This PhD project provides new knowledge into research on adolescents as subjects in consumer studies as well as person, product and person-product interrelated determinants influencing their affective response to foods such as fruit and vegetable based snacks. Three consumer studies were conducted and four consumer methods were applied. The adolescents successfully used the consumer methods they were exposed to (two types of rating, best-worst scaling and incomplete ranking). Personal determinants, especially gender, played a significant role in their affective response to snacks. Perceived complexity also had an effect on visual preference.
Correction sheet

Corrections added in the PhD thesis by Line Holler Mielby

Status of paper 4 has been changed from submitted to accepted in Journal of Sensory Studies and the newest version has been included in this thesis
Affective response of adolescents towards fruit and vegetable based snacks

- a methodological approach

PhD thesis by
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Abstract

Most adolescents are aware that fruit and vegetables are healthy. Despite this they do not meet the recommended daily guidelines of 300 g of fruit and 300 g of vegetables per day. Preferences are closely linked to food choice and intake. Conditioning processes have successfully changed children’s preferences for fruit and vegetables and are strategies that can also be used by parents. However, it seems doubtful that parents can successfully alter adolescent preferences in favour of fruit and vegetables due to their emerging independence. In the COOL SNACKS project, of which this PhD project has been part of, developing appealing fruit and vegetable based snacks was considered an alternative approach for increasing adolescents’ (10-16 years old) intake of fruit and vegetables. This is a way of meeting adolescents in their own food sphere since they are reported as being frequent snackers. The overall aims of this PhD project were: 1) to clarify important determinants for adolescents’ affective response towards fruit and vegetable based snacks and 2) to include adolescents in sensory and consumer science through the application of a variety of consumer methods as well as assessing the efficacy of two specific methods. Three large consumer studies were established to study the person, the product and the person-product interrelated determinants of adolescents’ affective response. Four different consumer methods were applied in these studies: rating on a 7-point hedonic rating scale; rating on a 7-point Likert scale; best-worst scaling; and incomplete ranking. A brief summary of the five papers presented in relation to this thesis is given below, followed by a summary of the conclusions.

In Paper 1, the efficacy of adolescents’ use of best-worst scaling (of wanting) and rating (of wanting) of twenty-one pictures of common Danish snacks was investigated by assessing the ability of the methods to predict real snack choice. Both methods were able to predict real choice, but rating performed best. In addition, boys reported a high level of hunger and chose baked savoury and sweet snacks, whereas girls chose fruit snacks.

In Paper 2, the relationship between perceived complexity and adults’ and adolescents’ visual preference for pictures of fruit (F), vegetable (V) and combined fruit and vegetable (FV) mixes was investigated using incomplete ranking. Inverted U-shaped relationships between perceived complexity and visual preference for both groups were found for the V mixes and the F mixes but not the FV mixes. To the authors’ knowledge, this is the first empirical evidence for the theoretical bell-shaped relationship between perceived complexity and affective response found for food related stimuli. The optimal level of perceived complexity was also dependent on whether the subjects were adolescents or adults, their gender and frequency of fruit and vegetable intake. The number of colours...
and the colour contrast among the products in the mixes were major contributors to the level of perceived complexity.

In Paper 3 a method of measuring adolescents’ individual perception of complexity was proposed. A sensory descriptive profile where perceived complexity was included as an attribute was developed and terms that correlated with it were identified. This is suggested as a feasible way to identify and generate terms that can be used to individually evaluate adolescents’ perception of complexity.

Paper 4 investigated adolescents’ rating of expected liking, actual liking, attractiveness and simplicity of fruit and vegetable based snack combinations. In general, the snack combinations containing only pure fruit or vegetables received the highest affective ratings (expected liking, actual liking and attractiveness ratings) compared to snack combinations where other food products were included. Girls in particular responded more positively to the pure fruit and vegetables combinations, whilst the boys responded more positively to the surprise snacks containing sensory sensations not anticipated from the visual cues. Neophilic adolescents also gave higher affective ratings (expected liking, actual liking and attractiveness ratings) for all the fruit and vegetable based snack combinations compared to those who were more neophobic.

In Paper 5, adolescents’ use of a modified child and a modified adult neophobia scale adjusted to fit snacking situations was compared. The results indicate that the modified child neophobia scale was more appropriate among adolescents in snack situations. However, more adjustments are needed before the scale is tailored exactly to this age group.

In summary, this PhD project provides new knowledge and valuable insight into research on adolescents as subjects in consumer studies as well as the determinants influencing their affective response to foods such as fruit and vegetable based snacks. The adolescents successfully used the consumer methods they were exposed to: rating on a 7-point hedonic rating scale; rating on a 7-point Likert scale, best-worst scaling and incomplete ranking. Personal determinants, especially gender, played a significant role in their affective response to fruit and vegetable based snacks. Girls generally gave higher affective responses to pure fruit and vegetable snacks than boys. Perceived complexity also had an effect on visual preference. The bell-shaped relationship between perceived complexity and preference was empirically proven for pictures of F and V mixes. Girls had a higher optimal level of perceived complexity compared to boys and adolescents with a high fruit and vegetable intake had a higher optimal level of perceived complexity compared adolescents with a low intake.
**Sammendrag**

De fleste 10 til 16 årige ved at frugt og grønt er sundt. Alligevel indtager de ikke den anbefalede mængde af 300 g frugt og 300 g grønt om dagen. Menneskers valg og indtag af fødevarer er i høj grad påvirket af deres sensoriske præferencer. Samtidig er det blevet bevist at man kan ændre børns fødevarepræferencer i en sundere retning ved hjælp af forskellige tilvænningsteknikker. Disse kan blandt andet bruges af forældre til at påvirke deres børn til højere præferencer for frugt og grøntsager. De unges behov for uafhængighed fra deres forældre gør det imidlertid besværligt for forældrene at have held med at anvende disse tilvænningsteknikker til at ændre deres unges præferencer i retning mod et øget indtag af frugt og grøntsager. I COOL SNACKS projektet, som dette ph.d.-projekt har været en del af, har den grundlæggende ide været at udvikle forskellige spisemetoder og grøntsagsbaserede snacks kan være en alternativ til at øge unges (10-16 år) indtag af frugt og grøntsager. Ideen var at møde unge på deres egen banedel, idet de er kendt for at være hyppige forbrugere af snacks. Desuden rapporterede drenge et højere niveau af sult end pigerne og de valgte i højere grad bagte, krydrede og søde snacks, mens pigerne valgte frugt.

I artikel 1 blev unges brug af rating (af ønsket valg) og best-worst skalering (af ønsket valg) af 21 billeder af danske snacks undersøgt, og det blev sammenlignet, hvor gode de to metoder var til at forudsige de unges reelle valg af 21 snacks. Begge metoder var i stand til at forudsige unges reelle valg, men rating klarede sig bedst. Desuden rapporterede drenge et højere niveau af sult end pigerne og de valgte i højere grad bagte, krydrede og søde snacks, mens pigerne valgte frugt.

I artikel 2 blev forholdet mellem opfattet kompleksitet og voksne og unges visuelle præferencer for billeder af frugt (F), grøntsags- (V) og kombinerede frugt og grøntsags- (FV) blandinger undersøgt ved hjælp af ufuldstændig rangering. Forholdet mellem opfattet kompleksitet og voksen og unges visuelle præferencer havde et klokkeformet forløb for både V og F blandinger, men ikke for FV blandinger. Efter forfatterens kendskab er dette de første empiriske beviser for det teoretisk klokkeformede forhold mellem opfattet
kompleksitet og den subjektive opfattelse fundet for fødevarerelaterede stimuli. Det optimale niveau for opfattet kompleksitet blev desuden fundet afhængig af om deltagerne var unge eller voksne, deres køn, samt hvor ofte de spiste frukt og grønt. Piger havde et højere optimalt niveau af opfattet kompleksitet i forhold til drenge. Derudover havde unge med et højt indtag af frukt og grøntsager et højere optimalt niveau af opfattet kompleksitet i forhold til unge med et lavt indtag af frukt og grøntsager. Antallet af farver og farvekontrasten imellem produkterne i de forskellige blandinger havde den største påvirkning på den opfattede kompleksitet af blandingerne.


I artikel 5 blev unges anvendelse af to neofobiskalaer sammenlignet – en modificeret børne- og en modificeret voksenskala, der begge havde fokus på snacksituationer. Resultaterne indikerede, at den modificerede børneneofobiskala var mest egnet til unge i snacksituationer. Dog skal skalaen yderligere justeres, før den er optimal til videre brug til denne aldersgruppe.

Dette ph.d.-projekt viste, at unge var i stand til at bruge alle de forbrugersanalysemetoder, som de blev udsat for, rating på en smiley 7 punkts-skala, rating på en Likert 7 punkts-skala, best-worst samt ufuldståend dartering. De unges subjektive opfattelse af frukt- og grøntsagsbaserede snacks var påvirket af personlige faktorer og især køn. Piger gav generelt højere subjektive bedømmelser af rene frukt- og grøntsagsbaserede snacks i
forhold til drenge. Opfattet kompleksitet have også en effekt på unges visuelle præferencer, og et klokkeformet forhold mellem opfattet kompleksitet og visuel præference blev fundet for billeder af F og V blandinger. Det optimale niveau for opfattet kompleksitet var afhængig af om deltagerne var unge eller voksne, deres køn samt hvor ofte de spiste frugt og grønt. Dette ph.d.-projekt bidrager herved med ny og værdifuld viden og indsigt i unge som respondenter i forbrugerundersøgelser samt med viden om faktorer, der påvirker unges subjekive opfattelse af fødevarer såsom frugt- og grøntsagsbaserede snacks.
Publication list

Paper 1: Comparison of rating, best-worst scaling, and adolescents’ real choices of snacks
*Food Quality and Preference, 25*(2), 140-147.

Paper 2: Adolescent and adult visual preferences for pictures of fruit and vegetable mixes – Effect of complexity
*Food Quality and Preference 26*(2), 188-195.

Paper 3: Approaching a way to measure adolescents’ perception of complexity for pictures of fruit and vegetable mixes

Paper 4: Affective response of adolescents towards fruit and vegetable based snacks and the role of neophobia, gender and age

Paper 5: Comparisons of a child and an adult snack-neophobia scale applied on adolescents
Nørgaard, M. K.; Mielby, L. H. *Appetite*, 2012, Submitted
List of abbreviations

F: Fruit
FNS: Food Neophobia Scale (Pliner and Hobden 1992)
FSQ: Food Situations Questionnaire (Loewen and Pliner 2000)
FV: Fruit and vegetable
G: Grammes
HI-STIM: High stimulating situations
LO-STIM: Low stimulating situations
PCA: Principal Component Analysis
SNADULT: Snack neophobia adult questionnaire scale developed in relation to the study reported in Paper 4 and 5
SNCHILD: Snack neophobia child questionnaire scale developed in relation to the study reported in Paper 4 and 5
V: Vegetable
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Introduction
Adolescents generally eat fewer fruit and vegetables than the recommended Danish guidelines of 300 g of fruit and 300 g of vegetables per day (Yngve et al. 2005). This is despite their knowledge of fruit and vegetables as being “good for you” (Hill et al. 1998). An increased consumption of fruit and vegetables is of major importance for this age group, not only for their health benefits but also considering the rapid growth and cognitive development of adolescents (Sheperd et al. 2006). Moreover, eating behaviours adopted during childhood and adolescence are likely to persist into adulthood (Lake et al. 2004; Lien et al. 2001).

Preferences are closely linked and predictive of food intake, including that of fruit and vegetables (Gibson et al. 1998; Larson et al. 2008; Wardle et al. 2003). Conditioning processes such as mere exposure, flavour-flavour learning and flavouro-nutrient learning have been proven scientifically to positively change children’s preferences and perceptions of fruit and vegetables (Birch and Marlin 1982; Capaldi and Privitera 2008; Havermans and Jansen 2007). One of the major benefits of these particular conditioning processes is that they can be applied by parents on their children at home. However, parental success at conditioning older children and adolescents regarding fruit and vegetables seems doubtful due to adolescent independence traits (Brown et al. 2000). Other approaches are thus needed to increase adolescent intake of fruit and vegetables.

One approach could be to meet adolescents in their own food-sphere by serving attractive fruit and vegetable based snacks as adolescents are known to be frequent snackers, in that they often eat outside the context of main meals (Bech-Larsen et al. 2010; Jahns et al. 2001; Savige et al. 2007). Therefore, optimising already available fruit and vegetable based snacks may be the solution to increase their intake of fruit and vegetables. Reports have highlighted the possibility of raising the profile of fruit and vegetable based snacks, especially if they were presented in a more attractive way than they currently are (Hill et al. 1998; Jack et al. 1997).

This idea was included in the cross-disciplinary COOL SNACKS project with the vision to increase 10-16 year old Danish adolescents’ intake of fruit and vegetables. The strategy underlying the COOL SNACKS project was to use a multi levelled approach to map an array of determinants of importance for the success of such fruit and vegetable based snacks, which can later be used in development of new products. This PhD thesis is part of the COOL SNACKS project.

Snacks in the COOL SNACKS project are defined as food consumed outside the context of the three main meals: breakfast, lunch and dinner. Furthermore, all fruit and vegetables
incorporated in the snacks should be minimally processed. Minimally processed fruit and vegetables has previously been defined as fresh vegetables or fruit processed to increase their functionality without greatly changing their fresh like properties, such as cutting and washing (Ragaert et al. 2004).

Affective response towards fruit and vegetable based snacks is crucial for increasing adolescent intake of fruit and vegetables via snacks. In this aspect sensory and consumer science is highly appropriate disciplines to engage in. Through sensory and primarily consumer studies, one of the **aims** of this PhD thesis, was to elucidate important determinants for adolescents’ affective response towards the snacks in order to develop successful snacks targeted at adolescents. In the context of this thesis, affective response is defined as subjective responses towards stimuli retrieved from preference and acceptance tests. For the purpose of this thesis, consumer studies relate to the sensory consumer studies described by Martens (1999), not to consumer studies conducted from a market research perspective.

Adolescents have a huge impact on family food choices and have a large market share in the western world (Tufts 2007). Even so hardly any sensory and consumer studies have been published on the feasibility of methods used by this age group. Therefore, this thesis also **aims** to apply a variety of consumer methods on adolescents. Furthermore, two selected consumer methods and their ability to predict adolescents’ real choices of snacks were tested for feasibility. Below is an overview of wider **idea, aim, strategy and vision** of the COOL SNACKS project and the position this PhD thesis occupies within it (Figure 1).

![Figure 1: Overview of the idea, aim, strategy and vision for the COOL SNACKS project and this PhD thesis](image-url)
The intention is that the fruit and vegetable based snacks based on the insights provided by the COOL SNACKS project should attract and be purchased by the adolescents themselves, not only their parents. The primary focus of this thesis was thus to elucidate the effect of snack visual stimuli, as this is often the only stimuli available before we choose a product. However, one thing is persuading adolescents to choose a snack the first time, it is quite another to get them to repeat their choice. Expectations are relevant as they have a large influence on first time and repeated food choice (Deliza and Macfie 1996). In one study conducted in relation to this thesis, the expected liking generated from the visual stimuli of fruit and vegetable based snacks was investigated. Expected liking was compared with the actual liking of the snack products amongst others to see how adolescents responded if their expectations of the snack were not met.

In this thesis affective response towards a food product was assumed to be dependent on the product itself (the snack), the person perceiving the product (the adolescent) and interrelated determinants between the product and the person. The following determinants were studied: visual appearance (product related determinant); age; gender; (trait) neophobia (person related determinants); and perceived complexity and expectations (interrelated determinants). These are only a few of the many determinants of adolescent affective responses to fruit and vegetable based snacks. However, these determinants were chosen as they were of high importance from a sensory and consumer science perspective. Other very important determinants such as social context, effect of labelling, adolescents’ use of media etc. have been studied by other partners in the COOL SNACKS project.

An overview of the studied determinants in relation to the response retrieved from consumer analysis is depicted in Figure 2.

![Figure 2: An overview of studied determinants in relation to responses retrieved from consumer analysis conducted in relation to this thesis](image-url)
Existing knowledge together with the aims of the COOL SNACKS project have led to the following hypotheses and aims for the current PhD project.

Two broad hypotheses underlie this PhD thesis:

- Adolescents’ affective response towards fruit and vegetable based snacks are affected by the visual appearance of the snacks; the perceived complexity of the snacks; the expectations of the snacks; and personal determinants such as age, gender and neophobia.
- The same consumer methods as used with adults apply to adolescents, such as rating and best-worst scaling.

These hypotheses in turn have defined two aims, which form the basis of this thesis:

- To elucidate the effect of visual appearance, perceived complexity, expectations and personal determinants such as age, gender, neophobia on adolescents’ affective response to fruit and vegetable based snacks
- To include adolescents in sensory and consumer science through the application of a variety of consumer methods, to assess the efficacy of two of these methods when used on adolescents and to relate this to their real choice of snacks

Specific sub-aims are:

1. To elucidate the effect of visual appearance on adolescents’ affective response towards fruit and vegetable based snacks. (Paper 1-4+ unpublished results)
2. To include adolescents in sensory and consumer science by subjecting them to a variety of consumer methods. Furthermore to clarify knowledge about the efficacy of adolescents’ use of best-worst scaling and rating by investigating the predictability of adolescents’ real choice of snacks. (Paper 1-5)
3. To suggest a method for evaluating adolescents’ perceived complexity and to study the effect of perceived complexity on their affective response towards the visual appearance of fruit and vegetable based snacks compared to adults. (Paper 2-3)
4. To elucidate the relationship between expectations generated from visual stimuli and adolescents’ actual liking of fruit and vegetable based snacks. (Paper 4)
5. To explore the effect of personal determinants such as age, gender and neophobia on adolescents’ affective response to fruit and vegetable based snacks and to compare appropriate scales to measure trait neophobia (Paper 1-5)
With these aims in mind, this thesis will include adolescents as subjects in the field of sensory and consumer science by:

- Providing knowledge about adolescents and their affective response to food using fruit and vegetable based snacks as a model
- Improve knowledge about performing consumer analysis using adolescents as subjects, as regards to use of methods and experimental procedures. For research as well as industry innovation this knowledge is valuable in a society where adolescents have immense influence on the food market, through their own choices as well as those of their susceptible parents.

The methods used in this project can be extended to other subject groups. Thus the outcome is to also obtain methods which can predict consumers’ affective response towards foods in the future.

The overall purpose of this thesis is to discuss the results obtained in relation to established research. The structure of the thesis reflects this. **Extended abstracts of the papers included in this thesis** follow the Introduction. They have been added to give a quick overview of the aims, methods, subjects and results prior to the discussion in the later chapters. **Chapter 1 (Setting the scene)** reviews the relevant background, such as children and adolescent’s relationship with fruit and vegetables, their food preferences and snacks. **Chapter 2 (Around children and adolescents)** briefly addresses the subject group that has been the focus of this PhD. The intention is to give a general introduction to the subject group, their development and behaviour without addressing their behaviour towards food. **Chapter 3 (Consumer testing methods)** describes and discusses some of the methods of analysis applied in consumer science relevant to this thesis. Due to the vast number of different methods, only those related to the work conducted in this thesis will be presented here. These methods are then described and discussed with regards to their application to children and adolescents. **Chapter 4 (Determinants of importance for adolescent’s affective response of fruit and vegetable based snacks)** examines the determinants highlighted in the studies conducted and which were found to be important for adolescents’ affective response to fruit and vegetable based snacks. Finally **Conclusions** and **Perspectives** on the work conducted are given.
Extended abstracts of papers included in this thesis

Paper 1: Comparison of rating, best-worst scaling and adolescents’ real choices of snacks

Introduction: Despite great power on the consumer market, adolescents are an overlooked segment in sensory and consumer science. This segment’s ability to master different sensory and consumer tests have not been studied.

Aim: This study aimed to investigate the efficacy of adolescents’ use of best-worst scaling and rating of 21 different snacks by investigating best-worst scaling and ratings’ predictability of adolescents’ real choice of snacks. This was investigated by means of: Discrimination between samples, best prediction of real choice, and ease of use of methods from adolescents’ as well as experimenter’s perspectives. Additionally, the aim was to explore differences in adolescents’ real choices of snacks depending on their age, gender, hunger and urban/rural origin.

Method and stimuli: Adolescents evaluated their intended choice of 21 different snacks by both rating and best-worst scaling using pictures of the snacks. Afterwards they performed a real choice of the 21 actual snack products.

