

# The Development of Taste Preferences in Children

A Longitudinal Study of Norwegian Preschoolers

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De Gustibus Non Est Disputandum

- Latin maxim



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This dissertation originates in my hunger of understanding everything related to development, in particular food preferences. This dissertation also exists in a much vaster and more complex context: in the hope of gaining knowledge that can later help influence the food habits of tomorrow's children. If the knowledge this dissertation has collected can facilitate in this, it is mostly due to the hard work of the 151 children who participated in the study. So, to all of you: Most of you drank bitter water twelve times during the span of this study. Still you almost always smiled and one of you even told me that it tasted like butterflies. Your perseverance and imagination have and will continue to inspire me.

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## Abstract

The proportion of overweight children in the population is an increasing problem, partly due to unhealthy diets. Taste preferences are part of the foundation for diets but has not previously been longitudinally investigated in preschoolers. A better understanding of taste preferences in childhood can contribute to facilitating healthier diets for children, as childhood is a stage where nutrition can benefit or hinder children in reaching their full potential.

The overall aim of this dissertation was to investigate how taste preferences develop within the preschool years from age four to six. It was also to investigate how these preferences relate to taste sensitivity, parenting practices, and food exposure. Furthermore, it was to design protocols that would ensure reliable and valid investigation of the sensitivity and preference, as no such measures existed for the age-group.

The data in this dissertation was collected with 151 children born in 2011, using a longitudinal design during the spring of 2015, 2016, and 2017. In each year, the children's preferences for different intensities of basic tastes were investigated with a gamified ranking by elimination procedure. The taste carriers used were drinks differing in intensity of basic taste: either sweetness (sucrose; 4% vs. 12% vs. 18%), sourness (citric acid; 0.13% vs. 0.21% vs 0.35%), or bitterness (isolone; 0.001% vs. 0.002% vs 0.003%). A solid food modality was introduced with chocolate differing in both bitterness (cocoa; 45% vs. 55% vs. 65%) and sweetness (sucrose; 53% vs. 42% vs. 32%). The sensitivity of the children was investigated each year, using taste detection with a paired comparisons procedure. Sensitivity was investigated with four concentrations for each basic taste, in sweetness (sucrose), sourness (citric acid), umami (monosodium glutamate), bitterness (quinine), and saltiness (sodium chloride).

Additionally, two parental questionnaires were employed each year. The Ages and Stages Questionnaire investigated each child's individual development using measures on communication, problem solving, fine motor, gross-motor, and personal-social skills. The second questionnaire investigated parental practices (parental attitudes, parental use of rewards, parental style), food exposure and liking, as well as several demographic variables.

The preference for intensity of sweetness developed during the span of the study, with a significant increase in preference for sweeter drinks. There was also a development in preference for chocolate between the age of four and six, with a significant increase in preference for the sweeter, less bitter chocolates. Together, this indicates a heightened preference for sweetness in childhood. In both bitter and sour drinks, there was no developmental difference as the children were consistent in their preference throughout the span of the study.

Taste sensitivity was related to taste preference only through bitterness and sweetness. Sensitivity for sweetness was related to preference in sweet drinks during the span of the study, and children that were more sensitive had a lower preference. At age six, children more sensitive to bitterness preferred less sweet drinks. In addition, children more sensitive to either sweetness or bitterness preferred more bitter/less sweet chocolate at age four and five. There was a significant decrease in sensitivity for sweetness during the study, and an increase in sensitivity between the age of four and six in both sourness and saltiness. For bitterness and umami, the sensitivity was consistent throughout the study.

How parental practices influenced preferences in their children was investigated. Parents who used food as a reward had children with a higher sweet preference. Parents also differed in what foods they exposed their children to. This significantly influenced the children in three ways: children who were exposed to more sweet foods had a higher sweet preference (in both sweet drinks and chocolate), children who were exposed to more fruits had a lower sweet preference (in sweet drinks), and children who were exposed to more bitter foods had a higher bitter/less sweet preference (in chocolates). Food exposure was indicated to act as a mediator between taste preference and sensitivity, as a lower exposure to sweet foods was related to higher sweet sensitivity. In addition, more bitter sensitive children were exposed to more bitter snacks. Food exposure was related to both family size and parental attitudes. Children with older siblings were exposed to more sweet foods and less fruit. Parental attitudes towards sugar and taste were related to their child's exposure to sweet foods. In addition, parents with a more health conscious attitude exposed their children to more fruit and less sweet foods.

Retests with a subset of the children indicated that the protocols for the tests were reliable, as children showed consistency for all tastes. Performance in any of the tests was not related to

difference in cognitive level between the children. There was a high participation rate for all tests during the span of the study, ranging from 5% withdrawal rate the first year to 3% the last year. Data from the sensitivity test revealed that 7% (sourness) and 16% (saltiness) of the children correctly and consistently discriminated between cups of water but labelled the cups counter to what was expected when designing protocols. Two labelling criteria were introduced in analyses: Experimenters Scoring Criterion and Children's Scoring Criterion. Except for sour taste, there were no differences in sensitivity score across labelling criteria. This finding highlights the importance of taking the child's perspective in scientific research.

The study has limitations. One is the appropriateness of the taste carriers used, in both the sensitivity and preference test. Different concentrations and taste carriers could have yielded different results, and the results are thus not necessarily applicable to other stimuli. In addition, the participating parents generally had a high level of education compared with the rest of the Norwegian population.

In conclusion, children as young as four years old can provide reliable answers to both sensitivity and preference testing if careful considerations are taken into designing the protocols. Taste preferences increased for sweetness but were stable for both sourness and bitterness. Taste sensitivity can only partly explain preferences. It seems that there are separate developmental trajectories across tastes, both for sensitivity and preference. Food exposure might serve as a mediator between taste sensitivity and preference. In addition, food exposure can, alongside the parental practice of using food as rewards, influence taste preferences. This indicates that parents can influence the taste preferences of their children, and thus influence the child towards a taste preference associated with healthier foods. This has important implications, for the children both today and later in their life, and in a broader context in a society with an increasing proportion of overweight children.



## Sammendrag

Overvekt i barndomsårene er et økende problem, delvis på grunn av usunt kosthold. Smakspreferanser er en del av grunnlaget for kosthold, men har ikke tidligere blitt undersøkt longitudinelt hos barnehagebarn. En bedre forståelse av smakspreferanser hos barn kan bidra til å legge til rette for sunnere kosthold for barn. Dette er spesielt viktig siden ernæring enten kan hjelpe eller hindre barn i å nå sitt fulle potensial.

Det overordnede målet med denne avhandlingen var å undersøke hvordan smakspreferanser utvikler seg mellom fire og seks år. Et annet mål var å undersøke hvordan disse smakspreferanse relaterer seg til smakssensitivitet, foreldrepraksis og mateksponering. Videre var det å designe protokoller som ville sørge for reliable og valide målinger av sensitivitet og preferanse hos barn, siden ingen slike protokoller eksisterte for aldersgruppen.

Dataene i denne avhandlingen ble samlet inn med 151 barn født i 2011, og det ble brukt et longitudinelt design våren 2015, 2016 og 2017. Barnas preferanse for forskjellige intensiteter av søthet, surhet og bitterhet ble undersøkt hvert år med en spillifisert og tilpasset metode (rangering ved eliminering). Smaksbærerne var saft med forskjellig intensitet av grunnsmak: enten søthet (sukrose; 4% vs. 12% vs. 18%), surhet (sitronsyre; 0.13% vs. 0.21% vs. 0.35%) eller bitterhet (isolone; 0.001% vs. 0.002% vs 0.003%). Smakspreferanser ble også undersøkt i sjokolade som varierte i både bitterhet (kakao; 45% vs. 55% vs. 65%) og søthet (sukrose; 53% vs. 42% vs. 32%). Barnas sensitivitet ble også undersøkt hvert år, og det ble brukt en parvis sammenligning. Sensitivitet ble undersøkt med fire konsentrasjoner per grunnsmak, i søthet (sukrose), surhet (sitronsyre), umami (mononatriumglutamat), bitterhet (kinin) og salthet (natriumklorid). En retest ble gjennomført det første året for å undersøke testens reliabilitet.

Barnas foreldre svarte i tillegg på to spørreskjemaer hvert år. Det første spørreskjemaet (Ages and Stages Questionnaire) undersøkte hvert barns individuelle utvikling gjennom mål på kommunikasjon, grovmotorikk, finmotorikk, problemløsning og personlig/sosiale ferdigheter. Det andre spørreskjemaet undersøkte foreldrepraksis (foreldrenes holdninger, brukt av belønning, foreldrestil), eksponering og liking av mat, samt flere demografiske variabler.

Preferansene for intensitet av søt smak utviklet seg gjennom studiet, og det var en signifikant økning i preferanse for søtere saft. Det var også utvikling i preferanse for sjokolade fra fire til seks år, med en signifikant økning i preferanse for den søtere, mindre bitre sjokoladen.

Sammen indikerer disse funnene en økt preferanse for søthet i denne aldersgruppen. Det var ingen utvikling i preferanse gjennom studien for sur eller bitter smak i saft.

Smakssensitivitet var relatert til smakspreferanse bare gjennom bitterhet og søthet. Sensitivitet for søthet var relatert til preferanse for søte drikker gjennom hele studien, og mer sensitive barn hadde en lavere søt preferanse. Som seks-åring foretrakk de mer bitter-sensitive barna mindre søt saft. I tillegg foretrakk barn som var mer sensitive for søthet og/eller bitterhet mer bitter/mindre søt sjokolade som fire og fem-åring. Sensitivitet for søthet sank signifikant gjennom studien, mens det derimot var en økning i sensitivitet for surhet og salthet mellom fire og seks år. Sensitivitet for bitterhet og umami var stabile gjennom studien.

Det ble undersøkt hvordan foreldre praksis påvirket barnas preferanser. Foreldre som brukte mat som belønning hadde barn med signifikant høyere preferanse for intens søt smak.

