a significant effect of age ($F (4, 108) = 41.7$, $p < .001$). Post hoc Bonferroni corrected comparisons revealed adults matched significantly less on the basis of colour than each group of children. On the second administration of the task, when the target items were labelled with basic and superordinate level information prior to response selection, children made fewer colour choices with increasing age. A one-way between-subjects ANOVA revealed the age effect was significant ($F (3, 83) = 9.82$, $p < .001$) and post-hoc Bonferroni comparisons showed that 6-year-old children made significantly fewer colour matches than 3- and 4-year-olds. In addition, post-hoc paired t-tests (Bonferroni corrected for multiple comparisons, $p < .25$ at least) found a significant main effect of task for 4-, 5- and 6-year-olds (4-years: $t (22) = 2.78$, $p = .011$; 5-years: $t (22) = 3.09$, $p = .005$; 6-years: $t (20) = 3.79$, $p = .001$) with each age-group making significantly more colour-based matches in the 'no label' compared to 'label' task. In contrast, no significant effect of task was found for 3-year=olds ($t (19) = 1.98$, $p = .06$).

Table 22. Mean (SD) of colour-based matches made for each age group across the food and non-food tasks in Experiment 4.4

Age group	No label	Label
3 years	16.8 (4.2)	13.45 (7.56)
4 years	19.5 (4.8)	12.68 (9.55)
5 years	18.1 (5.6)	9.05 (11.39)
6 years	19.9 (8.3)	8.8 (9.73)
Adults	2.3 (1.9)	N/A

To explore further the influence of providing basic and superordinate level labelling information on the categorisation of 'fruits' and 'vegetables', a series of one-group chi-square analyses were conducted, which compared the consistency of responses across the two task administrations compared to chance (50%). If providing explicit labelling to food items influences the basis of categorisation, it would be expected that there would be more colour-to-class switches than expected by chance. For each age group, the number of items that were matched consistently on colour over both administrations was determined, as was the number of items for which children shifted their response criterion from colour at the first administration (no labels provided) to class at the second administration of the task (labels given).

Table 23. Colour consistent and colour to class matches

	Colour consistent	Colour to class switch	Expected
3 years	257	79	168
4 years	287	114	200
5 years	203	200	201
6 years	87	284	185

Results showed that 3- and 4-year-old children matched consistently on the basis of colour, irrespective of whether or not the target items were labelled prior to response selection (3-year-olds: $\chi 2 = 94.3$, $p < .001$; 4-year-olds: $\chi 2 = 74.64$, $p < .001$, Table 23). In contrast, 5-year-olds made a similar number of colour consistent and colour-to-class switches across administrations ($\chi 2 = .02$, $p > .05$); whilst 6-year-olds significantly switched from categorising on the basis of colour to taxonomic class when the target items were labelled ($\chi 2 = 104.6$, $p < .001$).

As chapter 2 revealed only disliked 'purple' and 'green' items were categorised by children on the basis of colour, further analyses were conducted to determine if children in Experiment 4.4 made more colour-based matches when the target stimulus was a 'purple and green' item than for 'all other food colours'. An independent samples t-test was conducted comparing the number of colour based matches across all children for 'purple and green items': apple (green), aubergine, blackberries, broccoli; and 'all other colours':

kiwi fruit, pepper (red), orange, sweetcorn (off the cob), strawberry, banana, cauliflower, melon, onion, carrot. No significant difference was found ($t(12) = -1.45$, $p = .174$) suggesting categorisation of 'fruits' and 'vegetables' on the basis of colour is not specific to 'disliked' food colours (e.g., purple and green). Thus children may also use colour to categorise 'liked' foods'.

Experiment 4.4: Discussion

Consistent with Experiment 4.3, these results demonstrate that when no labelling information is provided, children aged 3- to 6-years categorise 'fruits' and 'vegetables' on the basis of colour over taxonomic class, irrespective of whether the food item belongs to a 'liked' or 'disliked' food colour. However, when provided with basic level, colour, and superordinate level labelling information prior to response selection, 5- and 6-year-old children switch to categorising on the basis of taxonomic class. Moreover, the shift from categorising on the basis of colour to taxonomic class when target items were labelled prior to response selection was significant at 6-years, which is also the age at which children switch from categorising food on the basis of colour to shape (Experiment 4.1). These findings corroborate those of previous studies that have shown a similar influence of labelling on the categorisation of non-food objects, whereby naming objects causes a shift in categorisation principles from colour to shape (e.g., Gelman & Markman, 1987; Landau et al., 1988; Nazzi & Gopnik, 2001). Although the effect of labelling on categorisation seems to function in a similar manner across food and non-food items, the age at which this effect operates appears to be later for foods. As adults categorise food by taxonomic class, Experiment 4.5 sought to establish the point in development when children adopt a conceptual, taxonomic class-based, system of food categorisation when explicit labelling is not provided.

4.2.5. Experiment 4.5: Categorisation of 'fruits' and 'vegetables' by colour or taxonomic class in 7- to 10-year-olds.

Results thus far have indicated adults to categorise 'fruits' and 'vegetables' on the basis of taxonomic class, whereas children up to 6-years use a perceptual, colour-based, system of categorisation in the absence of explicit labelling information. Therefore, Experiment 4.5 was conducted to determine the age at which children over the age of 6-years, without labelling information, switch to categorising foods on the basis of taxonomic class, over colour.

Experiment 4.5: Method

To assess the point in development when children start to use a taxonomic class-based rather than a perceptual colour-based method to categorise 'fruits' and 'vegetables', without explicit labelling information, a sample of children older than 6-years was required. In total, 71 typically developing English-speaking children (aged 84 – 131 months) were recruited from University of Nottingham volunteer databases. Prior consent was obtained from parents or guardians. Children were divided into four age groups (Table 24).The same match-to-sample task employed in Experiments 4.3 and 4.4 was adopted in this experiment.

Table 24. Gender and Mean (SD) age (months) of participants in Experiment 4.5

	N	Male	Female	Mean (SD) age
7 years	21	8	13	88.95 (3.26)
8 years	18	9	9	101.5 (3.35)
9 years	13	5	8	112.7 (3.3)
10 years	19	7	12	126.1 (3.49)

Experiment 4.5: Results

For each participant the number of choices based on colour (out of 28) was determined then the mean number of colour choices was calculated per age group. Results indicated a similar mean number of colour-based matches per age group (Table 25). A one-way between-groups ANOVA conducted on the number of colour choices made confirmed there was no significant effect of age ($F(3, 70) = .65$, $p > .05$).

Table 25. Mean (SD) of colour matches by age in Experiment 4.5

	Mean (SD) number of colour matches
7 years	9.57 (9.77)
8 years	9.5 (9.22)
9 years	5.69 (8.06)
10 years	7.26 (9.59)

To investigate further the basis of categorisation within each age group a series of one-group chi-square analyses was conducted, in which the total number of choices based on colour and taxonomic food class (observed frequency) per age group was compared to the expected frequency based on chance (50%). Results showed that all groups matched significantly more on the basis of food class than colour: 7-year-olds ($\chi2 = 58.84$, $p < .001$), 8-year-olds ($\chi2 = 47.06$, $p < .001$), 9-year-olds ($\chi2 = 128.16$, $p < .001$) and 10-year-olds (, $\chi2 = 123.19$, $p < .001$) (Table 26).

Table 26. Number of colour- and class-based matches per age group in Experiment 4.5

	Colour matches	Class matches	Expected
7 years	201	387	294
8 years	175	329	252
9 years	74	290	182
10 years	138	394	266

<u>Experiment 4.5: Discussion</u>

These results demonstrate clearly that by 7-years and above children categorise 'fruits' and 'vegetables' on the basis of taxonomic food class, even when explicit labelling information is not provided. Thus, a shift in categorising 'fruits' and 'vegetables' occurs from a perceptual, colour-based system, to a conceptual, taxonomic class-based, system after 6-years of age (Experiments 4.3 and 4.4). This supports the prediction that with increasing knowledge and exposure to different foods, changes in the principles governing food categorisation occur.

4.2.6. Experiment 4.6: Categorisation of food by colour, texture and size.

Results from Experiments 4.1 - 4.4 indicate clearly that young children use colour to categorise food, supporting the findings of chapter 2. However previous research (e.g., Blossfeld et al., 2007; Harris, 2009, Koivisto & Sjoden, 1996) has indicated other perceptual features of food, such as texture (e.g., firm) and size (e.g., small) may also influence food categorisation, in addition food size was found to influence food preference in chapter 2. Experiment 4.6 thus investigated the role of different perceptual attributes, namely colour, texture and size, in food categorisation across development, to determine if there is a special case for colour in food categorisation over other perceptual attributes.

Experiment 4.6: Method

Participants

A total of 87 typically developing English-speaking children (aged 37 – 83 months) and 22 undergraduates participated in this experiment (Table 27). Prior consent was obtained from parents or guardians for each child. Children were recruited from Dunston Primary School, Derbyshire, and the University of Nottingham volunteer databases. Participants were divided across the following age groups.

Table 26. Gender and Mean (SD) age of participants in Experiment 4.6

	N	Male	Female	Mean (SD) age
3 years	20	9	11	40.5 (2.87)
4 years	24	14	10	53.4 (2.92)
5 years	21	11	10	65.9 (2.92)
6 years	22	13	9	77 (2.79)
Adult	22	10	12	18.77 (1.02)

Apparatus and materials

A set of 16 different food items was selected from the larger set of 230 items, used in the Explicit Preference Task (chapter 2) to incorporate items to match on colour, texture or size. Stimuli used are shown in Appendix 6c. As image colour was not altered, the exact shade of different food items representing a particular colour differed slightly across items, but each was a clear example of that colour. The set of 16 stimuli varied systematically in colour (brown, orange, yellow or white), texture (firm and soft), and size (small and medium). For example, an onion was rated as brown, firm, and of medium size. The same PC laptop computer, version of E-Prime, stimulus area, and viewing distance adopted in Experiment 4.1, was used.

Procedure

The procedure was the same as in Experiment 4.1 except that this task employed a three alternative forced choice of items to match the target stimulus. The stimulus display can be seen in Figure 11. Each of the three alternative choices had only one attribute in common with the target stimulus (e.g., colour) but differed on each of the other attributes (e.g., texture and size). For example, if the target stimulus was brown, firm and of medium size (e.g., an onion) the stimulus that matched in texture was also firm, but was yellow and small (e.g., sweetcorn - off cob). Each of the 16 different food items was presented once as a target stimulus, in a random order, in a block of trials. Each block of 16 trials was presented twice, producing a total of 32 trials.

<u>Experiment 4.6: Results</u>

For each participant the number of matches based on colour, texture, and size was calculated, then the mean number of colour, texture, and size matches per age group was determined. One way between-subject ANOVA's were conducted to investigate mean differences across age groups in the number of matches based on colour, texture, and size. Significant main effects were further explored using post-hoc Bonferroni tests (significant if $p < .05$).

Results showed that, except for 3-year-olds, the mean number of colour-based matches decreased with age (Table 28). A significant main effect of age on colour-based matches was found (F (4, 108) = 6.15, p < .001) as adults made significantly fewer matches based on colour than children aged 4-, 5- and 6-years. Age significantly affected the number of texture-based matches made (F (4, 108) = 8.4, p < .0001) as adults matched significantly more on the basis of texture than 4-, 5- and 6-year-olds, and 4- and 5-year-olds made significantly fewer texture-based matches than 3-year-olds. In contrast, the number of size-based matches was fairly consistent across age groups and no significant effect of age was found (F (4, 108) = .94, p > .05).

Table 28. Mean (SD) number of matches per perceptual attribute in Experiment 4.6

	Mean (SD)		
	Colour	Texture	Size
3 years	12.3 (5.1)	9.1 (4.7)	10.6 (3.6)
4 years	16.8 (5.3)	5.7 (3.6)	9.5 (4.1)
5 years	15.2	5.5 (3.3.)	11.2 (3.9)
6 years	15.7	6.8 (4.7)	9.5 (3.7)
Adult	9.9 (4.6)	11.1 (3.1)	10.9 (4.4)

Figure 11. Experiment 4.6: Food items

Colour versus texture and size

To investigate the basis of categorisation within each age group a series of one-group chi-square analyses was conducted, which compared the total number of colour, texture, and size matches made (observed frequencies) to the expected frequency based on chance (33.33%). When significant, pairwise one-group chi-square tests were conducted (Bonferroni corrected for multiple comparisons $p < .025$ at least) to investigate which of the three attributes was preferred. Results revealed a consistent pattern of matching on the basis of colour and then size over texture for all groups of children, whereas adults showed no particular preference for any of the three attributes. All groups of children matched significantly more on the basis of colour than texture, and all groups, except for 3-year-olds, matched significantly more on the basis of colour than size, and size than texture (Table 29).

Table 29. Observed and expected matches per perceptual attribute by age

	Colour	Texture	Size	Expected
3 years	246	182	212	213
4 years	402	138	228	256
5 years	320	116	236	224
6 years	346	150	208	234
Adult	218	246	240	234

Results showed that 3-year-olds made ($\chi 2 = 9.63$, $p = .008$), 4-year-olds made ($\chi 2 = 140.72$, $p < .001$), 5-year-olds made ($\chi 2 = 93.86$, $p < .001$), 6-year-olds made ($\chi 2 = 86.65$, $p < .001$) and adults made ($\chi 2 = 1.86$, $p > .05$).

Experiment 4.6: Discussion

These results support the findings of the Explicit Preference Task (chapter 2) as it has been found that perceptual attributes of food are more salient to children than adults when making novel food category judgements. Whilst adults showed no preference for any of the three attributes investigated, children showed a consistent pattern of preference, matching significantly more on the basis of colour than texture and (except for 3-year-olds) size. Furthermore, a preference for size over texture was found for children aged 4-years and above and a tendency for this was also apparent in 3-year-olds. These results confirm those found in Experiments 4.1-4.4 and in chapter 2, and show that when making perceptual category judgements about food, colour is particularly salient to young children. Evidently, these results demonstrate that young children willingly group together food items on the basis of perceptual attributes, especially colour, but that this diminishes by adulthood, indicating once again that changes in the principles governing food categorisation occur across development.

4.3. Discussion

This chapter has investigated the principles by which young children categorise food compared with non-food objects. Chapters 2, 3 and 4 have focused on the relationship between perceptual attributes and food preferences, with findings indicating food colour to be used by children to categorise and reject, novel foods. Previous research into categorisation and concept formation has indicated a shape bias in the categorisation of non-food objects in human children, although there is evidence to suggest non-human primates use colour as a basis of categorisation for items depicted as food (e.g., Santos et al., 2001; Shutts et al., 2009), thus this chapter explicitly compared categorisation of food to non-food objects by human children to determine if there is a special case for the categorisation of food.

The primary purpose of food is nutrition, which is signified by taste, and (as noted earlier) although the function of many non-food items (e.g., plants and vehicles) may be predicted by shape, taste is unlikely to be predicted by food shape. In contrast, the colour of food may provide a more reliable cue to taste than shape, especially early in development, when children may have limited experience of different foods. Evidence that children may use food colour to categorise novel foods was provided by the Explicit Preference Task presented in chapter 2 and further evidence was provided in chapter 4. It was thus hypothesised that children may use colour over shape to categorise food, therefore the shape bias that is seen when young children categorise other common non-food objects may not extend to food. Experiment 4.1 tested this hypothesis.

Although some previous studies have included both food and non-food items in their experiments (e.g., Imai et al., 1994; Liu et al., 2001), no previous study has systematically investigated the role of shape over colour in the categorisation of food and non-food items. Consistent with previous research (e.g., Baldwin, 1989; Brian & Goodenough, 1929; Pitchford & Mullen, 2001; Suchman & Trabasso, 1966), Experiment 4.1 showed that children aged 3- to 6-years grouped together common objects, such as cars and flowers, on the basis of shape. In contrast, children used colour as a basis for categorising foods up to 6-years of age, at which point they matched on the basis of shape. Seemingly, at the same point in development children use very different principles for categorising basic level food compared to non-food objects. These results show that at a time when young children categorise non-food objects on the basis of shape, they categorise food by colour, suggesting the shape bias observed for non-food items cannot be extended to the categorisation of food objects.

Next novel category judgements made at the superordinate level were considered, where shape is less predictive of category membership. It was hypothesised that children would shift from a perceptual, colour-based, system of categorisation to a conceptual, taxonomic class-based, system of categorising food once they had gained sufficient exposure to, and knowledge of, different foods to realise that food class may be more reliable than food colour in predicting taste. Consistent with the hypothesis, Experiment 4.2 showed that young children aged 3- to 6-years categorised 'fruits' and 'vegetables' on the basis of colour rather than class whilst they categorised non-food objects ('vehicles' and 'plants') on the basis of taxonomic class. Thus, these results clearly show that the principles by which young children categorise food and non-food objects differ not only for basic level items (Experiment 4.1) but also at the superordinate level (Experiment 4.2).

It was possible that differences in familiarity of the food ('fruits' and 'vegetables') and non-food ('vehicles' and "plants') superordinate level categories contrasted in Experiment 4.2 may have led children to adopt a different criterion on which to base novel category judgments. However, results from Experiment 4.3 showed that children grouped together food items on the basis of colour, even when they knew the superordinate category to which particular items belonged. Prior knowledge of food class seemingly had little influence on the use of a perceptual, colour-based, system of categorisation when young children were asked to make novel category judgements about food. However, when basic level (e.g., "carrot"), colour (e.g., "orange"), and superordinate level (e.g., "vegetable") information was provided immediately prior to response selection (Experiment 4.4), children aged 5- and 6-years switched from categorising foods on the basis of colour to taxonomic class, whilst younger children continued to match by colour. In addition adults were found to categorise food on the basis of taxonomic class over colour (Experiment 4.4) as were children aged 7-years and above, even in the absence of explicit labelling (Experiment 4.5).