Subjects: Three hundred and eighty-seven Danish adolescents (11-16 years old) from 5th, 7th and 9th grades in eight Danish public schools participated. Four of the schools were located in urban areas whereas the other four schools were located in rural areas.

Results: Rating and best-worst scaling were both able to predict real choice of snack on an individual level but rating performed best. However, best-worst scaling showed greater sample discrimination. With regards to easiness, the adolescents found rating the easiest to perform. Best-worst scaling was found more time consuming to work with, both during the experiment as well as during data handling before data analysis. The adolescents’ real choice of snacks and background data showed that boys reported a high level of hunger and chose baked savoury and sweet snacks, whereas girls chose fruit snacks.
Paper 2: Adolescent and adult visual preferences for pictures of fruit and vegetable mixes – Effect of complexity

**Introduction:** Complexity is an important parameter for the appreciation of foods as a bell-shaped relationship between hedonic appreciation and perceived complexity has been found by Berlyne (1970).

**Aim:** The aim of this study was to examine the relationship between adolescents’ and adults’ visual preferences and perceived complexity for vegetable (V), fruit (F), and combined fruit and vegetable (FV) mixes.

**Method and stimuli:** Subjects performed three incomplete rankings of visual preference of eight pictures of V mixes, eight pictures of F mixes, and eight pictures of FV mixes, respectively. The three sets of pictures were designed using a 2³ design and varied in their level of designed collative properties by varying the cut, colour, number of products, type of product, and combination of products. In addition, the pictures were evaluated for perceived complexity by a sensory descriptive panel.

**Subjects:** Two hundred and forty-two adolescents (10-16 years old) and 119 adults (16< years old) participated in the study. The adolescents were recruited from 5th, 7th and 9th grades in two Danish public schools. The adults were recruited from a Danish supermarket in one of the largest shopping centres in Denmark (Kvickly, Rosengaardscenteret, Odense). Ten trained sensory assessors participated in the sensory descriptive analysis of the pictures.

**Results:** The results show high correlations between designed collative properties and perceived complexity. Inverted U-shaped relationships between visual preference and perceived complexity were found for both the V mixes and the F mixes but not for the FV mixes. For the V and the F mixes, the subjects’ optimal level of perceived complexity was found dependent on whether they were adolescents or adults, their gender and frequency of eating fruits and vegetables. Adults had a significantly higher optimal level of perceived complexity than adolescents for V and F mixes. Girls had a significantly higher optimal level of perceived complexity than boys for the V and F mixes. A high frequency of eating vegetables had a significant, positive effect on the optimal perceived complexity level for the V mixes, while a high frequency of eating fruit had a significant, positive effect on the optimal perceived complexity level for F mixes.
Paper 3: Approaching a way to measure adolescents’ perception of complexity for pictures of fruit and vegetable mixes

**Introduction:** Complexity is an important parameter for food product developers and food scientists alike. A bell-shaped relationship exists between hedonic appreciation and perceived complexity (Berlyne, 1970). However, difficulties are frequently encountered in describing and measuring collative properties.

**Aim:** The aim of this study was to investigate whether sensory descriptive analysis is an effective tool for deriving terms which can be used to measure adolescents’ perception of complexity for pictures of fruit and vegetable mixes.

**Method and stimuli:** A sensory descriptive panel evaluated 10 sensory descriptive attributes including simplicity and complexity for 24 pictures of fruit and vegetable mixes. Two consumer groups consisting of adolescents (n=242) and adult (n=86) subsequently rated the same pictures on simplicity and attractiveness. Simplicity was derived from the sensory descriptive analysis.

**Subjects:** Ten trained sensory assessors participated in the sensory descriptive analysis of the pictures. Two hundred adolescents (10-16 years old) and 86 adults (above 25 years old) participated in the consumer study. The adolescents were recruited from 5th, 7th and 9th grades in two Danish public schools. The adults were recruited from a Danish supermarket in one of the largest shopping centres in Denmark (Kvickly, Rosengaardscenteret, Odense).

**Results:** The sensory descriptive analysis of the pictures illustrated and revealed a strong relationship between complexity and simplicity. With this in mind, simplicity was used as a term to evaluate perceived complexity in consumer studies using both adolescent and adult consumers. Pearson’s correlation coefficients revealed strong correlations between the sensory panel’s and both consumer groups’ use of simplicity. This suggests that simplicity can be used to evaluate perceived complexity among consumers. In addition, different optimal levels of simplicity in relation to attractiveness of pictures of fruit mixes were found for different segments of adolescent consumers.
Paper 4: Adolescents’ affective response towards fruit and vegetable based snacks and the role of neophobia, gender and age

**Introduction:** Snacking is a common dietary behaviour among adolescents and is identified as one of the main causes of adolescent obesity. Since snacks are not easily excluded from their diet, promotion of nutritious snacks, such as fresh fruit and vegetables, is essential as is research into adolescents’ perception of them.

**Aims:** The intention was to study adolescents’ rating of expected liking, liking, attractiveness and simplicity of snack combinations based on four different approaches. The impact of the adolescents’ gender, age and level of neophobia, on their responses towards snack combinations and the difference between their expected and real liking of snack combinations was also investigated.

**Method and stimuli:** The adolescents rated their expected liking, liking, level of attractiveness and simplicity of examples of snack combinations based on four different approaches: 1) combining one or more colour in the snack; 2) adding high energy stimuli to an otherwise low energy vegetable snack; 3) combining fruit and vegetables with savoury and sweet snack products; and 4) creating surprising snack products through adding aromas, sensations and flavours not anticipated from visual cues of the snack. Their level of (trait) neophobia was also measured.

**Subjects:** Two hundred and seventy-eight adolescents (10-16 years old) from 5th, 7th and 9th grades in three Danish schools participated in the study.

**Results:** The only approach that proved partly successful was adding high-energy stimuli (dips and bread) to a low energy vegetable snack (cucumber). Apart from that, the most simple pure fruit or vegetable combination received the highest affective ratings. In general, neophilic adolescents gave higher ratings compared to those who were more neophobic. As regards gender, boys responded more positively to the surprise snacks, whilst girls generally responded more positively to the pure fruit and vegetables combinations. Expected liking was rated higher than actual liking for all snack combinations, aside from the snack combinations creating surprise experiences not anticipated from visual cues of the snack. The results show the importance of tailoring snacks to different target groups as these may result in an alternative affective response.
Paper 5: Comparisons of a child and an adult snack-neophobia scale applied on adolescents

Introduction: Neophobic reactions to novel food influence children’s food perceptions, preferences and choices. During adolescence, many biological and psycho-social changes occur. Adolescents develop independence traits and search for new food experiences, such as in the snack category, to distinguish themselves from their parents and further their development as individual consumers. Despite their significant role as food consumers, not much research has been conducted on snack neophobia among European adolescents and so no existing scale seems appropriate.

Aim: The aim of our empirical study was to compare modifications of a child and adult neophobia scale among adolescents in snacking situations.

Method and stimuli: The original child and adult neophobia scales were modified to suit adolescents and to target snacking situations rather than general food consumption. By means of an online survey performed at primary schools, comparisons were investigated based on method-and content-issues and by age and gender differences.

Subjects: Two hundred and seventy-nine adolescents (10-16 years old) from 5th, 7th and 9th grades in three Danish schools participated in the study.

Results: Our findings indicate that the modified child neophobia scale is most appropriate among adolescents aged 10 to 16 years in snack situations. However, when solely considering the acceptable amount of text and time spent, the adult scale seems superior. For future use, the modified child neophobia scale needs further adjustment to be more appropriate for this adolescent age group.
1. Setting the scene

Children and adolescents intake of fruit and vegetables
Healthy eating, including regular consumption of fresh fruit and vegetables, contributes to an overall sense of wellbeing and helps reduce the risk of a number of health related conditions such as heart disease (Joshipura et al. 2001); some types of cancer (Paolini et al. 2003) and obesity (Pesa and Turner 2001; Yannakoulia et al. 2010). Furthermore healthy eating for children and adolescents is important and necessary for growth and cognitive development (Sheperd et al. 2006). Eating behaviours adopted during childhood are likely to persist into adulthood, underlining the importance of encouraging healthy eating as early as possible (Lake et al. 2004; Lien et al. 2001).

Nevertheless, children and adolescents in many countries, including Denmark, eat below the recommended daily amount of fruit and vegetables (Yngve et al. 2005). A European study found consistency in daily intake of fruit across the European population, but the picture was not as consistent for vegetable intake (Yngve et al. 2005). As mentioned, the recommended Danish daily intake of fruit and vegetables for children and adolescents over 10 years is 300g of vegetables and 300g of fruit excluding potatoes (Yngve et al. 2005). Fruit consumption in Denmark is higher than that of vegetables and girls consume more compared to boys (Pedersen et al. 2010; Yngve et al. 2005). A large Danish cross sectional study conducted between 2003 and 2008 found that adolescent girls (10-17 years old) consumed 126g (± 70g) of vegetables and 282g (±204g) of fruit per day, whereas boys in the same age group consumed 137g (±81g) vegetables and 234g (±226g) fruit per day (Pedersen et al. 2010).

These Danish results are in agreement with several from across the world. There is a long list of publications showing that girls tend to consume and like fruit and vegetables more compared to boys and that the gender effects are larger as children move from mid to late adolescence (Brug et al. 2008; Cooke et al. 2005; Le Bigot Macaux 2001; Nu et al. 2007; Reynolds et al. 1999). Brug et al. (2008) argue that one reason why girls consume more fruit and vegetables may be due to the fact that they have stronger taste preferences towards this food category compared to boys. Furthermore, the energy requirements of boys of all ages are larger than those of girls, therefore boys’ preference for more energy dense food groups, rather than fruit and vegetables, may serve an adaptive purpose (Cooke et al. 2005; Wardle et al. 2004). Older children and adolescents are aware of the health benefits of fruit and vegetables (Hill et al. 1998). An additional reason could be that girls pay more attention to dietetics compared to boys (Cooke et al. 2005; Nu et al. 2007). A British study of adolescents aged 12 to 18 years old found a striking difference in body image, restraint and food attitudes between girls and boys as early as 12 or 13 years old.
Girls felt fatter and expressed guilt related to eating, whereas boys did not have as many concerns (Wardle and Beales 1986).

**Development of food preferences in children and adolescents**

Food preferences are closely linked to, and predictive of, food intake in children and adolescents (Gibson et al. 1998; Larson et al. 2008; Wardle et al. 2003). Understanding the development of food preferences and behaviour in childhood and adolescence is therefore essential to the discussion about increasing intake of fruit and vegetables. However, it is important to note that socio-cultural, socio-economic and physical environment factors, which affect the availability and accessibility of food, nutrition knowledge and cognitive abilities should also be considered with regards to children and adolescents’ intake of fruit and vegetables (Brug et al. 2008; Neumark-Sztainer et al. 2003; Rasmussen et al. 2006). Due to the scope of this thesis and the structure of the COOL SNACKS project, these factors have not been studied here despite their importance.

Numerous studies, including longitudinal ones, have found that eating behaviour and food preferences formed in early childhood can persist into later childhood and even into the start of adult life (Devine et al. 1998; Nicklaus et al. 2004; Skinner et al. 2002; Skinner et al. 2011). This makes food preferences of children and adolescents even more important to study. Though it should be noted that preferences for different food groups, such as for cheese and vegetables, do not necessarily persist to the same extent. A French study followed food preferences of subjects from early childhood (2-3 years old) on to childhood (between 4 and 12 years old), the teenage years (between 13 and 16 years old) and adulthood (between 17 and 22 years old). The researchers found that for the overall food categories (animal products, vegetables, starchy foods and combined foods such as quiches and tarts) preferences were most stable for cheese followed to a lesser extent by vegetables. Preferences for vegetables were found to increase with age. The study also showed that different preferences remained depending on whether the subject segments was males or female (Nicklaus et al. 2004).

**Innate and learned food preferences**

While some food preferences are genetically predisposed, many are acquired through childhood and adolescence and are primarily determined by cultural factors (Rozin et al. 1986).

Broadly speaking, and with the benefit of an evolutionary perspective, we have a strong innate preference for the taste of sweet, salt and umami, so reject many sour and bitter tastes (Beauchamp and Mennella 2009; Birch 1999; Birch and Fisher 1998). With regards to salt, liking has been reported for a moderate level of salt in 4 month-old infants (Mela
In addition, new-borns quickly develop a preference for energy dense foods as they learn to associate intake of high energy dense foods with positive post-ingestive satiety (Birch et al. 1998).

Nevertheless, these innate tendencies and food preferences can generally be modified through repeated exposure. Modifications of food preference continue throughout life, though most are formed during early childhood. Even before birth through prenatal exposure via the mother’s diet, foetuses can learn to appreciate certain flavours. For instance, exposure to a flavour through the mother’s diet affected preference for the same flavour (anise) in babies a few days old (Schaal et al. 2000) and after 6 months (when exposed to carrot juice) (Mennella et al. 2001).

As noted before, preferences formed in early childhood are fairly stable (Nicklaus et al. 2004). A high stability in food preferences exists particularly between the ages of 2 and 8 years of age (Skinner et al. 2002). This might be due to the fact that during the third year of life children are at a neophobic stage and introducing new food into the diet becomes difficult. Beyond the age of 8 years old children again become more willing to taste any new food they encounter (Nicklaus 2009). New and lasting preferences may also develop during puberty where factors which may influence eating behaviour occur (Nu et al. 2007). Some of these factors are discussed in Chapter 2.

**Modifying food preferences of children and adolescents**

Preferences can be modified to a certain degree. This can occur through so-called ‘conditioning processes’ (Figure 1.1).

![Figure 1.1: Conditioning processes used to modify food preferences](image-url)
During the conditioning process, an association is established between the flavour of a food and the atmosphere of eating (social learning), a familiar and liked flavour (flavour–flavour learning) or the post-ingestive consequences (flavour–nutrient learning) (Zeinstra et al. 2009). Another process is mere exposure to a food. These processes have been applied in an attempt to change children’s aversion to fruit and vegetables as one of the reasons why children have a reluctance to eat fruit and vegetables is that they simply do not like them (Gibson et al. 1998; Havermans and Jansen 2007). These conditioning processes are briefly described below.

**Mere Exposure** to a specific taste/flavour have been found to increase its liking in adults and encourages children to eat more of that food (Birch and Marlin 1982; Pliner 1982). One study found that 10 consecutive days of exposure increased children’s acceptance of a particular vegetable taste. They were also found more willing to try other types of vegetables (Wardle et al. 2003). The effect of mere exposure was not initially demonstrated within food science. It was first identified and expressed across various scientific areas by Zajonc (1968). According to his paper: “exposure of the individual to a stimulus is a sufficient condition for the enhancement of his attitude toward it. By ‘mere exposure’ is meant a condition which just makes the given stimulus accessible to the individual’s perception” (Zajonc 1968). He suggested that an initial novel stimulus elicits negative effects due to its novelty but that mere exposure will reduce the degree of novelty resulting in an increased positive attitudinal response.

**Flavour-flavour learning** refers to a form of Pavlovian conditioning in which a neutral flavour is paired with an already preferred flavour. Due to this pairing one acquires an association between the neutral flavour and the liked flavour, resulting in a positive shift in liking towards the initially neutral flavour (Havermans et al. 2007). Havermans et al. (2007) have successfully applied a flavour-flavour learning procedure to increase children’s preference for a specific vegetable taste. The enrolled children received six pairs of conditioning trials comprised of the tasting of a sweetened vegetable and another unsweetened one. The children then had to evaluate the unsweetened vegetables. Results showed an increase in preference for the previously sweetened vegetable.

**Flavour-nutrient learning** is another form of Pavlovian conditioning where a neutral flavour is consistently paired with a high calorific density by adding macronutrients to the flavour. Subjects therefore learn to associate the flavour with the post ingestive effects. One advantage with this conditioning process compared to mere exposure, is that it requires few learning trials to succeed. However the problem is the ingested calories associated with it (Havermans et al. 2007). Flavour-nutrient learning has shown successful results. In an American study mixing grapefruit juice with sucrose (the nutrient) increased children’s
(between 2 and 5 years old) liking for the bitter/sour taste of unsweetened grape fruit juice for weeks. Mixing broccoli and cauliflower with sugar (the nutrient) also increased the liking of unsweetened vegetables in young adults (with a median age of 18 years old) (Capaldi and Privitera 2008). Failed flavour-nutrient learning has also been reported. In a Dutch study, vegetable juices prepared from cucumber, carrots, beetroot, iceberg lettuce, red bell pepper and plum tomatoes, were adjusted in sweetness (the nutrient) to test the effects of flavour-nutrient learning. The study did not show the expected results and the authors argue that this could be due to high taste intensity or to pre-learned associations with the juices. They suggested that mixing vegetables with other foods could induce conditioning instead (Zeinstra et al. 2009).

Problems do arise when researching conditioning processes as it is challenging to completely separate flavour-nutrient learning from flavour-flavour learning, since highly nutritious foods are usually also flavourful foods as also seen from above (Capaldi and Privitera 2007). By supplying cream cheese in a regular and a light version, in a full factorial combination with banana and orange flavour, Capaldi and Privitera (2007) found that both flavour-nutrient learning and flavour-flavour learning occurred.

The above mentioned conditioning processes have been studied in controlled experiments. A great benefit with such conditioning processes is that parents can repeat them at home with their children. For children up to the age of 11 years, parents are important social agents and heavily influence their fruit and vegetable consumption (De Bourdeaudhuij et al. 2008; Hanson et al. 2005). However as adolescents grow older they develop independence traits and separate themselves from their parents (Brown et al. 2000; Nu et al. 2007). In this stage of life, it is highly unlikely that parents are as influential as before and hence they are not given the opportunity to affect their children’s food preferences to the same extent as before. Other approaches influencing adolescent’s eating behaviour, including their intake of fruit and vegetables, must therefore be used. In addition to eating what is available at home, this age group have their own money to spend on food as they wish (Tufte 2007). In order to find a suitable approach for increasing adolescents’ intake of fruit and vegetables it could be beneficial to approach them in their own food-sphere.
Snacks – an approach to increase adolescents’ intake of fruit and vegetables

Snacking is prevalent and increasing in popularity across all age groups in the Western world (Piernas and Popkin 2009; Savige et al. 2007). In Europe and in the US, adolescents are frequent snackers, especially in their leisure time (Bech-Larsen et al. 2010; Jahns et al. 2001; Savige et al. 2007). A study on comfort food found that young people preferred snack related comfort food compared to adults who preferred warm hearty, meal related comfort food (men) or sweet, snack related comfort food, such as chocolate (females) (Wansink et al. 2003). Wansink et al. (2003) discuss this from a developmental perspective: as people age and experience a wide range of food, their taste preferences evolve accordingly. As younger people often have a limited range of experience (and perhaps a limited range of food appreciation), they may prefer foods for their hedonic qualities. Due to a higher preference for saltiness and intense sweetness, young people may appreciate snacks more because of the pronounced tastes and flavours, such as sweetness and saltiness, often found in them (Wansink 2003).

Studies have reported that adolescents mostly snack after school, whilst watching television and socialising with friends (Bech-Larsen et al. 2010; Savige et al. 2007). One study reported that boys are more likely to snack than girls, whilst other studies have had mixed results (Nu et al. 2007; Savige et al. 2007). One study looked into Danish adolescents snacking conventions and dilemmas in detail (Bech-Larsen et al. 2010). They found that adolescents primarily engage in two distinct forms of snacking: the ‘in between meals’ snacking and the ‘for fun’ snacking. This falsifies the previous general assumption that snacking is socially unrestricted. The adolescents enrolled in the study described the ‘in between meals’ snacking as quick and easy meals and most often eaten alone. These snacks were often bought by parents and satisfied the basic requirements of being filling, tasty, refreshing and convenient. They were often consumed in breaks at school before sports etc. On the other hand, ‘fun’ snacking were fast ‘on the go’ meals which were often the focal points of social interaction or watching television and tended to be less healthy compared to the ‘in between’ snacks. They were also perceived to contribute to instant, but not particularly lasting, energy and most importantly were often bought with the adolescents’ own money.

As discussed, a snack can fulfil many purposes. De Graaf (2006) broadly distinguishes between a meal and a snack in the following way: “The term ‘meal’ usually refers to the three main eating moments of the day, including breakfast (in the morning), lunch (at the beginning of the afternoon), and dinner (at the beginning at the evening). The term
'snack’ refers to other eating episodes, and includes all foods and drinks consumed outside the context of the three main meals.” This definition is also used in this thesis.