Foreldrene varierte også i hvordan de eksponerte barna sine for mat, og det påvirket barna signifikant på tre måter: Barn som var eksponert for mer søtmat hadde høyere preferanse for søthet (i både søt saft og sjokolade), barn som var eksponert for mer frukt hadde lavere søt preferanse (i søt saft), og barn som var eksponert for mer bitter mat hadde en preferanse for mer bitter/mindre søthet (i sjokolade). Mateksponering kan være en mediator mellom smakspreferanse og smakssensitivitet, og en lavere eksponering til søtmat var relatert til høyere sensitivitet for søthet. I tillegg var de mer bitter-sensitive barna mer eksponert for bitter mat. Mateksponering var relatert til både familiestørrelse og foreldrenes holdninger. Barn med eldre søsken var eksponert for mer søtmat og mindre frukt. Foreldrenes holdninger til sukker og smak var relatert til hvordan deres barn ble eksponert for søtmat. I tillegg eksponerte foreldre som var mer opptatt av helse barna sine for mer frukt og mindre søtmat.

Retester med en undergruppe av barna fant at svarene var reliable, siden barna var konsistente for alle smaker. Barnas utførelse av testene var ikke relatert til forskjeller i kognitivt nivå.

Deltagerandelen var høy for alle tester gjennom hele studien: Bare mellom 3% (siste året) og 5% (første året) av barna trakk seg fra testen.

Data fra sensitivitetstesten viste at 7% (surhet) og 16% (salthet) av barna korrekt og konsistent diskriminerte mellom vann og vann med smak, men plasserte vannet motsatt av hva som var forventet da protokollen ble designet. To forskjellige skåringskriterier ble derfor introdusert i analysen: Forskerens skåringskriterie og Barnas skåringskriterie. Bortsett fra for sur smak var det ingen forskjell i sensitivitets skår på tvers av kriteria brukt. Dette funnet understreker viktigheten av å ta barnas perspektiv i vitenskapelig forskning.

Studien har begrensninger, som valget av smaksbærere, i både sensitivitets og preferansetesten. Andre konsentrasjonsnivåer eller andre smaksbærere kunne ha ført til andre resultater, og resultatene i denne studien er derfor ikke nødvendigvis overførbare til andre smaksbærere. I tillegg hadde foreldrene i undersøkelsen høyt utdannelsesnivå sammenlignet med resten av den norske befolkningen.

For å konkludere: Barn ned til fire år kan gi reliable svar på både preferanse og sensitivitets testing hvis protokollene er tilpasset. Smakspreferanser for søthet økte, mens preferansene for surhet og bitterhet var stabile. Smakssensitivitet kan bare delvis bidra til å forklare preferanser. Det ser ut som om det er forskjellige utviklingsstier på tvers av smaker, både for sensitivitet og preferanse. Mateksponering kan være en mediator mellom sensitivitet og preferanse. I tillegg kan mateksponering sammen med foreldres bruk av mat som belønning påvirke smakspreferanser. Dette indikerer at foreldrene kan påvirke sine barns smakspreferanser, og derfor påvirke barna sine til smakspreferanser som understøtter sunnere matvalg. Dette har viktige implikasjoner, både for barn i dag og senere i deres liv, og i en større kontekst i et samfunn med et økende overvektsproblem.



# List of Papers

## Paper 1

Vennerød, F.F.F., Hersleth, M., Nicklaus, S., and Almli, V.L. (2017). The magic water test. An affective paired comparison approach to evaluate taste sensitivity with preschoolers. *Food Quality and Preference*, 58, 61-70.

## Paper 2

Vennerød, F.F.F., Almli, V.L., Berget, I., and Lien, N. (2017). Do parents form their children's sweet preference? The role of parents and taste sensitivity on preference for sweetness in preschoolers. *Food Quality and Preference*, 62, 172-182.

## Paper 3

Vennerød, F.F.F., Nicklaus, S., Lien, N., and Almli, V.L. (2018). The development of taste sensitivity and preferences in preschoolers. *Appetite*, 127C, 130-137.



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## Introduction

There is a global issue in the proportion of overweight children in the population, and as of 2016, 41 million children under the age of five were categorized as overweight or obese (UNICEF & World Health Organization, 2017). Among other challenges, being overweight is related to cardiovascular disease in childhood (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; L'Allemand-Jander, 2010). Additionally, it is related to a continued issue with weight into adulthood (Singh, Mulder, Twisk, Van Mechelen, & Chinapaw, 2008), where it serves as a risk factor for several non-communicable diseases (Y. H. Chang, Chang, Lin, Shin, & Lee, 2011; Field et al., 2001). To prevent a high proportion of overweight children, the World Health Organization (2017) recommends increased physical activity and healthier diets.

The foundation for both diet (Nicklaus, Boggio, Chabanet, & Issanchou, 2005) and diet-related health status (Biro & Wien, 2010) is based on food habits in childhood. A habit is when we perform behaviours without requiring information to make decisions, and is often specific to the situation (van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011). Food behaviour is often habitual. Having healthy food habits will lead to unconsciously making healthy food choices (van't Riet et al., 2011) – for example eating vegetables for dinner without making an effort to do so, but because it is what one typically consumes. Thus, habits are the key to health (Aldridge, Dovey, & Halford, 2009; Olsen, Møller, & Hausner, 2013; Savage, Fisher, & Birch, 2007; Skouteris et al., 2012). Understanding the foundation of food habits in children can help lay a foundation for unconsciously healthier lifestyles.

Taste preferences are a common determinant for food choices across cultures (French, 2003; Glanz, Basil, Maibach, Goldberg, & Snyder, 1998; Urala & Lähteenmäki, 2003), also in children (Birch, 1979; Cooke & Wardle, 2005; Liem & Mennella, 2002). Inborn taste preferences drive us to prefer sweetness and reject bitterness (Schwartz, Issanchou, & Nicklaus, 2009), and children's preferences generally do not align with a healthy diet (Russell & Worsley, 2007). More specifically, a high preference for sweetness is associated with higher consumption of sweet foods (Liem & Mennella, 2002; Mennella, Finkbeiner, & Reed, 2012; Mennella, Reed, Mathew, Roberts, & Mansfield, 2014). Additionally, children tend to reject vegetables because of bitter tastants (Russell & Worsley, 2007; Wardle, Carnell, &

Cooke, 2005). Adding to the important influence of taste preferences on health, preference for sweeter taste has been related to being overweight in children (Lanfer et al., 2013). Our innate taste preferences were essential to our survival, both as a species and as individuals, but may now be our demise (Prescott, 2013).

Authorities such as the World Health Organization (2003) and the Norwegian Directorate of Health (2011) generally advise children and adults alike to consume less sweets, and more fruit and vegetables. As presented above, consumption of sweet foods and vegetables is related to preference and perception for sweetness and bitterness. Additionally, sour preference has been associated with higher consumption of fruit in children (Blossfeld et al., 2007; Liem, Bogers, Dagnelie, & de Graaf, 2006). Childhood is a stage with a particular emphasis on sweetness (Mennella, Pepino, & Reed, 2005; Schneider, Jerusalem, Mente, & De Bock, 2013; Schwartz et al., 2017; Yuan et al., 2016), and this dissertation had a particular focus on sweet preferences, but also investigated preferences for sourness and bitterness. This dissertation begins the next chapter with describing taste preferences more thoroughly.

The two following chapters in this dissertation describe influences on taste preferences from taste perception and then parental practices. Taste perception relates to taste preferences for example in sweetness evoking pleasure through the stimulation of the taste buds. Differences in taste perception might modulate distinctly different pathways to food preferences (Prescott, 2013). Parental practices relate to taste preferences for example with a heightened preference for sweetness due to frequent consumption of sweets. The influences of taste perception and parental practices collaborate in creating taste preferences.

Taste preferences are not constant and vary both between individuals and in each individual over time. Unfortunately, little is known about how taste preferences develop in the preschool years. To understand the preference for sweetness, sourness, and bitterness in childhood, it is essential to understand if the preferences are stable or variable. Early childhood seems to be of particular importance to develop healthy food preferences, as food preference at age four is the most important predictor for food preference at age eight (Skinner, Carruth, Bounds, & Ziegler, 2002). The present study therefore investigated children between the year they turned four and the year they turned six years old.

There are to my knowledge no other longitudinal studies investigating both taste sensitivity and preferences in the preschool years. One of the reasons for this is the challenging nature of testing preschoolers. A section of this thesis is devoted to how one can tailor sensory tests to children, and the challenges that doing such work can raise.

The research in this dissertation was conducted to better understand the foundation for a healthy diet in childhood. However, no food or taste preferences are healthy or unhealthy per se. I do however argue that preferring lower sweet taste, and accepting both bitterness and sourness, can lead to consuming more fruit and vegetables, as well as less sweet foods, and thus a “healthier” general diet. When I use the word “healthy” in this dissertation, I use it in this manner - interchangeably with a diet consisting of more fruit and vegetables, and less sweet foods, which is in accordance with the main general recommendations for healthy eating both in Norway (Norwegian Directorate of Health, 2011) and globally (The World Health Organization, 2003; The World Health Organization & Unicef, 2003).

## **What Are Taste Preferences?**

In its strictest form, taste is not a multisensory experience, but the distinct response of stimulating the taste buds in the fungiform papillae on our tongues (Hersleth & Rødbotten, 2009). The taste buds have taste receptors for the basic tastes: sweet, sour, bitter, salty, and umami (a savoury, broth-like taste). The density of taste buds on our tongues varies between individuals. Having more taste buds will generally lead to a more intense taste perception, as the foods we consume will stimulate more taste receptors. Our perception of taste results from taste receptors being stimulated, and through different processes, signalling to the thalamus, medulla, somatosensory and orbitofrontal cortex. Food sensation is thus determined in these areas, collapsed with input from other sources, such as olfaction, which is the sense of smell (Hersleth & Rødbotten, 2009; Prescott, 2013). In addition, hearing, tactile feeling, and a multitude of cognitive influences will be involved. In this dissertation, the focus is on taste, and not on the rest of the chemosensory experience.

Even though we all have the same general taste-system, there are many smaller variances between individuals. Differences in taste perception may modulate distinctly different pathways to taste and food preferences (Prescott, 2013). A *preference* can be defined as choosing one thing over another (Rozin, 1990). It is usually measured with selecting one from

several samples (Lawless & Heymann, 2010). Preference and liking are different concepts - we can prefer food we like, but we can also prefer one food to another even though we dislike both, as preference can be guided by factors such as perceived healthiness. *Liking*, on the other hand, is the immediate affective response to an item (Rozin & Vollmecke, 1986). It is not necessary to like something to prefer it, but degree of liking can influence preference.

The preference for intensity of taste in foods is often an inverted U, where the liking increases with intensity to a certain peak, from which it decreases (Moskowitz, 1977) – i.e. the preferred intensity of taste is usually neither too low or too high, but in the middle range.