Thus, providing explicit labelling information prior to response selection decreased the age at which children categorise food on the basis of taxonomic class, from 7-years without explicit labelling, to 5- and 6-years with labelling. As children were more likely to shift from grouping foods on the basis of colour to class, than class to colour, when given labelling information, the effect of providing basic level, colour, and superordinate level information appears to operate most at the level of taxonomic food class. Similarly, labelling of common non-food objects (e.g., "car") has been shown to encourage a shift from a colour- to a shape-based system of categorisation (Gelman & Markman, 1987; Landau et al., 1988; Smith, Jones & Landau, 1992), even in infancy (Nazzi & Gopnik, 2001). Thus, the effect of labelling appears to be similar across food and non-food items, but the age at which labelling influences categorisation appears to operate much later for food than non-food objects. Previous research has demonstrated the importance of naming in categorisation of object function (Horne et al., 2005; Lowe et al., 2006). The findings presented here suggest that in the domain of food, labelling plays a key role in identification of taxonomic class for children over 5-years of age. Prior to this, colour is seemingly more informative of object function, in terms of taste, thus category labels are ignored in preference for a colour-based method of categorisation.

These results show that the shift from a perceptual to conceptual system of categorisation occurs at around 6 years for food, yet for other non-food objects the shift happens much earlier, at around 3 years. The reasons for this lateness are currently not clear, although it most likely reflects differences in the reliability with which colour predicts object function across food and non-food items. As mentioned earlier, for most common objects shape is more predictive of object function than is colour (e.g., Gelman & Markman, 1987; Landau et al., 1988). Conversely for food items, colour is likely to be more predictive of taste than is shape. Accordingly, it seems that children continue to categorise foods on the basis of colour until they realise that knowledge about food class may be a better predictor of food taste than colour. Like other non-food objects, language appears to modify this process by increasing awareness of the conceptual similarities between objects (Gelman, 2009).

This raises an interesting possibility for using taxonomic class labels to mould how children categorise food, which may in turn influence their willingness to try novel food items. As labelling has been shown to facilitate class-based categorisation in 20-month-olds for non-food items (Nazzi & Gopnik, 2001), it may be possible that providing superordinate level (e.g., "fruit") rather than basic level (e.g., "banana") information to very young children when presenting them with different food items could encourage a shift away from a reliance of categorising foods on the basis of colour to class. For example, if children like a particular vegetable, such as sweetcorn, and are taught the superordinate level label of that item (i.e., "vegetable"), they may be willing to try a novel vegetable, such as broccoli, that is also introduced at the superordinate rather than basic level. This hypothesis needs to be tested explicitly but could be informative as to how the principles of generalisation in word learning (e.g., Rescorla, 1980) may influence food acceptance behaviour.

Colour is known to be salient to young children (Pitchford & Mullen, 2001) especially in relation to foods (Macario, 1991; Matheson et al., 2002) and Experiment 4.6 confirmed the salience of colour over texture and size in food categorisation. Results showed that children aged 3- to 6-years preferred to match items on the basis of colour, and then size, over texture, whilst adults showed no preference for any attribute. This suggests that perceptual properties of food are more salient in childhood than adulthood, especially colour, and that a developmental shift occurs in the principles governing food categorisation with increased exposure to food.

5.4. Conclusion

Through systematically exploring the basis of categorisation by children and adults for both food and non-food objects chapter 5 has demonstrated the salience of food colour to children up to the age of 6 years. At a time when children are categorising non-food objects on the basis of object shape they are using colour to categorise foods, with the switch to shape occurring significantly later than has been observed in previous research for non-food objects. Furthermore, it has been seen how food labelling can be an effective mechanism to reduce the age at which the switch from colour- to taxonomic class-based categorisation occurs.

Chapter 5: General Discussion

The findings presented in this thesis do not contradict or disregard previous factors found to be influential; however they could serve to enhance the awareness of how these factors may influence developing food preferences. Awareness of the mechanisms by which children may associate 'liked' and 'disliked' foods, which may inform acceptance or rejection, is vital to parents and health practitioners when considering concerns over encouraging children to develop healthier and more varied diets. This chapter brings together the findings of this thesis in relation to previous research into the development of food preferences presented in the general introduction (chapter 1). First the relative individual influence of perceptual and cognitive factors is discussed prior to consideration of the relationship between these factors in relation to the development of food preferences. The role of perceptual and cognitive factors is put into context alongside other factors found to be influential in previous research (e.g., innate taste preference, exposure). Consideration is given to the theoretical and applied implications of the findings presented in this thesis, and suggestions are made for future research into the development of food preferences to consider the role of perceptual and cognitive factors.

The overall objective of this thesis was to investigate, for the first time, the influence of perceptual and cognitive factors in the development of food preferences. This objective was considered through several key aims. First, it was necessary to determine if and how perceptual attributes, namely colour, texture and size, influence children's food preferences with consideration of individual differences in body mass index (BMI) and socio-economic status (SES). Thus the first experimental chapter, chapter 2, developed an objective measure of food preference to consider this aim. Second, as exposure is known to be a key factor in the development of food preferences it was necessary to consider the association between any perceptual attributes found to influence food preferences and exposure. Chapter 2 utilised a measure of exposure (Food Frequency Questionnaire) and further to this chapter 3 used a Longitudinal Food Diary to explore exposure in terms of both frequency and quantity. Finally, if perceptual attributes were found to influence food preferences it is likely this occurs through overextension and categorisation of foods on the basis of colour. However much previous research into object categorisation has indicated a shape bias, thus chapter 4 experimentally tested the role of colour in the categorisation of food compared with non-food objects.

5.1. The Influence of Perceptual Factors in the Development of Food Preferences

The objective measure of food preference

In order to systematically investigate the role of perceptual attributes in the development of food preferences it was necessary to develop an objective measure of food preference allowing children to self-report on their preference across a large number of food items. Methods used to determine preference in previous research, for example food preference questionnaires (e.g., Breen et al., 2006; Cooke & Wardle, 2005; Nicklaus et al., 2004) and tasting tests (e.g., Birch et al., 1980; Leon et al., 1999; Wardle et al., 2003), have not allowed for the specific role of perceptual attributes to be explored. Food preference questionnaires for instance have not differentiated between foods that differ only in colour, such as comparing a green apple to a red apple; and tasting tests are limited in the number of items than can be included at any one time. Vereecken et al., (2010) have recently demonstrated the feasibility of using food photographs to determine the food preferences of pre-school children. Therefore, an objective experimental methodology (the Explicit Preference Task) was developed. Unlike the method used by Vereecken et al., (2010), the Explicit Preference Task consisted of a dichotomous (like, dislike), rather than a typical rating scale of preference. This enabled children as young as 20-months to indicate their food likes and dislikes across 230 food items, which may not have been possible using the method of Vereecken et al., (2010). In combination with food preference and frequency questionnaires completed by parents, the relative influence of perceptual attributes in line with other factors known to influence food preference (e.g., exposure) were able to be systematically explored.

This thesis has demonstrated the feasibility of gaining self-report assessment of food preferences in very young children. With previous research suggesting food preferences established prior to the age of 4-years predicting food preferences in adulthood (Skinner et al., 2002), it is essential to develop methods allowing assessment of food preferences in children younger than 4-years. Although typical measures of food preference, such as parental report through questionnaire, have been found to be reliable, they do not allow for consideration to be given as to the role of specific attributes in the development of food preferences. For example, we may learn from parental report that a child likes 'apples' however we cannot determine if the child likes all apples, or only ones of certain colours. And although not explicitly tested here, it is unlikely parents would distinguish preference on this basis. In addition we may learn a child has never tried 'aubergine', however we would not know if the child was offered aubergine if it would be accepted or rejected, and the basis by which this decision was made. Thus, future research ought to move away from typical measures of preference in order to enable the contribution of the properties of the food items considered to be assessed. This information can be combined with other factors known to influence preferences, such as taste preferences and increased exposure, thus helping to build a model of developing preferences in childhood.

The influence of perceptual attributes

For the first time this thesis has provided support for the theory that there may be an influence of perceptual attributes on children's food preferences. Specifically results have indicated children to dislike specific coloured foods, namely purple and green, more than other coloured foods; in addition small foods were found to be preferred to medium and large foods. There is little prior research considering the influence of perceptual factors on children's food preferences. However, parents have provided anecdotal evidence that their children use perceptual attributes to reject foods 'on sight'. For example, a child may have tried and disliked broccoli, they may then associate the colour of broccoli ('green') with the disliked taste and categorise novel foods on the basis of colour, thus rejecting green foods presuming they will also taste like broccoli. In addition, a study by Addessi et al., (2005) reported children would be more inclined to accept a novel food if it was the same colour as a food a significant adult was eating, suggesting children are aware of and use food colour as a basis for acceptance or rejection of foods.

In addition this thesis has provided evidence to suggest that children may use food colour as a basis for rejection of novel foods, thus corroborating anecdotal reports from parents. Overall children were more likely to presume they would 'like' the majority of foods, irrespective of whether it was novel or familiar, however for disliked food colours ('purple' and 'green'), novel, but not familiar items, were more likely to be presumed to be disliked than liked. This finding suggests colour may be a particularly salient perceptual attribute to young children and one they associate with taste. As the majority of purple and green items in the data set belonged to the disliked category of vegetables, and many vegetables have a bitter taste, it is possible children make a colour-flavour association when presented with a novel food. Specifically, presuming novel purple and green foods belong to the food category of 'vegetables' and are therefore likely to taste bitter and thus be disliked. Moreover, when novel food items were removed from the data set there was no effect of colour on preference, thus providing further support for the use of colour to categorise novel foods, aiding the decision regarding acceptance or rejection. This is the first study to my knowledge which has observed human children using perceptual attributes to categorise foods; previous research has reported non-human primates to categorise objects depicted as foods on the basis of colour, although this was not considered in relation to preference (e.g., Santos et al., 2001; Shutts et al., 2009).

This finding may be of particular interest to parents and health practitioners in aiding understanding of the cognitive processes used by children when presented with a new food. Parents could use the knowledge that children pay attention to perceptual attributes, such as colour, and may associate colour with flavour, to encourage new foods to be accepted. For example, it is well established that children like sweet foods (e.g., Desor et al., 1973) and dislike bitter foods (e.g., Anliker et al., 1991). Although in some instances colour may be indicative of taste (e.g., broccoli and cabbage are both green and both have a bitter taste) colour and flavour are not always paired (e.g., grapes can be sweet, but are also green). Thus parents may use this information to help children to move away from the colour-flavour association that may occur by offering a sweet green food, such as grapes, before offering a bitter green food, such as broccoli. Although not explicitly tested here, if children do associate colour with flavour, and like the sweet green grape, they may be willing to try broccoli; whereas if broccoli was offered first, and disliked, the child may be unwilling to try the green grape. This could prove to be an important finding for parents, particularly with previous research suggesting exposure to play a key role in the development of food preferences (e.g., Birch and Marlin, 1982; Cooke and Wardle, 2005). If children reject new foods on the basis of colour, and thus limit exposure to a whole range of foods, they may be limiting the likelihood of developing preferences for these foods.

Of course, as stated earlier, preferences are likely to be determined on the basis of taste, as such broccoli is not necessarily going to be liked. However, it would be interesting to see if tasting a green food that has been found to be liked, prior to one that is disliked, encourages children to rethink their process of rejection on the basis of colour and encourage acceptance of novel purple and green foods. This thesis has not considered variation in man-made to natural food products. Although there were a number of man-made food items included in the Explicit Preference Task (e.g., ice-cream, biscuits, sweets) there were no artificial products that corresponded to the disliked colours observed. Hence it would be interesting to determine if the potential influence of food colour on rejection of novel foods may extend to man-made products, such as a cupcake with green icing, or to green sweets; or if this is specific to the categories of fruits and vegetables as demonstrated here.

Alongside an influence of colour on preference there was also an effect of food size, with children preferring small foods to medium and large. Again this is the first study to my knowledge which has indicated food size may bear an influence on children's food preferences, although advocates of Baby-Led weaning (e.g., Rapley, 2005) would be unsurprised by this finding. It is unlikely the effect of size is related to categorisation in the same manner as colour, as the size of food items used in the task were normally distributed across all food class categories, unlike colour where the disliked colours ('purple' and 'green') belonged to specific food categories (e.g., fruits and vegetables). In line with the views of Baby-Led weaning it is possible children prefer small foods as a result of being able to pick up these items and feed themselves, rather than relying on the use of utensils or an adult to feed them. Although there has been recent research indicating Baby-Led weaning is feasible for the majority of children (Wright et al., 2010), as this is the first study to suggest a preference for small foods in young children, further research into the role of food size and Baby-Led weaning ought to be conducted to further establish if the ability to feed oneself is a desirable and/or beneficial trait for young infants.

As discussed in chapter 2, awareness that children may prefer small foods could be informative to parents; by offering foods children can pick up and feed themselves meal times may be more relaxed for families and parents may not need to display as much pressure or control over their children's feeding behaviour. Pressure to eat has been found to lead to negative comments in young children during meal times (Galloway et al., 2006), and has been linked to dietary restraint in adulthood (Batsell et al., 2002). Therefore, informing parents of perceptual attributes that may ease consumption of food in young children may reduce the need for parents to pressure their children to eat. Again this theory needs to be explicitly tested.

In contrast to colour and size where there is little prior research investigating these attributes, there is most support in previous literature for the role of texture (e.g., Harris, 2009). However no effect of texture on children's food preferences was observed through the methods used in this thesis. This does not imply that food texture is unimportant. Recent research with selective eaters has shown that texture is an important attribute for determining food acceptance. For example Harris (2009) notes that selective eaters will reject a normally accepted food, such as yogurt, if they see it has 'bits' in, thus texture may influence food preference in the same manner as food colour, perhaps through categorisation. It is likely methodological differences between studies may account for the relative importance of these attributes being apparent. Photographic stimuli and questionnaire measures were used here to assess food preferences whereas previous research reporting effects of texture have typically used tasting tests. Although previous studies have been limited in terms of the number of items assessed, the method of tasting tests may identify the importance of texture where the use of photographic stimuli may not.

However it is also possible that colour may be more influential than texture when categorising novel foods, as colour may be more reliable and salient for this kind of judgement. It is clear to see if a food is inappropriately coloured (e.g., if meat is cooked, or bread is mouldy), however if for example a piece of fruit is over ripe, although colour can be an indication of ripeness, it may not be clear through sight alone. A tasting test however would distinguish this, as through biting into a piece of fruit it would be apparent how ripe it was through texture. Thus colour may have an influence on food preference through acceptance and refusal to try novel foods that belong to the same colour category as a disliked food, however after a food has been accepted and is tasted texture may develop as an important object attribute that may influence preference.

The relationship between perceptual attributes and exposure

Exposure to a food may serve to strengthen connections between the concept of that food item and its preference; this could operate on an item level but may generalise to a category level. For instance, a child is offered a novel food item (e.g. aubergine), the child may form a perception of the food based on its visual appearance (e.g., colour). The child may then map this visual input onto the sensory input obtained by tasting the food, which may link in with innate taste preference. In future when aubergine is offered the child may use their previous experience to recall their preference for aubergine. This mapping may also be used for foods that are similar in terms of perceptual features to aubergine; hence the concept of a food could operate on a category level. This could be particularly marked in children who experience neophobia (the avoidance of new foods) or become selective eaters as comparing perceptual characteristics of foods may be a simple method to avoid foods previously disliked. This thesis aimed to determine if and how perceptual and cognitive factors influence developing food preferences. The specific impact of these factors for selective eaters has not been able to be established here, thus future research would need to be conducted to specifically investigate the use of perceptual attributes in food rejection for selective eaters.

No previous research to my knowledge has conducted a food diary study for a period longer than 7-days (e.g., Belderson et al., 2003; Cade et al., 2006). With careful consideration over methodology a longitudinal food diary study, completed for 28 consecutive days, on a quarterly basis, was found to be feasible. The benefit of a longitudinal method, although still relying on parental report, is the ability to gain a representative, naturalistic, indication of the foods children are being offered and consuming throughout the year. Cross-sectional methods providing a 'snap-shot' of food consumption may be less valid; a 7-day record of a person's diet may not be reflective of their diet across a period of time. Furthermore, many previous diary studies have relied on 24-hour recalls, which may be less valid than 7-day food diaries.

The Longitudinal Food Diary method, in contrast to the Explicit Preference Task allowed consideration of exposure not only in terms of frequency but also the quantity of food offered to and consumed by children. This enabled examination of whether the effect of colour observed in the Explicit Preference Task could be attributed to a lack of exposure to purple and green foods. Due to estimates of portion sizes not being age adjusted, the relationship between exposure and preference needs to be interpreted with caution. Although purple and green foods were found to be offered less than other food colours, children actually consumed the same proportion of these foods as they did for other food colours. To demonstrate, despite being offered two portions of a green food, and four portions of a brown food, a child is likely to consume half of the amount offered for both green and brown foods. Thus regardless of the amount initially offered by parents, a child appears to be likely to consume the same proportion of the amount offered.

The Explicit Preference Task (chapter 2) revealed children to dislike purple and green foods (specifically vegetables) irrespective of either their BMI or SES. However, differences were observed in the amount of exposure children have to these foods, with results indicating children with higher BMI's to be exposed to purple and green foods, and hence vegetables, less frequently than children with lower BMI's. In combination with previous literature these findings suggest children with higher BMI's consume more high fat food and fewer vegetables than children with lower BMI's. However, as there was no relationship observed between preference for the food colours that are associated with vegetables and BMI, it could be implied that all children dislike these kinds of foods; hence the lack of exposure children with higher BMI's have to these foods is unlikely to be related to lower preference. Thus it appears unlikely that food preferences bear any influence on a child's BMI and suggests exposure to be driving this difference. In the pre-school years parents are responsible for the majority of the food that their children are exposed to, hence in line with previous research this thesis provides support for evidence of the role of parents in the development of food preferences.