Snacking has been identified as one of the main causes of adolescent obesity (Bech-Larsen et al. 2010; Jahns et al. 2001; Savige et al. 2007). People do not generally account for the calories they get from snacks, especially not for those consumed on an irregular basis, which may contribute to a higher energy intake (de Graaf 2006). In addition a large proportion of the studies conducted on adolescents and their relationship with snacks concern the impact of snacking meal patterns. This is in particular regard to family dinners (Neumark-Sztainer et al. 2003), meal skipping (Savige et al. 2007) and an increased tendency to eat away from the home (Nielsen et al. 2002). With this in mind, limiting the consumption of snacks seems advisable. However, snacking is a common dietary behaviour among adolescents and one not easily excluded from their diet. Instead of working against it, which seems an impossible task, we could embrace and try to influence it. As some researchers have argued, development and promotion of nutritious snacks such as fresh fruit and vegetables, bread/toast, milk and fruit juice is crucial (Jahns et al. 2001; Savige et al. 2007).

**Fruit and vegetable based snacks**
With regard to fruit and vegetable based snacks, Jack et al. (1996) and Hill et al. (1998) argue that there may be scope to increase fruit and vegetable consumption by promoting them as a snack. However, it is likely that without sufficient attention to the suitability of the selected fruit and vegetables as snack replacements, such strategies may not succeed (Hill et al. 1998; Jack et al. 1997). As well as the quality of snacks, snack foods in general must satisfy a range of additional needs depending on the snacking situation. They may be used to ‘bridge a gap between meals and may even be expected to be filling (Jack et al. 1997).

Jack et al. (1997) conducted a study in Edinburgh looking at adult women’s perception of fruit and vegetables as snacks. Women perceived fruit, canned and fresh, as suitable when wanting a natural, healthy and refreshing product. Fruit were also more suitable in the morning, to eat in the summer and during/after exercise than manufactured snack foods. On the other hand, manufactured snacks were perceived as more convenient and suitable for indulgence and comfort eating.

In a study from New Zealand, teenagers viewed fruit as an appropriate snack food, since no preparation was required. However, their expectation was that fruit was a snack provided by parents. Only three out of ten teenagers said they had sometimes bought fruit as a snack with their own money. Other teenagers said that they did not think of spending their own
money on fruit (Hill et al. 1998). Although the teenagers in this study perceived fruit as convenient to eat as a snack, they did not perceive it as convenient to purchase. It was also mentioned that fruit was normally sold by the kilo and not the piece (Hill et al. 1998). In the same study, vegetables were perceived as inconvenient for eating between meals as snacks even when they were liked. The main reason given was because they were not instantly available. Although teenagers reported occasionally eating a carrot or tomato as a snack, the preparation time required for vegetables was seen as a disincentive (Hill et al. 1998). Although the teenagers believed fruit and vegetables were ‘good for you’, consumption was highly affected by the teenagers’ perceptions of the desirability of different foods and the degree of independence or parental control in different eating situations. Snack food bought with the teenagers’ own money was often part of socialising with friends after school and at weekends. Furthermore some foods were more suitable for sharing than others. Sweet and salty snack foods, desirable and attractively presented, were readily available at school and shared easily among friends. Fruit as a snack at school had few of these characteristics (Hill et al. 1998).

Jack et al. (1997) argue that fruit (and vegetables) could adopt a much higher profile and be presented in many more attractive ways than they currently are. Fruit and vegetables are sold in Denmark as raw and ‘pure’ products. Mini carrots, cherry tomatoes, whole pieces of fruits and a small selection of pre-cut and pre-washed fruits are such examples. The sociable snacking and lunch-sharing behaviour reported in the studies mentioned above may suggest ways of developing and marketing new, easily shared fruit or vegetable products. Besides developing the actual snack products, pricing and promotion of fruit and vegetables as snacks would need to match the highly successful strategies used to market confectionery, salty snacks and fast food to teenagers and their families (Hill et al. 1998).

By developing snack products and their image, their attributes and ‘personality’ could make them something special, rather than a commercial product lacking any social benefit for the adolescent consumer. According to Schifferstein (2010) in order for new food products to succeed they should provide good eating quality and be appealing. They should also offer an interesting and engaging experience to seduce the consumer into buying them and so withstand the competition from other food products in a highly saturated market.

Appearance is of great importance in our acceptance and rejection of food (Cardello 1996; Hurling and Shepherd 2003). It is often the first sensory stimulus that is presented to the consumer and the one influencing expectations. The visual properties may produce positive sensations leading to acceptance of the food or negative sensations leading to rejection. Appearance is also important for minimally processed fruit and vegetables
(Ragaert et al. 2004). To increase adolescents’ intake of fruit and vegetables by introducing fruit and vegetable based snacks, they need to be attracted to them, have them as their first choice, to repeat the choice and to consume them. In competition with other food products the appearance of these fruit and vegetable snacks, either loose or in a wrapping, is of major importance. This last point, the visual appearance of fruit and vegetable based snacks without their wrapping, has been a large focal point of this thesis.
2. Around children and adolescents

Human development is a lifelong process of physical, behavioural, cognitive and emotional growth and change. In the early stages of life from childhood to adolescence, and adolescence to adulthood, enormous changes take place (Scherf et al. 2011).

The term adolescence originates from the Latin word *adolescere* which means ‘to grow to maturity’ (Oxford Dictionaries 2012). It refers to the transitional stage of physical sex and mental development generally occurring between puberty and adulthood (MedlinePlus 2012; Oxford Dictionaries 2012).

Due to the large number of changes at this stage of life, adolescence has attracted much attention. Depending on one's field of science, the more descriptive definitions and age ranges of adolescence differ. However, one common agreement is that adolescents are in a transition phase. Developmental psychologist and psychoanalyst, Erik Erikson defined the age span of adolescence from 12 to 18 years of age, while others argue for a broader age range such as 10 to 19 years of age (Brown et al. 2000; Erikson 1968; Gentry and Cambell 2002). The age range in the COOL SNACKS project and this PhD project is 10 to 16 years of age, so both fall within the boundaries of the definition above.

Conferring to Coleman et al. (1977) no consideration of adolescence is complete without some reference to the issues surrounding identity. Erik Erikson created a developmental theory which describes the development of identity through different stages of life. The development from adolescence and upwards was described as primarily concerning what we do as opposed to what is done to us as in the stages prior to adolescence. During this time adolescents attempt to find their own identity - spending time working out social interactions as they try to find their role as individuals. This includes somewhat separating themselves from their families and becoming much more influenced by peers (Erikson 1968; Marcia 2001). It is a time where making choices in all aspects of life: social, sexual, occupational and ideological becomes significant (Coleman et al. 1977). Prior to the stage of adolescence, Erikson defined the school age stage as children from 6 to 12 years old. During this stage children are able to learn new skills and acquire new knowledge. In addition, although parents are still important they are not the complete authorities they once were (Erikson 1968).

The French psychologist, Jean Piaget also worked with human development during childhood and adolescence. He introduced the cognitive development theory consisting of four successive stages: the sensory motor period (0 to 2 years); the pre-operational stage (2 to 7 years); the concrete operational stage (7 to 11 years); and the formal operational stage (11 to 15 years). Thinking during these stages changes from concrete to abstract as children
are able to replace overt actions by mental representations. Their egocentrism and centration diminishes, they become more detail oriented, are able to process more information and their problem-solving skills become more advanced (Flavell 1963). In relation to stimulus evaluation, in the pre-operational stage children are more likely to focus on a single aspect of a stimulus. In the concrete-operational stage children are able to perceive stimuli multi-dimensionally. In the formal operational stage children acquire the ability to think about abstract concepts (Popper and Kroll 2007).

Research has focused on studying adolescent behaviour, often as a result of the aforementioned developments - such as developing independence traits, separating themselves from their parents and being more influenced by peers (Brown et al. 2000; Nu et al. 2007). Adolescents have been characterised as engaging in risky behaviour such as reckless driving, unprotected sexual activities and smoking marijuana (Hampson et al. 2008). Risky behaviour is related to sensation seeking. Sensation seeking refers to the tendency to seek out novel, varied, complex and highly stimulating experiences and the willingness to take risks in order to attain them (Roberti 2004; Zuckerman et al. 1978).

Until a decade ago it was believed that major brain development was complete as early as 3 years of age and that it was fully mature by 10 or 12 years old. However, it has since been found that the greatest changes to the frontal lobe, corpus callosum, parietal lobes and temporal lobes, all parts of the brain responsible for functions such as self-control, judgment, emotion, and organisation, occur between puberty and adulthood. This may explain in part some of the adolescent development and behaviour listed above such as recklessness, self-awareness and emotional outbursts (ACT for Youth 2002; Giedd et al. 1999).

Even though it is difficult to pinpoint the precise amount, it is evident that children and adolescents have a large market share in many parts of the world (Popper and Kroll 2005). Consequently children and adolescents have also attracted a lot of attention in consumer and marketing science. Adolescents (13 to 18 years old) in Denmark are a consumer group with one of the largest disposable incomes (Tufte 2007) who also influence and act out their power through their parents (O’Dougherty et al. 2005; Tufte 2007). According to Tufte (2007) they have a say in all purchases made by the family, including cars and computers. They also have a huge impact on food choices, again through their parents and through their own spending power (O’Dougherty et al. 2005; Popper and Kroll 2005; Tufte 2007). They have more power over their own diet than ever before and are constantly confronted with more choice (Popper and Kroll 2005). In their search for identity, these choices can be used to express their personal preferences and exercise control over themselves as well as their environment. Furthermore adolescents’ food choices can be
used as a way of appearing older and more mature than they actually are - a highly attractive and important prospect (Marcia 2001; Popper and Kroll 2005).
3. Consumer testing methods

Knowledge abuts and prediction of consumer perception, affective response and choice of food is vital to the food industry in order to develop and market food products (Cardello 1995; Hein et al. 2008). This knowledge is also highly relevant to the development of fruit and vegetable based snacks. Preference, acceptance and the sensory properties of food are regarded in sensory and consumer science as some of the most important criteria in determining food choice (Lawless and Heymann 2010; Mustonen et al. 2007). Consumer perception and affective experience cannot be shared directly with others, but must be inferred from responses by means of descriptive or numerical data (Jones et al. 1955; Lim 2011).

Consumer analysis is the sensory method that deals with affective and subjective measurements of products. The main objective when using this method is to try to quantify the relative preference or degree of acceptance of a set of products (Lawless and Heymann 2010). This can be done either by determining consumer preference for one product over another (preference testing), or by allowing respondents to rate a certain product on a hedonic scale according to their liking or other relevant affective parameters (acceptance testing) (Lawless and Heymann 2010). Acceptance testing gives interval or ratio data directly unlike preference methods, where choices are given and intervals are indirectly measured (Thurstone 1928).

The results retrieved in consumer analysis depend greatly on the evaluation techniques used. Opinion differs as to which of the existing testing methods are the best and it seems to be heavily dependent on particular factors such as sample size and product (Hein et al. 2008; Jaeger et al. 2008; Lim 2011). This chapter will introduce and discuss the various methods applied in the studies included in this thesis. Arguments for the choice of methods used and the responses retrieved will be presented here as well. Sub-chapters are devoted to the special consideration given to children and adolescents in consumer science.

Rating

It has been standard practice in sensory and consumer research to use acceptance scaling and monadic ratings on category or line scales to measure the intensity of perception and affective response of the attribute or attitude asked for. Scaling also forms the basis of many types of sensory descriptive analysis (Jaeger et al. 2008; Lawless and Heymann 2010). Sensation and affective experience measurements require two main stages of processing: sensory and cognitive. The sensory process refers to the sensory function whereas the cognitive process refers to the response to a stimulus. Since sensory scientists are often interested in the perception of products and not sensory process per se, they have
generally used scaling and rating methods by focusing on the differences between sensory and affective magnitude rather than on their absolute magnitude (Lawless and Malone 1986; Lim 2011).

During the last half century a number of scales have been developed and used to measure affective response in psychophysical as well as applied research (Lim 2011). One large advantage of these testing methods is that they provide information about the degree of liking compared to preference testing which gives information about a choice made.

The most commonly used rating scale in the food industry for assessing liking and disliking is the 9-point hedonic scale developed by Peryam and Girardot (1952) and Peryam and Pilgrim (1957). The primary reason for its popularity is the fact that participants and researchers find it is easy to use (Lim 2011; Peryam and Pilgrim 1957). In addition, simple category scales, such as the 9-point hedonic scale, are reportedly just as sensitive to product differences as other scaling techniques and both line marking and magnitude estimation are more difficult to handle from a data analysis perspective (Lawless and Malone 1986a; Lawless and Malone 1986b; Lim 2011). However, a challenge with this scale, as well as some others, is that the intervals among the affective labels are unequal. This is a problem as the variance in ratings of a particular food may then be misinterpreted as indicating different levels of preference, rather than different ways of understanding the rating scale, the latter calls for the use of non-parametric statistics (Jones et al. 1955; Nicolas et al. 2010). The 9-point hedonic scale was considered as having equal subjective spacing between its nine categories (Peryam and Girardot 1952). In a later study, different variations of this scale were tested, and numbers and wordings were not found compatible (Nicolas et al. 2010). Even though problems with the unequal verbal spacing were noted, Peryam and Pilgrim (1957) argued that in practice the results achieved by treating the data as if it were equal were similar to treating the data as if it was not.

Due to the age range of the subjects focused on in this project, the related 7-point hedonic facial scale (Chen et al. 1996) which is suitable for younger subjects was applied instead in Paper 1, 4 and 5. The external validity of the 7-point hedonic facial scale and best-worst scaling were tested in Paper 1 with regards to their ability to predict adolescents’ real choice of snacks. Since the 7-point hedonic facial scale proved highly predictable of adolescents’ real choice of snacks and was easy for them to understand, it was used again in Paper 4 and 5. More information on the external validity of both the 7-point hedonic facial scale and best-worst rating is given in the sub-chapter ‘Consumer testing methods and actual food choice’ in this chapter.
Hedonic facial scales are considered suitable for use with children or those who are illiterate (Coetzee and Taylor 1996). They have a long history of use in the study of food preference and habits among children (Birch et al. 1980; Birch et al. 1982). For instance, the 7-point hedonic facial scale from 'super good' to 'super bad' was used to report liking of school meals among children between 7 to 10 years of age (Pagliarini et al. 2005). Hedonic facial scales have also been successfully applied to older children and adolescents. This is why they were found appropriate in the context of this thesis. For instance Kildegaard et al. (2011c) used a 5-point hedonic facial scale to measure older children and adolescents’ (9 to 14 years old) liking and desire for beverages. The same 5-point hedonic facial scales were used to evaluate liking and wanting for an acidified milk product using the same age group (Kildegaard et al. 2011a). Furthermore, teenagers aged 12 to 15 years old have also used 5-point hedonic facial scales to evaluate branded and unbranded products (Allison et al. 2010). In Paper 1, 4 and 5, a 7-point hedonic facial scale rather than a 5-point hedonic facial scale was applied. This was to provide sufficient answering alternatives for the adolescents as some subjects may avoid the end categories (Lawless and Heymann 2010). Adolescents were also found to be highly capable of using a 7-point hedonic facial scale, just as children as young as 4 or 5 years of age were (Chen et al. 1996; Kimmel et al. 1994).

However, hedonic facial scales have received criticism when applied to children. According to Popper and Kroll (2007), hedonic facial scales may introduce unintended bias or confusion especially in younger children. This is because a face, which is intended to represent a level of dislike, can also be interpreted as conveying anger etc. In addition, they state that some younger children would simply choose the face they like best in an evaluation situation. This was not found to be a problem in the context of this project since the subjects included were adolescents.

A wide variety of other scales with fixed labels are currently used in consumer science. One example is the Likert scale which can be used to measure attitudes and opinions based on the extent to which the consumers agree or disagree with a statement (Likert 1932). Like the 9-point hedonic scale, the Likert scale is a bipolar scaling method measuring either positive or negative responses to a stimulus. The Likert scale was developed by the psychologist Rensis Likert and has been applied in many fields of science where the measure of attitudes was relevant including sensory and consumer science (Mielby and Frøst 2010; Verdú Jover et al. 2004; Wansink 2003). A 7-levelled Likert scale was used to measure attractiveness and simplicity of pictures of fruit (F), vegetable (V) and combined fruit and vegetable (FV) mixes in Paper 3. The Likert scale was found interesting when applied to adolescents as it measures their agreement to a statement rather than the magnitude of a certain attribute. A Likert scale in three levels has been applied on young children between 2 to 5 years old to assess their liking of high fibre snacks (Kranz et al.
However, in Paper 3 it was not known beforehand whether the adolescents would be able to use the 7-levelled Likert scale. When looking at the raw data for this particular method, it did not seem as if they had any problems using the scale, as the majority of test subjects used most of the seven answering levels. Significant results were obtained when applying the Likert scale (Paper 3). A 7-levelled Likert scale was also applied in Paper 5 to access adolescents’ neophobia level.

The 7-point hedonic facial scale, as well as the Likert scale, makes use of labelled categories. According to the new edition of Lawless and Heymann (2010), there has been a recent shift away from using labels or integers in case these might be subject bias. Another reason for this shift from labelled categories may be the international use of the scales. The different scales are applied all over the world with research conducted to translate the scales into languages other than English. Due to language, as well as cultural, differences this is not an easy task (Curia et al. 2001; Daroub et al. 2010; Yeh et al. 1998). With regards to the 7-point hedonic facial scale applied in Paper 1, it was chosen to have anchors only at the ends. In Paper 4 and 5, the hedonic facial scales had anchors at the ends and in the middle. In the three aforementioned papers few anchors were chosen so as not to bias and confuse the adolescents in case they found discrepancies between the faces and the verbal labels (Lawless and Heymann 2010). In addition, the adolescents did not seem to have a problem understanding the scales without labels. An example of the application of the 7-point hedonic facial scale used in Paper 1 is shown below (Figure 3.1).

**Figure 3.1 Example of the application of the 7-point hedonic facial scale (Paper 1)**

**7-point facial hedonic scale**

How much do you want this snack right now?

Apple

I want it a lot I do not want it at all
A further difference between the 7-point hedonic facial scale applied in Paper 4 and 5 compared to that used in Paper 1 was the inclusion of an ‘I don't know’ category. This was not considered appropriate to include in Paper 1 since the results from the rating and the best-worst scaling were compared with a forced real choice of snack. However, in Paper 4 and 5 no forced choices were required and so an ‘I don’t know’ category was included. In Paper 5 the ‘I don’t know’ category was of particular interest in order to elucidate and compare adolescents’ use of two modified trait food neophobia scales.

Ranking
An alternative to scaling techniques, such as rating, is ranking. Ranking is the preference method where products are ranked with regards to a property of interest either affectively or objectively. Ranking can be performed ‘complete’, meaning that all products are ranked, or ‘incomplete’, where for instance the most and the least preferred options are chosen (Kidwell et al. 2008). In Paper 2, adolescents and adults performed incomplete ranking of pictures of F, V and FV mixes. Ranking is regarded as a feasible method when participants have difficulty understanding scaling instructions, such as working with children or the elderly, those who are illiterates or across cultural boundaries (Barylko-Pikielna et al. 2004; Coetzee et al. 1996; van Herk and van de Velden 2007). Therefore the incomplete ranking procedure performed in Paper 2 was not expected, nor found to cause any problems for the participating adolescents.

The incomplete ranking was performed using a computer programme previously used in studies dealing with visual preferences for meals among adults (Reisfelt et al. 2008) and for smoothies, yoghurt, buns and juices among older children and adolescents between the ages of 9 to 10 and 12 to 13 years (Kildegaard et al. 2011b; Olsen et al. 2012). This method was found suitable in the context of this project, as Kildegaard et al. (2011b) reported good external validity for incomplete ranking as it was found predictive of children’s actual choices of smoothies. However, it is important to note that the real choice tasks performed by Kildegaard et al. (2011b) and those for Paper 1 were carried out in an unnatural classroom setting. Although they approach a real food choice they were not conducted under completely natural settings and conditions. This will be further elaborated on in the sub-chapter ‘Consumer testing methods and actual food choice’ in the present chapter.