After a certain point, what we perceived as good and sweet becomes *too* sweet. But what is too sweet? Too sour? An overall higher preference for more intense taste might be present in some individuals, as children who prefer higher concentrations of sweetness have been found to also prefer higher concentrations of saltiness (Mennella, Finkbeiner, Lipchok, Hwang, & Reed, 2014). However, other studies found no associations between preferences for intensity for the different basic tastes (Lanfer et al., 2013; Liem, 2004; Liem & De Graaf, 2004; Liem & Mennella, 2002), indicating that preference for intensity in taste can be taste specific.

## **Influences of Taste Perception on Taste Preferences**

Taste preferences at birth display our basic biology, as the same tendencies are found in newborns across studies and cultures. Infants show an innate acceptance for sweet taste (Lawless, 1985; Schwartz et al., 2009), as well as an aversion towards bitter and sour stimuli (Lawless, 1985; Schwartz et al., 2009). These reactions seem to be universal in primates, as infant monkeys show the same acceptance of sweetness and rejection of bitterness as humans do (Steiner, Glaser, Hawilo, & Berridge, 2001). Innate taste preferences are theorised to be evolutionary traces: Telling us that food is safe, ripe and thus full of nutrients (i.e. sweet) or poisonous (i.e. bitter or sour). The pleasant hedonic perception of sweet foods is thus an evolutionary product, as it would motivate us to eat safely. Taste perception is innate, but innate factors can be affected by extrinsic factors, as even our genetic expression can be modulated by the environment (López-Maury, Marguerat, & Bähler, 2008).

Children have repeatedly been found to prefer more intense tastes than adults, both in sweetness (Lawless, 1985; Schwartz et al., 2009), and sourness (Liem & De Graaf, 2004; Liem & Mennella, 2003). Some argue that the heightened taste preferences in youth is due to

a lower taste sensitivity (Lanfer et al., 2013). *Taste sensitivity* can be expressed as the ability to perceive a taste (Lanfer et al., 2013). Understanding taste sensitivity is important as it can relate to differences in liking and disliking of foods (Prescott, 2013). A relationship between taste sensitivity and preference seems obvious, but little is known regarding how these two factors interact in childhood, and a cross-sectional study found no association between sensitivity and preference in children aged six to nine (Lanfer et al., 2013). Described below are the relationships between taste sensitivity and preference both within and across taste modalities.

In sour taste, a proportion of children prefer a much higher intensity of taste than their mothers - in one study, 35% of children aged five to nine years preferred the gelatine with most citric acid, whereas almost none of the mothers did (Liem & Mennella, 2003). The heightened preference for sour taste was not due to a lower sensitivity for sour taste, as the children did not differ in ability to rank the gelatines from least to most sour. The sour preference is thought to actually stem from a higher preference for sour, not a lower ability to perceive and discriminate for sour. A high preference for sourness with no correlation to sensitivity has also been found in children aged seven to 12 years (Liem, Westerbeek, Wolterink, Kok, & De Graaf, 2004). To my knowledge, there are no other studies investigating the relationship between taste sensitivity and preferences in preschoolers.

The relationship between taste sensitivity and food choice has however been more researched. Taste sensitivity has repeatedly been found to influence food choice and liking (Duffy, Peterson, Dinehart, & Bartoshuk, 2003; Hartvig, Hausner, Wendin, & Bredie, 2014; Hayes & Duffy, 2008). In a study researching bitter sensitivity, children that were more sensitive to bitter taste were found to consume more of the sweet juices provided, and less of the bitter grapefruit juice (Hartvig, 2013). A sensitive child can have a harder struggle to overcome his or her basic biology and to develop healthy food habits, as bitter sensitive children consume less leafy vegetables (Keller, Steinmann, Nurse, & Tepper, 2002). Although such children are not destined never to consume leafy vegetables, as a group, they will be associated with a taste pattern differing from that of their less sensitive peers. This suggests that differences in sensitivity to basic tastes can affect food intake, an effect that might be due to differences in bitter preference.

Certain genotypes relate to differences in preferences and perception of tastes. How the genetic differences in the alleles of the TAS2R38 gene influence the perception of the bitter tastant 6-*n*-propylthiouracil (PROP) is particularly well described. So-called supertasters of PROP (Bartoshuk, 1993) are unusually sensitive to bitterness and sweetness. Prescott (2013) explains the difference between being a supertaster or not with a colour analogy: A drink will be pink for a normal taster, but red for the supertaster. PROP-taster status is related to preference for bitterness and to a certain degree sweetness (Mennella et al., 2005), and to a higher intake of sugar (Joseph, Reed, & Mennella, 2016) and sweets (Keller et al., 2014) in children. Particularly for bitter taste, the system is quite complex. In addition, there might be several interactions across taste modalities that are not straightforward. As such, PROP-tasters have a higher intake of salt than non-tasters, probably due to saltiness suppressing bitter taste (Hayes, Sullivan, & Duffy, 2010).

An adult twin study has found the genetic effect on sour preference to be larger than the effect of the shared environment (Törnwall et al., 2012). The same has been found for sweetness, as individuals can be non-likers for sweetness due to a genetic influence (Keskitalo et al., 2007). However, these results were found with adults, and the genetic contribution could be different in childhood. Exemplifying this, the expression of the genes associated with PROP-status can show differences in bitterness perception in children and adults (Mennella et al., 2005). Care should be taken in extrapolating from studies done with adults. Unfortunately, to my knowledge, few studies are done on genetic effects on children's taste preferences.

In addition, the relationship between preference and sensitivity is more difficult to understand as they both can undergo development within the childhood years. Sensitivity is not stable within the individual but evolves through the lifespan. There is typically an increase in sensitivity in childhood, and later in life, a decrease with age during the elderly years (Mojet, Christ-Hazelhof, & Heidema, 2001). However, although sensitivity for all five basic tastes has been comprehensively studied in adults (see e.g. (Bartoshuk, 1974; Bitnes, Martens, Ueland, & Martens, 2007; W.-I. Chang, Chung, Kim, Chung, & Kho, 2006; Hoehl, Schoenberger, & Busch-Stockfisch, 2010; Masi, Dinnella, Monteleone, & Prescott, 2015)), little is known regarding how taste sensitivity develops in the preschool years. Several cross-sectional studies have been conducted. An increase in sucrose sensitivity has been reported from age three until age six (Visser, Kroeze, Kamps, & Bijleveld, 2000) as well as an

increase in perceived intensity from childhood to young adulthood (De Graaf & Zandstra, 1999). For bitterness there seems to be more stability, as studies found sensitivity for 6-*n*-propylthiouracil (PROP) to be similar between early readers and adults (Anliker, Bartoshuk, Ferris, & Hooks, 1991), and similar for female pre-teens and adults (James, Laing, & Oram, 1997). To my knowledge, there is a lack of literature about the development of children's taste sensitivity with regards to particularly sourness (Liem & Mennella, 2003; Liem, Westerbeek, et al., 2004), but also saltiness (Bobowski & Mennella, 2015; Goldstein & Leshem, 2014; Knof, Lanfer, Bildstein, Buchecker, & Hiltz, 2011; Lanfer et al., 2013) and umami (Bobowski & Mennella, 2015; Knof et al., 2011; Lanfer et al., 2013). Developmental differences in taste sensitivity indicate that it could have a different relationship with taste preferences at different times.

## **Parental Practices and Taste Preferences**

Taste preferences are dynamic, and we are not slaves to our basic biology, and thus cursed to reject bitter stimuli or prefer high sweetness throughout life. Emphasizing this, there is a small but significant decrease of acceptance of sweet taste early in life (Schwartz et al., 2009). The decrease in acceptance corresponds with the time children are weaned and start to ingest solid foods – i.e. from the age of three to twelve months (Schwartz et al., 2009). Consuming food that is less sweet than breastmilk is argued to lead to a lower acceptance for sweetness. Food preferences show plasticity as early as age one, as there are individual differences in food preferences associated with different exposures to food (Yuan et al., 2016).

As parents usually are the gatekeepers to the foods their children are exposed to at home, they have a clear influence on their children's food environment. However, the relationship between parental and child's taste preferences might not always be linear. This is illustrated by the lack of correlation between mother's and children's sour preference (Liem & Mennella, 2003). The parental effect on taste preference might not be direct but mediated by other factors such as food served. The food parents serve to their child will be more familiar to the child, and thus influences the child to have taste preferences reflecting foods they are familiar with (Liem & Mennella, 2002).

## **Familiarity and exposure**

Children like what they know, and eat what they like (Cooke, 2007). One of the most important factors regarding whether a child will like a food is how familiar it is (Birch, 1979; Birch & Marlin, 1982; Cooke, 2007), as exposure has been shown to heighten the trust and liking of foods. The role of exposure and familiarity is central when identifying children's food and taste preferences (Aldridge et al., 2009). Although the exposure is from the outside, and thus extrinsic, the change is intrinsic and linked to cognitive development. Familiarity is really metaknowledge, as the child will compare the presented food to previously presented food, and thus depends on script-knowledge as well as categorizing when assessing a served food (Aldridge et al., 2009). The concept of familiarity is therefore related to the cognitive development of the child (Lafraire, Rioux, Giboreau, & Picard, 2016; Rioux, Picard, & Lafraire, 2016). To be familiar with more categories of food will expand what food is accepted as safe – and thus good and acceptable to eat.

The theorised psychological influence of familiarisation is supported by several studies, also with taste preferences. Children aged 18 months who consumed fruits more frequently and at a higher quantity and variation accepted a higher sour solution than their peers (Blossfeld et al., 2007). An experiment investigating the effect of exposure to different lemonades over eight days found an effect for preference in sweetness, but not for sourness (Liem & De Graaf, 2004). This indicates that the effect of exposure can be different across taste modalities. Associating basic taste with a food is a learned process (Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011). An early exposure to salt and sweet tastes may teach a child that some food items are supposed to have these tastes (Schwartz et al., 2011). The child is implicitly taught that ice cream should be sweet – perhaps even very sweet - and might later reject ice cream that is not as sweet. Altogether, this indicates the importance of familiarity and exposure through the diet on food and taste preferences.

Familiarity is related to expected liking, and can along with implicit memories influence children's preferences (for a review, see Laureati, Pagliarini, Toschi, and Monteleone, 2015). Although adults will have more implicit memories related to foods, the effect is even present in children. A study with odours found that the preference for the smell of beer is stronger in preschoolers whose parent consume this drink (Mennella & Garcia, 2000). The preference is

however mediated by the emotional state of the parents when drinking – demonstrating the complexity of influences that contribute in forming preferences.