Parents with children who have higher BMI's may be limiting their child's exposure to fruits and vegetables more so than parents of children with lower BMI's. Although these findings were not corroborated by the Longitudinal Food Diary study (chapter 3) this may be a result of there being less variation in terms of BMI across participants in the Food Diary Study than in the Explicit Preference Task. Therefore further research, perhaps using a food diary methodology with a larger sample size than presented here, is needed to clarify if children with higher BMI's are exposed to purple and green foods, and hence certain vegetables, less frequently than children with lower BMI's.

Previous research has indicated the role of parents in shaping children's food preferences, through restriction (e.g., Fish & Birch, 1999), pressure to eat (e.g., Galloway et al., 2006) and reward (e.g., Birch et al., 1984). This thesis suggests there may be other more subtle ways in which parents may unknowingly influence their children's developing food preferences which have not been considered previously. It is possible that children's early representations of foods are categorised on the distinction between foods their parents restrict and foods they have free access to. As foods that are restricted appear to become more desirable children may generalise restricted foods, for example foods high in fat and sugar, to novel foods that are high in fat and sugar, perhaps on the basis of perceptual attributes; hence children who had restricted access to high fat high sugar foods may form preferences for these types of foods as adults. As this thesis did not directly investigate restriction, further research would be needed to determine the relationship between restriction and categorisation. This could be achieved by restricting children's access to a specific desirable food item, and then allowing free access to a selection of foods, including items that are perceptually similar to the restricted food. If children consume more of the foods that are perceptually similar to the restricted food, rather than the other items offered, this could indicate a relationship between restriction and categorisation. Similar associations may occur for other factors suggested in previous research to influence food preferences of children, such as reward and pressure to eat.

In addition to supporting previous research into the role of exposure in developing food preferences, these findings indicate the subtle role that parents may play in shaping developing food preferences. If parents increase the amount of food from disliked colour categories (e.g., purple and green) that they offer, children may increase the amount of these foods that they consume. Support for this theory would need to be obtained through further research specifically designed to explore the relationship between the amount of food offered to and that consumed by young children, with further consideration of how this may influence future food preferences. It is well established that food preferences can be influenced by increasing exposure, thus if parents offer more 'purple' and 'green' items, thus increasing exposure to 'fruits' and 'vegetables', preference for fruits and vegetables may increase as a function of exposure. However this needs to be explicitly tested.

Food colour and categorisation

This thesis provides support for the theory that perceptual attributes, specifically colour, may be used by children to categorise foods on the basis of 'like' or 'dislike'. It can be implied from these findings that children may be using perceptual attributes to form a conceptual representation of what a food may taste like, based on previous experience with other foods that are perceptually similar. Chapter 4 systematically explored the use of perceptual attributes to categorise food and considered how this may vary compared with categorisation of non-food objects. The findings of this chapter are discussed next.

5.2. The Influence of Cognitive Factors in the Development of Food Preferences

Much previous research into categorisation and concept formation has not systematically differentiated food from non-food items or disentangled specific perceptual attributes exerting an influence on categorisation. Chapter 4 therefore consisted of a series of match-to-sample experiments specifically conducted with the aim of comparing how children and adults categorise food compared with non-food objects and the importance of perceptual (e.g., colour) over taxonomic (e.g., class) attributes in object categorisation. As it has been seen in previous chapters that different perceptual attributes influence preference in different ways it was important to determine which, if any, perceptual attributes were used in the categorisation of food and non-food objects.

Results revealed significant differences in the conceptualisation of food compared with non-food in children. Up to the age of 6-years children would categorise foods at both the basic (e.g., apple) and superordinate (e.g., fruit) levels on the basis of colour, whilst categorising non-food objects (e.g., car, vehicle) on the basis of shape or taxonomic class, even when they knew which superordinate category the item belonged to. Interestingly when superordinate and basic level labels were provided prior to response selection children switched their basis for categorising foods from colour to taxonomic class at the age of 5 years. In contrast, without explicit labelling being provided the age at which children switched from a perceptual to a conceptual method of food categorisation was 7 years.

By highlighting the salience of food colour for children up to the age of 6 years this series of experiments supports the findings of the Explicit Preference Task presented in chapter 2 which is in stark contrast to the categorisation of non-food objects where the switch from perceptual to conceptual categorisation occurs much earlier, at around 3 years of age. Furthermore these results are also in line with previous research which has indicated perceptual attributes to be of importance to young children up until the age of 6 years, from which point other methods (e.g., taste) are utilised to categorise objects, such as taxonomic class (e.g., Oram et al. 1995). Hence, chapter 4 has provided evidence to suggest there is a special case for the categorisation of food and has indicated a link between the role of perceptual and cognitive factors on children's food preferences.

In a series of studies Horne, Lowe and Hughes (various combinations) have demonstrated the importance of naming in categorisation of object function. For example, Lowe et al., (2005) taught children ambiguous names ('zog', 'vek') for arbitrary stimuli (green wooden shapes) which were associated with one of two actions (clapping or waving). Following this, when naming other stimuli as 'zog' or 'vek', although not trained to do so, children went on to do the action (clapping or waving) that they had associated with the name previously. Furthermore, in a follow-up study, Horne, et al., (2006) found naming to be particularly important in categorisation. Not all of the children who participated named the objects, however, only those children who had learned common names of objects went on to categorise the stimuli; in contrast those who did not name, did not categorise. These findings indicate the relationship between naming and categorisation; thus it is possible similar principles apply in the development of food preferences.

If children do associate colour with flavour, as implied by results in this thesis, then parental labelling of foods to distinguish between items of the same colour that vary in taste may also impact on food acceptance. For example, labelling items at both the basic (e.g., broccoli) and superordinate levels (e.g., vegetable) may encourage children to distinguish between food colour and food class. Specifically if a child learns that both 'broccoli' and 'sweetcorn' are vegetables, but they differ in terms of colour and in terms of taste, and alternatively 'grapes' are a fruit which although share the same colour as 'broccoli', do not taste the same; then they may begin to learn that colour is not always indicative of a food's taste. Thus a combined use of the knowledge that food colour may be associated with flavour, and that food labelling may be overextended on the basis of colour, could be used by parents to modify developing food preferences. It is important to note that children will learn the distinction between colour and flavour as they develop; it was observed in chapter 4 that from the age of 7-years children no longer use colour as a basis for categorisation of food items. However, early food preferences predict later food preferences, thus methods than can shape food preferences in the pre-school years could have a lasting impact.

Although the direct relationship between overextension of object labels and preference was unable to be systematically explored in this thesis, it is well established in previous literature that children overextend object labels during the language acquisition process (e.g., Rescorla, 1980). Hence, it is possible the same principle operates for food names. Furthermore, as demonstrated in this thesis overextension of semantic constructs on the basis of colour has been seen to occur for food items, therefore it is likely there is a relationship between the overextension of object labels and the overextension of food colour. Future research could usefully establish the role of overextension in the acquisition of food names and how this impacts on preference. For example, it could be considered if when asking for a 'banana' a child accepts another fruit or a yellow vegetable. It would be necessary to test this empirically by tracking food naming, exposure and preference across children with a comparison of parents who are actively increasing labelling of disliked foods and parents who are not, to determine if parental labelling of disliked foods can increase child labelling of disliked foods.

This thesis has consistently demonstrated that children may use perceptual attributes, specifically colour, to categorise novel foods and suggests children may use this as a basis to develop early semantic constructs based on 'like' or 'dislike' to determine early food preferences. Next a conceptual model is proposed which incorporates both perceptual and cognitive factors in the development of food preferences, with consideration of how these factors may fit with previous research.

5.3. The Relationship Between Perceptual and Cognitive Factors

Although there is a substantive literature into the development of food preferences there has been little previous research considering the role of perceptual and cognitive factors in the development of food preferences. Although factors considered in previous research and reported in chapter 1, such as heritability, reward and modelling, undoubtedly influence food intake in humans; other factors, such as the ability to conceptualise foods, have been shown in this thesis to have the potential to play a role in shaping the development of food preferences in early childhood. To gain a thorough understanding of the development of food preferences future research needs to take an integrated approach, which considers how genetic, biological, and environmental factors may interact with perceptual and cognitive factors, to form a conceptual representation of food that governs food choice. Many factors have previously been found to exert an influence on the development of food preferences (e.g., innate taste preferences, heritability, exposure etc). However, these factors are unlikely to operate in isolation, but most likely interact with a child's emerging conceptual representation of food, so as to shape food preferences.

Incorporating the evidence presented in this thesis, outlined below are two mechanisms which may be influential to children in forming their early food preferences (Figure 12). Firstly, children as young as 7 years are known to use perceptual features when categorising objects, such as animals or toys (Gilmore, 1990) and this thesis has indicated children may use a similar system of classification for foods (chapters 2 and 4). In addition, research indicates that perceptual properties of food are important to adults in terms of indicating, for example, if food is mouldy, or if fruit is ripe. Children are known to be able to discriminate colours from four months of age (Bornstein et al., 1976) therefore it is unsurprising that colour has been shown in this thesis to possibly be used by children to identify the food they are eating.

Theories of semantic memory organisation and concept formation can be utilised to explain the conceptual model proposed here. When trying to identify an object, such as a canary, Collins & Quillian (1969) proposed a model of semantic memory organisation in which people retrieve information by working through various levels from the superordinate (e.g., animal) to the basic level category (e.g., bird) to the subordinate category (e.g., canary). Each level contains nodes, which provide information attached to each category (Figure 11). This hierarchical model saves retrieval time and space in semantic memory as theoretically it is not necessary to store information about a canary's ability to fly, as this information is stored at the basic level that a bird can fly.

If this model is the method used in category organisation then it is possible young children use a similar method to categorise foods. The categories used by children may, however, not be easy to identify. For instance, foods can be categorised in a number of ways, in terms of 'food class', 'foods that are the same colour', 'foods that are the same size' or "foods that I like". The Explicit Preference Task (chapter 2) provided evidence that early categorisation of food may be made on the basis of colour. As a result categorisation on the basis of perceptual attributes, particularly when determining acceptance or rejection of a novel food, could be associated with overgeneralisations of these early semantic constructs on the basis of colour.

Overextension is confined to the same superordinate class (e.g., animals), which could help explain the categorisation of various foods observed by parents and demonstrated through the Explicit Preference Task (chapter 2). Children may observe a food, they try it, and if they dislike it, they may then use the information they have available (e.g., colour) to place novel foods of a similar appearance into the same category of 'dislike' even though they have not yet tried them. Evidence that children may do this was presented in chapter 2.

There is much debate in the literature regarding how children learn to categorise objects, whether this is based on relational similarity (the extent to which two objects perform the same roles) or by perceptual similarity (the extent to which objects share perceptual attributes) (Opfer & Bulloch, 2007). Gelman & Markman (1987) found that five year olds generalise properties to a bat-like bird from a flamingo rather than from a bat, hence ignoring perceptual similarities. In this instance children had been provided with category labels for each of the animals and most probably where using this added information in forming their judgements. This study also found when given no prior information children will categorise objects on the basis of perceptual attributes. Sloutsky & Fisher (2004) suggest that perhaps when given label information children use this as a perceptual feature rather than a category marker. If two objects have the same name they become, in the child's mind, more similar. For instance when children generalise from a flamingo to a blackbird, common labels (e.g., bird) may simply increase the two birds' perceptual similarity. Smith et al., (1996) have suggested that children's novel word interpretation is characterised by context specific selective attention to object properties. When a label is known children will most likely use this to help form their categories, however when it is not known they will use what they have available, in terms of perceptual attributes to help group objects. The perceptual attributes used may vary depending on the context.

For instance shape and size may not be as informative about the similarities in terms of taste that two foods possess as colour may be. Chapter 4 has demonstrated food colour may be a more salient perceptual property than texture, size or shape when categorising food compared with non-food objects. An example of the process of colour-based categorisation that children may be using is the following; the majority of green foods are vegetables (with the exception of a few fruits) as such the colour green is a reliable indication that a food belongs to the same category of vegetable as another green food which may be associated with a bitter taste. Shape and size however may not be as reliable to children in classifying novel foods, for example foods that are the same size and shape as peas could belong to the categories of sweets or nuts. In this context categorising foods on the basis of shape or size would not be functional in informing the child of possible taste, and therefore would not inform their judgement as to whether a food ought to be accepted or rejected. Previous research has indicated the basis for categorisation to differ in monkeys dependent on whether a stimulus is depicted as a food or as a tool, with colour being the used to categorise items depicted as food (Santos et al., 2001; Shutts et al., 2009). Furthermore, it has been suggested that for certain objects such as foods, and canonically coloured objects (e.g., fire engine) that colour may be more indicative of object function than shape, which is typically used by children to categorise non-food objects (Macario, 1991).

Figure 11.A Hierarchical network representation of concepts (Collins and Quillian, 1969)

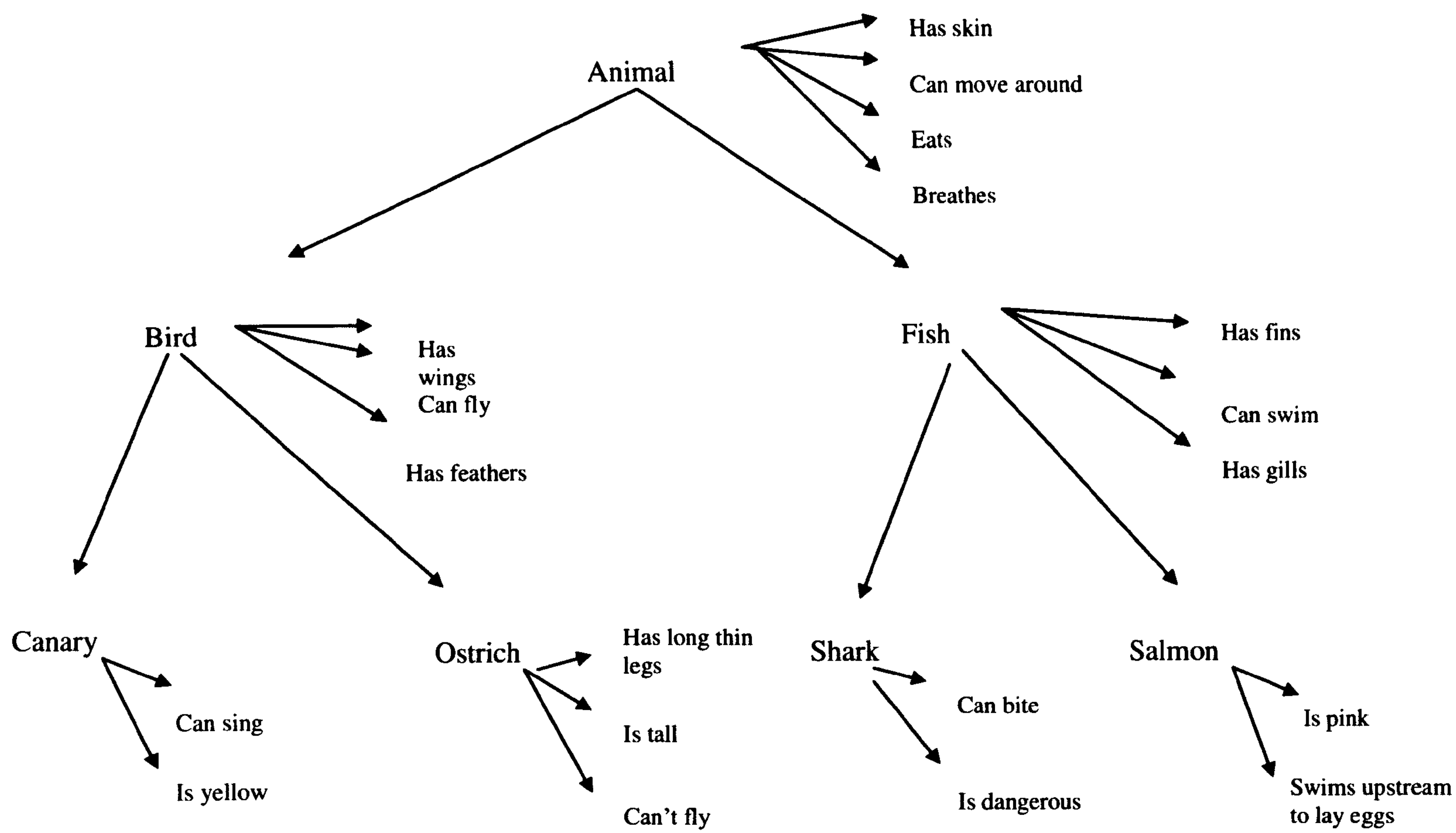
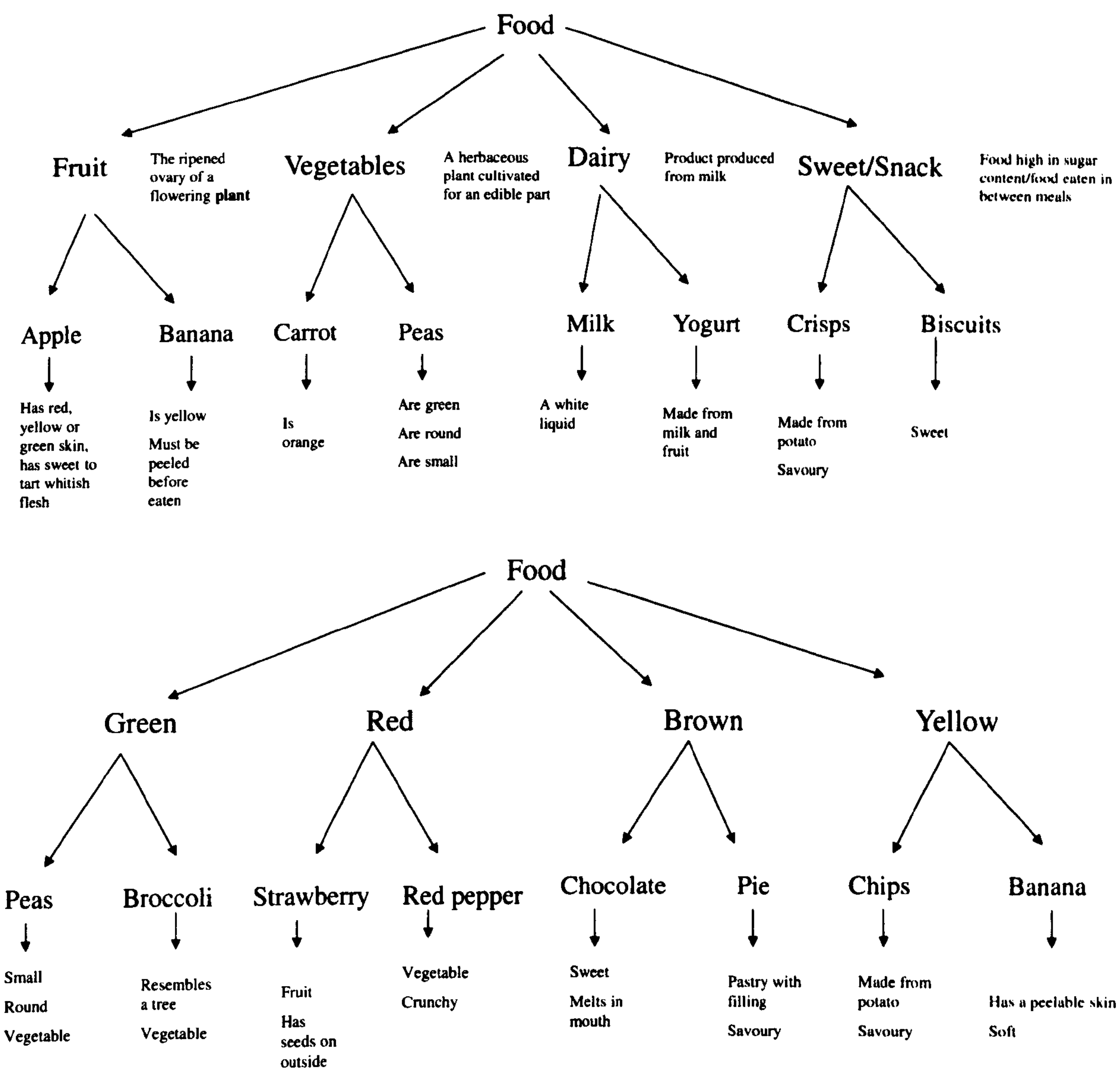