In the incomplete ranking performed in Paper 2, the most preferred, second most preferred and least preferred choice were measured. The benefit of this procedure compared to a complete ranking is that the subjects are required to make fewer choices. Collecting the least preferred choice with an incomplete ranking may also retrieve some important information rather than only retrieving the most preferred results (Reisfelt et al. 2008). A Finnish study that somewhat supports this notion (Mustonen et al. 2007) looked
at the association between liking and the selection of six cheeses over three evaluation sessions. The researchers found that although weak at precisely predicting their choices, subjects knew quite accurately which cheeses they would not pick. Rather than only looking at acceptable options, the researchers suggested that, an important strategy in food choice measurements may be to eliminate unacceptable options and alternate them amongst the acceptable ones.

In Paper 2 the relationship between adult and adolescent preferences and a descriptive panel’s evaluation of perceived complexity for pictures of F, V and FV mixes was investigated. In theory the optimal level of perceived complexity is an individual matter. In this regard, incomplete ranking was not the most optimal method, since the data obtained could not be used on an individual basis. Nevertheless this data provided some extremely interesting results on an joint level. They will be discussed in the sub-chapter ‘Perceived complexity’ in Chapter 4.

**Best-worst scaling**

Best-worst scaling was also applied in the context of this thesis (Paper 1). This discrete choice methodology is one of preference testing and fairly new to sensory and consumer science. It was introduced by Jaeger et al. (2008) as an alternative to monadic rating forms. Best-worst scaling has also found applications within marketing (Finn and Louviere 1992) and health economics (Flynn et al. 2007). Best-worst scaling was originally developed by Louviere and Woodworth (1990) as a multiple choice extension of Thurstone’s method of paired comparisons (Thurstone 1927). It’s first application was published in 1992 (Finn et al. 1992). Best–worst scaling is based on the well tested theory of human decision-making (McFadden 1974; Thurstone 1927) and one fundamental benefit is forcing subjects to make choices between competing options. Since preference methods have previously been applied to children, Paper 1 tested best-worst scaling using adolescents. Furthermore, a comparison of best-worst scaling and rating was interesting as best-worst scaling is closely related perceptually to real choice in a shopping situation. This last point is particularly relevant as the stimuli used in Paper 1 were 21 diverse, but common snacks, found in Danish supermarkets and so not designed stimuli as such.
Best-worst scaling involves subjects selecting the best as well as the worst option available within a subset of samples generated from a block design. Figure 3.2 below shows an example of a best-worst scaling subset.

Figure 3.2 Example of the application of best-worst scaling (Paper 1)

<table>
<thead>
<tr>
<th>Cherry tomatoes</th>
<th>Wine gums</th>
<th>Banana</th>
<th>Cookies</th>
<th>Mini cucumbers</th>
</tr>
</thead>
</table>

Please mark your most wanted snack choice

Please mark your least wanted snack choice

These two choices are then converted into individual scores for each sample. These scores are subtracted from each other, resulting in a best minus worst score for each sample. Best-worst scaling data can be analysed using the theoretically based, most appropriate multi-nominal logit (MNL) or by just using the best minus worst scores for each sample. Due to simplicity of the analysis it is standard practice to use the best minus worst scores for each sample (Hein et al. 2008; Jaeger and Cardello 2009). This has given the same results as the appropriate MNL method (Finn et al. 1992; Jaeger et al. 2009; Jaeger et al. 2008). This simpler method was also applied in Paper 1. Either way, compared to rating scales the advantage is that the sample scaling is known, rather than the interval properties, which are assumed to be present in rating (Jaeger et al. 2008).

Best-worst scaling has in a sensory and consumer context been tested against various methods. Examples are the 15 cm unstructured line scale, the labelled affective magnitude (LAM) scale, the 9-point hedonic scale, and preference rankings (Hein et al. 2008; Jaeger et al. 2009; Jaeger et al. 2008). In all instances the result of best-worst scaling were equal to or superior as regards sample discrimination (Hein et al. 2008; Jaeger et al. 2009; Jaeger et al. 2008). In Paper 1, best-worst scaling displayed the greatest sample discrimination when compared to a 7-point hedonic facial scale rating. Best-worst scaling was developed with the aim of improving sample discrimination so this result was anticipated (Finn et al. 1992).
From an experimental point of view, one of the drawbacks highlighted when using best-worst scaling is that a complete dataset from each subject is required otherwise it cannot be used. Many different sample subsets are presented to the subjects so missing data is likely. In addition, it has been found rather tedious to perform due to the large amount of samples and designs tested (Hein et al. 2008; Jaeger et al. 2009; Jaeger et al. 2008). This was confirmed in Paper 1 were rating proved less time consuming to work with during the experiment as well as during data handling prior to data analysis. Paper 1 also found that adolescents considered rating easier to perform compared to best-worst scaling (Table 4.6 in the sub-chapter on ‘Age’ in Chapter 4).

The affective responses used
For the purposes of this thesis it is important to define what exactly is meant by preference in the context of sensory and consumer science. The concepts of preference and liking are often used interchangeably, but they do not mean the same thing (Mela 2001). Preference expresses a choice between two or more products and is measured using preference testing methods. Preference was used in Paper 2. On the other hand, liking is measured independently of other products via acceptance methods using an internal scale of reference, such as rating (Lawless and Heymann 2010; Mela 2001; Rozin and Vollmecke 1986). Liking was measured in Paper 4. Preferences do not necessarily resemble liking, as one product may be preferable over another even though neither of them are actually liked (Mela 2001). Liking is one of the very powerful factors which often account for a food preference. This is why ratings of liking and preference are often viewed as congruent (Rozin 1989; Rozin et al. 1986).

This thesis used preference and different acceptance measurements. In Paper 1, the 7-point hedonic facial scale was applied to measure adolescents’ degree of wanting for a snack. This question, as well as the one posed in the best-worst scaling task, was formulated in a way as similar as possible to the question posed in the real choice task. This was done to ensure that differences found between the methods were not due to the questions asked, but simply due to the methods themselves. In Paper 2, the question used in the incomplete ranking was which picture of the F, V and FV mixes they fancied the most, second most and the least. This question was relevant, as the adolescents did not think it made any sense to ask about expected liking when measuring appreciation since it only referred to pictures. Similarly, attractiveness, which was rated in Paper 3, was a term generated by the adolescents themselves in a pilot study to describe the pictures of F, V and FV mixes. In Paper 4, ratings of expected liking, actual liking, attractiveness and simplicity were given for the snack combinations. Since real products and not pictures of products were the stimuli it was acceptable to ask about expected liking and liking. Attractiveness was also
included since different affective measurements reveal different aspects of acceptance (Tuorila et al. 1998). Including attractiveness in this study also generated some interesting results which will be discussed in the sub-chapter ‘Gender’ in Chapter 4.

**Consumer testing methods and actual food choice**

Consumer testing methods often try to predict consumers’ actual food choice (Lawless and Heymann 2010; Mustonen et al. 2007; Wichchukit and O’Mahony 2011). However, actual food choices are often made impulsively and are generally unconscious (Wansink and Sobal 2007). Although research aims to develop and refine consumer testing methods, first affective impressions are often poor predictors of final liking and choice (Köster et al. 2002). Empirical studies confirm this statement. For instance, a Dutch study investigating intended and actual choice between healthy and unhealthy snack products revealed discrepancies between them (Weijzen et al. 2009). However, it is important to be aware that in this study different types of healthy and unhealthy snacks were presented on two consecutive days. As the authors suggest, it is possible that some participants did not consider the health issues when making their snack choice and used a different rule to be consistent, such as sensory and physical similarities. This was confirmed by the results as the participants chose physically similar snacks (Weijzen et al. 2009). An American study, using self-administered questionnaires, also found a lack of association between young (9 to 18 years of age) subjects intended and actual healthy eating behaviour (Fila and Smith 2006). Discrepancies between 'liking', 'buying' and ‘take away’ preference were found in another study where there were inconsistencies between what food consumers actually took away and what they reportedly liked more or what they would likely buy or choose. This underlines the fact that what consumer’s claim they do should be interpreted with caution (Wichchukit and O’Mahony 2011).

Regarding actual food choice and consumer testing methods, Köster et al. (2002) conducted a study on repeatability of consumer sensory measurements. They point out that judging the effectiveness of sensory methods, the last of three criteria which include: sensitivity or discrimination, power of the method and the reliability or repeatability of the method and its external validity which is often neglected or taken for granted., The external validity of 7-point hedonic rating and best-worst scaling was tested in Paper 1 by comparing the results with a real choice test. By looking at the individual data for each participating adolescent, both methods were found able to satisfactorily predict real choice of snacks, but the 7 point hedonic rating performed the best.

Paper 1 reported the following procedure. Adolescents first completed the rating and best-worst scaling test in their classroom. They were then taken individually to a separate room where they had to choose between the 21 types of snacks included in the questionnaire.
This was a rather unnatural setting as real snack choices are usually made in a purchase situation involving money. In addition, in a shopping situation a display of diverse unwrapped snacks side by side is not common. Furthermore, diverse products such as fruit, mini pizzas and wine gums are not lined up side by side in a supermarket. Despite the rather unnatural setting, this approach was thought best able to show and compare the external validity of 7-point hedonic rating and best-worst scaling. However, as stated by Wichchukit and O’Mahony (2011), the external validity of consumer testing methods, consumer choices and buying behaviours should ideally be observed for several months. In a study by Rosas-Nexticapa et al. (2005) consumer purchasing behaviour of brands of strawberry yoghurt was followed over a year after they had evaluated them on a 9-point hedonic scale and a purchase intent scale. To disguise of the real purpose of the study, the consumers were led to believe that they were enrolled in a dietetic study. The researchers found that the highest rated yogurts tended to be the ones purchased throughout the year and so the ratings were a better predictor of purchase frequency than price. The procedure applied in Paper 2 was similar to that of Wichchukit et al. (2011), where consumers were allowed to take away some of the foods used in the test and their choice was observed. However the researchers note that ‘take away’ preference should not be seen as a substitute for observing consumer behaviour over several months. It can instead be thought of as a step in the right direction.

**Consumer testing with children**

The market for foods directed at children continues to grow. This means that children now have a large impact on their own food choices (Popper and Kroll 2005). Much research on food products for children is carried out using adults even though adult responses are not adequate to predict success of a product aimed at a younger market (Chen et al. 1996; Léon et al. 1999). Consequently, consumer testing methods have also been tested and applied, not only on adults but also on children of different ages.

Childhood is a time of change. This is important in sensory and consumer testing using children as it includes changes in verbal skills and attention spans (Chen et al. 1996; Guinard 2001; Popper and Kroll 2007). According to Guinard (2001), sensory and consumer tests using children should take into account the wide range of sensory and cognitive abilities from infancy to teenage. For methods to be suitable, they should be simple enough for children to understand but robust enough to reliably measure their food preferences despite changes in behaviour during the experiments (Léon et al. 1999). Due to rapid development during childhood, age is an important parameter for determining which methods are feasible to employ. However, it should be noted that age is not a perfect
predictor of a child’s ability to participate in research, as there are large variations in skill amongst children of the same age (Popper and Kroll 2007).

Aside from the literature already mentioned, a significant amount of it has, over the last 15 years, focused on the appropriateness of various methods for different age groups. Especially the group of very young children have been elucidated thoroughly (Chen et al. 1996; Guinard 2001; Léon et al. 1999; Popper and Kroll 2007; Popper and Kroll 2005). Guinard (2001) summarised the published studies regarding children’s ability to perform various sensory testing methods according to their age. He also included a table from the ASTM’s Committee 18 on Sensory Evaluation showing different developmental skills (verbal, attention, reasoning, decision making, understanding scales, and motor skills) (Table 3.1 below).

<table>
<thead>
<tr>
<th>Skill/behaviour</th>
<th>Infant Birth–18 months</th>
<th>Toddler 18 months–3 years</th>
<th>Pre-school 3–5 years</th>
<th>Early readers 5–8 years</th>
<th>Pre-teen 8–12 years</th>
<th>Teenage 12–15 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language—Verbal, reading/writing, language vocabulary</td>
<td>Pre-verbal, rely on facial expressions. Cannot read. Cannot write.</td>
<td>Beginning to vocalise, adult interpretation still required. Cannot read. Cannot write. Early word usage developing.</td>
<td>Early language development. Can observe facial expressions, respond to questions and pictures. Generally, reading and writing skills are just beginning, if present.</td>
<td>Moderately developed verbal and vocabulary skills; understanding increases. Early reading and writing skills, may still require adult assistance for some tasks.</td>
<td>Limited by understanding of task and interest level, challenge.</td>
<td>Very verbal—able to express themselves adequately. Reading and written language skills increase rapidly and are sufficient for most self-administered tasks.</td>
</tr>
<tr>
<td>Attention span</td>
<td>Caused by eye contact</td>
<td>Caused by eye contact or involvement with task, bodily movement.</td>
<td>Limited, but increasing.</td>
<td>Limited by understanding of task and interest level, challenge.</td>
<td>Potential attention span is increasing, but holding interest is critical.</td>
<td>Similar to adults, involvement and interest subject to外 pressure.</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Limited to pain and pleasure.</td>
<td>Limited, but concept of ‘no’ becoming a factor.</td>
<td>Limited, but beginning to be able to know what is liked and what is not.</td>
<td>Developing with increased learning, cause/effect concepts</td>
<td>Full ability for understanding and reasoning, capable of decision making</td>
<td>Reasoning skills are fully developed and similar to adults.</td>
</tr>
<tr>
<td>Decision making</td>
<td>Does not make complex decisions.</td>
<td>Does not make complex decisions, but “yes/no” can be decisive.</td>
<td>Limited, but concepts of what is liked and what is not are not strengthened. Able to choose one thing over another.</td>
<td>Ability to decide if increase, but influence of adult approval is evident.</td>
<td>Fully capable of complex decisions, peer influences a factor</td>
<td>Fully capable of adult decision processes, subject to peer influences</td>
</tr>
<tr>
<td>Understanding scales</td>
<td>Does not understand scales</td>
<td>Does not understand scales</td>
<td>Understanding of simple scales beginning, sorting or identification tasks more effective</td>
<td>Scale understanding increasing, simple is best.</td>
<td>Capable of understanding scaling concepts with adequate instruction</td>
<td>Similar to adults</td>
</tr>
<tr>
<td>Motor skills</td>
<td>Possesses some gross motor skills, few fine motor skills</td>
<td>Rapid gains in gross motor skills, few fine motor skills still limited.</td>
<td>Development of both gross and fine motor skills increasing.</td>
<td>Gross motor skills developed, fine skills becoming more refined</td>
<td>Hand to eye and other fine motor skills developed.</td>
<td>Similar to adults</td>
</tr>
<tr>
<td>Adult involvement</td>
<td>Primary caregiver, trained observer, experimenter.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adult participation not required, unless inappropriate to evaluation technique.</td>
</tr>
</tbody>
</table>

Table 3.1: Cognitive skills of children and young adolescents according to age (from ASTM’s Committee 18 on Sensory Evaluation) (Guinard, 2001)

Based on this he recommended evaluation techniques fitting children according to their age. According to Guinard’s (2001) extensive review and the table from the ASTM’s Committee 18 on Sensory Evaluation, children between the ages of 2 to 3 years are able to express preference for no more than two choices. By the time children are 4 or 5 years old they are capable of performing attribute-based paired comparisons; sorting, matching and ranking products in terms of preference; and using simple hedonic scales. At 6 or 7 years old, children are able to perform more complex scaling tasks and discrimination tests.
Finally, from the age of 12, children are reportedly able to participate in standard tests (Guinard 2001).

Léon et al. (1999) compared the feasibility of evaluating biscuits spread with jam by using paired comparison; ranking by elimination; and hedonic categorisation with stylised faces, on children aged from 4 to 10 years old. They found that children over 5 years old made reliable food choices when tested with all three methods and that the methods lead to the same results. To test validity and as a reward after the evaluation, they let the children choose between the packages of tested biscuits. These results were more in line with the results of the paired comparison and the ranking by elimination than the results from the hedonic categorisation.

Ensuring sensory testing with children is successful not only includes the use of age-appropriate measurement scales, but it also depends on the instructions given and the wording of questionnaires. All of which also make the child feel at ease in the research environment (Popper and Kroll 2005). The relationship between researcher and child is very important. The researcher should use an appropriate tone and body language to make the child feel as comfortable as possible. However, as with consumer studies on adults, the researcher’s behaviour should not influence that of the child (Guinard 2001). The testing area is also important as an unfamiliar setting may cause unease. Testing should be carried out in a familiar place such as school to make the children feel comfortable hereby in order to get honest, trustworthy responses (Chen et al. 1996; Jensen 1988; Lyon 2001). Regardless of where the testing takes place, children are known to interact and influence each other. The researcher must be aware of this and make a decision about how to handle the potential the bias caused by children interacting with each other (Popper and Kroll 2005).

The requirements concerning human subject protocols differ according to country regarding the ethics of using children in consumer studies. However, to the authors’ knowledge, consent is always required and extremely important to ensure that both the child and its parents approve of the testing. In Denmark parents’ consent, either verbal or written, is required since children are minors. In addition, it is good practice to give the parents and children information on: the study itself; the procedures involved; alternatives to participation; risks and benefits; assurances of confidentiality; any costs or compensation; the right to refuse or withdraw from the study; and contact information if there are any questions before or after participation.
Consumer testing with adolescents

Like children, adolescents have a huge impact on food choice and have a large market share in the western world, both through their parents as well as through their own spending power. According to Tufte (2007), Danish adolescents are a consumer group with one of the largest disposable incomes. A reason why only few studies have been published on this age group may be that studies have shown that by the age of 12 young adolescents are capable of all evaluation techniques (Guinard 2001; Léon et al. 1999). Due to their large market share, they are still an important consumer group to study. It may also be the case that although adolescents’ cognitive abilities are fully developed, other processes and changes going on will diminish focus and concentration which may affect their performance in sensory and consumer tasks. Some of the changes that could have an impact are described in Chapter 2. Another reason, which is rarely written down, is adolescents’ general reputation for capriciousness (Nu et al. 2007).

As only few studies have been published on this particular age group, it is difficult to know the right balance between using procedures appropriate for children and those appropriate for adults. Procedures appropriate for children may be perceived as being too childish, whereas those appropriate for adults may be too demanding. Both situations are highly unfavourable for the test results.

A Danish research project, Step-by-Step changing of children’s preferences towards healthier foods, looked into how to push food products in a healthier direction as well as changing children and adolescents’ (9 to 14 years of age) preferences for healthier foods. The age group was younger than the one in the current project, but they successfully applied procedures appropriate for older children (Kildegaard et al. 2011a; Kildegaard et al. 2011b; Kildegaard et al. 2011c; Olsen et al. 2011; Olsen et al. 2012a; Olsen et al. 2012b). Some of the age group in the COOL SNACKS project did however overlap with the Step-by-Step age group. In light of this and due to the success of the Step-by-Step project in applying these procedures, the studies included in this thesis also made use of procedures appropriate for older children as a starting point. After various events and pilot studies, procedures were developed accordingly to fit the adolescents as best as possible.

One parameter that was found very important when working with 10 to 16 year olds was not to make questionnaires and information given too childish, as the oldest adolescents especially would react negatively. Questionnaires were formulated and information was given as objectively and simply as possible, so that all was understandable without being condescending. Consideration was given as to whether it was possible to use the same measurement techniques for all adolescents, as the group aged 10 to 16 years is very broad and it was decided not to differentiate between measurement techniques according to age.
groups. Measurement techniques that were thought appropriate for all adolescents to retrieve affective response were developed and successfully applied. One of the successful criteria was that the adolescents only commented positively on the procedure and asked questions, which showed they understood it. The raw data was also inspected to ensure that the adolescents had completed the questionnaires and had not repeatedly used the same answer category. However, the need for different measurement scales according to age was suggested in Paper 5, where modifications of two neophobia scales were compared. This was because the youngest age group spent considerably more time replying to the questions asked compared to the oldest age group. The time spent conducting the tasks reported in other studies was not registered but no large time difference between the age groups was experienced. One reason could be the difficulty in answering attitudinal questions compared to affective questions regarding a physical product.

As mentioned adolescent subjects are noted as capricious (Nu et al. 2007). However, there were many benefits from working with this age group during this project. Most adolescents took their ‘job’ as an experimental subject seriously (Picture 3.1) and were direct and honest in expressing their perception of the measurement techniques, procedures, samples etc. This also resulted in some adolescents not wishing to participate simply because they did not feel like it. However, it should also be noted that a few adolescents began by saying they did not want to participate, but when this statement was amicably accepted by us they wanted to participate regardless. This can be viewed as a small and peculiar way of asserting their own independence (Brown et al. 2000).