### **Parental style**

Parental style is an underlying trait that influences general parenting, and the context in which the child is socialised (Maccoby & Martin, 1983). As it is a trait-like behaviour, it is usually quite stable within the parent, also between siblings (Maccoby & Martin, 1983). Two different domains influence parental style: Demandingness (control over the child) and responsiveness (support for the child). There are thus four different parental styles: Authoritative (high demandingness + high responsiveness), authoritarian (high demandingness + low responsiveness), indulgent (low demandingness + high responsiveness), and uninvolved (low demandingness + low responsiveness) (Hughes, Power, Fisher, Mueller, & Nicklas, 2005). Some theorists instead use three parental styles, with the two first stable, and the latter two merged to permissive style (Rigal, Chabanet, Issanchou, & Monnery-Patris, 2012). Relating to the food environment, a permissive style will fulfil the desire of the child (child can eat what they want), whereas an authoritarian style will force the child to fulfil the parental wishes (eat what is served). Contrastingly, an authoritative style will take both the wishes of the parents and the child into consideration: child should eat what is served, but can influence what is served (Hughes et al., 2005).

In general, the authoritative style is associated with more positive outcomes in children (Maccoby & Martin, 1983), and the same is true for food habits, as it is related to a higher consumption of both fruit (Kremers, Brug, de Vries, & Engels, 2003; Patrick, Nicklas, Hughes, & Morales, 2005) and vegetables (Patrick et al., 2005). Contrastingly, lower consumption of fruit and vegetables is related to both authoritarian (Patrick et al., 2005) and permissive style (Hoerr et al., 2009; Vereecken, Keukelier, & Maes, 2004). Permissive style is in addition related to higher consumption of sweet foods and soft drinks (Vereecken et al., 2004). The positive effect of an authoritative style is proposed to be due to the higher involvement of the children in the food environment through higher responsiveness (Patrick et al., 2005), along with the parents providing healthier foods because they have higher demands on their children's diets. This exemplifies how the parental style can be an important mediator in what the child will actually consume. Parents with both an authoritative and an

authoritarian style can have a high demand on their child's diet, and thus serve healthy foods. However, a lower responsiveness to the child can lead the child to consume less of the food.

### **Parental attitudes**

Attitudes can be defined as summary evaluative judgments (Aikman, Crites, & Fabrigar, 2006), consisting of information from different sources such as knowledge and experience. Unlike parental style, attitudes are prone to change (Aikman et al., 2006). However, within the preschool context, attitudes of the parents are quite stable (Faith et al., 2004). Parental attitudes can influence their own food habits, as having a low health concern is associated with a liking for sweet food in adults (Pohjanheimo & Sandell, 2009). This can influence food exposure in children, as parents have been found not to provide foods they dislike themselves (Skinner et al., 2002).

In addition, parental attitudes can guide decisions on what foods they provide for their children (Alm, Olsen, & Honkanen, 2015; Dennison, Erb, & Jenkins, 2001). More specifically, parents with higher health concern serve less sugared foods to their children (Schneider et al., 2013), and their children consume more fruit (Gibson, Wardle, & Watts, 1998) and have a general healthier diet (Oellingrath, Hersleth, & Svendsen, 2013). Attitudes can thus guide behaviours.

### **Parental behaviour**

Parental behaviour will perform as a child-parent dyad, and always be dynamic in nature, as the behaviour of the child will influence the parents, and vice versa (Belsky, 1984). Parental behaviour regarding food will be influenced by their parenting style and attitudes, but also by the different stages in their child's life, and the general life-situation of the family (Musher-Eizenman, de Lauzon-Guillain, Holub, Leporc, & Charles, 2009).

The food parents serve their child is a behaviour that will be influenced by several contextual factors, such as differences in economy, time, and family size. Thus, unlike parental style, parental behaviour is typically different for each child in a family. Typically, child order will influence food exposure. The first-born child is served more fruit and vegetables than later children (Scott, Chih, & Oddy, 2012), and the younger siblings are also served more snacks (North & Emmett, 2000; Robinson et al., 2007). North and Emmet (2000) propose two

explanations for this: Firstly, parents with more children have larger time-constraints and serve more ready-meals, and less healthy foods. This has been supported by recent research (Alm et al., 2015). Secondly, parents try to delay serving snacks to children until they are older for the first-born, but the younger children will receive snacks earlier as the first-born child already receives it. To give children the same upbringing and perform the same parental behaviour towards them, the parents would have to serve their children different foods at the same time. This is to say that to treat children the same, they would have to be treated differently, which might not always be feasible or practical.

The behaviours of the parents will perform as a model for their child. In general, as stated by Bandura's social learning theory, children learn through observations and modelling from others (Bandura, 1986). Parents are the most important role models (Maccoby & Martin, 1983). Children try to behave similarly to their role models, and it is theorised that watching someone else consume food items can benefit a heightened acceptance and preference (Rozin, 1990). Supporting this, the diet of children has been found to be correlated with their parents' diet (Brown & Ogden, 2004; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Vereecken et al., 2004).

Parental behaviour will also influence the meal situation. A large review study found families that share meals together to have a higher dietary quality than other families, with higher consumption of healthy foods such as fruits and vegetables, and lower consumption of unhealthy foods such as fast foods and snacks (Fulkerson, Larson, Horning, & Neumark-Sztainer, 2014).

Parental level of restriction of how much and when their children can consume specific food items can influence children's food preferences, and is a parental behaviour that is related to the feeding style of authoritarian parents (Patrick et al., 2005). Restricting food can lead to a general higher desire for the food (Jansen, Mulkens, & Jansen, 2007), which in most cases is the opposite of what the parents wanted. It is also related to a higher body mass index in the child (Faith et al., 2004; Monnery-Patris et al., 2011). In a study with preschoolers, a significantly higher proportion of children with restrictive parents than with less restrictive parents were found to prefer the sweetest orange juice (Liem, Mars, & De Graaf, 2004b). Interestingly, parents who use either very high or very low restriction have been found to have

children who consume more food in grams (Jansen et al., 2007). These results fit well with the commodity theory (Brock, 1968) from social psychology, which states that humans crave scarce resources, and particularly want what is restricted to them. In adolescents and adults, this has been demonstrated with cigarettes, alcohol (Godfrey, 1989), and pornography (Zellinger, Fromkin, Speller, & Kohn, 1975).

It is common among parents to use food as rewards for good behaviour (Casey & Rozin, 1989; Schneider et al., 2013). The use of rewards can have both positive and negative consequences. Even though the use generally is to influence children towards healthier diets, children of parents who use food rewards consume more sweets (Vereecken et al., 2004). Commonly, the food that is used as a reward is unhealthy. Being rewarded with a liked food item reinforces the positive relationship towards the food (Cooke et al., 2011; Schneider et al., 2013). The conditioned response to frequently being rewarded with certain foods might be a heightened preference (Birch & Fisher, 1998; Newman & Taylor, 1992). Additionally, a higher preference for unhealthy foods might develop even though unhealthy foods are rarely consumed, if the food items are given as rewards.

### **Tailoring Research Procedures to Children**

Studies have experienced methodological challenges concerning measuring taste sensitivity and preferences reliably in children. No reliable protocol existed for children under the age of six (Lanfer et al., 2013), and thus the present study developed and tested protocols particularly for this study.

Research with children should always be mindful of the abilities that can be expected of the children, and should be tailored to the age-group (Laureati et al., 2015). Illustrating this, different developmental trajectories have been found for odour thresholds when using age-appropriate methods and when using methods developed for adults (Monnery-Patris, Rouby, Nicklaus, & Issanchou, 2009). To tailor procedures to an age-group, the expected abilities need to be investigated beforehand. Preschoolers as a group have limited abilities, and this can greatly influence testing. Researchers should always keep in mind that the differences within an age can be as large as between the ages, and that the individual development of each child can influence testing performance (ASTM, 2013).

Several functions are under development in the preschool years. Executive functions can be defined as goal-directed behaviours, and undergo vast development during the preschool years (Garon, Bryson, & Smith, 2008). A vital executive function is the ability to direct attention, which is important to complete a task (Reck & Hund, 2011).

Several other functions and behaviours will also undergo development. Children generally have a short attention span (Guinard, 2000), but this will increase with age, along with reasoning and decision making. Additionally, verbal capacity will differ greatly both within and between age-groups. Differences in development can influence testing performance (Guinard, 2000; Popper & Kroll, 2005), and it can be difficult to design protocols that will address all this along with actually investigating the question at hand. Particularly, taste sensitivity is more challenging to study in preschoolers than in older children and adults, and there is a lack of adapted testing procedures for children under the age of six (Knof et al., 2011). Preschoolers can participate in paired comparison tasks, as well as sorting procedures (Popper & Kroll, 2005), but the tasks still need to be tailored to the age. Several constraints must be taken into consideration to fit testing procedures to the children.

### **Adapt to developmental level**

As described above, developmental differences can be an important confounding variable in tests with children. Generally, it is advisable to investigate if developmental differences are influencing the results. Both cognitive development and other abilities such as personal-social skills can be inspected with either standardised questionnaires or standardised tests.

In addition, tests can be designed to lessen the influence of developmental differences. Using an analytical approach to sweetness sensitivity testing, Liem, Mars, and de Graaf (2004a) found that four-year-olds could not reliably discriminate between samples of orangeade due to limited cognitive abilities. In contrast to analytical approaches, an affective procedure measures the intuitive response - i.e. the experience of feeling or emotion (Pretz & Totz, 2007), towards the stimuli provided. Affect tests rely less on cognitive encoding (Zajonc, 1980), which will lessen the influence of developmental differences in children. Tests that are affective will to a lower degree be impacted by developmental differences between the children.

### **Reduce the effect of verbal differences**

In addition to general developmental differences, there are large differences in verbal capacity among preschoolers. In a study on odour thresholds, Monnery-Patris et al. (2009) reported a large influence of verbal capacity when evaluating odour identification in children aged 4-12 years. In general, preschool children will have trouble understanding the concept of analytical and comparative labels such as “sweeter than” (Guinard, 2000; Liem, Mars, et al., 2004a).