Figure 12. Possible hierarchical representations used in food categorisation



Considering this theory in relation to the development of food preferences it could be proposed that children may use food colour as an early basis of categorisation, associating colour with previous experience of similar coloured foods to determine if a food will be 'liked' or 'disliked'. However, through increased experience, and the ability to name foods children may develop more sophisticated methods as a basis for categorisation. For parents and health practitioners awareness that children may use colour to categorise foods could help modulate early food preferences, or encourage acceptance of a wider range of novel foods.

In summary the findings of this thesis lend to a new model integrating perceptual and cognitive factors in the development of food preferences. As such, when children are presented with a novel food they may compare the perceptual properties to other foods they recall from their semantic memory and make a decision based on their previous experience of foods as to whether the new food will be 'liked' or 'disliked' and thus accepted or rejected. Much more research is required to determine the influence of perceptual and cognitive factors on the development of food preferences.

5.4. Conclusions and Future Directions

This thesis began with the intention of exploring the role of perceptual and cognitive factors in the development of food preferences. Through this process it has become apparent that children's food preferences are a complex process with many influential and confounding factors. However it has been found that perceptual and cognitive factors could play an important part in the development of food preferences in relation to acceptance or rejection of novel foods. A range of methodologies have been developed and have complemented one another in aiding the knowledge of how perceptual and cognitive factors interact to influence the development of food preferences.

There are many questions still unanswered. This is the first large scale investigation into the role of perceptual and cognitive factors in the development of food preferences. There needs to be a considerable amount of future research to explore further the potential role of these factors in shaping developing food preferences, with specific consideration of the interaction between perceptual attributes and exposure in relation to developing food preferences. In addition, further work is required to determine the impact on child BMI and for children who develop into selective eaters. It is clear that parents play a key role in shaping children's food preferences, and this thesis has uncovered areas in which parents may be exerting an influence unknowingly. Thus this thesis has opened up the scope of factors that need to be considered when exploring children's food preferences. It is suggested that there is a relationship between perceptual and cognitive factors in the domain of food and future research ought to build on this. With an increase in the variety of food available to choose from, and concerns over levels of child obesity, it is essential to consider all aspects that may drive emerging food preference, choice and acceptance in young children.

References

Addessi, E., Galloway, A. T., Visalberghi, E., & Birch, L. L. (2005).Specific social influences on the acceptance of novel foods in 2-5-year-old children. *Appetite*, 45(3), 264-271.

Aeberli, I., Amman, R. S., Knabenhans, M., & Zimmermann, M. B. (2008). The national prevalence of overweight in school-age children in Switzerland has decreased between 2002 and 2007. *International Journal of Obesity*, 32(Suppl. 1), S214.

Albertson, A., Anderson, G. H., Crockett, S., & Goebel, M. T. (2003). Ready-to-eat cereal consumption: Its relationship with BMI and nutrient intake of children aged 4 to 12 years. *Journal of the American Dietetic Association*, 103(12), 1613-1619.

American Diabetes Association. (2000). Type 2 diabetes in children and adolescents. *Pediatrics,* 105(3), 671-680.

Andries van der Ark, L. (2007). Mokken Scale Analysis in R. Journal of Statistical Software, 20(11), 1-19.

Anliker, J. A., Bartoshuk, L., Ferris, A. M., & Hooks, L. D. (1991). Childrens' Food Preferences and Genetic Sensitivity to the Bitter Taste of 6-Normal-Propylthiouracil (Prop).*American Journal of Clinical Nutrition*, 54(2), 316-320.

Baldwin, D. A. (1989). Priorities in children's expectations about object label reference – form over colour. *Child Development,* 60, 1291-1306.

Baranowski, T., Baranowski, J. C., Cullen, K. W., Thompson, D. I., Nicklas, T., Zakeri, I. F., & Rochon, J. (2003). The Fun, Food, and Fitness Project (FFFP): The Baylor GEMS pilot study. *Ethnicity & Disease*, 13(Supplement 1), S1-30-S31-39.

Batsell, W. R., Brown, A. S., Ansfield, M. E., & Pashcall, G. Y. (2002). "You will eat all of that!": A retrospective analysis of forced consumption episodes. *Appetite*, 38(3), 211-219.

Beauchamp, G. K., Cowart, B. J., & Moran, M. (1986).Developmental Changes in Salt Acceptability in Human Infants. *Developmental Psychology*, 19(1), 17-25.

Beauchamp, G. K., Gary, K., & Moran, M. (1984). Acceptance of sweet and salty tastes in 2-year-old children. *Appetite*, 5(4), 291-305.

Beauchamp, G. K., & Pearson, P. (1991). Human-Development and Umami Taste. *Physiology and Behaviour,* 49(5), 1009-1012.

Belderson, P., Harvey, I., Kimbell, R., O'Neill, J., Russell, J., & Barker, M. E. (2003). Does breakfast-club attendance affect schoolchildren's nutrient intake? A study of dietary intake at three schools. *British Journal of Nutrition*, 90(6), 1003-1006.

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

Benton, D. (2004). Role of parents in the determination of the food preferences of children and the development of obesity. *International Journal of Obesity*, 28(7), 858-869.

Birch, L. L. (1980).Effects of Peer Models Food Choices and Eating Behaviors on Pre-schoolers Food Preferences. *Child Development*, 51(2), 489-496.

Birch, L. L. (1981).Generalization of a Modified Food Preference. *Child Development*, 52(2), 755-758.

Birch, L. L. (1998). Development of food acceptance patterns in the first years of life. *Proceedings of the Nutrition Society*, 57(4), 617-624.

Birch, L. L. (1999). Development of food preferences. *Annual Review of Nutrition*, 19, 41-62.

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., & 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, 353-360.

Birch, L. L., Marlin, D. W., & Rotter, J. (1984). Eating as the 'Means' Activity in a Contingency: Effects on Young Children's Food Preference. *Child Development*, 55, 431-439.

Birch, L. L. & Ventura, A. K. (2009). Preventing childhood obesity: what works? *International Journal of Obesity*, 33, S74-S81.

Birch, L. L., Zimmerman, S. I., & Hind, H. (1980).The Influence of Social-affective Context on the Formation of Children's Food preferences. *Child Development*, 51, 856-861.

Blossfeld, I., Collins, A., Boland, S., Baixauli, R., Kiely, M., & Delahunty, C. (2007). Relationships between acceptance of sour taste and fruit intakes in 18-month-old infants. *British Journal of Nutrition*, 98(5), 1084-1091.

Blossfeld, I., Collins, A., Kiely, M., & Delahunty, C. (2007). Texture preferences of 12-month-old infants and the role of early experiences. *Food Quality and Preference*, 18(2), 396-404.

Bloom, P., (2000). How children learn the meanings of words, MIT Press, Cambridge, MA.

Booth, A. E., & Waxman, S. R. (2008).Taking stock as theories of word learning take shape. *Developmental Science*, 11 (2): 185-194.

Borah-Giddens, J., & Falciglia, G. A. (1993). A meta-analysis of the relationship in food preferences between parents and children. *Society for Nutrition Education*, 25, 102-107.

Bornstein, M. H., Kessen, W., & Weiskopf, S. (1976). Categories of Hue in Infancy/Erbenol and Trans. *Science*, 191(4223), 201-202.

Breen, F. M., Plomin, R., & Wardle, J. (2006). Heritability of food preferences in young children. *Physiology & Behavior*, 88(4-5), 443-447.

Brian, C. R., & Goodenough, F. L. (1929). The relative potency of color and form perception at various ages. *Journal of Experimental Psychology*, 12, 197-213.

Brown, A. and Lee, M. (2011). A descriptive study investigating the use and nature of baby-led weaning in a UK sample of mothers. *Maternal & Child Nutrition*, 7, 34–47.

Brown, K. A., Ogden, J., Vogele, C., & Gibson, E. L. (2008). The role of parental control practices in explaining children's diet and BMI. *Appetite*, 50(2-3), 252-259.

Busick, D. B., Brooks, J., Pernecky, S., Dawson, R., & Petzoldt, J. (2008). Parent food purchases as a measure of exposure and pre-school-aged children's willingness to identify and taste fruit and vegetables. *Appetite*, 51(3), 468-473.

Caballero, B., Clay, T., Davis, S. M., Ethelbah, B., Rock, B. H., Lohman, T., Norman, J., Story, M., Stone, E. J., Stephenson, L., Stevens, J., & Pathways Study Res, G. (2003). Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren. *American Journal of Clinical Nutrition*, 78(5), 1030-1038.

Cade, J. E., Frear, L., & Greenwood, D. C. (2006). Assessment of diet in young children with an emphasis on fruit and vegetable intake: using CADET - Child and Diet Evaluation Tool. *Public Health Nutrition*, 9(4), 501-508.

Carroll, J. B., & White, M. N. (1973). Age-of-acquisition norms for 220 picturable nouns. *Journal of Verbal Learning and Verbal Behavior*, 12, 563–576.

Carper, J. L., Fisher, J. O., & Birch, L. L. (2000). Young girls' emerging dietary restraint and disinhibition are related to parental control in child feeding. *Appetite*, 35(2), 121-129.

Chinn, S., & Rona, R. (2001). Prevalence and trends in overweight and obesity in three cross sectional studies of British children, 1974-94, *British Medical Journal*, 322(7277), 24-26.

Christensen, C. M. (1983). Effect of color on aroma, flavor and texture judgments of foods. *Journal of food science*, 48, 787-790.

Craeynest, M., Crombez, G., De Houwer, J., Deforche, B., Tanghe, A. and De Bourdeaudhuij, I. (2005).Explicit and implicit attitudes towards food and physical activity in childhood obesity. *Behaviour Research and Therapy*, 43, 1111 – 1120.

Collins, A. M., & Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of verbal learning and verbal behavior*, 8, 240-247.

Connor, S. M. (2006). Food-related advertising on preschool television: Building brand recognition in young viewers. *Pediatrics*, 118(4), 1478-1485.

Cooke, L. J., Chambers, L. C., Anez, E. V., Croker, H. A., Boniface, D., Yeomans, M. R., and Wardle, J. (2010). Eating for pleasure or profit: The effect of incentives on Children's enjoyment of vegetables. Psychological Science, 1-7

Cooke, L. J., & Wardle, J. (2005).Age and gender differences in children's food preferences. *British Journal of Nutrition*, 93(5), 741-746.

Cooke, L. J., Wardle, J., Gibson, E. L., 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.

Cowart, B. J., Yokomukai, Y., & Beauchamp, G. K. (1993, Oct 03-05). Bitter Taste in Aging - Compound-Specific Decline in Sensitivity. *Physiology & Behavior*, 56(6), 1237 – 1241.

Dahl, L. K. (1972). Salt and Hypertension. *American Journal of Clinical Nutrition*, 25, 231-244.

Deheeger, M., Akrout, M., Bellisle, F., Rossignol, C., & Rolland-Cachera, M. F. (1996). Individual patterns of food intake development in children: A 10 months to 8 years of age follow-up study of nutrition and growth. *Physiology & Behavior*, 59(3), 403-407.

De Houwer, J. (2003). The Extrinsic Affective Simon Task. *Experimental Psychology*, 50, 77–85.

Deitel, M. (2002). The International Obesity Task Force and "Globesity". *Obesity Surgery*, 12(5), 613-614.

Desor, J. A., Maller, O., & Turner, R. E. (1973). Taste in Acceptance of Sugars by Human Infants. *Journal of Comparative and Physiological Psychology*, 84(3), 496-501.

Diesendruck, G., Markson, L., & Bloom, P. (2003). Children's reliance on creator's intent in extending names for artifacts. *Psychological Science*, 14, 164–168.

Domel, S. B., Thompson, W. O., Davis, H. C., Baranowski, T., Leonard, S. B., & Baranowski, J. (1996). Psychosocial predictors of fruit and vegetable consumption among elementary school children. *Health Education Research*, 11(3), 299-308.

Donnelly, J. E., Jacobsen, D. J., Whatley, J. E., Hill, J. O., Swift, L. L., Cherrington, A., Polk, B., Tran, Z. V., & Reed, G. (1996). Nutrition and physical activity program to attenuate obesity and promote physical and metabolic fitness in elementary school children. *Obesity Research*, 4(3), 229-243.

Drewnowski, A. (1997). Taste preferences and food intake. *Annual Review of Nutrition*, 17, 237-253.

Drewnowski, A., Henderson, S. A., & Barratt-Fornell, A. (1998). Genetic sensitivity to 6-n-propylthiouracil and sensory responses to sugar and fat mixtures. *Physiology & Behavior*, 63(5), 771-777.

Falciglia, G. A. and Norton, P. A. (1994). Evidence for a genetic influence on preference for some foods. *Journal of the American Dietetic Association* 94 (2), 154 -158.

Fazio, R. H. (1990). Multiple processes by which attitudes guide behaviour: the MODE model as an integrative framework. *Advances in Experimental Social Psychology*, 23, 75–109.

Fisher, J. O., & Birch, L. L. (1995). Fat Preferences and Fat Consumption of 3-Year-Old to 5-Year-Old Children Are Related to Parental Adiposity. *Journal of the American Dietetic Association*, 95(7), 759-764.

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

Flores, R. (1995). Dance for Health – Improving fitness in African-American and Hispanic adolescents. *Public Health Reports*, 110(2), 189-193.

Foster, E., Matthews, J. N. S., Nelson, M., Harris, J. M., Mathers, J. C., & Adamson, A. J. (2006). Accuracy of estimates of food portion size using food photographs – the importance of using age-appropriate tools. *Public Health Nutrition*, 9, 509-514.

Food Standards Agency (2002).R. A. McCance and E. M. Widdowson's The Composition of Foods, Sixth summary edition. Cambridge. Royal Society of Chemistry.

Galloway, A. T., Fiorito, L. M., Francis, L. A., & Birch, L. L. (2006). 'Finish your soup': Counterproductive effects of pressuring children to eat on intake and affect. *Appetite*, 46(3), 318-323.

Gelman, S. A., & Markman, E. M. (1987). Young children's inductions from natural kinds - the role of categories and appearances. *Child Development, 58*, 1532-1541.

Gibson, E. L., Wardle, J., & Watts, C. J. (1998).Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. *Appetite*, 31(2), 205-228.

Gilmore, L. (1990). Categorisation and concept development. *Queensland Researcher*, 6, (2), 48-54.

Graham, S. A., & Diesendruck, G. (2010).Fifteen-month-old infants attend to shape over other perceptual properties in an induction task. *Cognitive Development*, 25(2), 111-123.

Graham, S. A., & Poulin-Dubois, D. (1999). Infants' use of shape to extend novel labels to animate and inanimate objects. *Journal of Child Language*, 26, 295–320.

Greenhalgh, J., Dowey, A. J., Horne, P. J., Lowe, C. F., Griffiths, J. H., & Whitaker, C. J. (2009). Positive- and negative peer modelling effects on young children's consumption of novel blue foods. *Appetite*, 52(3), 646-653.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the Implicit Association Test. *Journal of Personality and Social Psychology*, 74, 1464–1480.

Guo, S. S., Roche, A. F., Chumlea, W. C., Gardner, J. D., & Siervogel, R. M. (1994). The predictive value of childhood body-mass index values for overweight at age 35 Y. *American Journal of Clinical Nutrition*, 59(4), 810-819.