![Picture 3.1: Adolescent girl focussed on the task (Photo: Lars Kruse, AU kommunikation).](Image)
Aside from using the same questionnaires across the different ages, there were other common factors for all the studies included in this thesis. They were all procedures appropriate for older children but seemed to work well for the adolescent age group too, and included:

- Classrooms and adjacent rooms at the selected schools were chosen to conduct the tests to ensure that the adolescents felt comfortable and relaxed when participating in the experiments (Jensen 1988; Lyon 2001). The adolescents were familiar with their school facilities and knew the teachers and the other adolescents at school. This helped make the experiments a comfortable experience. Furthermore, parents were expected to understand that their adolescents participated in the test when it was carried out in a school setting. However, one disadvantage may be that some adolescents associate this setting with a school test or examination, which could be stressful.

- The adolescents were given a common and thorough introduction to the test in the classroom and instruction to the procedures used. If they had any questions they were encouraged to ask them during the instruction or evaluation since this may be beneficial for everyone.

- The wording of the questionnaires was short and simple (Jensen 2002) and always included a short introduction and completion instructions (Lyon 2001; Scott 2000). After each study all adolescents were gathered in the classroom and given a piece of fruit as a token of appreciation.
4. Determinants of importance for adolescents’ perception of fruit and vegetable based snacks

Many determinants, both conscious and unconscious, contribute to consumer food choice. Sensory attributes, as well as social and cultural influences; mood and emotions; product expectations generated from information and packaging; situational and market factors; learning and previous experience; and our bodily state, all contribute to this choice. Given the huge number of factors involved, predicting consumer food choice is very difficult (Cardello 1995; Gibson 2006). It was of interest to this project to search for insight regarding some determinants of importance for adolescents’ affective response towards fruit and vegetable based snacks. Visual appearance, expectations, perceived complexity and adolescents’ personal determinants, namely age, gender and neophobia were chosen for detailed examination.

Visual appearance

Human senses mediate information from the environment and are essential for our survival. When it comes to food, our senses help us distinguish between edible and non-edible material. All sensory modalities are involved in the perception of food, including fruit and vegetables. However the senses play important roles in different phases (Tuorila 2007). Visual perception and olfactory signals are often the first to provide information and generate expectations regarding food quality (Barret et al. 2010; Francis 1995; Hutchings 1999; Reisfelt et al. 2008; Tuorila 2007). Eyesight also acts as a major screening sense in a purchase situation, as we cannot taste everything before we buy it (Hutchings 1999). Therefore, the appearance of our food is of paramount importance to health and well-being, since the optical properties of foods give us clues about what is fit to eat (Clydesdale 1993; Hutchings 1999; Zellner et al. 2010). Furthermore when we eat to savour and enjoy, rather than to just survive, those extra pains taken to use colour and appearance to increase temptation and appetite prior to and during consumption are worthwhile (Hutchings 1999).

We are not only affected by appearance when deciding if foods are fit or not. Research has shown that visual appearance is a key factor for affective responses towards a particular food and that masking visual cues (eating in darkness) decreases food acceptance and intake (Wansink et al. 2012; Zellner et al. 2010). When it comes to children’s food choices, visual appearance is an essential driver (Kildegaard et al. 2011b; Léon et al. 1999; Marshall et al. 2006; Olsen et al. 2012a). Despite its importance, it should be noted that individuals differ in the degree to which they attend to different sensory inputs of food when they make their affective judgments. Food is complex and it is therefore difficult to isolate the effect of any one sensory input without confounding others (Moskowitz and Krieger 1995).
In addition, the dominant sensory modality for the product experience may also depend on the product in question. This was the case, in a non-food study looking at the effect of colour and aroma (Fenko et al. 2009).

The visual appearance of snacks has been studied on different occasions in this project (Paper 1 to 4). Apart from Paper 4, where actual snack products were used, pictures were used to study visual appearance (Paper 1 to 3). Pictures have previously been used to study the visual appearance of foods, such as pears (Gamble et al. 2006); smoothies and yoghurts (Kildegaard et al. 2011b); and even meals (Reisfelt et al. 2008). Short-term studies have showed good predictive power of visually based methodologies when using children and adolescent subjects (Cardello et al. 2000; Kildegaard et al. 2011b; Olsen et al. 2012a). Likewise, Paper 1 shows great prediction of real choice of snacks when using pictures for rating and best-worst scaling. One of the key criteria to ensure the success of visually based methodology is that the stimuli must be well known to the subject to ensure that they have a basis for creating realistic expectations of the food (Reisfelt et al. 2008). This and the role of expectations, will be discussed further in the sub-chapter ‘Expectations’ in this chapter.

Visual appearance of food is an all-inclusive term, involving physical forms such as size and shape, texture, mass, gloss, colour and mode of presentation (Francis 1995; Reisfelt et al. 2008). We also respond to the aesthetic nature of colour, pattern and design. Of course, for each foodstuff appearance has deeper meaning and association (Hutchings 1999). This is important to be aware of in this project where fruit and vegetable based snacks were the focus and visual appearance was studied.

A large body of research exists on the effect of colour on people’s perception of food. Colour may be defined as the impact of wavelengths of light in the visible spectrum, between 390–760 nm, on the human retina (Francis 1995). Colour has been described as one of the major attributes affecting consumer perception of quality (Francis 1995). Judgements in one sensory modality or dimension are often affected by information from another, even if they do not physically or physiologically interact. This is especially true for colour (Clydesdale 1993). For instance, the major impact of colour on the identification and discrimination of food flavour has been well demonstrated. Congruent colours help identify corresponding flavours. On the other hand, absence or more severely, incongruence of colour can give rise to misled associations in flavour identification tasks (Clydesdale 1993; Tuorila 2007; Zampini et al. 2007; Zampini et al. 2008). Colour perception is also known to affect and interact with other sensory attributes such as sweetness (Francis 1995). Lavin and Lawless (1998) found an effect of colour on perception of sweetness by children, adolescents and adults. Perceptual differences were also found
between adolescents (11 to 14 olds) and adults. The adolescents perceived the light-red fruit beverages as more sweet compared to the dark-red beverage. This was opposite to the adults’ perception of the beverages (Lavin and Lawless 1998).

Within the culinary arts, colour and balance are both seen as important factors contributing to the aesthetic appeal of food on a plate (Zellner et al. 2010). Balance is important too in Western art. To acquire balance, the perceived weight of the elements within a composition is determined by the size, shape, colour, location within the composition and implied directionality of the elements (Locher 1996). In an American study, food was placed on plates in a very ordered and designed manner, varying balance and colour. Colour was found to increase the attractiveness of the balanced plate and not the unbalanced one. Subjects were also more willing to try monochrome plates compared to coloured plates (Zellner et al. 2010).

Despite their large influence, colour is often taken for granted in product development. It could be of benefit when creating more appealing foods for different segments of society (Clydesdale 1993). As for fruit and vegetables, their shape, size, gloss, and vibrant colours attract and entice us to pick them by fork or by hand (Barret et al. 2010). Due to the large variation in appearance, particularly colour, of fruit and vegetables, many visual and very distinct combinations can be made. This is true especially when starting to cut the fruit and vegetables. The shape of food influences the affective response towards it. In a study of children’s (7 to 12 years old) liking and wanting of snack products, it was found that over a long exposure period, smaller sized snacks were preferred to larger sized ones (Liem and Zandstra 2009).

Adolescents’ and adults’ visual preferences and affective response towards vegetable (V), fruit (F) and combined fruit and vegetable (FV) mixes have been studied in connection with this thesis (Paper 2 and 3). The mixes studied were created by using a 2³ design and by varying the design factors: cut; colour, including colour contrast; number of products; type of product; and combination of products. This resulted in eight pictures of V mixes, eight pictures of F mixes, and eight pictures of FV mixes. Since balance was not included as a design factor, but known to be of importance (Zellner et al. 2010), all the products included in the different mixes were arranged in as equally balanced a way as possible. The design factors and their two levels are shown for the three various mixes, respectively, in Table 4.1.
Table 4.1: Design factors and levels used to create the V, F and the FV mixes

<table>
<thead>
<tr>
<th>V (bell pepper) mixes</th>
<th>Level 0</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design factor</strong></td>
<td><strong>Level 0</strong></td>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td><strong>F1</strong> Colour</td>
<td>Yellow bell pepper</td>
<td>Yellow and red bell pepper</td>
</tr>
<tr>
<td><strong>F2</strong> Colour</td>
<td>Without orange bell pepper</td>
<td>With orange bell pepper</td>
</tr>
<tr>
<td><strong>F3</strong> Cut</td>
<td>Sticks</td>
<td>Cubes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F mixes</th>
<th>Level 0</th>
<th>Level 1</th>
</tr>
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<tr>
<td><strong>Design factor</strong></td>
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<td><strong>Level 1</strong></td>
</tr>
<tr>
<td><strong>F1</strong> Colour</td>
<td>Green grapes</td>
<td>Green and blue grapes</td>
</tr>
<tr>
<td><strong>F2</strong> Product type</td>
<td>Without blueberries</td>
<td>With blueberries</td>
</tr>
<tr>
<td><strong>F3</strong> Cut</td>
<td>Big apple slices</td>
<td>Small apple cubes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FV mixes</th>
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<th>Level 1</th>
</tr>
</thead>
<tbody>
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<td><strong>Level 0</strong></td>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td><strong>F1</strong> Colour</td>
<td>Yellow bell pepper</td>
<td>Yellow and red bell pepper</td>
</tr>
<tr>
<td><strong>F2</strong> Product type and combinations</td>
<td>Without blueberries</td>
<td>With blueberries</td>
</tr>
<tr>
<td><strong>F3</strong> Product combinations</td>
<td>Green grapes</td>
<td>Carrots</td>
</tr>
</tbody>
</table>

This design resulted in the following pictures (n=24), which were shown to the adolescents and adults (Figure 4.1). The name codes below the pictures refer to the levels of design factor F1, F2 and F3 displayed in the table above.

Figure 4.1: The pictures and their names, which correspond to the design factors listed in the Table 4.1

In Paper 2, and to some extent in Paper 3, the emphasis was put on the relationship between adolescents’ and adults’ visual preferences and perceived complexity for pictures.
of the mixes. However, it was also interesting to look at the effects of the single design factors. Therefore, a total of six fixed effect analyses were performed with regards to adolescents’ and adults’ visual preference for the V mixes, F mixes and FV mixes, respectively. In the fixed effects models (subjects were treated as fixed effects), the design factors were included as both main effects and two-way interaction effects. Table 4.2a, b and c shows the p values and level means for visual preference for the V, F and FV mixes for both adults and adolescents, with regard to the design parameters F1, F2 and F3 given in Table 4.1. In general, adults’ visual preferences for the mixes were affected by all the investigated design factors (cut, colour, addition of uncommon product types and product combinations). On the other hand, adolescents’ visual preferences were only affected by colour (F1 and F2) in the V mixes as well as in the F mix (F1). This meant the inclusion of a combination of unfamiliar blueberries and cut apples in the fruit case (F2*F3) and the addition of either grapes or carrots in the case of the FV mixes (F3). Colour had an effect on both adolescents and adults visual preferences. It seems that colour contrast was particularly important. It is worth noting that the adults were affected by all the investigated design parameters whereas the adolescents were not. When conducting the study the participants were instructed to look at and evaluate the pictures of the mixes by considering them as if they were presented as a snack. Since the chances are bigger that adolescents, compared to adults are more likely prepare food at home, including cut fruit and vegetables. It is possible that this greater experience gave rise to more detailed opinions of how the preferred mix should be designed for adults. During the course of study, the adults took more time looking at the pictures and completing the test compared to the adolescents. This might have resulted in more considered choices and so a larger influence of the design factors on visual preferences for the mixes. Unfortunately the completion time for each participant was not recorded, and it is therefore hard to conclude anything about the effect of processing time for each picture. Previous work has found that processing time has an effect on the perception of visual stimuli (Leder et al. 2006). The specific results for the V, F and the FV mixes are described below.

As regards pictures of the V mixes (Table 4.2a), colour (F1 and F2) and cut (F3), as well as their interaction effects (F1*F2, F1*F3 and F2*F3) were significant for adult visual preferences for the mixes. By contrast, only colour (F1 and F2) and colour interaction (F1*F2) were significant for the adolescent visual preferences for the mixes. When also taking the level means into consideration, no large differences were found between adults’ and adolescents’ visual preferences for the mixes. According to the colour interaction effects, both groups visually preferred the colour contrast full yellow and red bell pepper mix the most. This was followed by the yellow, red and orange bell pepper mixes, since these factor level combinations displayed the largest level means. The yellow bell pepper
The least preferred visually was the mix containing blueberries and apples in slices. For the adults, the cut (F3) and the corresponding interaction effects (F1*F3 and F2*F3) were also found significant. In general, the bell peppers cut in sticks were preferred visually compared to those cut into cubes.

Different results were obtained for adults and adolescents, for the F mixes (Table 4.2b) which varied in colour (F1), product type (F2) and cut (F3). All the main effects of colour (F1), product type (F2) and cut (F3), as well as the interaction effect, F1*F2 (colour*product type), were significant for the adults. Only the interaction effect, F2*F3 (product type*cut), was significant for the adolescents. The adults visually preferred the fruit mixes containing the most colour and uncommon product types. In particular, the addition of blueberries had a positive effect on the adults’ visual preference for the F mixes. Up until a few years ago, blueberries were an uncommon fruit in Denmark compared to grapes and apples (Bisgaard 2009). Blueberries are now popularly known as being very healthy due to their antioxidant content. It is likely that this popularity is due to their acclaimed health benefits as well as their relative unfamiliarity, which made the mixes more exciting and preferable (Schifferstein 2010). Had the blueberries been too unfamiliar, the mix would probably not have been so popular, as familiarity on many occasions is positively related to affective response towards food (Tuorila et al. 1994; Tuorila et al. 1998). The colour-product type mix least visually preferred was the one containing only green grapes and apples. The adults generally visually preferred apples cut in slices. The significant interaction effect (F2*F3) found for the adolescents, means that they visually preferred different cuts of apples in the mix depending on the presence/absence of blueberries, independent of the presence of grapes. The most preferred combination for the adolescents was apples in slices without blueberries, with blueberries and apples in cubes coming second. The least visually preferred mix was blueberries and apples in slices. However, the differences were not that large and so make it hard to generalise the results. Nevertheless they may be an indication of adolescents’ visual preference for mixes where the components are similar in size.

As regards the FV mixes (Table 4.2c), differences between the visual preferences of the adults and adolescents were also found for the fruit and vegetable mixes. The main effects for bell pepper (F1) colour, presence/absence of blueberries (F2) and grapes or carrots (F3) were significant for the adults. The interaction effects, F1*F2 (colour*presence or absence of blueberries) and F2*F3 (presence/absence of blueberries*grapes or carrots) were also significant for the adults, whereas the factors F1, F3 and F1*F2 were significant for the adolescents. With regards to the interaction effect F1*F2, adults and adolescents agreed that multi-coloured bell peppers were visually preferable compared to yellow bell pepper on its own.
Tables 4.2 a,b and c: P-values and level means for preference of significant factors for vegetable mixes (a); fruit mixes (b); and fruit and vegetable mixes (c) for both adults and adolescents with regards to the design parameters F1, F2 and F3. Only significant P-values are given.

<table>
<thead>
<tr>
<th>Factors</th>
<th>p-value</th>
<th>Levels</th>
<th>Level means</th>
<th>Factors</th>
<th>p-value</th>
<th>Levels</th>
<th>Level means</th>
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</thead>
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<td>p&lt;0.005</td>
<td>Level 0: Yellow</td>
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<td>F1 Color</td>
<td>p&lt;0.005</td>
<td>Level 0: Yellow</td>
<td>-.125</td>
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<td></td>
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<td>.625</td>
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<tr>
<td>F2 Color</td>
<td>p&lt;0.03</td>
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<td>F2 Color</td>
<td>p&lt;0.012</td>
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<td></td>
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<td>Level 1: Orange</td>
<td>.294</td>
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<tr>
<td>F3 Cut</td>
<td>p&lt;0.005</td>
<td>Level 0: Sticks</td>
<td>.349</td>
<td>F3 Cut</td>
<td>p&lt;0.074</td>
<td>Level 0: Sticks</td>
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<td></td>
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<tr>
<td>F1 * F2</td>
<td>p&lt;0.005</td>
<td>F1 Level 0: Yellow</td>
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<td>F1 * F2</td>
<td>p&lt;0.005</td>
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<td></td>
<td></td>
<td>F2 Level 0: No orange</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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</tr>
<tr>
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<td>-</td>
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<td></td>
<td>F2 * F3 Product types*Cut</td>
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<tr>
<td>F1 Colour</td>
<td>&lt;0.005</td>
<td>F1 level 0: Yellow</td>
<td>0.074</td>
<td>F1 Colour</td>
<td>&lt;0.005</td>
<td>F1 level 0: Yellow</td>
<td>0.117</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
<td>0.426</td>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
<td>0.385</td>
</tr>
<tr>
<td>F2 Product types</td>
<td>&lt;0.005</td>
<td>F2 level 0: No blueberries</td>
<td>0.172</td>
<td>F2 Product types</td>
<td>-</td>
<td>F2 level 0: No blueberries</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 level 1: Blueberries</td>
<td>0.328</td>
<td></td>
<td></td>
<td>F2 level 1: Blueberries</td>
<td>-</td>
</tr>
<tr>
<td>F3 Product combinations</td>
<td>&lt;0.005</td>
<td>F3 level 0: Grapes</td>
<td>0.351</td>
<td>F3 Product combinations</td>
<td>&lt;0.005</td>
<td>F3 level 0: Grapes</td>
<td>0.446</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F3 level 1: Carrots</td>
<td>0.149</td>
<td></td>
<td></td>
<td>F3 level 1: Carrots</td>
<td>0.554</td>
</tr>
<tr>
<td>E1 * F2 Colour*Product types</td>
<td>&lt;0.031</td>
<td>F1 level 0: Yellow</td>
<td>F2 level 0: No blueberries</td>
<td>-0.083</td>
<td>E1 * F2 Colour*Product types</td>
<td>&lt;0.005</td>
<td>F1 level 0: Yellow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
<td>F2 level 1: Blueberries</td>
<td>0.210</td>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
</tr>
<tr>
<td>E1 * F3 Colour*Product combinations</td>
<td>-</td>
<td>F1 level 0: Yellow</td>
<td>F3 level 0: Grapes</td>
<td>0.445</td>
<td>E1 * F3 Colour*Product combinations</td>
<td>-</td>
<td>F1 level 0: Yellow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
<td>F3 level 1: Carrots</td>
<td>0.445</td>
<td></td>
<td></td>
<td>F1 level 1: Yellow, red and orange</td>
</tr>
<tr>
<td>E2 * F3 Product types*Product combinations</td>
<td>&lt;0.005</td>
<td>F2 level 0: No blueberries</td>
<td>F3 level 0: Grapes</td>
<td>0.176</td>
<td>E2 * F3 Product types*Product combinations</td>
<td>-</td>
<td>F2 level 0: No blueberries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 level 1: Blueberries</td>
<td>F3 level 1: Carrots</td>
<td>0.168</td>
<td></td>
<td></td>
<td>F2 level 1: Blueberries</td>
</tr>
</tbody>
</table>
While adults visually preferred this colourful blend combined with blueberries, the adolescents did not. If the blend only contained yellow bell peppers, both adults and adolescents visually preferred the presence of blueberries. This result could be an indication of a different effect of colour variety on adult and adolescent visual preference, rather than simply the presence of an uncommon product such as blueberries. Adult perception of the presence/absence of blueberries in the mixes was also affected by having either carrots or grapes in the mix. Green grapes were generally visually preferable compared to carrots, especially in combination with blueberries. Blueberries and carrots were the least preferred mix visually.

These results add to knowledge of the effect of colour and shape and the differences in adolescent and adult visual preference. Since these results are based on real fruit and vegetable products and not model stimuli such gels or liquids, they should be seen in the context of the products used, expectations surrounding them, as well as the appropriateness of product combinations within the mixes. Food products are most often eaten in combination with other foods (Cardello 1995), which makes this type of study very relevant. A study by Zellner et al. (2010) found that red colouring added to tahini paste increased the attractiveness of a balanced plate of tahini paste and water chestnuts, but that subjects were more willing to try monochrome plates (non-coloured tahini paste) compared to coloured plates. The authors argue that this may be due to the reluctance of subjects to try unfamiliar and new foods, a phenomenon called food neophobia (Pliner and Hobden 1992). However, it could also be due to the context and appropriateness of coloured tahini paste.