The relationship between memory and language in preschoolers (Simcock & Hayne, 2003), can also influence testing performance. Specific to sensory testing there is an impact of language on memory for tastes. Flavour labelling was associated with higher linguistic abilities in children between three and six years of age (Lumeng, Zuckerman, Cardinal, & Kaciroti, 2005). Several tests regarding sensitivity, such as measuring recognition threshold, rely on verbally identifying the basic taste in a taste carrier. In addition to the influence of differences in vocabulary, children can struggle to differ between concepts such as bitter and sour (Guinard, 2000). This can be particularly poignant with the more foreign concept of umami, which has been confused with saltiness in children (Overberg, Hummel, Krude, & Wiegand, 2012). It can be argued that tasks with young children should not include taste recall, as this would be influenced by both verbal and memory capacity. Generally, tests with preschool children should as far as possible be non-verbal for the children’s part, and can use appropriate tests such as detection threshold, as the study in this dissertation employed.

An additional issue with verbal tasks is the phrasing of questions. One problem is that children have a limited vocabulary, and it is essential that all children understand the questions asked and statements made. Furthermore, young children are prone to assent bias, as they like to please adults, and may confirm what the adult is saying, even though it is not true (Guinard, 2000; Tatlow-Golden, Hennessy, Dean, & Hollywood, 2013). Studies should try to exclude asking “Yes” and “No” questions, as children would be more prone to answering yes. A study found almost half of three-year-old children to answer “yes” to all questions (Tatlow-Golden et al., 2013). Even though a task is non-verbal for children, they could still falsely answer in the affirmative through non-verbal communication. Care must be taken with the exact phrasing of questions and statements by experimenters, both before and during testing. As young children like confirming what adults say, tests should be double-

blind so the children are not involuntarily guided in their answers by the experimenter (Guinard, 2000; Mennella, Spector, Reed, & Coldwell, 2013).

### **Familiarise children to experimenters**

A child will not give valid results if feeling uncomfortable. Actions need to be taken to make sure that the child is comfortable. Testing has been reported to be more accurate when children are interviewed by their mother than by an unfamiliar experimenter (Popper & Kroll, 2005). However, parental interviews can have two important draw-backs: Firstly, the parents are usually not trained as interviewers, and could easily involuntarily influence the results. Secondly, using parents as experimenters can be a logistical challenge when testing a higher number of children. Instead, experimenters can take care in familiarising the children to themselves by sharing activities with the children before testing begins. Particularly, experimenters should facilitate shy children in feeling comfortable, as shy children could hesitate to interact with unknown adults (Crozier & Perkins, 2002; Ford, Sladeczek, Carlson, & Kratochwill, 1998). Testing the children in the familiar setting of kindergarten or school is also advisable (Guinard, 2000), rather than an unfamiliar lab.

A drawback of the heightened familiarisation can be that when children are accustomed to the experimenters, they can grow to like them and want to impress them.

### **Gamification of procedures**

Preschoolers are not motivated by extrinsic factors such as contribution to science. Therefore, participating in a test must be rewarding in itself. Gamification is a technique used to heighten the interest of both adults and children but could be argued to be particularly important with the latter. In a study with six to nine year old children, a higher enjoyment in participating was related to a higher performance (Liem & Zandstra, 2010). A more enjoyable test for the child might not only facilitate a higher participation rate, but also a perhaps more valid data set.

Structuring tests as a game can facilitate in overcoming both reluctance to participate and children's short attention-span (Knof et al., 2011; Visser et al., 2000), and has been used to satisfaction in several studies (Bell & Tepper, 2006; Kimmel & Guinard, 1994; Knof et al., 2011; Monnery-Patris et al., 2009; Visser et al., 2000). The structure as a game can be as complex as a board game, or much simpler, such as children taping stickers on pictures of the

appropriate food after tasting it. From the age of two, children can metarepresent - i.e. understand and engage in pretend speak (Friedman, Neary, Burnstein, & Leslie, 2010), and thus participate in structured games, and pretend-play in a testing context. Procedures can then introduce stuffed animals or other characters as part of the testing (Knof et al., 2011; Visser et al., 2000), which can both soothe a shy population, and encourage higher involvement in the procedure.

## Main Research Objectives

The overall aim of this dissertation was to design and carry out a longitudinal study to measure the development of preference for the basic tastes sweet, sour, and bitter of children from age four to six. These three basic tastes were chosen as they are particularly interesting in the childhood years. The high preference for sweetness and rejection of bitterness in childhood do not correspond to healthy food habits, as sweetness generally relates to high-sugar foods, and bitterness to vegetables. Sourness is related to both fruit and vegetables.

The specific research objectives of this dissertation were as following:

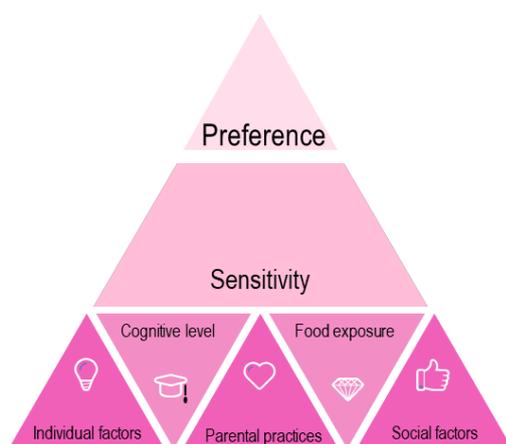
To examine how taste preferences are affected by development between the age of four and six (Papers 1-3)

To investigate how taste preferences and sensitivity interact (Paper 2 and Paper 3)

To examine how parental practices and food exposure influence sweet preferences (Paper 2)

To investigate the reliability and validity of doing sensory tests with preschoolers (Papers 1-3).

Figure 1 describes the factors investigated in this dissertation. The pyramid displays



“preference” on top and the factors theorised to influence preference below. Taste sensitivity is expected to contribute to preference. ‘Individual Factors of the child (age, gender) and Cognitive level as well as Parental practices, Food exposure and Social factors are all theorised to also influence preferences. Sensitivity is theorised to act as a modulator between these factors and preferences.

*Figure 1: Pyramid displaying factors investigated in this dissertation*

## **Materials and Methods**

### **General Overview**

The dataset presented in this dissertation consists of a longitudinal study with 151 children. The children were tested for the first time during the spring of 2015, and the tests were repeated in the springs of 2016 and 2017. The testing each year consisted of a preference test for sweet, sour, and bitter stimuli, and sensitivity tests for sweet, sour, umami, salty, and bitter stimuli. The parents of the children also received questionnaires each year of the data collection. To investigate differences between the kindergartens, all pedagogic leaders answered a questionnaire regarding food environment. Ethical approval and research clearance was obtained from the relevant national ethical committee, Norwegian Social Science Data Services (NSD).

### **Participants**

#### *Recruitment*

In autumn 2014, 19 kindergartens were invited to participate in the study. Only kindergartens from a predefined region were eligible for the study. Eighteen of these kindergartens chose to participate. During November 2014, two scientists visited the 18 kindergartens to explain the project more thoroughly and to deliver informed consent forms for all parents with children born in 2011. Out of 170 invited children, 140 children received parental consent to participate from 2015, while 11 additional children were added to the study during the span of the study.

#### *Children*

All 151 children that participated in the study are born in 2011. Five children only participated in 2015, four only in 2015-2016, five only in 2016-2017, and six only in 2017. The children who left the study did so because they no longer attended a kindergarten partaking in the study. In the spring of 2016, parents of four new children were invited to participate in the study, as these children had just started in a kindergarten where all their peers contributed to the study. For the same reason, five new children were accepted in 2017. In total, 131 children participated in the study for all three years. See Table 1 for further

description. The data presented regards the 131 children that consistently participated in the study from the first year, if not else noted.

Paper 1 only describes the first year of the study, and the sample consists of 140 children. In Paper 2, both the first and the second year of the study are included, and it consists of data from 135 children. Paper 3 regards all three years, and the data used is from the 131 children who participated in the study for all three years.

**Table 1:**  
Main characteristics of the participants in the longitudinal study

Age	Respondent population (Invited)	Min age - Max age in months	Mean age in months (SD)	Boys
Age 4 <sup>1</sup>	140 (170)	39-51	46.3 (3.4)	56%
Age 5 <sup>2</sup>	140 (145)	51-63	57.5 (3.3)	58%
Age 6 <sup>3</sup>	141 (146)	63-75	66.5 (3.2)	58%
All years (age 4 to 6) <sup>4</sup>	131	39-75		58%

<sup>1</sup> Age 4 is defined as the year the children turned 4, <sup>2</sup> Age 5 the year they turned 5, <sup>3</sup> Age 6 the year they turned 6. <sup>4</sup> Corresponds to the children that participated throughout the study

The overall sample of 151 children consists of 58% boys (Table 1). Table 2 describes the weight status of the children, and the majority of the children were normal weight throughout the study. Eighty-four percent of the children were breast-fed at six months of age, and only 3.6% of the children were never breastfed.

**Table 2:**  
Percentage of children in the longitudinal study according to weight-status groups (from WHO), using Z-BMI\*

	Underweight	Normal weight	Overweight
Aged 4	8%	78%	14%
Aged 5	15%	64%	21%
Aged 6	6%	76%	18%

\*Numbers given in percentages. Reference numbers from WHO (2007)

## *Parents*

All parents who answered questionnaires lived with their child, but 8% only part-time (stable throughout the study). The parents generally had a higher level of education than the Norwegian population over the age of 20 (Norway Statistics, 2017b), see Table 3.

**Table 3:**

Parental level of education in the longitudinal study, compared to the Norwegian population over 20 in the brackets \*

	Secondary school	High school	1-4 years of College/Uni	4+ years of College/Uni	Other
<b>Mother</b>	2% (18%)	30% (30%)	30% (38%)	38% (14%)	0%
<b>Father</b>	0% (24%)	14% (39%)	44% (25%)	41% (12%)	1%

\*Numbers given in percentages. Numbers in brackets refer to the average for Norwegians between the age of 20 and 49 (Norway Statistics, 2017b).

## *Kindergartens*

All the kindergartens are based in the same area in the eastern part of Norway. The kindergartens have similar food profiles. Two kindergartens serve a warm lunch four times a week, whereas the others serve it twice a week. All kindergartens serve bread with spreads for the remaining lunches. The kindergartens all serve fruit and vegetables as a snack, but this varies from the same four fruits once a week to a selection from thirteen different fruits and vegetables daily. Additionally, there were differences in food behaviour from kindergartens employees, with some using the meals as a modelling situation, while most did not share meals with the children.