Guthrie, C. A., Rapoport, L., & Wardle, J. (2000). Young children's food preferences: a comparison of three modalities of food stimuli. *Appetite*, 35(1), 73-77.

Harper, L. V., & Sanders, K. M. (1975). Effect of Adults Eating on Young Childrens Acceptance of Unfamiliar Foods. *Journal of Experimental Child Psychology*, 20(2), 206-214.

Harris, G. (2008). Development of taste and food preferences in children. *Current Opinion in Clinical Nutrition and Metabolic Care*, 11(3), 315-319.

Harris, G., Thomas, A., & Booth, D. A. (1990). Development of Salt Taste in Infancy. *Developmental Psychology,* 26(4), 534-538.

Harvey-Berino, J., & Rourke, J. (2003). Obesity prevention in preschool Native-American children: A pilot study using home visiting. *Obesity Research,* 11(5), 606-611.

Hendy, H. M. (2002). Effectiveness of trained peer models to encourage food acceptance in preschool children. *Appetite,* 39(3), 217-225.

Hendy, H. M., & Raudenbush, B. (2000). Effectiveness of teacher modeling to encourage food acceptance in preschool children. *Appetite,* 34(1), 61-76.

Hoff-Ginnsberg, E. (1998). The relation of birth order and socioeconomic status to children's language experience and language development. *Applied Psycholinguistics,* 19, 603-629.

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

Horne, P. J., Hardman, C. A., Lowe, C. F., & Rowlands, A. V. (2009).Increasing children's physical activity: a peer modelling, rewards and pedometer-based intervention. *European Journal of Clinical Nutrition,* 63(2), 191-198.

Horne, P.J.; Hughes, J.C.; & Lowe, C.F. (2006). Naming and categorization in young children. IV. Listener behavior training and transfer of function. *Journal of the Experimental Analysis of Behavior.* 85(2) 247-273.

Horne, P. J., Tapper, K., Lowe, C. F., Hardman, C. A., Jackson, M. C., & Woolner, J. (2004).Increasing children's fruit and vegetable consumption: a peer-modelling and rewards-based intervention. *European Journal of Clinical Nutrition,* 58(12), 1649-1660.

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

Imai, M., Gentner, D., & Uchia, N. (1994). Children's theories of word meaning: the role of shape similarity in early acquisition. *Cognitive Development, 9*(1), 45-75.

Jamieson, J., (2004). Analysis of covariance (ANCOVA) with difference scores. *International Journal of Psychophysiology,* 52(3), 277 – 283.

Jansen, E., Mulkens, S., & Jansen, A. (2007). Do not eat the red food!: Prohibition of snacks leads to their relatively higher consumption in children. *Appetite,* 49(3), 572-577.

Jebb, S. A., Rennie, K. L., & Cole, T. J. (2003).Prevalence and demographic determinants of overweight and obesity among young people in Great Britain. *International Journal of Obesity*, 27(supp1), s9.

Johnson, B., Hackett, A., Roundfield, M., & Coufopoulos, A. (2001). An investigation of the validity and reliability of a food intake questionnaire. *Journal of Human Nutrition and Dietetics*, 14(6), 457-465.

Kajiura, H., Cowart, B. J., & Beauchamp, G. K. (1992). Early Developmental-Change in Bitter Taste Responses in Human Infants. *Developmental Psychobiology*, 25(5), 375-386.

Keller, K. L., Steinmann, L., Nurse, R. J., & Tepper, B. J. (2002). Genetic taste sensitivity to 6-n-propylthiouracil influences food preference and reported intake in preschool children. *Appetite*, 38(1), 3-12.

Keskitalo, K., Knaapila, A., Kallela, M. Palotie, A., Wessman, M., Sammalisto, S., Peltonen, L., Tuorila, H., Perola, M. (2007). Sweet taste preferences are partly genetically determined: identification of a trait locus on chromosome 16. *American Journal of Clinical Nutrition, 86(1), 55 – 63.*

Koivisto, U., & Sjoden, P. (1996). Reasons for rejection of food items in Swedish families with children aged 2-17. *Appetite*, 26, 89-103.

Lakkakula, A. P., Zanovec, M., Silverman, L., Murphy, E., & Tuuri, G. (2008). Black Children with High Preferences for Fruits and Vegetables Are at Less Risk of Being at Risk of Overweight or Overweight. *Journal of the American Dietetic Association*, 108(11), 1912-1915.

Landau, B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development, 3,* 299-321.

Lanigan, J. A., Wells, J. C. K., Lawson, M. S., & Lucas, A. (2001). Validation of food diary method for assessment of dietary energy and macronutrient intake in infants and children aged 6-24 months. *European Journal of Clinical Nutrition*, 55(2), 124-129.

Lavin, T.A., and Hall, D.G. (2002). Domain effects in lexical development: learning words for foods and toys. *Cognitive Development*, 16, 929-950.

Leon, F., Couronne, T., Marcuz, M. C., & Koster, E. P. (1999). Measuring food liking in children: a comparison of non-verbal methods. *Food Quality and Preference*, 10(2), 93-100.

Liem, D. G., Bogers, R. P., Dagnelie, P. C., & de Graaf, C. (2006). Fruit consumption of boys (8-11 years) is related to preferences for sour taste. *Appetite*, 46(1), 93-96.

Liem, D. G., Mars, M., & De Graaf, C. (2004). Sweet preferences and sugar consumption of 4-and 5-year-old children: role of parents. *Appetite*, 43(3), 235-245.

Liem, D. G., & Mennella, J. A. (2002). Sweet and sour preferences during childhood: Role of early experiences. *Developmental Psychobiology*, 41(4), 388-395.

Liem, D. G., Westerbeek, A., Wolterink, S., Kok, F. J., & de Graaf, C. (2004). Sour taste preferences of children relate to preference for novel and intense stimuli. *Chemical Senses*, 29(8), 713-720.

Lillegaard, I. T. L., Loken, E. B., & Andersen, L. F. (2007). Relative validation of a pre-coded food diary among children, under-reporting varies with reporting day and time of the day. *European Journal of Clinical Nutrition*, 61(1), 61-68.

Lillegaard, I. T. L., Overby, N. C., & Anderson, L. F. (2005). Can children and adolescents use photographs of food to estimate portion sizes? *European Journal of Clinical Nutrition*, 59, 611–617.

Lillegaard, I. T. L. and L. F. Andersen (2005)."Validation of a pre-coded food diary with energy expenditure, comparison of under-reporters v. acceptable reporters". *British Journal of Nutrition*, 94(6): 998-1003.

Lioret, S., Touvier, M., Dubuisson, C., Dufour, A., Calamassi-Tran, G., Lafay, L., Volatier, J. L., & Maire, B. (2009). Trends in Child Overweight Rates and Energy Intake in France From 1999 to 2007: Relationships With Socioeconomic Status. *Obesity*, 17(5), 1092-1100.

Liu, J., Golinkoff, R. M., & Sak, K. (2001). One cow does not an animal make: Young children can extend novel words at the superordinate level. *Child Development*, 72(6), 1674 – 1694.

Lowe, C.F., Horne, P.J., & Hughes, J.C. (2005). Naming and categorization in young children: III. Vocal tact training and transfer of function. *Journal of the Experimental Analysis of Behavior*. 83(1), 47-65.

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), 510-22.

Macario, J. F. (1991). Young Childrens Use of Color in Classification - Foods and Canonically Colored Objects. *Cognitive Development*, 6(1), 17-46.

Macdiarmid, J., Loe, J., Craig, L. C. A., Masson, L. F., Holmes, B., & McNeill, G. (2009).Meal and snacking patterns of school-aged children in Scotland. *European Journal of Clinical Nutrition*, 63(11), 1297-1304.

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

Malecka-Tendera, E., & Mazur, A. (2006). Childhood obesity: a pandemic of the twenty-first century. *International Journal of Obesity,* 30, S1-S3.

Marshall, D., Stuart, M., & Bell, R. (2006). Examining the relationship between product package colour and product selection in preschoolers. *Food Quality and Preference,* 17(7-8), 615-621.

Martorell, R., Khan, L. K., Hughes, M. L., & Grummer-Strawn, L. M. (2000). Overweight and obesity in preschool children from developing countries. *International Journal of Obesity*, 24(8), 959-967.

Matsubara, H. (1957). Colour vision test plates for the infants, Handaya Company Ltd, Tokyo.

Matheson, D., Spranger, K., & Sax, A. (2002). Preschool children's perceptions of food and their food experiences. *Journal of Nutrition Education and Behaviour,* 34, 85-92.

McCrory, M. A., Fuss, P. J., McCallum, J. E., Yao, M., Vinken, A. G., Hays, N. P., & Roberts, S. B. (1999). Dietary variety within food groups: association with energy intake and body fatness in men and women. *American Journal of Clinical Nutrition*, 69, 440-447.

Miller, G. A, & Chapman, J. P. (2001). Misunderstanding Analysis of Covariance. *Journal of Abnormal Psychology,* 110(1), 40-48.

Mela, D. (2000). Why do we like what we like? *Journal of the Science of Food and Agriculture*, 81, 10-16.

Mennella, J. A., & Beauchamp, G. K. (1996). The human infants' response to vanilla flavors in mother's milk and formula. *Infant Behavior & Development*, 19(1), 13-19.

Mennella, J. A., Jagnow, C. P., & Beauchamp, G. K. (2001).Prenatal and postnatal flavor learning by human infants. *Pediatrics*, 107(6), art.no.-e88.

Mo-suwan, L., Pongprapai, S., Junjana, C., & Puetpaiboon, A. (1998). Effects of a controlled trial of a school-based exercise program on the obesity indexes of preschool children. *American Journal of Clinical Nutrition*, 68(5), 1006-1011.

Moore, L., Tapper, K., Dennehy, A., & Cooper, A. (2005).Development and testing of a computerised 24-h recall questionnaire measuring fruit and snack consumption among 9-11 year olds. *European Journal of Clinical Nutrition*, 59(7), 809-816.

Mustonen, S., & Tuorila, H. (2009). 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.

Nazzi, T., & Gopnik, A. (2001). Linguistic and cognitive abilities in infancy: when does language become a tool for categorization? *Cognition,* 80, B11-B20.

Nelson, M., Atkinson, M., & Darbyshire, S. (1994). Food photography II: use of food photographs for estimating portion size and the nutrient content of meals. *British Journal of Nutrition,* 76, 31-49.

Neumark-Sztainer, D., Story, M., Hannan, P. J., & Rex, J. (2003). New Moves: a school-based obesity prevention program for adolescent girls. *Preventive Medicine*, 37(1), 41-51.

Nicklaus, S., Boggio, V., Chabanet, C., & Issanchou, S. (2004). A prospective study of food preferences in childhood. *Food Quality and Preference*, 15(7-8), 805-818.

Nicklaus, S., Boggio, V., & Issanchou, S. (2005). Food choices at lunch during the third year of life: High selection of animal and starchy foods but avoidance of vegetables. *Acta Paediatrica*, 94(7), 943-951.

Ogden, C. L., Carroll, M. D., Curtin, L. R., Lamb, M. M., & Flegal, K. M. (2010) Prevalence of High Body Mass Index in US Children and Adolescents, 2007-2008. *Jama-Journal of the American Medical Association*, 303(3), 242-249.

Ogden, C. L., Carroll, M. D., Curtin, L. R., McDowell, M. A., Tabak, C. J., & Flegal, K. M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004.*Jama-Journal of the American Medical Association*, 295(13), 1549-1555.

Ogden C. L., Flegal K. M., Carroll M. D., Johnson C. L., (2002).Prevalence and trends in overweight among US children and adolescents, 1999-2000.*JAMA.*,288:1728-1732.

Ogden, J., Reynolds, R., & Smith, A. (2006). Expanding the concept of parental control: A role for overt and covert control in children's snacking behaviour? *Appetite*, 47(1), 100-106.

Opfer, J. E., & Bulloch, M. J. (2007). Causal relations drive young children's induction, naming, and categorization. *Cognition*, 105(1), 206-217.

Oram, N., Laing, D. G., Hutchinson, I., Owen, J., Rose, G., Freeman, M., & Newell, G. (1995).The Influence of Flavor and Color on Drink Identification by Children and Adults. *Developmental Psychobiology*, 28(4), 239-246.

Øverby, N. C., Lillegaard, I. T. L., Johansson, L., & Anderson, L. F. (2004).High intake of added sugar among Norwegian children and adolescents. *Public Health Nutrition*, 7, 285-293.

Pangrazi, R. P., Beighle, A., Vehige, T., & Vack, C. (2003). Impact of Promoting Lifestyle Activity for Youth (PLAY) on children's physical activity. *Journal of School Health*, 73(8), 317-321.

Parka, J., Shimojoa, E. and Shimojoa, S. (2010). Roles of familiarity and novelty in visual preference judgements are segregated across object categories. *PNAS*, 107 (33), 14552 – 14555.

Peneau, S., Salanave, B., Rolland-Cachera, M. F., Castetbon, K., & Hercberg, S. (2008). The prevalence of overweight and obesity in 7-9 year old children in France is stable between 2000 and 2007. *International Journal of Obesity*, 32, S196-S196.

Pitchford, N. J., & Mullen, K. T. (2001). Conceptualization of perceptual attributes: A special case for color? *Journal of Experimental Child Psychology*, 80(3), 289-314.

Pitchford, N. J., & Mullen, K. T. (2005). The role of perception, language, and preference in the developmental acquisition of basic color terms. Journal *of Experimental Child Psychology*, 90(4), 275-302.

Pliner, P., & Pelchat, M. L. (1986). Similarities in Food Preferences between Children and Their Siblings and Parents. *Appetite*, 7(4), 333-342.

Prescott, J. (2004). Effects of added glutamate on liking for novel food flavors. *Appetite*, 42 (2), 143 – 150.

Prescott, J., & Tepper, B. J. (2004). Genetic Variation in taste sensitivity. New York.

Rapley, G., & Murkett, T. (2005). Baby-led Weaning: Helping your baby to love good food. Vermillon.

Rakison, D.H., & Oakes, L. M. (2003). *Early category and concept development: making sense of the blooming, buzzing confusion*. New York: Oxford University Press.

Receveur, O., Morou, K., Gray-Donald, K., & Macaulay, A. C. (2008). Consumption of key food items is associated with excess weight among elementary-school-aged children in a Canadian first nations community. *Journal of the American Dietetic Association*, 108(2), 362-366.

Reed, D. R., Tanaka, T., & McDaniel, A. H. (2006). Diverse tastes: Genetics of sweet and bitter perception. *Physiology & Behavior*, 88(3), 215-226.

Rescorla, L. (1980). Overextension in early language development. *Journal of Child Language,* 7, 321-335.

Resnicow, K., Davis-Hearn, M., Smith, M., Baranowski, T., Lin, L. S., Baranowski, J., Doyle, C., & Wang, D. Q. T. (1997). Social-cognitive predictors of fruit and vegetable intake in children. *Health Psychology,* 16(3), 272-276.

Ricketts, C. D. (1997). Fat preferences, dietary fat intake and body composition in children. *European Journal of Clinical Nutrition,* 51(11), 778-781.

Robinson, T. N. (1999). Reducing children's television viewing to prevent obesity - A randomized controlled trial. *Journal of the American Medical Association,* 282(16), 1561-1567.

Roefs, A., & Jansen, A. (2002). Implicit and explicit attitudes towards high-fat foods in obesity. *Journal of Abnormal Psychology,* 111, 517–521.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382 – 439.

Rose, G., Laing, D. G., Oram, N., & Hutchinson, I. (2004). Sensory profiling by children aged 6-7 and 10-11 years. Part 2: a modality approach. *Food Quality and Preference,* 15(6), 597-606.

Sachs, M. (2011), Baby-led weaning and current UK recommendations – are they compatible? *Maternal & Child Nutrition,* 7, 1–2.

Sahota, P., Rudolf, M. C. J., Dixey, R., Hill, A. J., Barth, J. H., & Cade, J. (2001). Randomised controlled trial of primary school based intervention to reduce risk factors for obesity. *British Medical Journal,* 323(7320), 1029-1032.

Santos, L. R., Hauser, M. D. &Spelke, E. S. (2001). Recognition and categorization of biologically significant objects by rhesus monkeys (Macaca mulatta): The domain of food, *Cognition,* 82, 127–155.

Scaglioni, S., Salvioni, M., & Galimberti, C. (2008). Influence of parental attitudes in the development of children eating behaviour. *British Journal of Nutrition,* 99, S22-S25.

Schwartz, C., Issanchou, S., & Nicklaus, S. (2009). Developmental changes in the acceptance of the five basic tastes in the first year of life. *British Journal of Nutrition,* 102(9), 1375-1385.

Shutts, K., Condry, K. F., Santos, L. R., & Spelke, E. S. (2009). Core knowledge and its limits: The domain of food. *Cognition,* 112, (1), 120-140.

Selby, J. C., Robb, M. P., & Gilbert, H. R. (2000).Normal vowel articulations between 15 and 36 months of age. Clinical Linguistics and Phonetics, 14, 255-266.

Sjoberg, A., Lissner, L., Albertsson-Wikland, K., & Marild, S. (2008). Recent anthropometric trends among Swedish school children: evidence for decreasing prevalence of overweight in girls. *Acta Paediatrica*, 97(1), 118-123.

Skinner, J. D., Carruth, B. R., Bounds, W., & Ziegler, P. J. (2002). Children's food preferences: A longitudinal analysis. *Journal of the American Dietetic Association,* 102(11), 1638-1647.

Sloutsky, V. M., & Fisher, A. V. (2004).When development and learning decrease memory - Evidence against category-based induction in children. Psychological Science, 15(8), 553-558.

Smith, L. B., Jones, S. S., & Landau, B. (1992). Count nouns, adjectives and perceptual properties in children's novel word interpretations. *Developmental Psychology*, 28, 273-286.