Due to the effect of colour on adult and adolescent preference for F, V and FV mixes, the affective response (expected liking, actual liking and attractiveness) towards combinations of different coloured carrots was also studied (Paper 4). According to the aforementioned results, it was expected that a combination of different coloured carrots would receive the highest affective ratings. In contrast to expectation, the uniform orange coloured carrots received the highest affective ratings both before and after tasting. Orange carrots are by far the most common type of carrot in Denmark and these results may be due to unfamiliarity with other types. Unfortunately, the level of familiarity was not measured in relation to Paper 4. The yellow, orange and red bell peppers used in the previously mentioned study are all common in Denmark, which is why a variety of colour did not affect the level of familiarity. This comparison of results across products further highlights the importance of seeing these results, including those for colour, in the context of the products/stimuli used.
Expectations
As already mentioned in this chapter, the visual appearance of food adds to the generation of expectation about it (Hutchings 1999). Expectations play a huge role in the food choices we make (Deliza and MacFie 1996). Memory also plays a key role in developing food based expectations and may be one of the reasons why cues from one sense leads to expectation about perception though another (Mojet and Köster, 2005). Deliza and MacFie (1996) developed a model highlighting the role of expectations on consumer food choice and in sensory perception during consumption. Their model showed that prior expectations as well as the product itself, including packaging, labels, adverts and price, lead to certain expectations. Depending on these positive or negative expectations, a food choice will be made. Whether or not the product meets expectations after purchase, or if the experience was a positive one, will affect the choice to repurchase. This expectation disconfirmation model predicts that a confirmation of expectation leads to satisfaction and probably repeated product use. Disconfirmation is also able to cause satisfaction, but only if it is a positive one (Deliza and MacFie 1996).

A primary focus of this project has been to clarify the role of the visual appearances of snacks on adolescents’ affective response (Paper 1-4). However, the relationship between adolescents expected liking and actual liking was also found important. Therefore, both expected liking and actual liking of fruit and vegetable snack products by adolescents was measured in the study reported in Paper 4.

In most circumstances, expectations derived from visual cues are a reliable indicator of actual food quality, both in terms of overall recognition of the nature of the food and also as to whether the food is appropriate for ingestion (Yeomans et al. 2008). As noted by Reisfelt et al. (2008), this is particularly true if the stimuli are well known to the subject to ensure that they have a basis for creating realistic expectations of the food. A lack of congruence between the expected and actual sensory quality of a food may lead to perceptual confusion and so alter the sensory experience itself (Yeomans et al. 2008).

In Paper 1, pictures of 21 common Danish snack products were used as stimuli, whilst pictures of cut fruit and vegetables were used in Paper 2 and 3. Aside from the slightly unfamiliar blueberries contained in the mixes in Papers 2 and 3, the stimuli used in Papers 1 to 3 were considered so well known to the adolescents that they would be able to generate realistic expectations of the snacks. Therefore, visual cues were thought reliable indicators of actual appreciation of the snacks. This was not the case for the pineapple-sugar combinations included in Paper 4. Four different approaches were taken here to create highly likeable snacks consisting of fruit and vegetables combined with other foodstuffs. These approaches resulted in four different snack combinations. The carrot combination
consisted of up to four different varieties of carrots of different colours (orange, white, yellow and purple). The cucumber combinations were made of mixtures of cucumber, bread sticks and a sour-cream based dip. The pineapple-bell pepper combinations also included peanuts and pieces of dried fruit. The pineapple-sugar combinations also contained peppermint oil and chili powder. The four sets of snack combinations illustrated the following approaches: 1) combining one or more colours in a snack; 2) adding energy dense food sources to a low energy vegetable snack; 3) combining fruit and vegetables with savoury and sweet snack products; and 4) creating surprising snack products by adding sensory sensations not anticipated from visual cues. The overall results for all snack combinations included in this study showed that the ranking order of expected liking and actual liking were quite similar. For example the combination that received the highest rating with regards to expected liking also received the highest rating for actual liking. This was despite differences between expected liking and actual liking for some of the snack combinations and differences between which of the two (expected or actual liking) was rated the highest. With this information it was possible to obtain similar relative results independent from looking at expected or actual liking. Even so, differences were found between expected liking and actual liking for the different snack combinations. Aside from the snack combinations that contained sensory experiences not anticipated from visual cues, the adolescents rated expected liking lower than actual liking. One reason for this result may be that the adolescents knew that they were participating in a study and so did not completely trust the situation and therefore the snack combinations they were served. Trust is a very important factor in the eating experience and it is important in the response of consumers to new foods (Huotilainen et al. 2005).

In trying to measure consumer expectations of food products, different perceptions are often measured. These are the perception of the physical product (a sample of the raw product served blind), the product image (presented as product information or pictures, for instance) and finally the perception of the total product (the physical product in combination with the product image). One can measure responses to different perceptions, and so the discrepancy between different expectations caused by different product types by using these different product types (Schifferstein 2001). Only expected and actual liking data was collected in Paper 4 which did not make it possible to calculate the degree of confirmation/disconfirmation of expectations by the snack combination or its influence on liking.

When concerned with the effect expectations have on sensory perception and consumer behaviour towards food, four main psychological theories, relevant to expectation disconfirmation, were discussed:
- assimilation
- contrast assimilation
- contrast
- generalised negativity

These theories have been reviewed by Anderson (1973); Deliza et al.(1996); Schifferstein (2001), amongst others. It should be noted that these theories are based on experimental conditions much different from the ones usually employed in sensory food science studies and so may not apply completely to the studies included in this thesis (Hovland et al. 1957). These four theories are briefly explained below. If nothing else is stated, the three aforementioned articles are used as references. An illustration of the four theories is shown in Figure 4.2.

![Figure 4.2: Theories of disconfirmation of expectations. Modified from Anderson (1973).](image)

Assimilation Theory, also called Cognitive Dissonance, states that an unconfirmed expectation creates a kind of psychological discomfort since it contradicts the consumer’s original expectation. Consumers try to change and reduce this discomfort by altering their perceptions to bring them more in line with their expectations. Thus, perceived product performance lies between objective and expected performance, a phenomenon called assimilation.

Contrast Theory assumes that consumers anticipate a certain level of stimulation. Here expectation corresponds with the consumer’s level of perceptual or behavioural adaptation. An unexpected stimulus will result in an exaggeration of the disparity between the properties of expected and actual stimulus. For instance, according to this theory a modest understatement of an advertisement for a product will result in higher consumer satisfaction. On the other hand a product whose merits have been exaggerated will reduce
consumer satisfaction considerably. Contrast theory is therefore the reverse of assimilation.

Assimilation Theory and Contrast Theory can account for yet another theory, the so-called Assimilation-Contrast Theory. If the latitude of acceptance is small, consumer response will exhibit Contrast (Contrast Theory). On the other hand, if the latitude of acceptance is very large, the responses exhibit assimilation (Assimilation Theory).

Generalised Negativity Theory proposes that any inconsistency between one’s expectation and product performance will result in a generalised negative state making the product receive a less favourable rating than if it had matched expectations. Therefore, if a product performs differently to what is expected, it will be judged more harshly than if no expectations existed prior to exposure.

In the Paper by Deliza and MacFie (1996), empirical data was reviewed to find evidence for the expectation theories. They found that a large body of data was supportive of the Assimilation Theory (Allison and Uhl 1964; Anderson 1973; Schifferstein et al. 1999). One of the articles demonstrating this behaviour is a classical marketing study concerning the role of brand identification on taste perception of beer (Allison and Uhl 1964). In this study they found that the consumers as a group were unable to distinguish the difference in taste between the beers. Neither were they able to point out their own preferred beer in a blind test. However, ratings for labelled beers were significantly higher than those for the beers tasted blind. A study consisting of three sub-studies, one on sensory attributes of an edible film, one on written product information about a novel fruit beverage (pomegranate juice) and the third on acceptance of a well-known product (cola beverages) also investigated the usage of this theory. The first and the third sub-study once again supported an assimilation model, whilst the second study, concerning written product information, displayed evidence for a contrast model (Cardello and Sawyer 1992).

In Paper 4, actual liking for snack combinations that contained sensory sensations, which were not anticipated from visual cues, were rated significantly lower than expected liking. Though not measured, this large discrepancy between expectations and actual perception might be an indication of a contrast effect rather than an assimilation effect. These findings are in accordance with a study on slightly orange-coloured smoked salmon ice-cream (Yeomans et al. 2008). Here a decrease between expected and actual liking were seen both when the ice-cream was without a label, when labelled as savoury ice cream and especially when it was labelled as regular ice cream. The study by Yeomans et al. (2008) contributes to the few studies reporting contrasting effects with food stimuli (Cardello 2007; Cardello et al. 1992; Zellner 2001).
Perceived Complexity

Perceived complexity is an important parameter for the appreciation of food and has been linked to hedonic appreciation and aesthetics by Berlyne (1970). Schifferstein (2010) argues that aesthetics can be synonymous with terms such as ‘liking’, ‘pleasantness’ or ‘hedonic evaluation.’ These are all terms used in sensory evaluation and linked to ‘affective response’, as it is termed in this thesis. Perceived complexity was relevant for this project as it was thought possible to create visually very different fruit and vegetable mixes with regards to it. Perceived complexity was in this respect thought to be a determinant, which would influence affective response. Two of the papers (Paper 2 and 3) included in this thesis focus on perceived complexity.

The exact definition of perceived complexity has been a subject of controversy among psychologists, although there is some agreement on an intuitive level (Dember 1963). One aspect all definitions seems to share is the general assumption that “the more complex stimulus is, the one the individual can do more with: it affords more potential opportunities for responding than does the less complex stimulus” (Dember 1963). Furthermore, according to Berlyne (1960), perceived complexity increases with the number of elements and the dissimilarity between those elements. It also inversely varies “with the degree to which several elements are responded to as a unit”.

According to Berlyne’s collative motivation model, based on visual illustrations, there is a bell shaped relationship, in the manner indicated by the Wundt curve, between hedonic appreciation of a stimuli and arousal potential (Berlyne 1970) (Figure 4.3).

![Figure 4.3: The Wundt curve applied by Berlyne](image)

The arousal potential of a stimulus originates form three sources: psychophysical, ecological and collative properties of the stimuli (Martindale 1984). Collative properties refer to properties, which depend on a comparison (collation) of stimulus elements, either
appearing simultaneously or those that were perceived at different times (Berlyne 1966). Collative properties such as complexity, novelty, surprise and variability contribute the most to the arousal potential (Berlyne 1966). Visual illustrations with low arousal potential, and therefore low levels of collative properties, are not stimulating and leave the observer indifferent. Illustrations with very high arousal potential and so high levels of collative properties are too difficult to grasp and are considered unpleasant. Illustrations with a medium (or optimum) arousal potential, leading to the inverted u-shaped function between hedonic appreciation and arousal potential are preferred. Martindale (1984) argues that the link between collative properties and hedonic appreciation only applies when the psychophysical properties (such as intensity, loudness and brightness) and the ecological properties (such as meaningfulness and associative value) are kept constant (Martindale 1984). It is arguable whether it is possible to keep these variables (psychophysical and ecological) constant when working with food stimuli. Nevertheless the study of the effect of perceived complexity of a stimulus on a subject's perception has been extended to patterns other than the visual, including aroma, perfume and food products (Jellinek and Köster 1979; Jellinek and Köster 1983; Lévy et al. 2006; Reverdy et al. 2010; Sulmont et al. 2002; Sulmont-Rosse et al. 2008). The collative motivation model further states, that each individual has different arousal levels and therefore different optimal levels of perceived complexity. In addition, individuals have their own perception of complexity (Berlyne 1967; Dember and Earl 1957).

**Designing stimuli**

Stimuli with varying levels of perceived complexity need to be created to study the role of perceived complexity on hedonic appreciation and, for the purposes of this project, affective response. In Papers 2 and 3, the stimuli applied (pictures of F, V and FV mixes) are displayed in Figure 4.1 in the previous sub-chapter on ‘Visual appearance’. The mixes were developed with varying levels of collative properties, such as complexity. This was done by varying the cut, colour, number of products, types of products (common/uncommon) and combinations of fruit and vegetables. These design factors informed a designed collative property chart (Figure 1 in Paper 2) which was constructed based on the authors’ experience and intuition. However, the design factors which influenced it relate to original work by Berlyne (1966).

In his work on perceived complexity, measured with human subjects, Berlyne investigated different categories of visual stimuli which varied in perceived complexity. Some of the categories he studied and found important for perceived complexity of visual illustrations were: irregularity of arrangement; number of independent units; asymmetry; amount of material; heterogeneity of elements; irregularity of shape; incongruity; and incongruous juxtaposition (Berlyne 1966; Dember 1963).
The cut applied in the underlying design in Papers 2 and 3 both resulted in mixes which can be considered to differ in the number of independent units, heterogeneity of elements and irregularity of shape. This is due to the different number of pieces depending on the cut and size and shape differences in the pieces of the products within the mixes. The use of colour in the underlying design was not mentioned by Berlyne (1966) as one of the categories which could vary in perceived complexity. Colour is actually a psychophysical variable (Smets 1973), but it has been used to alter perceived complexity in one of the original texts on the subject as well as in the more applied studies (Berlyne 1970; Zellner et al. 2010). Zellner et al. (2010) applied the rationale that adding colour to an otherwise monochrome presentation should increase perceived complexity. For the papers included in this thesis, it was the number of different colours (and the contrast between them) that was thought to add to the arousal potential of the mixes. Different colours can add to the perception of the number of independent units. The number of products, ranging from a few to many, incorporated in the underlying design was thought to add to the perception of heterogeneity of elements as well as the irregularity of shape. The type of product (common/uncommon to Denmark) applied in the underlying design, is not thought related to the categories of perceived complexity but rather to the familiarity of the product. It can be argued that the fruit and vegetable combinations contribute to the incongruity of the mixes as it is unusual, at least in Denmark, to combine them in one snack.

In general, the aforementioned design factors and the designed collative property chart (Figure 1 in Paper 2) were a successful tool in designing fruit and vegetable mixes with varying collative properties such as perceived complexity. A linear relationship ($R^2=0.84$) was found between designed complexity and perceived complexity as evaluated by a descriptive panel. However, the colour contrast of the mixes seemed to have a larger effect than what was expected. This is in accordance with the results found for the mixed effects models reported in the sub-chapter on ‘Visual appearance’.

One of the benefits of the studies reported in Papers 2 and 3 is the large number of stimuli used. When studying the evolution of affective response as a function of perceived complexity, the number of stimuli is important (Smets 1973). The eight V mixes, eight F mixes and eight FV mixes used in Papers 2 and 3 are a higher number of stimuli than the three levels of perceived complexity used in earlier work by Berlyne (Smets 1973). In general, studies within odour and food have used more than three stimuli. For instance Jellinek and Köster (1979) used nine odours, Porcherot and Issanchou (1998) used five different flavoured crackers and Sulmont-Rossé et al. (1998) used four uncommon drinks whilst Lévy et al. (2006) used nine drinks. The stimuli mentioned here did not differ visually why the same design factors as used in this project did not apply. Lévy et al. (2006) made use of Berlyne’s (1960) notion that perceived complexity increases by
increasing the number of elements and the dissimilarity of those elements. This was achieved by modifying the flavour complexity by adding more flavours, whilst minimising all other sensations (pungency and intensity), which could also affect perceived complexity.

**Measuring perceived complexity**

Agreement on an intuitive level of what perceived complexity is, is not lacking (Dember 1963). Nevertheless one of the most difficult but essential points when conducting studies focusing on perceived complexity is the actual fact of measuring it and how this can be done. Different approaches have been applied to measure perceived complexity within food and aroma science. According to some consumer studies, the simplest way of measuring perceived complexity seems to be by asking the subjects directly how they perceive the complexity of a product (Porcherot and Issanchou 1998; Sulmont et al. 2002; Sulmont-Rosse et al. 2008). Porcherot et al. (1998) and Sulmont et al. (2002) included other measurements of perceived complexity in food, such as ease of description, ease of identification, composed of few foods etc. Another study has indirectly measured perceived complexity by deducing it from other related attributes (Lévy et al. 2006). This was done using focus group techniques to generate and define attributes to assess, among other things, the collative properties of soft drinks prior to actual testing (Lévy et al. 2006).

In order to directly ask about perceived complexity of stimuli, all subjects should unambiguously understand the concept ‘complexity’. Papers 2 and 3 included in this thesis studied both adolescent and adult visual preference for pictures of F, V and FV mixes varying in designed collative properties including complexity. It was questioned whether an average adolescent would know the concept of ‘complexity’ even on an intuitive level. Therefore, it was decided not to ask any of the subjects about their perceived complexity of the mixes. A French study has looked at the effect of perceived complexity on children’s food preferences (Reverdy et al. 2010). Instead of asking about perceived complexity they applied the following questions to measure children’s perceived complexity: ‘which samples contain the highest amount of taste?’ and ‘which sample is the most surprising.’ They found that the two questions did not describe the same thing. Furthermore, surprisingness is a collative property in itself (Berlyne 1966), so it is difficult to know whether the question ‘which sample is the most surprising’ measures perceived complexity or not. Due to the characteristics of the stimuli used in Paper 2 and 3 (pictures of food rather than actual food) and the fact that surprise is a collative property, none of these questions were found suitable to measure perceived complexity in Paper 2 and 3. In these studies a generic sensory descriptive analysis was applied to characterise the pictures of fruit and vegetable mixes ahead of the consumer studies. In Paper 2 sensory descriptive analysis results of the attribute, ‘perceived complexity’, was used as an alternative measure
of adult and adolescent perception of complexity bearing in mind that perception of complexity is an individual matter (Berlyne 1970; Walker 1980) (Figure 4.4).

Figure 4.4: Procedure of the study reported in Paper 2

However, it is correct to look at the relationship between perceived complexity and affective response on an individual level, as the relationship is a personal one, where individuals have their own level of optimal perceived complexity (Lévy et al. 2006). Terms for measuring adolescents’ perception of complexity, rather than using an external evaluation of it was therefore found important.

Paper 3 explored a way to approach this individual perception of complexity. In this paper sensory descriptive analysis was used to characterise the pictures. The results from this were then used to derive a term for the sensory attributes, which could then be used to measure adolescent perception of complexity (Figure 4.5).

Figure 4.5: Procedure of the study reported in Paper 3
The sensory descriptive panel came up with, and agreed upon, the descriptive terms used in the analysis. They defined perceived complexity as: ‘the more energy you spend to get an overview of the picture of the mix the more complex it is’. Previous studies have also included perceived complexity as an attribute in their sensory descriptive analysis (Paulsen et al. 2011; Stolzenbach et al. 2011). The results from the descriptive analysis conducted in relation to Paper 2 and 3 showed that perceived complexity was positively correlated to colour contrast and the irregularities in shape between products in the mix and highly inversely correlated ($r = -0.96$) to how simple the panel found the pictures (Figure 2, Paper 3). On a previous occasion, adolescents also used the term ‘simplicity’ to describe the pictures. It is a common every day word and assumed as familiar to everyone. Therefore, simplicity was used as a (reverse) approximation of measuring adolescent and adult perception of complexity for pictures of F, V and FV mixes instead of using colour contrast and irregularity of shape. To test agreement on simplicity between adult and adolescent consumers and a descriptive analysis panel, Pearson’s correlation coefficients were calculated between the results from the descriptive analysis and the results from the adolescent and adult consumer groups. In general, strong correlations were found regarding the use of simplicity between the descriptive panel and adolescent and adult consumers. This may indicate that simplicity, in this case, could be used to measure perceived complexity. In previous studies on perceived complexity, simplicity has often been used as an antonym for perceived complexity (Dember 1963; Porcherot et al. 1998; Sulmont et al. 2002; Sulmont-Rosse et al. 2008). With respect to individuality, adolescents were segmented based on their ratings of simplicity in Paper 3. They were divided into segments based on similar perceptions of simplicity. This was an approximation for looking at individual data and gave a more nuanced overview compared to numerous studies looking at data on a joint level (Jellinek and Köster 1979; Porcherot et al. 1998; Reverdy et al. 2010; Sulmont et al. 2002; Sulmont-Rosse et al. 2008).