## **Pre-Study and Pilot-Testing**

During autumn 2014, a comprehensive pre-study took place (H. P. Kristiansen, 2015). The pre-study aimed at generating a protocol for both taste sensitivity and taste preference testing with children aged three to six years old. The pre-study and pilot-testing were conducted in several phases and included 43 children in total with a mean age of 4.4 years (SD: 0.9), age

range 3.25-4.25 years. To begin, a literature review to investigate appropriate methods to use with children was conducted. Paired comparisons and ranking by procedures were chosen as these methods are suitable with the target age-group (Guinard, 2000; Laureati et al., 2015; Popper & Kroll, 2005). Protocols were developed for both the sensitivity and the preference test, described more thoroughly below. The same two experimenters always conducted the pre-study and the pilot tests.

The pre-study yielded both quantitative measures and qualitative observations on the children's ability to participate. Based on these results, protocols to use in the longitudinal study were developed. Five children then participated in semi-structured interviews and gave feedback on the protocol and stimuli provided. Both protocols were then fine-tuned, and pilot-tested with 10 children. A more specific description of the findings and conclusions from each test is presented below.

### *Sensitivity test*

The pre-study investigated the validity and reliability of the protocols, not taste sensitivity per se, and did not employ tests for all five basic tastes. Instead, it consisted of paired comparison tests of plain water versus water with varying concentrations of sweet (sucrose) or sour (citric acid monohydrate) taste. The taste concentrations were based on the International Organization for Standardization (ISO) Standard 3972 (2003).

The protocol developed involved a story-telling session about a fairy that drank magic water of different tastes. The story told was an early version of the one used in the longitudinal study, included in Appendix 1. The children were tested individually with two experimenters. During testing, the children were asked to place the cups with "magic water" on a placemat with a fairy. The children always started with the pair with the strongest dilution, but the serving order within pairs was randomized, as children can be prone to position bias (Finistrella, Morino, Curcio, & Manco, 2012). The first outcomes of the pre-study indicated that under this protocol, the children were engaged in the test and rate fulfilling the test was high. To investigate if the children did perceive a difference in taste or were guessing, one of the taste concentrations was repeated. Results showed that the children were able to reliably and consistently discriminate between pairs of water versus water with taste in paired comparison tests.

There were however several constraints with the protocol. The youngest subjects (three years old) displayed problems with performing the task when the paired comparisons started with the weakest taste concentrations. Moreover, starting with sourness led to more withdrawals than starting with sweetness, which is a more generally accepted taste. In addition, some children tended to place all cups on the picture of the fairy independently of their taste perception, just because they wanted to play the game. Finally, the eldest children (five years old) tended to be confused with attributing the task of different “magic” water tastes (sweet and sour) to the same magical character.

Based on these inputs, a protocol extended to all five basic tastes was developed. The new protocol tested the strongest concentrations first, and included a water drop place-mat for the children to place the plain water cups on. It also featured one magical character per taste, i.e. five in total, as seen in Figure 2. The magical characters were designed to induce positive emotions in children. Qualitative interviews with six children were conducted on draft drawings of the characters. Based on their feedback the characters were adjusted to make sure that all characters were interesting and looked friendly. The protocol involving the new characters was pilot-tested and fine-tuned with ten children, until a final protocol for the main study was reached.



*Figure 2: The five magic characters after adjustments. From top left, the fairy corresponds to sweetness, elf to sourness, mermaid to bitter taste, waterman to saltiness, and wizard to umami taste.*

### *Preference test*

The general approach was the same for the pre-study, the pilot-tests and the actual longitudinal study. In the pre-study, jelly was used as it is common for children to consume and could be served at room-temperature. Additionally, it was possible to manipulate the exact amount of added basic taste. Cups with water with added basic taste were also used. All taste carriers presented varied in added basic taste of either sweetness (sucrose) or sourness (citric acid). The children were first presented with small servings of jelly in triads and indicated their preference by ranking. After the jelly was consumed, the children were presented with cups with straw, which contained the water dilutions. The children generally rejected both the jelly and the water, as it was not pleasant enough to consume. Another issue with the jelly was that since the gelatine contained residues from swine, 33% of the children withdrew from tasting it. Together, these concerns led to the choice of new taste carriers that were a better fit to the child population, and drinks and chocolates were produced as described below. These products were then pilot-tested with children, and all children accepted these taste carriers.

Additionally, several of the children struggled with drinking from straws. Cups without straws were used in the longitudinal study. Except from these constraints, the preference test protocol showed that the children were engaged in participating and understood the tasks. Importantly, we did not observe differences in performance based on age.

### **Test Procedure**

The test procedure was the same for all three years, and consisted of three phases: First, an introductory meeting between the scientists and the children. Secondly, sensitivity testing, divided into two separate sessions. Thirdly, the preference test. The first year a fourth phase was also added: A re-test. The introductory meeting always took place two weeks before the testing commenced. The rest of the testing then took place over three weeks, always on the same weekday. Timeline of the procedure can be found in Figure 3. The two same experimenters always executed all stages of testing in each separate kindergarten. I trained all experimenters in the story, prepping the taste carriers, conducting the protocol, and plotting the data.

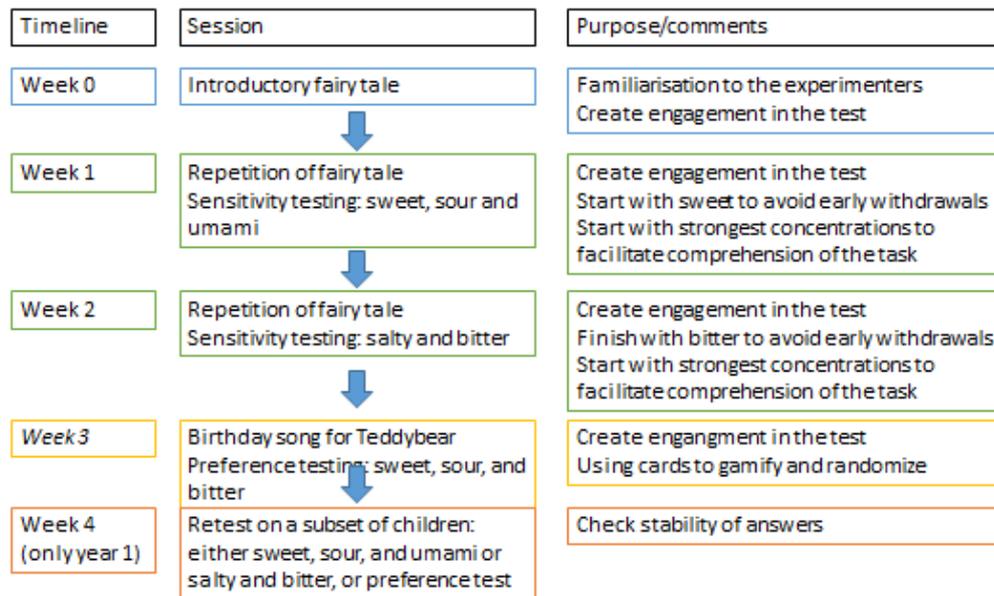


Figure 3: Timeline of the procedure at each year. The purpose of each stage is described to the right. Reproduced from Vennerød, Almli, et al (2017).

### ***Introduction to the children***

Before the testing began, two experimenters visited each kindergarten to familiarise the children to both the story of the sensitivity test, and to the experimenters. The experimenters read the fairy-tale written for this study (see Appendix 1). The introduction phase is described thoroughly in Paper 1.

### ***Sensitivity testing***

The goal of the sensitivity testing was to investigate the sensitivity of the children for all five basic tastes, and to investigate how the sensitivity developed during the study, also in relation to taste preferences. All five basic tastes were tested with the respective taste component diluted in water. The children were tested with paired comparisons and sorted the cups onto the corresponding place-mats. See Figure 4 for a presentation of the procedure. The procedure is more thoroughly described in Paper 1, but also Paper 2 and 3.



*Figure 4: Presentation of procedure in sensitivity test. The first pair is presented to be tasted by the child and placed on either of the corresponding placemats. The three impending pairs are seen behind the placemats.*

### ***Preference testing***

The main objective of the preference testing was to investigate differences in preferences for sweetness, sourness, and bitterness, both within the age-group each year, and in a developmental perspective. Because of time-constraint, we did not have the ability to test preferences for all five basic tastes. We decided to concentrate on sweet, sour, and bitter taste. These three were chosen as they feature prominently in both sweet foods, fruits and vegetables, which are foods that in different ways are important in the childhood diet.



*Figure 5: Set up for preference test. Three cards lay face down, and the child chooses one to turn around. Here, the child has picked the card that corresponds to the pink cups and will start with the three pink cups. The cards were introduced to both be an element of gamification, and to randomize the order of the taste carriers between tastes.*

The taste carriers used were three cups with drinks per taste (sweet, sour, or bitter), and three pieces of chocolate. The children performed ranking by elimination in a gamified procedure by the set-up presented in Figure 5. The preferred beverage was chosen by picking it up, as seen in Figure 6. The procedure is thoroughly described in Paper 2 and 3.



*Figure 6: Children chose the preferred beverage out of three by picking it up (as this child) or pointing at it.*

### ***Retest***

During the first year of testing (2015), the procedure also involved a retest. One week after the preference test session, a retest was conducted in eight of the kindergartens, with 52 children. The kindergartens participating were the kindergartens that were not closed due to a national holiday. The children participated in a repetition of one of the three sessions.

### **Parental Questionnaire**

Two questionnaires were distributed to the parents each year. One measured each child's level of development, where the other measured different factors involving food habits. During all three years, the mothers of the children mainly filled out the questionnaires: 80% the first year, 87% the second year, and 85% the last year.

#### **Parental practices and Food habits questionnaire**

All parents received web-based questionnaires. If it was not possible or desirable for the parents to fill it out online, they received the same questionnaire on paper. The questionnaire includes items from several different questionnaires, presented below, as no Norwegian questionnaire included all items that were relevant. The questionnaire in entirety is presented in Appendix 2.

#### ***Food exposure***

The main part of the questionnaire is the items regarding food exposure. These items are derived from a food taste database (Martin, Visalli, Lange, Schlich, & Issanchou, 2014), and thoroughly described in Paper 2.

#### ***Neophobia and pickiness***

The six neophobia and pickiness items are from the Children's eating questionnaire (Monnery-Patris et al., 2011; Rigal et al., 2012), which is a validated questionnaire regarding children's eating difficulties. The Neophobia and Pickiness items were translated into Norwegian from English following a back-translation procedure.