Smith, L. B., Jones, S. S., & Landau, B. (1996). Naming in young children: a dumb attentional mechanism? *Cognition,* 60, 143-171.

Smith, L. B., Jones, S. S., Landau, B., Gershkoff-Stowe, L., & Samuelson, L. K. (2002). Object name learning provides on-the-job training for attention. Psychological Science, 13(1), 13-19.

Smith, L. B., and Samuelson, L. (2006). An Attentional Learning Account of the Shape Bias: Reply to Cimpian and Markman (2005) and Booth, Waxman, and Huang (2005). *Developmental Psychology,* 42(6), *1339-1343*

Stamatakis, E., Wardle, J., & Cole, T. J. Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *International Journal of Obesity*, 34(1), 41-47.

Stillman, J. A. (1993). Color Influences Flavor Identification in Fruit-Flavored Beverages. *Journal of Food Science*, 58(4), 810-812.

Strahan, R., & Gerbasi, K. C. (1972). Short, homogenous versions of Marlow-Crowne social desirability scale. *Journal of Clinical Psychology,* 28(2), 191.

Suchman, R. G., & Trabasso, T. (1966). Color and form preference in young children. *Journal of Experimental Child Psychology, 3,* 177-187.

Sullivan, S. A., & Birch, L. L. (1990). Pass the Sugar, Pass the Salt - Experience Dictates Preference. *Developmental Psychology*, 26(4), 546-551.

Tepper, B. J. (1993). Effects of a slight color variation on consumer acceptance of orange juice. *Journal of Sensory Studies*, 8(2), 145-154.

Thorndike, E.L. (1901). Animal intelligence: An experimental study of the associative processes in animals. Psychological Review Monograph Supplement, 2, 1–109.

Tuorila, H. & Mustonen, S. (2010). Reluctant trying of an unfamiliar food induces negative affection for the food, Appetite 54(2), 418-421.

Turconi, G., Guarcello, M., Berzolari, F. G., Carolei, A., Bazzano R., & Roggi, C. (2005).An evaluation of a colour food photography atlas as a tool for quantifying food portion size in epidemiological dietary surveys. *European Journal of Clinical Nutrition*, 59, 923–931.

Vereecken, C. A., Vandervorst, S., Nicklas, T., Covents, M., and Maes, L. (2010). Test-retest reliability and comparison of children's reports with parents' reports of children's fruit and vegetable preferences. *Appetite*, 55, 574 – 581.

Walsh, L. M., Toma, R. B., Tuveson, R. V., & Sondhi, L. (1990). Color Preference and Food Choice among Children. *Journal of Psychology*, 124(6), 645-653.

Wardle, J., Cooke, L. J., Gibson, E. L., Sapochnik, M., Sheiham, A., & Lawson, M. (2003). Increasing children's acceptance of vegetables; a randomized trial of parent-led exposure, *Appetite*, 40(2), 155-162.

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.

Wardle, J., Sanderson, S., Gibson, E. L., & Rapoport, L. (2001). Factor-analytic structure of food preferences in four-year-old children in the UK. *Appetite*, 37(3), 217-223.

Wardle, J., Sanderson, S., Guthrie, C. A., Rapoport, L., & Plomin, R. (2002). Parental feeding style and the intergenerational transmission of obesity risk. *Obesity Research*, 10(6), 453-462.

Warren, J. M., Henry, C. L. K., Lightowler, H. L., Bradshaw, S. M., & Perwaiz, S. (2003). Evaluation of a pilot school programme aimed at the prevention of obesity in children. *Health Promotion International*, 18(4), 287-296.

Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D., & Dietz, W. H. (1997). Predicting obesity in young adulthood from childhood and parental obesity, *New England Journal of Medicine*, 337(13), 869-873.

Williams, C. L., Strobino, B. A., Bollella, M., & Brotanek, J. (2004). Cardiovascular risk reduction in preschool children: The "Healthy Start" project. *Journal of the American College of Nutrition*, 23(2), 117-123.

Wright, C. M., Cameron, K., Tsiaka, M., and Parkinson, K. N. (2010). Is baby-led weaning feasible? When do babies first reach out for and eat finger foods? *Maternal & Child Nutrition,* 7, (1), 27-33.

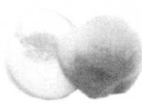
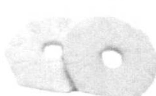
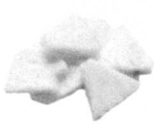
Yokomukai, Y., Cowart, B. J., & Beauchamp, G. K. (1993).Individual-Differences in Sensitivity to Bitter-Tasting Substances, *Chemical Senses*, 18(6), 669-681.

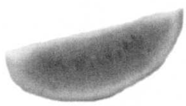
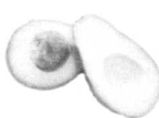
Appendix

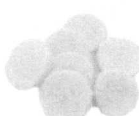
Appendix 1. Stimuli, ratings and accepted labels for all items in the Explicit Preference and Naming Tasks

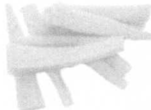
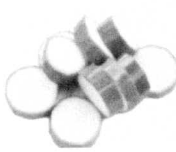
Label	**Image**	**Class**	**Colour**	**Texture**	**Size**	**Accepted Label**
Apple		Fruit	Green	Firm	Medium	Apple
Apple		Fruit	Red	Firm	Medium	Apple
Apple		Fruit	Red	Firm	Medium	Apple
Banana		Fruit	Cream/White	Soft	Medium	Banana, Nana
Banana		Fruit	Cream/White	Soft	Small	Banana, Nana
Banana		Fruit	Yellow	Firm	Medium	Banana. Nana
Blackberries		Fruit	Purple	Soft	Small	Blackberries, Berries
Blueberries		Fruit	Purple	Soft	Small	Blueberries, Berries

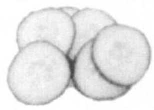
Cherries		Fruit	Purple	Soft	Small	Cherries
Grapefruit		Fruit	Yellow	Firm	Medium	Grapefruit
Grapefruit		Fruit	Yellow	Soft	Small	Grapefruit
Grapes		Fruit	Green	Firm	Small	Grapes
Grapes		Fruit	Purple	Firm	Small	Grapes
Kiwi		Fruit	Brown	Firm	Small	Kiwi
Kiwi		Fruit	Green	Soft	Small	Kiwi
Kiwi		Fruit	Green	Soft	Small	Kiwi
Mango		Fruit	Red	Firm	Medium	Mango
Mango		Fruit	Yellow	Soft	Small	Mango

Melon		Fruit	Green	Firm	Large	Melon
Melon		Fruit	Yellow	Firm	Large	Melon
Melon		Fruit	Yellow	Soft	Medium	Melon
Melon		Fruit	Yellow	Soft	Medium	Melon
Nectarine		Fruit	Orange	Soft	Small	Nectarine, Peach
Orange		Fruit	Orange	Firm	Medium	Orange
Pear		Fruit	Green	Firm	Medium	Pear
Pineapple		Fruit	Green	Firm	Large	Pineapple
Pineapple		Fruit	Yellow	Soft	Medium	Pineapple
Pineapple		Fruit	Yellow	Soft	Small	Pineapple

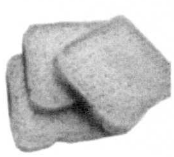
Plum		Fruit	Purple	Soft	Small	Plum
Raspberries		Fruit	Red	Soft	Small	Raspberries, berries
Strawberries		Fruit	Red	Soft	Small	Strawberry, Berry
Tangerine		Fruit	Orange	Firm	Small	Tangerine, Satsuma, Clementine, Orange
Watermelon		Fruit	Red	Firm	Medium	Watermelon, Melon
Watermelon		Fruit	Green	Firm	Large	Watermelon, Melon
Aubergine		Vegetable	Purple	Firm	Large	Aubergine
Avocado		Vegetable	Green	Soft	Medium	Avocado
Beetroot		Vegetable	Purple	Soft	Small	Beetroot
Broccoli		Vegetable	Green	Firm	Large	Broccoli, Broc Broc

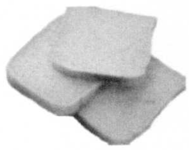
Broccoli (floret)		Vegetable	Green	Soft	Medium	Broccoli, Broc Broc
Butternut squash		Vegetable	Brown	Firm	Large	Butternut Squash, Squash
Butternut squash		Vegetable	Orange	Firm	Large	Butternut Squash, Squash
Cabbage		Vegetable	Green	Firm	Large	Cabbage
Cabbage		Vegetable	Green	Soft	Medium	Cabbage
Cabbage (red)		Vegetable	Purple	Firm	Large	Cabbage
Cabbage (red)		Vegetable	Purple	Soft	Medium	Cabbage
Carrot		Vegetable	Orange	Firm	Medium	Carrot
Carrot		Vegetable	Orange	Firm	Small	Carrot
Carrot		Vegetable	Orange	Firm	Small	Carrot

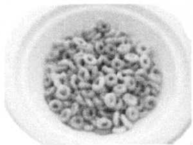
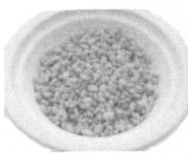
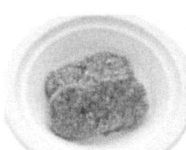
Carrot		Vegetable	Orange	Firm	Small	Carrot
Carrot		Vegetable	Orange	Soft	Small	Carrot
Cauliflower		Vegetable	Cream/White	Firm	Large	Cauliflower, Cauli
Celery		Vegetable	Green	Firm	Medium	Celery
Celery		Vegetable	Green	Firm	Small	Celery
Corn (baby)		Vegetable	Cream/White	Firm	Small	Corn, Sweetcorn
Corn (on cob)		Vegetable	Yellow	Firm	Large	Corn on the cob, Sweetcorn, Corn
Courgette		Vegetable	Green	Firm	Medium	Courgette, Zucchini
Courgette		Vegetable	Green	Firm	Small	Courgette, Zucchini
Cucumber		Vegetable	Green	Firm	Medium	Cucumber

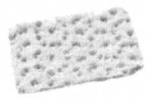
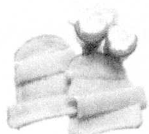
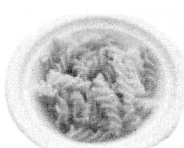
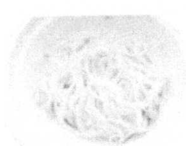
Cucumber		Vegetable	Green	Firm	Small	Cucumber
Cucumber		Vegetable	Green	Soft	Small	Cucumber
Cucumber		Vegetable	Green	Soft	Small	Cucumber
Kidney beans		Vegetable	Purple	Firm	Small	Kidney beans, Beans
Mange tout		Vegetable	Green	Firm	Small	Mange tout, beans
Mushroom		Vegetable	Brown	Soft	Small	Mushroom
Onion		Vegetable	Brown	Firm	Medium	Onion
Onion (red)		Vegetable	Purple	Firm	Medium	Onion
Parsnip		Vegetable	Cream/White	Firm	Medium	Parsnip
Parsnip		Vegetable	Cream/White	Firm	Medium	Parsnip

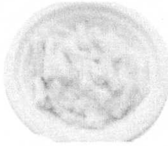
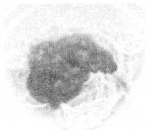
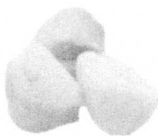
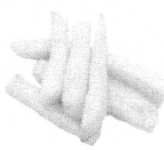
Peas (garden)		Vegetable	Green	Firm	Small	Peas
Peas (mushy)		Vegetable	Green	Soft	Small	Peas
Peas (processed)		Vegetable	Green	Soft	Small	Peas
Pepper		Vegetable	Green	Firm	Medium	Pepper
Pepper		Vegetable	Green	Firm	Small	Pepper
Pepper		Vegetable	Orange	Firm	Medium	Pepper
Pepper		Vegetable	Orange	Firm	Small	Pepper
Pepper		Vegetable	Red	Firm	Medium	Pepper
Pepper		Vegetable	Red	Firm	Small	Pepper
Pepper		Vegetable	Yellow	Firm	Medium	Pepper

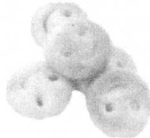
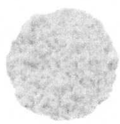
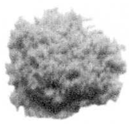
Pepper		Vegetable	Yellow	Firm	Small	Pepper
Spinach		Vegetable	Green	Soft	Medium	Spinach
Sprouts		Vegetable	Green	Soft	Small	Sprouts
Sweetcorn		Vegetable	Yellow	Firm	Small	Sweetcorn, Corn
Tomato		Vegetable	Red	Firm	Small	Tomato, Tom tom
Tomato (cherry)		Vegetable	Red	Firm	Small	Tomato, Tom tom
Beans		Carbohydrate	Orange	Soft	Small	Beans
Bread		Carbohydrate	Brown	Firm	Large	Bread
Bread		Carbohydrate	Brown	Soft	Medium	Bread
Bread		Carbohydrate	Brown	Soft	Small	Bread, Roll, Cob

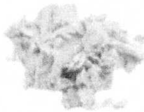
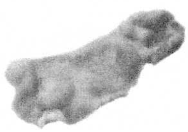
Bread		Carbohydrate	Brown	Soft	Small	Bread, Roll, Cob
Bread		Carbohydrate	Cream/White	Firm	Large	Bread
Bread		Carbohydrate	Cream/White	Soft	Medium	Bread
Bread (bagel)		Carbohydrate	Brown	Firm	Medium	Bagel, Bread
Bread (bagel)		Carbohydrate	Cream/White	Firm	Medium	Bagel, Bread
Bread (baguette)		Carbohydrate	Brown	Firm	Large	Bread, Baguette
Bread (croissant)		Carbohydrate	Brown	Soft	Medium	Croissant, Bread
Bread (crumpet)		Carbohydrate	Cream/White	Soft	Medium	Crumpet, Bread
Bread (naan)		Carbohydrate	Cream/White	Soft	Medium	Naan Bread, Bread
bread (pitta)		Carbohydrate	Brown	Soft	Medium	Bread, Pitta

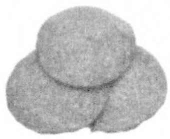
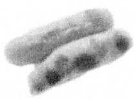
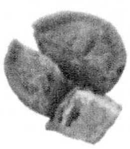
Bread (pitta)		Carbohydrate	Cream/White	Soft	Medium	Bread, Pitta
Cereal (cheerios)		Carbohydrate	Brown	Firm	Small	Cereal, Cheerios
Cereal (coco pops)		Carbohydrate	Brown	Firm	Small	Cereal, Coco pops
Cereal (cornflakes)		Carbohydrate	Yellow	Firm	Small	Cereal, Cornflakes
Cereal (muesli)		Carbohydrate	Yellow	Soft	Small	Cereal, Museli
Cereal (rice crispies)		Carbohydrate	Yellow	Firm	Small	Cereal, Rice crispies, Crispies
Cereal (shreddies)		Carbohydrate	Brown	Firm	Small	Cereal, Shreddies
Cereal (sugar puffs)		Carbohydrate	Yellow	Firm	Small	Cereal, Sugar puffs
Cereal (weetabix)		Carbohydrate	Brown	Soft	Medium	Cereal, Weetabix, Bix
Cracker (cream)		Carbohydrate	Brown	Firm	Medium	Cracker, Cream Cracker

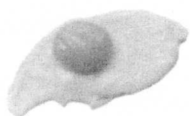
Cracker (ritz)		Carbohydrate	Yellow	Firm	Small	Cracker, Ritz
Cracker (ryvita)		Carbohydrate	Brown	Firm	Medium	Cracker, Ryvita
Cracker (tuc)		Carbohydrate	Yellow	Firm	Small	Cracker, Tuc
Egg (boiled)		Carbohydrate	Yellow	Soft	Medium	Egg
Onion Bahjee		Carbohydrate	Brown	Firm	Small	Onion Bahjee, Bahjee
Pancake		Carbohydrate	Brown	Soft	Small	Pancake
Pasta		Carbohydrate	Brown	Soft	Small	Pasta
Pasta		Carbohydrate	Brown	Soft	Small	Pasta
Pasta		Carbohydrate	Cream/White	Soft	Small	Pasta
Pasta		Carbohydrate	Cream/White	Soft	Small	Pasta

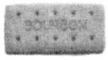
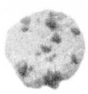
Pasta (macaroni cheese)		Carbohydrate	Yellow	Soft	Small	Pasta, Macaroni Cheese
Pasta (tomato sauce)		Carbohydrate	Red	Soft	Medium	Pasta
Potato		Carbohydrate	Brown	Firm	Medium	Potato, Tato
Potato (baked)		Carbohydrate	Brown	Soft	Medium	Potato, Tato, Baked potato, Jacket
Potato (boiled)		Carbohydrate	Brown	Soft	Small	Potato
Potato (chips)		Carbohydrate	Yellow	Soft	Medium	Chips, Fries
Potato (curly fries)		Carbohydrate	Yellow	Soft	Small	Chips, Fries
Potato (fries)		Carbohydrate	Yellow	Soft	Small	Chips, Fries
Potato (mashed)		Carbohydrate	Cream/White	Soft	Medium	Potato, Mash
Potato (roast)		Carbohydrate	Yellow	Soft	Small	Potato, Roast

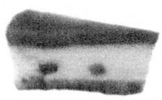
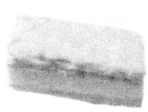
Potato (smiley faces)		Carbohydrate	Yellow	Soft	Medium	Smiley's, Potato
Potato (waffle)		Carbohydrate	Yellow	Soft	Medium	Waffle
Potatoes (new)		Carbohydrate	Brown	Firm	Medium	Potatoes
Rice		Carbohydrate	Cream/W hite	Soft	Small	Rice
Rice		Vegetable	Brown	Firm	Medium	Rice
Yorkshire pudding		Carbohydrate	Brown	Firm	Small	Yorkshire Pudding
Fish (battered)		Meat/fish	Orange	Soft	Medium	Fish
Fish (cod)		Meat/fish	Cream/W hite	Soft	Medium	Fish, Cod, Haddock (any other white fish)
Fish (crabsticks)		Meat/fish	Pink	Soft	Small	Crab sticks, Seafood sticks, Fish sticks
Fish (mackeral)		Meat/fish	Yellow	Soft	Medium	Mackeral, Fish