Many factors regarding the methods of measuring adolescent perception of complexity in papers 2 and 3 can be questioned and discussed. First of all, it is debatable whether it is possible to use a descriptive panel to describe and evaluate a collative property such as perceived complexity. Paulsen et al. (2011) also included perceived complexity as an attribute in their sensory descriptive analysis and investigated its correlation and relationship with the other attributes. However, they did not try to formulate a term able to replace perceived complexity in a consumer study as done in Paper 3. Sensory descriptive analysis is traditionally used to describe stimuli with singular non-redundant sensory attributes (Lawless and Heymann, 2010). However, there is a growing trend towards also using meta-descriptors and collative properties in sensory descriptive analysis (Frost and Janhøj 2007; Paulsen et al. 2011; Stolzenbach et al. 2011). Meta-descriptors refer to a
composite descriptor encompassing a number of other descriptors (Frøst and Janhøj 2007). In the context of this project, and in relation to papers 2 and 3, it was found possible to include perceived complexity in the sensory descriptive analysis since it was able to discriminate between the pictures of F, V and FV mixes. There was also a relatively large difference in the visual appearance of the pictures, which may have made it easier to evaluate (and agree on) the level of perceived complexity, despite the fact that its’ perception is individual (Berlyne 1967). This is one of the reasons why the results from the sensory descriptive analysis were applied directly in Paper 2.

Another concern with the approach taken in Paper 3 is the issue with correlation and causality. A strong inverse correlation was found between perceived complexity and simplicity. Simplicity was then used as an inverse measurement of perceived complexity. Even though it seems reasonable to conclude that the opposite of simple is complex and vice versa, this may be too basic a measurement. Perceived complexity can be comprised of many factors. However, simplicity does have some similar level of abstraction level as perceived complexity, which may advocate use of the word. As mentioned previously, other studies have approached perceived complexity by using more factors to explain it. Some of these studies have looked at the relationship between the different factors used to describe perceived complexity and found that these factors do not necessarily explain the same thing (Lévy et al. 2006; Porcherot et al. 1998). If all possible factors influencing subjects’ perception of complexity are included in these studies this may not be a problem. However, if only some factors are included, this may give an inaccurate impression. Additionally, if mixed results are retrieved from the different factors, how is it then possible to know which is more or less important for the overall impression of perceived complexity? Table 4.3, includes studies where perceived complexity was measured, together with some pros and cons of the approaches used.
Different approaches for measuring perception of complexity

<table>
<thead>
<tr>
<th>Method</th>
<th>Ask subjects directly how they perceived the degree of complexity of a stimuli</th>
<th>Ask subjects about their perception of terms scientists have discussed and agreed to describe perceived complexity</th>
<th>Ask subjects about their perception of terms focus groups have discussed and agreed to describe perceived complexity</th>
<th>Ask subjects about their perception of terms a descriptive panel have discussed and evaluated to describe perceived complexity</th>
<th>Measure subjects affective response to stimuli and relate it to other measures of perceived complexity, such as a descriptive analysis evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pros</td>
<td>Simple one step procedure</td>
<td>Certainty that the subjects reply on terms which scientists means describes perceived complexity</td>
<td>Certainty that the subjects reply on terms which a focus groups means describes perceived complexity. Focus groups are often other consumers with no knowledge about the underlying design as opposed to the engaged scientists</td>
<td>Different terms related to stimuli are derived and their importance due to their correlation with perceived complexity is measured</td>
<td>A measure of perceived complexity is obtained and can be related to the affective response of subjects independent of whether subjects understands the concept of perceived complexity or not</td>
</tr>
<tr>
<td>Cons</td>
<td>Perceived complexity is in general a difficult term for subjects to relate to and it is difficult to know if the subjects completely understand the term</td>
<td>Scientists perception of complexity is not necessarily the same as other people’s perception of complexity especially since the scientists are influenced by their background knowledge and the underlying design</td>
<td>Strong individuals in focus groups can dominate the discussion</td>
<td>Correlation between perceived complexity measured by a panel and a term does not necessarily warrant the use of the term in consumer studies</td>
<td>Perceived complexity is in this way not measured on an individual level. It is difficult to know if the subjects perception of complexity is the same as the measurement</td>
</tr>
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<td></td>
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<td></td>
<td>Difficult to know the relative importance of the terms discussed in a focus group</td>
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<td></td>
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<td></td>
<td></td>
<td>Difficulties in data interpretation</td>
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</table>

Table 4.3: Overview of approaches to measure subjects perception of complexity

Besides the pros and cons mentioned earlier in the text, those mentioned in Table 4.3 are related to the perception of complexity and to the person perceiving it. The study by Jellinek and Köster (1979) worked with three odour complexity levels:

- Chemical complexity
- Perfumer’s perception of complexity
- Subjects’ perception (which two bottles contain the mixture where the most different substances were present)
The results from this study show that neither the chemical nor the perfumers’ perceptions were able to predict the subjects’ perception of complexity. This demonstrates the importance of remembering who perceives complexity, but also whether it is measured directly or indirectly.

No ideal way of measuring perceived complexity was identified in relation to this thesis. Lévy et al. (2006) state that too little attention is often given to the development and definition of the proper attributes to describe collative properties such as complexity. Indeed Lévy et al. (2006), Sulmont et al. (2002), and Sulmont-Rosse et al. (2008) all call for more research on how to validate and/or improve the measurement of perceived complexity. In the context of this project this is also seen as an important development for future research. Furthermore, since this is a field of research with many pitfalls, more open discussion could be beneficial to highlight their advantages and drawbacks. This could be done for instance in the commentary sections sometimes included in journals such as Appetite where an invited main paper and commentary letters are published. The benefits and pitfalls of laboratory testing compared to ‘real life’ consumer testing have been discussed using this format and has resulted in good and highly relevant discussion (Meiselman 1992; Mela et al. 1992; Pliner 1992).

Evidence for the bell-shaped relationship
Others have also investigated the relationship between collative properties, such as complexity and hedonic appreciation following early work by Berlyne (1970), Dember et al. (1957) and Dember et al. (1957). G. Smets (1973) in her PhD thesis, tried to prove the relationship between hedonic appreciation and perceived complexity. Amongst others she investigated the relationship for both figures and colours, though not for combinations of colours. She was able to confirm the relationship for stimuli of medium levels of perceived complexity. However, she was not able to confirm the relationship for stimuli with very low levels or very high levels of perceived complexity (Smets 1973). Frith and Nias (1974) in a study on visual stimuli, found that subjects (n=88) generally preferred the simplest stimuli. This is in contrast with previous work, which reports a preference for intermediate degrees of perceived complexity (Frith and Nias 1974). Berlyne also acknowledged the limitations of his model when dealing with more naturalistic stimuli and products from daily life compared to abstract visual illustrations (Hekkert and Leder, 2008).

Despite these results, various studies within food science have included perceived complexity. This is mainly due to the effects of arousal and perceived complexity on the development food preference after repeated exposure (Köster et al. 2002; Lévy et al. 2006; Porcherot et al. 1998). However, studies on food products have also had problems reporting evidence on the relationship between liking and perceived complexity (Jellinek
and Köster 1979; Porcherot et al. 1998). Though, this may be due to the fact that linear, rather than curvilinear relationships between affective response and perceived complexity were studied. This in itself is rather problematic.

As no evidence for the bell shaped relationship for food stimuli has been reported before, it was considered of the utmost importance to test this relationship for food products in relation to this project. Therefore, in Paper 2, the relationship between preference and perceived complexity for pictures of F, V and FV mixes was tested. Inverted U-shaped relationships between visual preference and perceived complexity were found for both the V mixes and the F mixes, but not for the FV mixes. In addition, the subjects’ optimal level of perceived complexity for the V and the F mixes was dependent on whether they were adolescents or adults, their gender and the frequency of consumption of fruit and vegetables.

As regards the pictures of the V and the F mixes, adults preferred more complex mixes than adolescents and females preferred more complex mixes compared to males. In Figure 4.6 stylised bell-shaped curves are displayed, showing the difference in vertex between gender and age. The vertexes displayed are marked according to the results in Paper 2, whereas the bell-shaped curve is for illustration purposes only. Figure 4 in Paper 2 displays the actual overall fitted curves.
No effect was found for hunger. With regard to the frequency of eating fruit and vegetables, higher fruit consumption resulted in a greater optimal perceived complexity level for the F mixes. Alternatively, a large vegetable intake resulted in a higher optimal perceived complexity level for the vegetable mixes.

The results of the effect of age (adolescent/adult) and of a high intake frequency of vegetables and of fruit found in Paper 2, confirm that the theories of Berlyne (1970), Dember and Earl (1957) and Zajonc (1968) can be applied to pictures of vegetable mixes and fruit mixes but not to pictures of combined vegetable and fruit mixes. Females are reported to have a higher intake of fruit and vegetables (Pedersen et al. 2010) so the gender difference may combined with age and intake effects, be also related to the degree of exposure. Mere exposure studies, combined with theories of mere exposure and arousal potential, confirm that perceived complexity is an important factor in the development of
food preference in adult subjects (Lévy et al. 2006; Porcherot and Issanchou 1998) as well as in children (Reverdy et al. 2010).

The fact that a difference in optimal perceived complexity was found according to age, gender and frequency of eating fruit and vegetables, stresses the fact that there is a lack of similarity between people and their preferences (Grunert 2002; Köster 2007). This should be considered when developing food products such as fruit and vegetable based snacks where multiple product solutions should be considered. Furthermore, the fact that adolescents were found to have a lower optimal level of perceived complexity for the V and the F mixes compared to adults, stresses that this age group should be considered as a separate consumer group, especially considering their significant impact on the food market (Popper and Kroll, 2005). It could also have been interesting to clarify the optimal level of perceived complexity in children. Previous studies have reported that the older children become, the more complex food products they prefer (Zeinstra et al. 2007).

Paper 2 reported the reason why a bell shaped curve was not found for the FV mixes could be due to the optimal level of perceived complexity lying beyond the measurement area or that the psychophysical or ecological variables differed. When working with a mixed real food product it is difficult to know to what extent psychophysical and ecological variables can vary but still be perceived as relatively constant. To the author’s knowledge, no studies have been performed in this area.

The fact that a bell-shaped relationship for two out of three sets of pictures exists illustrates that it is possible to test and show evidence of the theoretical background on which many of the studies on perceived complexity of food stimuli are based. As mentioned, these studies are primarily conducted to show the effect of perceived complexity and food preference development in relation to mere exposure. However, it is also important that the bell-shaped relationship is valid for the products in question. More studies are definately needed to refine the method of measuring perceived complexity, but certainly also to explore the applicability and limitations of this theory. This is of crucial importance if these theories are to be used directly and actively in the food industry.
Personal determinants
Aside from product and product-person interrelated factors, personal determinants such as age, gender and neophobia were thought to influence adolescents' affective response towards fruit and vegetable based snacks. Many of the studies reported in this thesis focused on gender and age effects, whilst Paper 4 and, in particular, Paper 5 looked at neophobia. Table 4.4 presents an overview of the studies reported in this thesis and shows the personal determinants investigated. The influence affective response to the snacks was found is showed by + and -.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
<td>Best-Worst Scaling</td>
<td>Rating</td>
<td>Real choice</td>
<td>Incomplete ranking</td>
<td>Rating</td>
</tr>
<tr>
<td>Age</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>Segmentation was performed on adolescents evaluation of simple rather than personal determinants</td>
</tr>
<tr>
<td>Gender</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>This paper was not concerned with snacks as such, but instead measured neophobia</td>
</tr>
<tr>
<td>Neophobia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunger</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Origin (urban/rural)</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of consumption of fruit and vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Age
As seen from the Table 4.4, age significantly affected adolescents’ responses to the tested stimuli in all papers where it was studied, aside from those for rating in Paper 1. It should be noted that in Paper 2, age was defined as the difference between adolescents and adults. The adolescents were investigated separately and though the results were insignificant, the older ones tended to visually prefer more complex mixes.
In Paper 1, adolescents’ real choices of 21 different types of snacks available on the Danish market were correlated with age and other personal determinants in a Principal Component Analysis (PCA). Despite the effect age had in the best-worst scaling procedure and on adolescents’ real choice of snacks, no large tendencies regarding the snack categories chosen, were found between the different age groups. Furthermore, it was difficult to know if these effects were dependent on age rather than other personal determinants such as gender, since the distribution of males and females was not equal within the different age groups. As seen Table 4.5, there were a high proportion of girls in the 15-year-old category. Figure 2 in Paper 1 shows that the 15-year old adolescent were found highly correlated to girls and real choice of grapes. Due to the uneven distribution of males and females it is difficult to tell if this large frequency of real choice of grapes is attributable to females, 15 year olds or both.

Table 4.5: Proportion of males and females according to age (Paper 1)

<table>
<thead>
<tr>
<th>Age</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n)</td>
<td>46</td>
<td>19</td>
<td>61</td>
<td>27</td>
<td>22</td>
<td>21</td>
<td>196</td>
</tr>
<tr>
<td>Females (n)</td>
<td>39</td>
<td>15</td>
<td>52</td>
<td>24</td>
<td>45</td>
<td>16</td>
<td>191</td>
</tr>
</tbody>
</table>

By 11 to 12 years of age adolescents begin to understand how nutrients are incorporated into the diet and how these can affect the body (Contento 1981; Nu et al. 2007). Zeinstra et al. (2007) found that as children mature, social norms and the perspectives of peers become more important with regard to fruit and vegetables. This indicates that increasing age could somehow have a positive influence on children’s preferences for healthier foods and perceptions of health. However, a literature review looking at determinants of fruit and vegetable intake among children and adolescents found evidence to the contrary, as fruit and vegetable consumption decreased as they got older (Rasmussen et al. 2006). Proof of age as being a positive influence on adolescents’ preference towards fruit and vegetables was not found in Paper 1 either. Here personal determinants such as gender and hunger seemed to have a larger effect on adolescents’ real choice of snack. In a British and American study the effect of age on liking and preference for food was also investigated and no linear effects for liking of food categories, including fruits and vegetables, were found here either (Caine-Bish and Scheule 2009; Cooke and Wardle 2005). Paper 1 reported another non-linear relationship according to age, which was the ability of adolescents to correctly perform best-worst scaling the first time (Table 4.6). The 7th graders were better than both 5th and 9th graders at performing it correctly the first time.
This also shows that linear relationships between age and response should not be taken for granted.

Table 4.6: The ease of use of rating and best-worst scaling, including adolescents’ ability to correctly perform best-worst scaling.

<table>
<thead>
<tr>
<th>Grade</th>
<th>N</th>
<th>Rating was the easiest method</th>
<th>Best-worst scaling was the easiest method</th>
<th>Methods were equally easy</th>
<th>Correct best-worst scaling</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th</td>
<td>120</td>
<td>44 %</td>
<td>21 %</td>
<td>35 %</td>
<td>70 %</td>
</tr>
<tr>
<td>7th</td>
<td>165</td>
<td>50 %</td>
<td>19 %</td>
<td>31 %</td>
<td>85 %</td>
</tr>
<tr>
<td>9th</td>
<td>103</td>
<td>40 %</td>
<td>23 %</td>
<td>37 %</td>
<td>70 %</td>
</tr>
</tbody>
</table>

Rapid change occurs during adolescence, and the type of change is likely to be related to age. To further complicate the issue, adolescents can be at different stages of cognitive development despite being the same age (Popper and Kroll 2007). The 9th graders involved in the study conducted for Paper 1, seemed more interested in the opposite sex than the questionnaires, whilst the younger classes paid more attention when filling them out. This may also affect the results.

A trend was seen between age difference and affective response in Paper 2 where stimuli belonged to the same food category. This trend for age was also found to a certain extent in Paper 4, where the stimuli were snacks composed of different food categories. As shown in the previous sub-chapter on ‘Perceived complexity’ and in Paper 2, adolescents had lower levels of optimal complexity compared to adults for pictures of the V and the F mixes (Figure 4.1). Furthermore no significant differences in preference were found when looking at the adolescents separately. Although, a similar trend, was found for optimal complexity as it increased with age. This indicates that the main difference in preference is between adolescents and adults. Paper 2 and the sub-chapter on ‘Perceived complexity’, mentioned that age difference is argued to be an effect and a confirmation of the theories of exposure and prior experience (Berlyne 1970; Dember et al. 1957; Zajonc 1968). According to the theory, an individual’s optimal level of complexity depends on learning and experience. Through experience, one’s optimal level is assumed to move from less to more complex stimuli (Dember et al. 1957). Dember and Earl (1957) described this phenomenon by arguing that exposure to a more than optimal complex stimulus (a so-called ‘pacer’) will increase the individuals’ optimal level of complexity. Therefore a more complex stimulus becomes more appreciated compared to one not so complex. In the case of Paper 2, age was thought connected to experience since older people are the more likely to have been repeatedly exposed to a given stimuli. The fruit and vegetable stimuli used in Paper 2, apart from blueberries, were thought to be fairly common with a high degree of previous exposure. If other products had been chosen, experience may not so easily been connected.
with age. Children, adolescents and adults are reported to have different perceptions of tastants such as sucrose (de Graaf and Zandstra 1999) and different cross modal perceptions (Lavin et al. 1998). However the pictures of the F and the V mixes were not thought to differ in expected sweetness why this was not thought to be an influencing factor in this study. In Paper 4, the effects of age were found only for adolescents’ response towards the pineapple-bell pepper combination snacks and the pineapple-sugar combination snacks but not for the carrot combination snacks or the cucumber combination snacks. (For further details on snack combinations, please see the sub-chapter on ‘Expectations’ earlier in this chapter.) The fact an effect of age was not found for all combinations investigated makes it a fragile foundation to build upon. However, assuming that simplicity is an inverse measurement of perceived complexity, as discussed in Paper 3 and in the sub-chapter on ‘Perceived complexity’ earlier in this chapter, the results are interesting despite being sparse. First of all, the older adolescents found the pineapple-sugar combination simpler. This could be an indication of an age related change in perception of how simple or complex stimuli are. Perception of the level of collative properties, such as complexity, is an individual matter (Berlyne 1967). Although it may be that if the perceived differences are large enough within the stimuli, individuals will generally agree. Furthermore, the older adolescents (16 year olds) liked (actual liking) the least simple pineapple-bell pepper combination a lot more compared to the other adolescents. Moreover, they liked (actual liking) and found the least simple pineapple-sugar combination more attractive compared to the younger age groups. If simplicity can be used as a reverse measure of perceived complexity, these results fit well with the aforementioned results from Paper 2 which states that the older subjects become, the more they appreciate more complex products. This is also in accordance with previous studies on children’s preferences, which reports their expansion to include more complex food products as they get older (Zeinstra et al. 2007). Likewise, in a study of 10 to 17 year old adolescents, the older ones made meals containing more components compared to younger adolescents (Ahlström et al. 1990). In addition, Nu et al. (2007) reported differences in food preference, stating that younger adolescents prefer plain and more familiar foods whereas older ones prefer adult foods and tend to snack more.

In relation to snack development, initiatives should meet the need of adolescents. Based on the aforementioned results, this indicates that snack development should not only move away from products targeted children but also from those aimed at adults, since adolescents’ affective responses differed from adults. Furthermore, differentiation of snack products within this age group would also be beneficial. However due to the limited effects of age reported, snack development should focus on factors such as age in combination with others such as gender.
Gender
While the effect of age on adolescents’ response towards stimuli in the presented studies was not strong, clear results for gender across the studies were found. Gender differences were found in Paper 1, where fruit and vegetable snacks were presented alongside other types of snacks. For rating, best-worst scaling and the real choices of snacks, girls rated/chose fruit snacks, particularly grapes, higher/more than the boys. Moreover they rated/chose baked savoury and sweet snacks such as chocolate, mini pizza, muffins, rum balls, sausage rolls and wine gums lower/less than boys. Additionally, the PCA plot on real choices of snacks (Figure 2 Paper 1) shows that a high hunger state was highly correlated with boys. This may explain boys’ more frequent choice of baked savoury and sweet snacks compared to girls. Females had higher optimal levels of complexity regarding pictures of V and the F mixes in Paper 2. This was explained by their higher intake of fruit and vegetables and so more frequent exposure to the stimuli used. In Paper 4, the girls generally gave higher affective ratings for the pure fruit and vegetable combinations compared to the boys.