These items were mainly included as a means of control: Both neophobia and pickiness are associated with eating difficulties and disinterest in eating, which could help explain why some children do not want to participate in eating and/or drinking in a test. However, there were too few children who refused to participate (between 5% and 3%) to investigate if these children differed from their peers in their neophobia and pickiness traits.

### ***Parental attitudes and use of reward***

Items regarding Parental attitudes and behaviors towards food were included in the questionnaire, and fitted to the current study from the Norwegian Health & Taste Questionnaire (Oellingrath et al., 2013). It is described in Paper 2.

### ***Parental feeding style***

Parental feeding style was investigated using the Feeding Style Questionnaire (Monnery-Patris et al., 2011; Rigal et al., 2012). The parental feeding style corresponds to one of three styles; Authoritarian, Authoritative, or Permissive. The questions were translated into Norwegian from English following a back-translation procedure. As the questionnaire is originally in French, the validity of the translations was quality checked by a scientist proficient in both Norwegian and French.

These items were included to investigate the effect and interaction of different parental styles on both taste and food preferences. Unfortunately, there was not enough diversion between the Norwegian parents to investigate this, as almost all the Norwegian parents had an authoritative parental style for all three years. For several of the items, 100% of the Norwegian parents scored as authoritative (data not shown).

### ***Demographic variables***

The demographic questions included are from the Norwegian national survey Spedkost and investigates several parental characteristics such as maternal and paternal level of education, family size. It also examines several individual measures for each child, such as duration of breastfeeding, weight, length, and if the child was born prematurely. These measures are included to control for family situation and other demographic variables.

### **Ages and Stages Questionnaire**

As children present large differences in development within the same age group, a questionnaire to investigate the differences in development within the sample was included. The validated Norwegian version of the Ages and Stages Questionnaire (ASQ) was used (Janson & Squires, 2004; Richter & Janson, 2007). The ASQ is further described in Paper 1-3. As the use of the ASQ is restricted, it is not included in the appendix because of copyright laws.

### **Questionnaire to kindergarten personnel**

To investigate possible food-related differences between the kindergartens, a questionnaire was distributed to all pedagogic leaders during the second year of the study. The questionnaire investigated fruit and vegetables (frequency, variation), and what meals were served in kindergarten. Additionally, it investigated the food behaviour of the personnel, and food attitudes of the pedagogic leaders. The questionnaire is included in Appendix 3. There were however no differences between the children based on kindergarten attended (results not shown).

### **Ethical Considerations**

The Norwegian Social Sciences Data Services (NSD) approved the study (see Appendix 4). All parents received written information about the study and had to sign a consent form for their children to participate. Additionally, all children were informed verbally in words they could understand. The children were told that they could withdraw from testing at any time. Several constraints were taken to fine-tune the protocol so that shy children would also feel welcome to participate, and that all children would enjoy being a part of the study. Generally, the study was designed so that participation would be a pleasant activity for the child.

Not all parents signed the consent form. As the children looked forward to the test as well as discussed and pretend-played it outside of testing, the children who were not allowed to participate in the study could have felt left out. We were not allowed to include these children in the testing at all, but they were included in the general fairy-tale reading during the first visit, and it was highlighted that the gifts (stuffed vegetables and books) given to the kindergartens after testing commenced were for all the children in the kindergarten. Additionally, all experimenters were instructed in being particularly nice to the children that

were not allowed to participate, and to take the time to chat with them. Several children did nonetheless convey that they felt left out.

## Main findings

For the purpose of discussing the separate papers together, a summary of the most important findings from each paper is presented below. The findings are described thoroughly in each paper. To sum up, an overview table of the most important results regarding taste preferences are provided.

### Paper 1:

Paper 1 investigated the validity and reliability of the sensitivity test, as well as taste sensitivity, and used data from the first year.

**Reliability and validity.** The test-retest reliability showed that the children's answers were reliable for all tastes, using Spearman's rank correlation coefficients  $P$ ; Sweet (0.87), sour (0.93), umami (0.91), salty (0.87), and bitter (0.85). In addition, the sensitivity score was not related to neither age nor cognitive development.

**Two labelling criteria.** A substantial number of children consistently identified the cups with basic taste as water and the cups without basic taste as "magic water". To explore if there was a difference in ability to discriminate based on if water or water with taste was labelled as magic, five independent-samples t-tests using mean score were conducted, with labelling strategy as a dependent variable. For the sensitivity test, there was only a significant difference based on labelling strategy for sourness ( $t(105) = 4.084$ ,  $p = 0.001$ ,  $\eta^2 = 0.14$ ), where the children who labelled the sour taste as magic had on average a higher sensitivity score ( $M = 3.44$ ,  $SD = 1.23$ ,  $N = 80$ ) than the children who labelled plain water as magic ( $M = 2.41$ ,  $SD = 1.22$ ,  $N = 27$ ). This comparison across labelling strategies highlights that apart from sourness, the sensitivity scores were not dependent on the labelling strategy used by the children. Based on this, two different Scoring Criteria were used. Following the Experimenters' Scoring Criterion (ESC), a paired comparison was considered as correct only if the cup with taste was identified as magic and the one with plain water was identified as water. Following the Child Scoring Criterion (CSC), the assignment of the strongest concentration taste carrier (taste dilution D3 in Pair 1) to water or magic water defined the blueprint for each basic taste.

**Taste sensitivity.** To investigate the children's discrimination ability against chance levels, we compared confidence intervals of the children's sensitivity scores against chance levels of correct answers under both the ESC and CSC. The children scored better than by chance for all dilutions of sour taste (ESC and CSC), and for all or part of the dilutions for umami and salty tastes, but not better than chance for any other taste.

## **Paper 2:**

Paper 2 focused on investigating the influence of parents' practices and taste sensitivity on sweet preference. A partial least squared model was used.

**Sweet and bitter preference and sensitivity.** Children who were more sensitive to sweetness significantly preferred the less sweet drinks, but the association was small. More bitter sensitive children preferred the less sweet and bitterer chocolate. Sensitivity also had an indirect association with preference: Children who were more sensitive to sweetness were less frequently exposed to sweets. Additionally, there was an interesting association between sensitivity to bitterness and exposure to bitter snacks, with children more sensitive to bitter taste more frequently exposed to bitter snacks than the other children were.

**Sweet and bitter preferences and parental practices.** Higher parental use of food rewards was related to a preference for the sweetest chocolates and drinks. Parents who reported higher concern regarding health, sugar intake and/or taste importance for their child's food, exposed their children to less sweet foods and snacks. Additionally, a high parental score on health attitude was associated with higher fruit exposure for their children. Children with older siblings were more exposed to sweet food and snacks.

**Sweet and bitter preferences and food exposure.** A more frequent exposure to sweet foods and snacks was associated with a higher sweet preference in both drinks and chocolate. Children more often exposed to fruit preferred lower sweetness in drink, but no such association was revealed in chocolate. Higher exposure to bitter snacks was associated with a higher preference for the more bitter and less sweet chocolate.

### **Paper 3:**

The main aim of Paper 3 was to investigate the development of taste sensitivity and preferences, and how the two interact.

**Cognitive development effects.** The investigation of potential developmental effects with Pearson product-moment correlation coefficients revealed that there was no correlation between cognitive development (ASQ-score) and taste sensitivity or preference score at any year.

**Development of preferences.** Repeated measures analyses of variance showed that age had a statistically significant effect on sweetness preference  $F(2,124)=5.437$ ,  $p=.005$ . Paired samples t-tests revealed that there was a significant increase in sweet preference between the age of four ( $M=2.8$ ,  $SD=1.1$ ) and six ( $M=3.4$ ,  $SD=.88$ ),  $t(123)=-3.946$ ,  $p=.001$ , Cohen's  $d=0.60$ , and five ( $M=3.2$ ,  $SD=.97$ ) and six,  $t(123)=-1.725$ ,  $p=.048$ , Cohen's  $d=0.21$ . In addition, there was a statistically significant effect of age on chocolate preference,  $F(2,92)=3.109$ ,  $p=.048$ . Paired samples t-tests revealed that there was a significant difference between the age of four ( $M=2.8$ ,  $SD=.81$ ) and six ( $M=2.24$ ,  $SD=.96$ ),  $t(91)=2.503$ ,  $p=.014$ , Cohen's  $d=0.57$ , with a decrease in preference for higher levels of cocoa, corresponding to sweeter and less bitter taste. There were no other significant effects of age on preferences.

**Development of sensitivity.** Repeated measures analyses of variance revealed that age had a statistically significant effect on sensitivity for sweetness  $F(2,113)=11.925$ ,  $p=.001$ . Paired samples t-test revealed a significant decrease in sensitivity score from age four ( $M=1.82$ ,  $SD=1.31$ ) to age five ( $M=1.51$ ,  $SD=1.32$ ),  $t(112)=3.396$ ,  $p=.001$ , Cohen's  $d=0.24$  from age four to age six ( $M=1.04$ ,  $SD=1.18$ ),  $t(112)=4.615$ ,  $p=.001$ , Cohen's  $d=0.62$  and from age five to age six,  $t(112)=2.45$ ,  $p=.016$ , Cohen's  $d=0.37$ . In addition, a significant effect of age on sour sensitivity was found  $F(2,112)=3.109$ ,  $p=.048$ . Paired samples t-test revealed a significant increase in sensitivity score from the age of four ( $M=2.77$ ,  $SD=1.40$ ) to the age of five ( $M=3.20$ ,  $SD=1.38$ ),  $t(111)=-1.995$ ,  $p=.049$ , Cohen's  $d=0.36$ , and from age four to age six ( $M=3.38$ ,  $SD=1.12$ ),  $t(111)=-2.317$ ,  $p=.023$ , Cohen's  $d=0.55$ . For saltiness, a significant effect of age was revealed,  $F(2,125)=6.918$ ,  $p=.001$ . Paired samples t-test revealed a significant increase in sensitivity score from age four ( $M=2.21$ ,  $SD=1.26$ ) to age five ( $M=2.43$ ,  $SD=1.28$ ),  $t(124)=-4.546$ ,  $p=.001$ , Cohen's  $d=0.15$  and age four to age six ( $M=2.32$ ,

SD=1.30),  $t(124)=2.702$ ,  $p=.048$ , Cohen's  $d=0.08$ . No other effects of age on sensitivity was significant.