Fish (salmon)		Meat/fish	Pink	Soft	Medium	Fish, Salmon, Trout
Fish (tuna)		Meat/fish	Pink	Soft	Small	Fish, Tuna
Fish fingers		Meat/fish	Orange	Soft	Medium	Fish fingers
Meat (chicken)		Meat/fish	Brown	Firm	Large	Chicken, Meat
Meat (bacon)		Meat/fish	Pink	Soft	Small	Meat, Bacon
Meat (beef)		Meat/fish	Brown	Soft	Medium	Meat, Beef
Meat (beef)		Meat/fish	Brown	Soft	Small	Meat, Beef
Meat (burgers)		Meat/fish	Brown	Firm	Small	Meat, Burgers
Meat (ham)		Meat/fish	Pink	Soft	Small	Meat, Ham
Meat (ham)		Meat/fish	Pink	Soft	Small	Meat, Ham

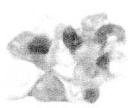
Meat (pork)		Meat/fish	Cream/White	Firm	Medium	Meat, Pork
Meat (pork)		Meat/fish	Cream/White	Soft	Medium	Meat, Pork
Meat (salami)		Meat/fish	Pink	Soft	Small	Meat, Salami, Pepperoni
Meat (sausages)		Meat/fish	Brown	Firm	Medium	Meat, Sausage
Pork pie		Meat/fish	Brown	Firm	Medium	Meat, Pie, Pork pie
Pork pie		Meat/fish	Brown	Firm	Medium	Meat, Pie, Pork pie
Cheese		Eggs/Dairy	Cream/White	Firm	Medium	Cheese
Cheese		Eggs/Dairy	Cream/White	Soft	Small	Cheese
Cheese		Eggs/Dairy	Yellow	Firm	Medium	Cheese
Cheese		Eggs/Dairy	Yellow	Soft	Small	Cheese

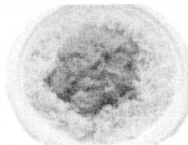
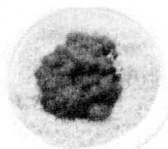
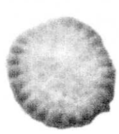
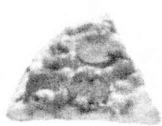
Cheese (babybel)		Eggs/Dairy	Yellow	Firm	Small	Cheese, Babybel
Cheese (blue)		Eggs/Dairy	Cream/White	Firm	Medium	Cheese
Cheese (dairy lea)		Eggs/Dairy	Yellow	Soft	Small	Cheese, Dairy lea, Cheese triangle
Eggs (fried)		Eggs/Dairy	Yellow	Firm	Small	Egg
Eggs (scrambled)		Eggs/Dairy	Yellow	Firm	Medium	Egg, Scrambled egg
Yogurt (greek)		Eggs/Dairy	Cream/White	Liquid	Medium	Yogurt
Yogurt (petit filou)		Eggs/Dairy	Pink	Liquid	Small	Yogurt, Petit Filou, Munch Bunch
Yogurt (strawberry)		Eggs/Dairy	Pink	Liquid	Small	Yogurt
Angel delight (banana)		Sweet/snack	Yellow	Liquid	Medium	Angel Delight, Mousse
Angel delight (chocolate)		Sweet/snack	Brown	Liquid	Medium	Angel Delight, Mousse

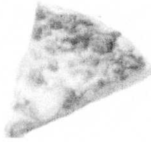
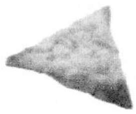
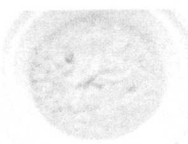
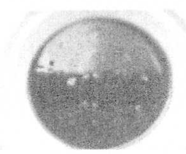
Angel delight (strawberry)		Sweet/snack	Pink	Liquid	Medium	Angel Delight, Mousse
Biscuit (bourbon)		Sweet/snack	Brown	Firm	Small	Biscuit, Bic bic, Bourbon
Biscuit (chocolate cookie)		Sweet/snack	Brown	Firm	Small	Biscuit, Bic bic, Cookie
Biscuit (chocolate digestive)		Sweet/snack	Brown	Firm	Small	Biscuit, Bic bic, Digestive
Biscuit (cookie)		Sweet/snack	Brown	Firm	Small	Biscuit, Bic bic, Cookie
Biscuit (custard cream)		Sweet/snack	Yellow	Firm	Small	Biscuit, Bic bic, Custard Cream
Biscuit (digestive)		Sweet/snack	Brown	Firm	Small	Biscuit, Bic bic, Digestive
Biscuit (wafer)		Sweet/snack	Cream/W hite	Firm	Small	Biscuit, Bic bic, Wafer
Biscuit (wafer)		Sweet/snack	Pink	Firm	Small	Biscuit, Bic bic, Wafer
Cake		Sweet/snack	Brown	Soft	Small	Cake, French Fancy, Fondant Fancy

Cake		Sweet/snack	Pink	Soft	Small	Cake, French Fancy, Fondant Fancy
Cake		Sweet/snack	Yellow	Soft	Small	Cake, French Fancy, Fondant Fancy
Cake (angel slice)		Sweet/snack	Pink	Soft	Small	Cake, Angel Slice
Cake (cheesecake)		Sweet/snack	Brown	Soft	Small	Cake, Cheeseca ke, Gateaux
Cake (cheesecake)		Sweet/snack	Pink	Soft	Medium	Cake, Cheeseca ke, Gateaux
Cake (chocolate)		Sweet/snack	Brown	Soft	Medium	Cake, Muffin, Bun
Cake (cream)		Sweet/snack	Cream/W hite	Soft	Large	Cake, Cream cake, Vanilla slice, Cream slice
Cake (eclair)		Sweet/snack	Brown	Soft	Medium	Cake, Chocolate éclair, Cream cake
Cake		Sweet/snack	Yellow	Soft	Small	Cake, Muffin, Bun
Cake (fruit)		Sweet/snack	Yellow	Soft	Large	Cake, Fruit cake

Cake (fruit)		Sweet/snack	Yellow	Soft	Medium	Cake, Fruit cake
Chocolate (dark)		Sweet/snack	Brown	Firm	Small	Chocolate, Choc choc
Chocolate (milk)		Sweet/snack	Brown	Firm	Small	Chocolate, Choc choc
Chocolate (white)		Sweet/snack	Cream/White	Firm	Small	Chocolate, Choc choc
Crisps		Sweet/snack	Yellow	Firm	Small	Crisps
Crisps (doritos)		Sweet/snack	Yellow	Firm	Small	Crisps, Doritos
Crisps (hoolahoops)		Sweet/snack	Yellow	Firm	Small	Crisps, Hoolahoops
Crisps (quavers)		Sweet/snack	Yellow	Firm	Small	Crisps, Quavers
Crisps (wotsits)		Sweet/snack	Orange	Firm	Small	Crisps, Wotsits
Danish pastry		Sweet/snack	Brown	Firm	Large	Cake, Bun, Danish Pastry

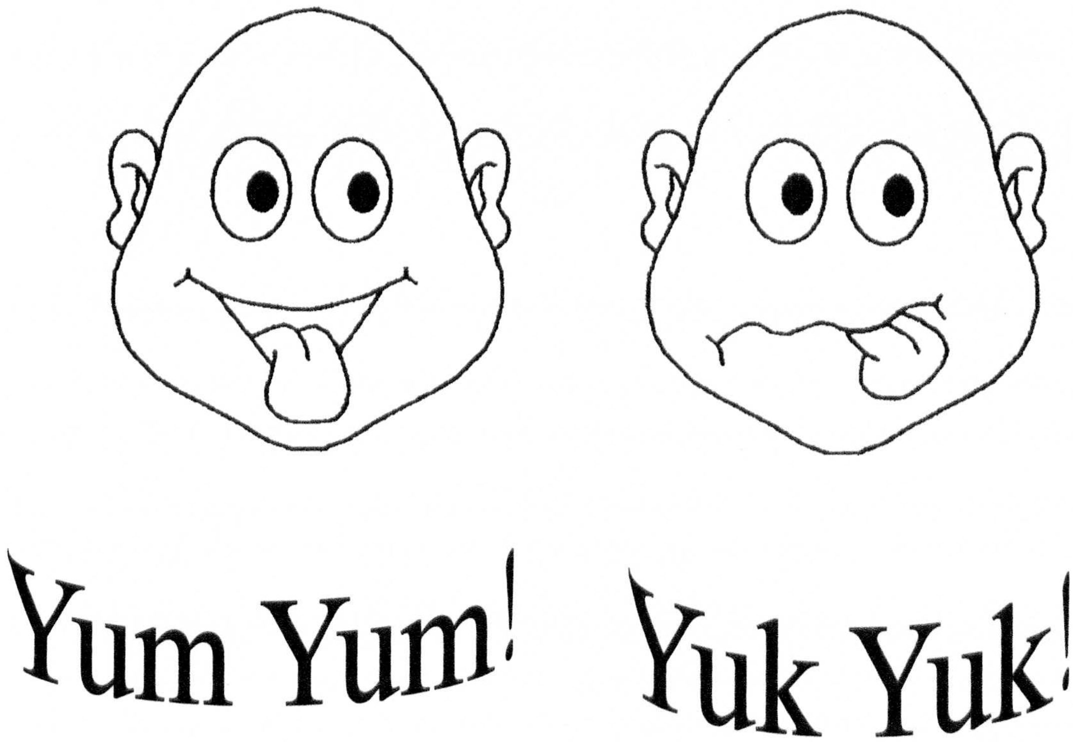
Ice cream (chocolate)		Sweet/snack	Brown	Soft	Medium	Ice cream
Ice cream (strawberry)		Sweet/snack	Pink	Soft	Medium	Ice cream
Ice cream (vanilla)		Sweet/snack	Cream/White	Soft	Medium	Ice cream
Jam donut		Sweet/snack	Brown	Soft	Medium	Cake, Donut, Jam Donut
Sweets		Sweet/snack	Pink	Soft	Small	Sweets, Jelly Babies
Sweets		Sweet/snack	Red	Soft	Small	Sweets, Jelly Babies
Sweets		Sweet/snack	Red	Soft	Small	Sweets, Haribo
Sweets		Sweet/snack	Red	Soft	Small	Sweets, Boiled sweets
Chicken (sweet & sour)		Mixed/Miscellaneous	Orange	Soft	Large	Chicken and rice, Sweet and sour chicken
Coca cola		Mixed/Miscellaneous	Purple	Liquid	Medium	Coke, Pepsi, Cola

Cottage pie		Mixed/Miscellaneous	Brown	Soft	Medium	Meat and potato, Cottage pie, Shepherd's pie
Curry (korma)		Mixed/Miscellaneous	Brown	Soft	Medium	Curry, Korma, Chicken and rice
Egg and bacon		Mixed/Miscellaneous	Cream/White	Soft	Medium	Egg and Bacon
Korma (jalfrezi)		Mixed/Miscellaneous	Red	Soft	Medium	Curry, Chicken and Rice
Lasagne		Mixed/Miscellaneous	Brown	Soft	Medium	Lasagne
Milk		Mixed/Miscellaneous	Cream/White	Liquid	Medium	Milk
Orange juice		Mixed/Miscellaneous	Orange	Liquid	Medium	Juice, Orange
Pie		Mixed/Miscellaneous	Brown	Firm	Medium	Pie
Pie		Mixed/Miscellaneous	Brown	Firm	Medium	Pie
Pizza		Mixed/Miscellaneous	Red	Firm	Medium	Pizza

Pizza		Mixed/Miscellan eous	Yellow	Firm	Medium	Pizza
Roast dinner		Mixed/Miscellan eous	Brown	Soft	Large	Roast dinner, Dinner, Sunday dinner
Samosa		Mixed/Miscellan eous	Brown	Firm	Small	Samosa
Sausage and beans		Mixed/Miscellan eous	Orange	Soft	Small	Sausage and beans
Sausage roll		Mixed/Miscellan eous	Brown	Soft	Medium	Sausage roll
Soup (mushroom)		Mixed/Miscellan eous	Cream/W hite	Liquid	Medium	Soup
Soup (oxtail)		Mixed/Miscellan eous	Brown	Liquid	Medium	Soup, Gravy
Soup (tomato)		Mixed/Miscellan eous	Red	Liquid	Medium	Soup
Soup (vegetable)		Mixed/Miscellan eous	Green	Liquid	Medium	Soup
Spaghetti bolognaise		Mixed/Miscellan eous	Red	Soft	Large	Spaghetti Bolognais e, Bolognais e, Pasta Bolognais e

Spaghetti hoops		Mixed/Miscellan eous	Orange	Soft	Small	Spaghetti hoops, Hoops
Spring roll		Mixed/Miscellan eous	Brown	Firm	Small	Spring roll

Appendix 2. Images depicting 'Yum Yum' and 'Yuk Yuk' from the Explicit Preference Task



Appendix 3. Food Preference and Frequency Questionnaire completed by parents

		Preference rating					Frequency rating						
Item	Never tried	Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Apple													
Banana													
Pear													
Raspberry													
Peach													
Strawberry													
Pineapple													
Watermelon													
Melon													
Blueberry													
Cherry													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once	Once a week	More than once a	Once a month	Less than once a
		5	4	3	2	1	7	6	5	4	3	2	1
Blackberry													
Mango													
Purple grapes													
Green grapes													
Orange													
Tangerine													
Plum													
Kiwi													
Grapefruit													
Aubergine													
Carrot													
Celery													

		Preference rating					Frequency rating						
Item	Never tried	Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Avocado													
Red cabbage													
Green cabbage													
Cucumber													
Spinach													
Butternut squash													
Baby corn													
Corn (on cob)													
Sweetcorn													
Tomato													
Courgette													

		Preference rating					Frequency rating						
Item	Never tried	Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Red pepper													
Green pepper													
Yellow pepper													
Orange pepper													
Mushroom													
Broccoli													
Cauliflower													
Mange tout													
Onion													
Parsnip													
Sprouts													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Peas													
Potato (mashed)													
Potato (roast)													
Potato (boiled)													
Potato (baked)													
Potato (chips)													
Cheese (white)													
Cheese (red)													
Cheese (blue)													
Cheese (Babybel)													
Cheese (dairy lea)													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Eggs (scrambled)													
Eggs (fried)													
Eggs (boiled)													
Chicken													
Beef													
Lamb													
Pork													
Ham													
Mackeral													
Salmon													
Cod													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Crabsticks													
Bacon													
Fishfingers													
Burgers													
Sausages													
Sausage roll													
Onion Bhajee													
Samosa													
Spring rolls													
Salami													
Cornflakes													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Coco pops													
Shreddies													
Cheerios													
Weetabix													
Muesli													
Rice crispies													
Sugar puffs													
White bread													
Brown bread													
Bread roll (white)													
Bread roll (brown)													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Pitta													
Naan bread													
Croissant													
Pancake													
Crumpet													
Pasta													
Rice													
Tomato soup													
Vegetable soup													
Oxtail soup													
Mushroom soup													

		Preference rating					Frequency rating						
Item	Never tried	Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Chicken soup													
Baguette													
Crisps													
Wotsits													
Doritos													
Quavers													
Hoolahoops													
Lasagne													
Cottage pie													
Macaroni cheese													
Sweet and sour chicken													

Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Curry													
Pie													
Pork pie													
Pizza													
Spaghetti bolognaise													
Potato waffle													
Cracker (cream)													
Cracker (Ryvita)													
Cracker (tuc)													
Cracker (ritz)													
Tuna													

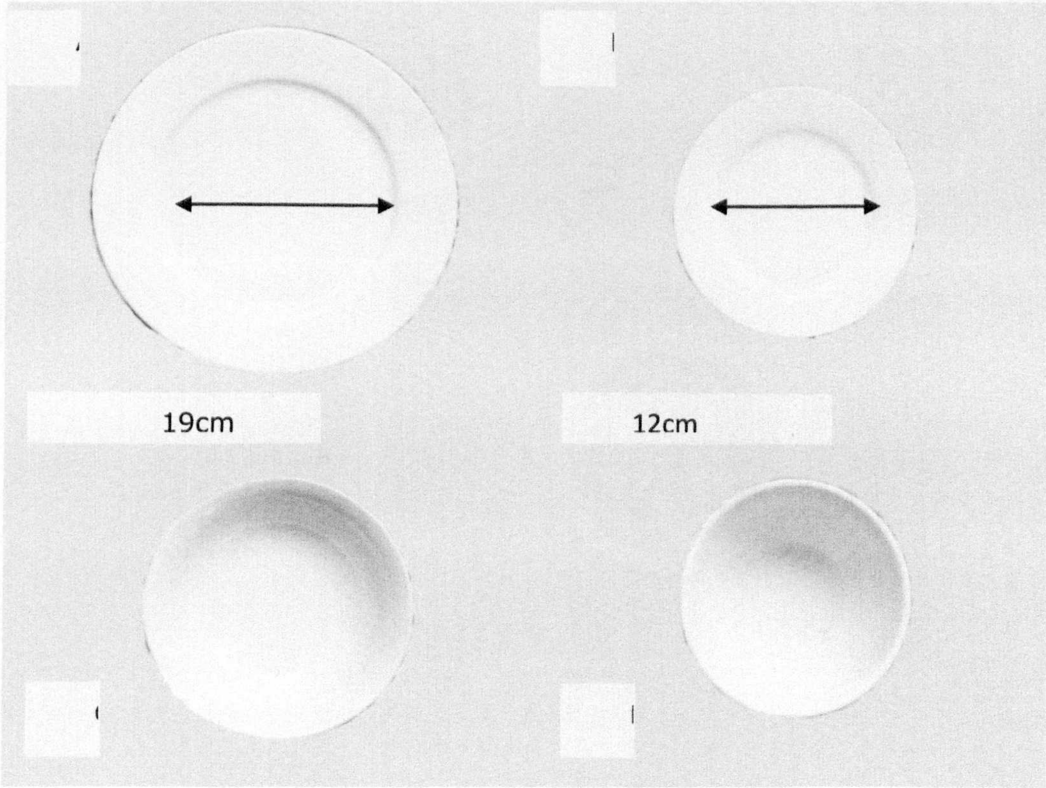
Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Tuna and mayonnaise													
Yorkshire pudding													
Cake (sponge)													
Cake (chocolate)													
Cake (fruit)													
Cake (cream)													
Danish pastry													
Bagel													
Baked beans													
Kidney beans													