The results reported in Paper 1, 2 and 4 are in agreement with previous studies, which reported differences between boys and girls regarding their food preferences (Wansink et al. 2003; Zeinstra et al. 2007). Furthermore, there is a long list of publications showing that girls consume and like fruit and vegetables more so compared to boys (Cooke et al. 2005; Le Bigot Macaux 2001; Nu et al. 2007; Reynolds et al. 1999). The reason for girls’ choice of fruit may be due to their interest in heath and dietetics (Cooke et al. 2004; Nu et al. 2007). Girls focus more on the body’s appearance and cultural aspects of health compared to boys (Wardle and Beales 1986). In addition, the finding that boys were correlated with hunger and chose baked savoury and sweet products (Paper 1) is expected. Boys’ energy requirements are greater than that of girls making their choice of more energy-dense food an adaptive purpose (Cooke et al. 2004).

In relation to snacks development, initiatives should target snack products directed at girls and boys differently. It seems relatively straightforward to develop fruit and vegetable based snacks for girls as they have an existing appreciation for fruit and vegetables, while it will be more difficult to do the same for boys. A compromise between more energy dense snacks and fruit and vegetables was thus thought a way of getting boys interested in consuming more fruit and vegetables. In Paper 4, four different approaches to create highly likeable snacks consisting of fruit and vegetables combined with other foodstuffs were applied, including adding energy dense food sources to a low energy vegetable snack. These four different approaches resulted in four different snack combinations (refer to the sub-chapter on ‘Expectations’ in this chapter for more details). Paper 1 found that male
adolescents were more correlated to a high hunger state than females. Since they have higher energy requirements, it was thought that boys would give a higher affective response to the more energy dense snacks compared to girls. However, the pineapple-sugar combinations were the only snacks where boys responded more positively than girls. For instance, boys rated the combinations containing pineapple-sugar-peppermint oil (PSPe) and those containing pineapple-sugar-peppermint oil and chili powder (PSPeC) significantly higher in attractiveness compared to girls. However, the girls rated these combinations higher in actual liking. This result is not considered an effect of boys’ being hungrier, especially when taking into consideration that girls liked the combinations more. Rather, the results are seen as an indication of boys’ reacting more positively to the combination of the products and the excitement of surprise, compared to the girls who already liked the pure fruit. This excitement might also overrule actual liking in the overall perception of the product. As argued in Paper 4, these results could be an indication of higher levels of sensation seeking in boys compared to girls (Roberti 2004; Zuckerman et al. 1978). Sensation seeking refers to the tendency to seek out novel, varied, complex and highly stimulating experiences and the willingness to take risks in order to attain them (Roberti 2004). In the context of adolescents, it has primarily been related to risky behaviour such as reckless driving and smoking marijuana (Hampson et al. 2008). It could also affect low risk behaviour such as snack consumption. Sensation seeking affects people’s relationship with food, particularly novel food (Pliner and Melo 1997). A Japanese study found a positive correlation between a sensation seeking score and preference for spicy food, meat and alcoholic beverages (Terasaki and Imada 1988).

Neophobia
In Paper 4, where expected liking, liking, simplicity and attractiveness of different snack combinations were measured, it was also relevant to test the effect of (trait) neophobia on adolescents’ response towards the snack combinations. Neophobia is defined as the reluctance to eat and/or the avoidance of novel foods (Pliner and Hobden 1992). Children are predisposed to react neophobically towards novel foods (Birch 1999) and it influences their perception of, and preference for certain foods (Loewen and Pliner 2000; Nicklaus et al. 2004). Neophilic children are reportedly more willing to taste novel foods compared to neophobic children (Loewen et al. 2000). As children grow their experience with food increases and they develop likes and dislikes, which reduces their neophobia (Cooke et al. 2005). A body of research suggests that a curvilinear relationship exists between neophobia and age. Food neophobia is minimal during infancy and increases during early childhood only for it to decrease again from childhood through adolescence into adulthood (Dovey et al. 2008). In Paper 5 a decrease in neophobia from younger to older adolescence
was also found when using the snack neophilia child questionnaire scale (SNCHILD). This scale was developed specifically for the study reported in Papers 4 and 5.

Pliner and Hobden (1992) developed the Food Neophobia Scale (FNS), which is a 10 item questionnaire scale to measure food neophobia in adult subjects between 19 to 25 years old (Table 4.7). According to Loewen and Pliner (2000), this scale had its shortcomings regarding the measurement of children’s food neophobia. Therefore a new questionnaire, the Food Situations Questionnaire (FSQ), was developed to measure food trait neophobia in children between the ages of 7 and 12 (Loewen et al. 2000) (Table 4.7). Both questionnaire scales were validated and the results for retest reliability and internal consistency were satisfactory. However, the FNS scale has primarily been used in studies where trait neophobia was relevant to measure (Mustonen et al. 2012; Nicklaus et al. 2005; Tuorila et al. 1998).

This project concerns adolescents and from this perspective none of the two original questionnaire scales were found completely compatible with the age group. For instance, the FSQ contains questions suggesting that those answering the questions are very reliant on their parents or the parents of their friends. These questions are not appropriate for the older adolescents who may be accustomed to preparing or buying their own sandwiches (question 2 in FSQ Table 4.7). On the other hand some of the FNS questions, such as one about eating out in restaurants, seem inappropriate for use with the younger adolescents (question 10 in FNS Table 4.7).

Therefore for Paper 5, the two original scales were modified to match the age group. They were also created to target snacking rather than general food consumption situations (Table 4.7). More specifically, the FSQ-scale was adapted to focus on snack situations involving best friends and peers, in school and outside of school. The FNS-scale was adapted to focus on snacks and on a European context, using a vocabulary matching adolescents’ vocabulary. Other studies have previously also modified the original scales to fit a certain purpose, such as the willingness to try fruit and vegetables (Rubio et al. 2008; Thomson et al. 2010).

Both adopted questionnaire scales were then tested on adolescents aged between 11 to 16 years old and then compared on method and content issues (Paper 5). Mixed results for the two questionnaire scales were found, but the SNCHILD seemed more appropriate especially because of its higher reliability values (Paper 5). However it needs further modification to be fully fit for its purpose. Nevertheless, the SNCHILD presented in Paper 5 was applied in Paper 4, as it was indicative of neophobic snacking behaviour. To further extend the use of this questionnaire scale more work should be conducted. Firstly, the
suggestions proposed in Paper 5 should be incorporated and secondly, the validity of the scale should be tested amongst others with regard to its prediction of neophobic snacking behaviour as done by Pliner and Hobden (1992).

Table 4.7: The original Food Neophobia Scale developed by Pliner and Hobden (1992) and the Food Situations Questionnaire developed by Loewen and Pliner (2000), plus the two modifications to the scales used in Paper 4 and 5.

<table>
<thead>
<tr>
<th>Food Neophobia Scale (FNS) (Pliner and Hobden 1992)</th>
<th>Snack neophobia adult questionnaire scale (SNADULT) (Paper 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am constantly sampling new and different foods. (R)*</td>
<td>POSITIVE (SNPOS) Strongly agree (1) to Strongly disagree (7)</td>
</tr>
<tr>
<td>I don’t trust new foods.</td>
<td>I like snacks from diff. countries( R)</td>
</tr>
<tr>
<td>If I don’t know what is in a food, I won’t try it.</td>
<td>I like to try new kinds of snacks (R)</td>
</tr>
<tr>
<td>I like foods from different countries. (R)</td>
<td>At snack meals I like to try new snacks (R)</td>
</tr>
<tr>
<td>Ethnic food looks too weird to eat.</td>
<td>I will eat almost any snacks (R)</td>
</tr>
<tr>
<td>At dinner parties, I will try a new food. (R)</td>
<td>I am constantly sampling for new foods (R)</td>
</tr>
<tr>
<td>I am afraid to eat things I have never had before.</td>
<td>NEGATIVE (SNNEG) Strongly disagree (1) to Strongly agree (7)</td>
</tr>
<tr>
<td>I am very particular about the foods I will eat.</td>
<td>I don’t trust new snacks</td>
</tr>
<tr>
<td>I will eat almost anything. (R)</td>
<td>I am afraid to eat snacks I have never tasted</td>
</tr>
<tr>
<td>I like to try new ethnic restaurants. (R)</td>
<td>I am very particular about the snacks I eat</td>
</tr>
<tr>
<td></td>
<td>When I don’t know the content then I won’t try the snack</td>
</tr>
<tr>
<td></td>
<td>Some snacks look too weird to eat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food Situations Questionnaire (FSQ) (Loewen and Pliner 2000)</th>
<th>Snack neophobia child questionnaire scale (SNCHILD) (abbreviated questions) (Paper 4 and 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low stimulating situations (LO-STIM) subscale</td>
<td>LO-STIM subscale (with the best friend and at school)</td>
</tr>
<tr>
<td>If your Mum or Dad made something for dinner that you had never tasted before, how would you feel about eating that?</td>
<td>Taste fruit sample from best friend in school canteen</td>
</tr>
<tr>
<td>If your Mum made a new and different kind of sandwich for your lunch box, how would you feel about eating the sandwich?</td>
<td>Taste sample from best friend in school canteen</td>
</tr>
<tr>
<td>If you went on a picnic with your friend’s family and they brought a food that you had never seen before, how would you feel about having some of their food?</td>
<td>Buy alone and share with best friend in school canteen</td>
</tr>
<tr>
<td>If your family went on a trip to a new place and all the food there was stuff you’d never had before, how would you feel about eating the food?</td>
<td>Taste vegetable sample from best friend in school canteen</td>
</tr>
<tr>
<td>If your Mum served a new kind of vegetable for dinner, how would you feel about eating that?</td>
<td>Buy alone in school canteen</td>
</tr>
</tbody>
</table>
In Paper 4, the neophilic adolescents rated the snack combinations significantly higher as regards expected liking, actual liking and attractiveness, compared to the neophobic ones. Also, the more neophilic the adolescents were, the more they liked the least simple combinations. Tuorila et al. (1998) reported similar results in a study of new snack foods evaluated by 15-year-old subjects. Since neophobia is defined as the reluctance to eat and/or the avoidance of novel foods, it is no surprise that neophilic adolescents generally give higher ratings to snack combinations compared to neophobic adolescents. However, since none of the questions in the SNCHILD were reversed, unlike in the snack neophobia adult questionnaire scale (SNADULT), it is also possible that this is due to certain adolescents giving higher ratings compared to others. However since the level of neophobia did not significantly affect the non-affective simplicity rating, this fortunately minimises this risk.

In Paper 4 it was expected that neophilic adolescents would give higher affective ratings to the snack combinations consisting of more food products, other than pure fruit and vegetables. Only the results for the pineapple-bell pepper snack combination were as expected, since the neophilic adolescents liked (actual liking) the least simple snack combination containing pineapple, bell pepper, peanuts and dried fruit equally compared to the other snack combinations. This combination was least liked by the neophobic and the medium neophobic group of adolescents. Even though this combination consisted of familiar products the combination was new. However, it is worth noting there was no effect of neophobia for any of the other snack combinations. Since younger adolescents were
more neophobic compared to older adolescents when using the SNCHILD (Paper 5), it is possible that a potential effect of neophobia was ‘masked’ by the effect of age.

**Other factors**

As mentioned previously in this thesis, many factors influenced people’s perception and affective responses towards food. According to a review by Rasmussen et al. (2006), important determinants of fruit and vegetable consumption among children and adolescents were gender, age, socio-economic background, preferences, parental intake of fruit and vegetables and home availability/accessibility. Urbanisation was also important, as three out of four papers reported evidence showing rural children and adolescents frequently consume more fruit and vegetables than their urban peers. This fits well with the results found in Paper 1 where urbanisation was included in the study design. Here rural adolescents gave higher affective responses to fruit and vegetable snacks (apart from bananas) compared to urban adolescents.

Hunger status was correlated in Paper 1 with boys and the real choice of more energy dense snacks other than fruit and vegetables. This is in accordance with a British study where hunger diminished the appeal of a fruit bar due to preconceptions about its lack of satiation (Gibson and Wardle 2001). However hunger did not have an effect on adolescents’ and adults' optimal level of perceived complexity for pictures of F and V mixes in Paper 2. This level was affected by the frequency of consumption of fruit and vegetables, which itself were connected to previous exposure and experience (Dember et al. 1957; Zajonc 1968).
Conclusions
This PhD project was part of the COOL SNACKS research project. The PhD project had two overall aims:

- To include adolescents (10-16 year olds) in sensory and consumer science through the application of a variety of methods and to assess the efficacy of two of these methods (7-point hedonic rating and best-worst scaling) when used on adolescents
- To reveal some important determinants for adolescents’ affective response towards fruit and vegetable based snacks

To provide an overview of the selected and studied determinants in relation to the responses retrieved from consumer analysis, Figure 2 is shown again with main conclusions added (Figure 5.1).

Adolescents were included in sensory and consumer science by exposing them to a variety of consumer methods. They were found able to successfully apply the following consumer methods:

- Rating on a 7-point hedonic rating scale and a 7-point Likert scale
- Best-worst scaling
- Incomplete ranking
Best-worst scaling and the 7-point hedonic rating scale both showed a high degree of external validity. Both methods were highly predictive of adolescents’ real choice of investigated stimuli. However, the 7-point hedonic rating scale was more suitable since the adolescents found this method easier to apply compared to best-worst scaling. The other important criteria for the successful use of all methods on adolescents were: a) power of discrimination between stimuli and b) that the methods were user friendly.

The same questionnaires formulated objectively and simply were applicable across the age group (10-16 years olds) apart from the modified snack neophobia scales specifically developed in relation to the COOL SNACKS project. More work on the modified snack neophobia scales is suggested, such as differentiating the scales for different age groups.

Adolescents’ affective response towards fruit and vegetable based snacks was affected by all the studied determinants: visual appearance (product related determinant); perceived complexity and expectations (product-person interrelated determinants); age, gender, and neophobia (person related determinants) (see Figure 5.1).

As regards visual appearance, colour and the colour contrast of pictures of fruit (F) and vegetable (V) mixes were found to have an impact on adolescents’ affective response (preferences) with large colour contrasts between products in the mixes being more preferable. On the other hand, a combination of familiar and unfamiliar coloured stimuli (purple, white, yellow and orange carrots) received lower affective ratings compared to a familiar, single coloured combination of stimuli (only orange carrots).

Investigation into the optimal level of adolescent and adult perceived complexity for food related stimuli was approached using the same pictures of F, V and combined fruit and vegetable (FV) mixes as mentioned above. The mixes were designed to vary in their level of collative properties including perceived complexity. Major design factors contributing to the level of perceived complexity were the number of colours and the colour contrast between products in the mixes. The bell shaped relationship between perceived complexity and hedonic appreciation, suggested by Berlyne (1970), was proven for the pictures of the F and the V mixes, but not the FV mixes. To the authors’ knowledge, this is the first set of empirical evidence demonstrating the bell shaped relationship for food related stimuli. The optimal level of perceived complexity for pictures of the F and V mixes was dependent on whether the subjects were adolescents or adults, their gender and frequency of consumption of fruit and vegetables. Adults had higher optimal perceived complexity levels than adolescents. Females had higher optimal perceived complexity levels than males. Subjects with a high regular fruit intake had greater levels of optimal perceived complexity for pictures of the F mixes, compared to those with a less regular intake. The
same trend was seen for vegetable intake and the optimal level of perceived complexity for pictures of the V mixes. Furthermore, a sensory descriptive profile was created where perceived complexity was included as an attribute. Sensory descriptive profiling is proposed as a feasible way to generate terms, which can then be used to individually evaluate adolescents’ perception of complexity.

Adolescents’ expected liking, generated from the visual stimuli, was lower than their actual liking of fruit and vegetable based snacks. The only exception was for snacks containing sensory sensations not anticipated from visual cues. The snack combinations were given the same rank order for expected liking and actual liking, which meant that the same relative results could be retrieved from both sets of data.

With regard to person related factors, adolescents’ affective response towards fruit and vegetable based snacks was affected especially by gender. Girls chose or liked pure fruit and vegetable snacks more so than boys. Boys, on the other hand, gave higher attractiveness ratings for snack combinations with sensory sensations not anticipated by visual cues. Age was also influenced their affective response to fruit and vegetable based snacks, but no clear trends were observed. Neophobia affected adolescents’ perception of fruit and vegetable based snacks. As expected, neophilic adolescents rated snack combinations higher than neophobic adolescents. However, the modified child neophobia snack scale that was used still needs modification for it to be completely suitable.

Other factors such as urbanisation, hunger state and frequency of fruit and vegetable consumption also affected adolescents’ perception of fruit and vegetable based snacks. Fruit and vegetable based snacks scored (best-worst scaling) higher for rural adolescents compared to urban ones. Hungry adolescents frequently chose energy dense snacks instead of fruit and vegetable snacks compared to less hungry ones. Finally, frequency of fruits and vegetables consumption affected their optimal level of perceived complexity for pictures of F and V mixes.

This PhD project provides new knowledge and valuable insight into research on adolescents as subjects in consumer studies as well as the determinants influencing their affective response to foods such as fruit and vegetable based snacks. It was demonstrated that adolescents are a consumer segment in their own right, distinct from adults. Much more research on this particular and important consumer segment is needed.
**Perspectives**

The knowledge acquired in this PhD project has many applications. In addition, the studies can be refined and possibilities have opened up for future research. Below are suggestions for the application of some of the results from the thesis, as are some concrete ideas for future research.

The methodological part of this project demonstrated that adolescents were capable of successfully applying the methods they were exposed to. Apart from studying their affective responses to food, these methods can evaluate other non-food product categories, which adolescents are also accustomed to using. For instance, these could be fashion products, perfume, make-up, (smart) phones and other electronic items which adolescents are large-scale consumers of.

It is highly relevant to look more into the snacking situation and its context. The studies reported in this thesis were undertaken within the framework of the school where individual responses were collected. However, the real life of adolescents is not restricted to school. Future research should further investigate their real choices in different, more natural contexts. This could be where they purchase snacks, such as supermarkets and convenience stores, or in-home testing and at social events where snacks are consumed.

The empirical evidence for the theoretically based bell-shaped relationship between perceived complexity and hedonic appreciation (preference here) is crucial. It is the foundation of many existing studies looking at the effect of perceived complexity on food preference development in relation to mere exposure. The differences found in optimal levels of perceived complexity within the subject group studied can be used to develop future food products targeted at different segments of adolescent and adult consumers. In particular, those developing products for adolescents should be aware of targeting both genders. Gender differences regarding optimal level of complexity and affective response in general were found throughout the research. However, adolescents’ origin (rural/urban), level of neophobia and the consumption frequency of the stimuli in question should also be taken into consideration.

Extending the research to different segments of the population would be highly relevant for investigating other important personal determinants of optimal level of perceived complexity for a given food related stimuli. Personal determinants, which are relevant to investigate, are cultural background, attitudes towards food (including level of neophobia) and social status. This could provide new knowledge for the development of new and healthier products and is essential for increasing fruit and vegetable intake.
The fact that the bell-shaped relationship was not proven for all pictures of the mixes investigated, stresses the need for more research to highlight when, and for which food related stimuli, this relationship exists. In future, if perceived complexity is proven to be an important parameter for appreciation of many food products, optimal ways of measuring it among children and adolescents should be identified. It should then be feasible to use these theories and implement them during product innovation and development. This project found that it was possible to design food related stimuli which varied in their level of perceived complexity. This variation should also be possible for other product categories, especially for more homogeneous food matrixes such as yoghurt and bread.

This thesis has primarily focused on visual stimuli to find a way of getting adolescents to choose fruit and vegetable based snacks the first time. Besides the relationship between perceived complexity and affective response, general rules and guidelines was sought identified. Adolescents’ affective response was particularly affected by the amount of colour and colour contrast. However, these results are context dependent and more research should be conducted on the role of colour on affective response to different food categories in order to generalise across different products.

This project explained adolescents’ response to fruit and vegetable based snacks on a single occasion. However, preferences are not stable over time (Köster 2007). It is therefore highly relevant to revisit adolescents’ choices and affective responses to fruit and vegetable based snacks several times over an extended period in order to assess their general intake.

Sensory and consumer science, the field in which this project is based, is mostly performed on an individual level. However, adolescent life is strongly affected by peers and the affective responses collected in relation to this thesis will benefit from being combined with research on their social interactions, use of media etc. to give an indication of actual behaviour. Future research should also try to combine the different research disciplines, such as social science, design and experience science, marketing science, sensory science and media science to further understand and predict real life and to develop successful, healthy food products for adolescents. Therefore, a new meta-science approach would be applicable, rather than a single disciplinary research strategy. This is a huge and difficult task to undertake, but it is of the utmost importance.
References