		Preference rating					Frequency rating						
Item	Never tried	Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Angel delight (banana)													
Angel delight (chocolate)													
Angel delight (strawberry)													
Ice cream (strawberry)													
Ice cream (vanilla)													
Ice cream (chocolate)													
Biscuit (digestive)													
Biscuit (chocolate digestive)													
Biscuit (bourbon)													

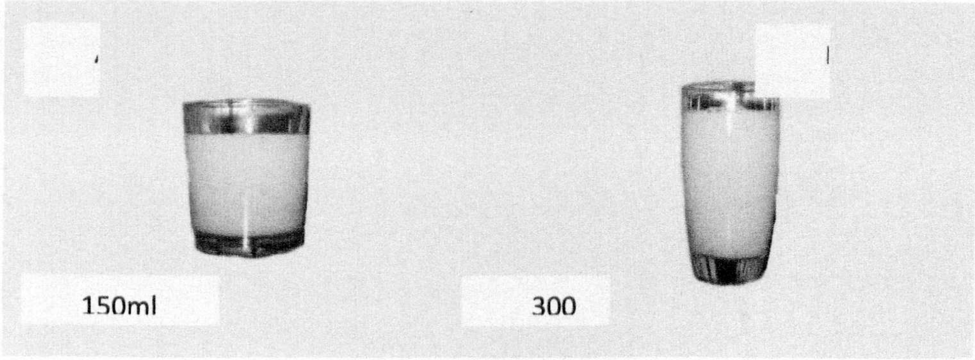
Item	Never tried	Preference rating					Frequency rating						
		Loves it	Likes it	It's ok	Dislikes it	Hates it	More than once a day	Once a day	More than once a week	Once a week	More than once a month	Once a month	Less than once a month
		5	4	3	2	1	7	6	5	4	3	2	1
Biscuit (custard cream)													
Biscuit (cookie)													
Cake (éclair)													
Cheese cake													
Chocolate (milk)													
Chocolate (dark)													
Chocolate (white)													
Sweets (jelly)													
Sweets (boiled)													
Jam donut													

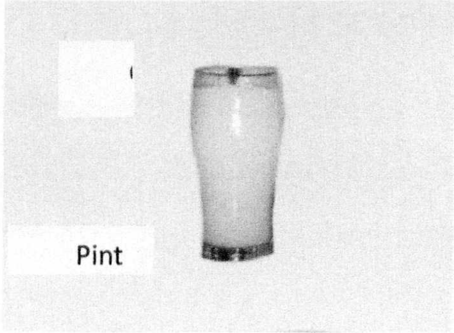
Appendix 4.Photographs to estimate portion size in the Food Diary Study

1. Plate Size

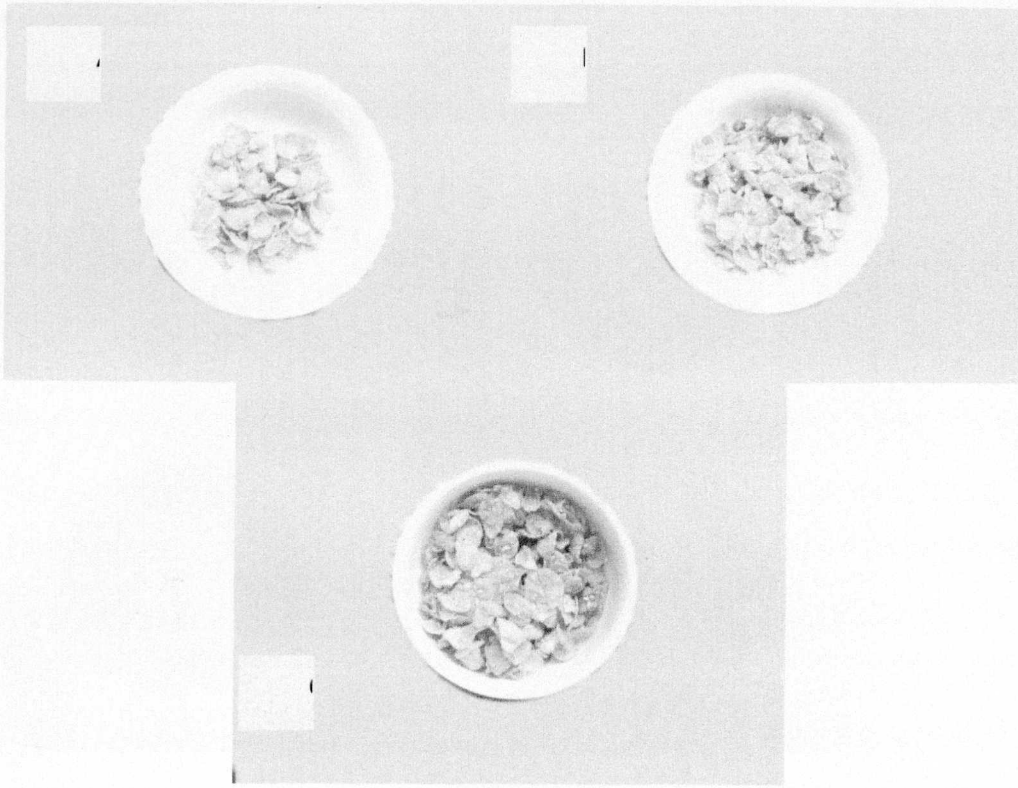


2. Drinks

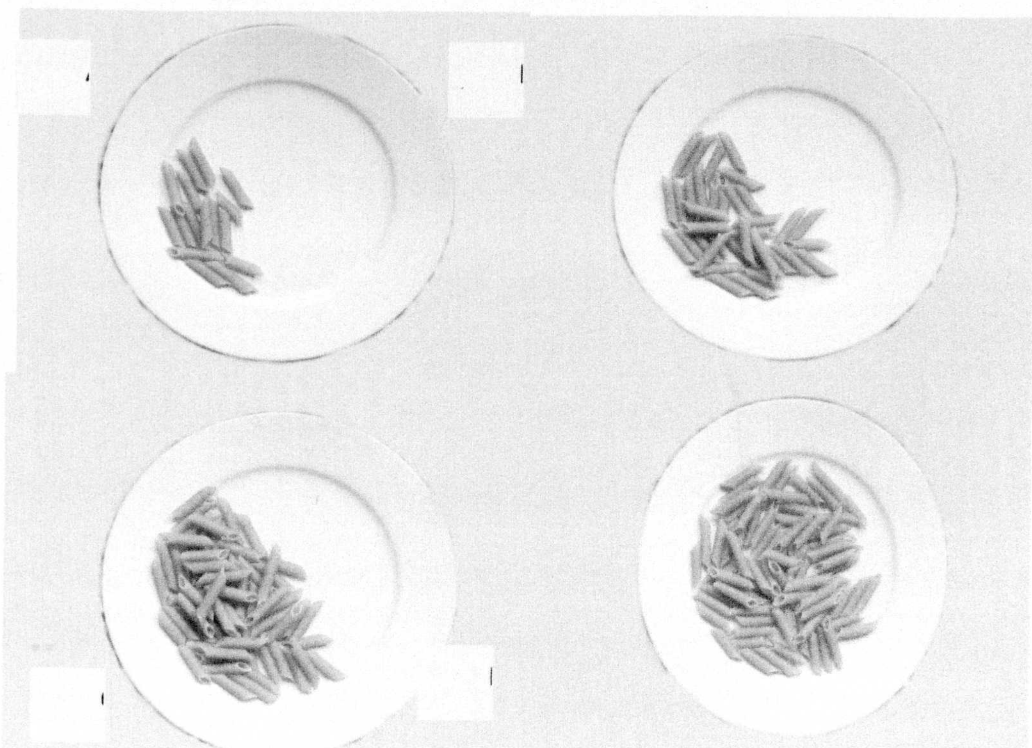




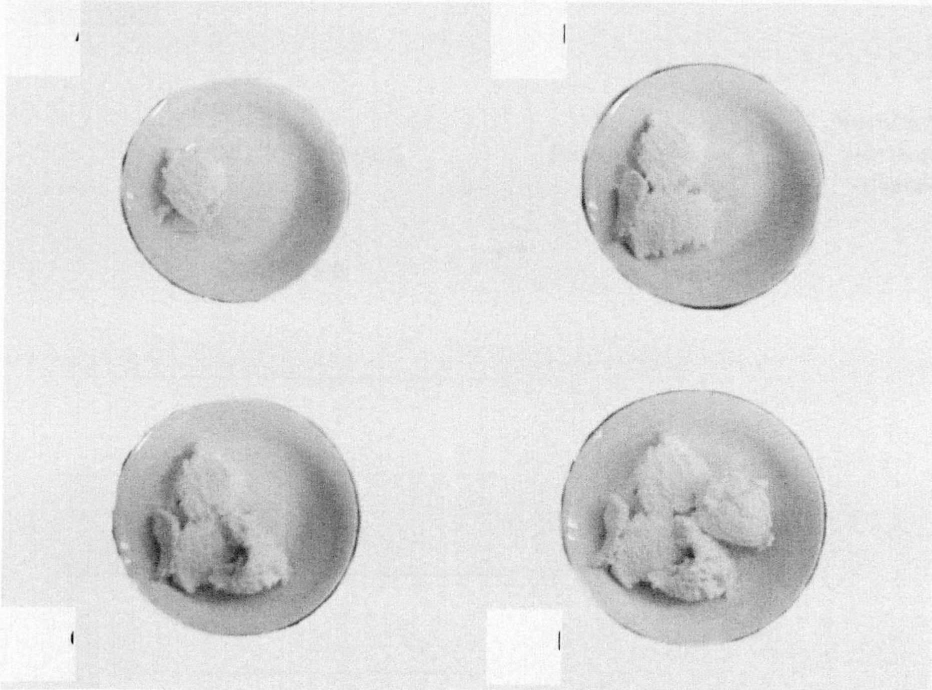
3. Cereal/porridge



4. Pasta/Rice/Potatoes/Chips



5. Ice cream/dessert



Appendix 5. Example of a 24 hour period from the Food Diary.

Day 1 Date (e.g. Mon 15/10/2007) ____________________
6am-10am

Food/Drink offered	Plate Size	Portion size	Number of portions offered	Number of portions consumed
Cornflakes	C	B	1	1
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐

10am-2pm

Food/Drink offered	Plate Size	Portion size	Number of portions offered	Number of portions consumed
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐
____________	☐	☐	☐	☐

2pm-6pm

Food/Drink offered	Plate Size	Portion size	Number of portions offered	Number of portions consumed
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

6pm-10pm

Food/Drink offered	Plate Size	Portion size	Number of portions offered	Number of portions consumed
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

10pm-6am

Food/Drink offered	Plate Size	Portion size	Number of portions offered	Number of portions consumed
______	☐	☐	☐	☐
______	☐	☐	☐	☐
______	☐	☐	☐	☐
______	☐	☐	☐	☐
______	☐	☐	☐	☐

Any other observations/comments (e.g. child was sick)

Appendix 6a. Stimuli used in each of the three tasks in Chapter 4: Experiment 4.1.

Task 1: Food (Fruit)

Target	Colour match	Shape match
Red apple	Red melon (slice)	Yellow apple
Yellow apple	Yellow melon (slice)	Red apple
Red melon (slice)	Red apple	Yellow melon (slice)
Yellow melon (slice)	Yellow apple	Red melon (slice)

Task 2: Non biological non – food (Vehicles)

Target	Colour match	Shape match
Red car	Red motorbike	Yellow car
Red motorbike	Red car	Yellow motorbike
Yellow car	Yellow motorbike	Red car
Yellow motorbike	Yellow car	Red motorbike

Task 3: Biological non-food (Plants)

Target	Colour match	Shape match
Red flower	Red tree	Yellow flower
Red tree	Red flower	Yellow tree
Yellow flower	Yellow tree	Red flower
Yellow tree	Yellow flower	Red tree

Appendix 6b. Stimuli used in each of the 2 tasks in Chapter 4: Experiment 4.2.

a) Task 1: Non-food, biological (plants) and non- biological (vehicles)

Target	Perceptual Match	Taxonomic Match
Green Car	Green Tree	Yellow Bike
Green Tree	Green Car	Yellow Flower
Yellow Bike	Yellow Flower	Green Car
Yellow Flower	Yellow Bike	Green Tree

b) Task 2: Food, fruits and vegetables

Target	Perceptual Match	Taxonomic Match
Green apple	Green pepper	Yellow melon
Green pepper	Green apple	Yellow sweetcorn (on cob)
Yellow melon	Yellow sweetcorn (on cob)	Green apple
Yellow sweetcorn (on cob)	Yellow melon	Green pepper

Appendix 6c. Stimuli used in each of the 16 trials given twice in Chapter 4: Experiment 4.6. Descriptors for colour, texture, and size are given below, where B = brown, O = Orange, W = white, Y = yellow, F = firm, S = soft, M = medium, and SM = small.

Target Stimulus	Colour match	Texture match	Size match
Onion B, F, M	Scotch Pancake B, S, SM	Sweetcorn (off cob) Y, F, SM	Banana (peeled) W, S, M
Chocolate ice cream B, S, M	Kiwi fruit B, F, SM	Cake (French fancy) Y, S, SM	Crisps 'Wotsits' O, F, M
Kiwi fruit B, F, SM	Chocolate ice cream B, S, M	Potato 'smiley faces' Y, F, M	Cauliflower floret W, S, SM
Scotch Pancake B, S, SM	Onion B, F, M	Banana (peeled) W, S, M	White chocolate W, F, SM
Crisps 'Wotsits' O, F, M	Orange segments O, S, SM	White chocolate W, F, SM	Chocolate ice cream B, S, M
Baked beans O, S, M	Carrot (diced) O, F, SM	Cauliflower floret W, S, SM	Onion B, F, M
Carrot (diced) O, F, SM	Baked beans O, S, M	Bagel W, F, M	Scotch Pancake B, S, SM
Orange segments O, S, SM	Crisps 'Wotsits' O, F, M	Banana (peeled) W, S, M	Kiwi fruit B, F, SM
Potato 'smiley faces' Y, F, M	Cake (French Fancy) Y, S, SM	Kiwi fruit B, F, SM	Baked beans O, S, M
Banana Y, S, M	Sweetcorn (off cob) Y, F, SM	Scotch Pancake B, S, SM	Crisps 'wotsits' O, F, M
Sweetcorn (off cob) Y, F, SM	Banana Y, S, M	Onion B, F, M	Orange segments O, S, SM
Cake (French fancy) Y, S, SM	Potato 'smiley faces' Y, F, M	Chocolate ice cream B, S, M	Carrot (diced) O, F, SM
Bagel W, F, M	Cauliflower floret W, S, SM	Carrot (diced) O, F, SM	Banana Y, S, M
Banana (peeled) W, S, M	White chocolate W, F, SM	Orange segments O, S, SM	Potato smiley faces Y, F, M
White chocolate W, F, SM	Banana (peeled) W, S, M	Potato smiley faces Y, F, M	Cake (French fancy) Y, S, SM
Cauliflower floret W, S, SM	Bagel W, F, M	Baked beans O, S, M	Sweetcorn (off cob) Y, F, SM

Raw Data

Chapter 2. Preference, liking, familiarity and exposure to items by colour, texture and size.

	Colour								Texture			Size		
	Red	Brown	Orange	Purple	Pink	Green	Yellow	White	Firm	Soft	Liquid	Small	Medium	Large
No of items within category	18	60	19	12	16	30	45	30	109	108	13	112	96	22
Total number of items (n = 230) liked across all children (n = 160)	1856	6358	2005	963	1763	2629	4697	3117	10875	11226	1287	12065	9413	1910
Total number of items (n = 230) disliked across all children (n = 160)	1024	3242	1035	957	797	2171	2503	1683	6565	6054	793	5855	5947	1610
Mean (SD) Child Preference	.35 (.13)	.34 (.15)	.34 (.14)	.50 (.16)	.31 (.15)	.45 (.13)	.35 (.14)	.35 (.16)	.38 (.17)	.35 (.13)	.38 (.14)	.33 (.14)	.39 (.15)	.46 (.13)
Mean (SD) adult preference	.21 (.10)	.23 (.13)	.19 (.09)	.21 (.09)	.36 (.14)	.20 (.09)	.22 (.09)	.21 (.11)	.21 (.11)	.23 (.11)	.32 (.11)	.23 (.12)	.23 (.11)	.21 (.09)
Number of familiar foods across all children	2145	6388	1881	932	862	3751	4768	3350	11640	11668	769	11413	10279	2385
Mean (SD) frequency of exposure	4.44 (.97)	4.79 (.76)	4.4 (.83)	5.28 (.51)	5.40 (.48)	4.42 (.79)	4.86 (.68)	4.19 (1.22)	4.70 (.96)	4.58 (.79)	5.11 (.82)	4.62 (.74)	4.61 (1.03)	5.06 (.69)