**Relationship between preference and sensitivity scores.** Repeated measures ANOVAS revealed that for beverages, there were a significant association between sweet taste sensitivity and preference at age four, ( $\tau_b=-.294$ ,  $p=.033$ , age five,  $\tau_b=-.297$ ,  $p=.031$ ), and at age six, ( $\tau_b=-.301$ ,  $p=.029$ ). Additionally, there was a significant association of small amplitude between bitter sensitivity and sweet taste preference, ( $\tau_b=-.163$ ,  $p=.049$ ), at age six, with children more sensitive to bitterness preferring less sweet drinks. There were no significant relationships between sour or bitter beverages and sensitivity. There was a significant association of small amplitude between preference for chocolate and sweetness sensitivity at both age four ( $\tau_b=-.208$ ,  $p=.018$ ,) and five ( $\tau_b=-.164$ ,  $p=.034$ ) and bitterness sensitivity at both age four ( $\tau_b=-.168$ ,  $p=.025$ ) and five ( $\tau_b=-.164$ ,  $p=.038$ ), with children more sensitive to both bitterness and sweetness preferring more bitter chocolate.

### Overview of Main Findings on Taste Preferences, Based on Longitudinal data with 131 Children From Age 4-6

	DEVELOPMENT OF TASTE PREFERENCE	RELATIONSHIP WITH SENSITIVITY	RELATIONSHIP WITH FOOD EXPOSURE	OTHER RELATIONSHIPS
<b>SWEET</b>	Increases with age	Preference is negatively related to sensitivity for sweetness and bitterness	Higher exposure to sweet foods is related to higher sweet preference Higher exposure to fruits is related to lower sweet preference	Parental use of reward is related to higher sweet preference Girls preferred sweeter drinks and chocolates than boys at age 4&5
<b>BITTER</b>	Stable with age in drinks, decreases in chocolates	Preference is positively related to sensitivity for bitterness in chocolates No relationship for bitterness in drink	Higher exposure to bitter snacks is related to higher bitter preference	Parental use of reward is related to preference for lower bitterness
<b>SOUR</b>	Stable with age	No relationship	Not investigated	None revealed

## **Discussion**

This dissertation had four main research objectives. The first objective was to examine how taste preferences are affected by development. The second was to investigate how taste preferences and sensitivity interact. The third research objective was to investigate the influence of parental attitudes and behaviours on sweet preferences. As these three research objectives are related, they are discussed together. The fourth was to design and carry out reliable and valid sensory tests with preschoolers. This is discussed separately before general methodological considerations.

At the time of writing, no other studies had investigated the preference for sweetness, sourness, or bitterness in a longitudinal perspective within the preschool years. Together, these results thus shed new light on an important part of the foundation for food habits.

### **General Influences on Taste Preferences**

The results indicate the dynamic nature of taste sensitivity and preference, although some tastes showed stability. Several factors influenced taste perception in opposite ways. I first discuss the factors that had a general influence on taste preferences.

A common belief is that everyone actually prefers the same intensity of taste (Prescott, 2013), but differ in taste perception. If so, the pattern of preference would be guided by individual sensitivity. However, not everyone agrees that such a relationship is of large amplitude (Prescott, 2013), and as presented in the introduction, contradictory research found small or no correlation between preferences and sensitivity (Lanfer et al., 2013; Liem & Mennella, 2003; Liem, Westerbeek, et al., 2004). Consistent with the latter view, although there was a relationship between preference and sensitivity in at least some tastes in this study, it was not strong and not consistent across tastes. Additionally, taste preference in the children could be explained by additional factors to taste sensitivity. The background for preference for intensity of taste therefore seems to be much more complex than if everyone actually preferred the same intensity.

Some children prefer strong taste, even if they are very sensitive (Liem & Mennella, 2003; Liem, Westerbeek, et al., 2004). Children that have a high sensitivity can thus either accept or reject the taste. This is further explained by Dunn's conceptual model (1997) that describes

the relationship between behavioural response and sensitivity thresholds with four groups of children: Children can be either high or low in their neurological threshold (sensitivity), but also in their response to stimuli. The response to stimuli provided can be as typically proposed (low preference if highly sensitive, high preference if low sensitivity). It can also be based on the behavioural response of the child: A child might be sensation seeking (high preference even if highly sensitive) or sensation avoiding (low preference even if low in sensitivity). This dissertation did generally assume that children act as typically proposed. If the children also belonged to the two groups acting in accordance with behavioural response, we would find four different sensitivity-preference relationships across two dimensions. However, when exploring the relationship between sensitivity and preference (Paper 2, 3), no trends emerged for sourness at all, and only in the typically proposed direction for sweetness (lower sensitivity related to higher preference). As such, Dunn's conceptual model can perhaps partially explain differences in preference based on an interaction between sensitivity and behaviour, and how behaviour modulates the relationship between preference and sensitivity. Future studies could therefore choose to further investigate how taste sensitivity might influence taste preferences in different directions based on behavioural response.

At age four and five, there was a gender influence on sweet preferences, and girls preferred sweeter drinks and chocolate than the boys did (Paper 2). As no gender effect on taste preferences has previously been demonstrated in preschoolers, the increase could be due to girls maturing earlier than boys, and that the boys in this study would later catch up in sweet preference (Paper 2). As such, there was not a present gender difference at age six (Paper 3). For the other basic tastes, there was no gender difference at any point in time (Paper 3). This indicates that the influence of gender on taste preference could be present at certain stages during development but could be due to developmental differences between genders.

An influence of food exposure on preferences was revealed (Paper 2), but only measured food exposures between the ages of four and six. The earlier family food environment could also have had a general influence on taste preferences. As the home environment is subject to change (see introduction), it could have been different at an earlier age. The exposure to fruit and vegetables at weaning can predict preferences in preschoolers (Cooke et al., 2004), and infant formula served can influence taste preferences (Mennella & Beauchamp, 2002).

Although the parents reported the time of weaning, they did not report with what foods they weaned their children, which could be related to difference in taste preferences.

There was no difference in taste preferences based on kindergarten attended, even if the kindergartens differed in fruit and vegetables served. In schools, it has been shown that having fruit and vegetables available at school lunch can increase liking (Bergamaschi et al., 2016) and preferences (Baxter & Thompson, 2002). Social influence is a primary determinant of eating, and secondary socialization agents such as kindergartens personnel and peers could be important (Cruwys, Bevelander, & Hermans, 2015), and also serve as role models in food situations (Birch, 1980; Stock et al., 2007) The influence from kindergarten personnel and peers could therefore generally have been similar between the kindergartens.

## **Different Trajectories Across Taste Modalities**

The majority of the findings in this study are taste specific, and the different taste modalities are therefore discussed separately.

### **Sweet preference**

The children had an increased preference for sweetness with age (Paper 3), in both chocolate and drinks. As the four-year-old children in general already had a high sweet preference, this is worrisome. The percentage of children that preferred the highest sweet beverage increased from 48% to 59% to 72%. Even though a high preference for sweetness has been previously reported in children (Beauchamp & Moran, 1984; De Graaf & Zandstra, 1999; Liem, Mars, et al., 2004b; Mennella et al., 2005), and was thus expected, it is important to keep in mind that the sweetest drink contained 18% sugar. To put this in perspective, the drink Coca-Cola contains 10.6% sugar (Coca-Cola, 2018), and in a cross-cultural study, adults preferred 10% sucrose, and more sugar was then associated with a gradual decline in liking (Prescott, 1998).

The increase in preference could partially be explained by differences in taste sensitivity (Paper 2, 3), as both bitter and sweet sensitivity were related to the two sweet taste carriers. Children that were more sensitive to sweetness had a lower preference for sweetness in both chocolate and drinks. Even though the association was small, and sweet sensitivity can only explain part of the difference in preference, it was present in the children throughout the study in drink, and for the first two years in chocolate. Additionally, sweet sensitivity seemed to influence sweet preference in the two different taste modalities in the same direction. I argue

that although small, there was a real influence of sweet sensitivity on preference. This is particularly interesting as the sensitivity for sweetness decreased in 40% of the children during the preschool years (Paper 3). The decrease in sensitivity can thus contribute to explaining the higher preference.

Additionally, there was a cross modal interaction of bitter sensitivity on taste preference: At age four and five, the children that were more bitter sensitive preferred more bitter/less sweet chocolate (Paper 2, 3), and at age six, the children that were more bitter sensitive preferred less sweet drinks (Paper 3). Although not significant, the trends were the same during the other years, and in the same direction: more sensitive to bitter related to a preference for lower sweetness. I suggest that the influence of bitter sensitivity on chocolate was not only due to the bitterness in the taste carriers, but also the sweetness – i.e. a higher preference for sweet stimuli. Supporting this, a relationship between bitter sensitivity and preference for sweetness has previously been detected (Mennella et al., 2005). Additionally, sucrose is able to mask bitter taste (Mennella et al., 2013), and differences in sucrose sensitivity interact with preference through this relationship. Together, these results suggest that bitter sensitivity is associated with sweet preference, and that the preference for sweetness can be partially explained by sensitivity across bitter and sweet taste modalities.

There was an important influence of parental factors on sweet preference (Paper 2), and I argue that the increase in sweet preference was also due to the family food environment, and what foods the children were exposed to at home. Parental attitudes helped modulate the foods they exposed their children to (Paper 2), and these foods had a direct influence of preference. The children with a higher sweet exposure had a higher sweet preference. The children with a high sweet exposure would be more familiar to sweet food items, and thus implicitly learn that these food items should taste sweet. They might therefore have preferred higher sweet items both in the test and in everyday life (Aldridge et al., 2009). This fits well with research on younger children, where early exposure can help explain later taste acceptance (Schwartz et al., 2011). Thus, general higher sweet preferences were established, and as the children were exposed to more foods, the preference increased. The parents also influenced the sweet preferences of their children through their use of food as rewards (Paper 2). Using food as rewards was associated with a higher sweet preference, as supported by previous research (Schneider et al., 2013; Vereecken et al., 2004).

Although the children generally had a very high sweet preference, several of the children consistently had the lowest preference for sweetness in both chocolate (20%) and sweet drinks (5%, Paper 3). In Norwegian four-year olds, drinks typically contribute to 17% of sugar in the diet, and is the second highest source of sugar after candy and chocolate, which contribute to 19% (Hansen, Myhre, & Andersen, 2017). Thus, it is important to understand mechanisms that could facilitate children in making healthier choices *within* sweet drinks and chocolate. As the children with lower sweet preferences were exposed to more fruit (Paper 2), it seems that fruit can have an additional role to what is previously established, which is a relation to prevention of disease (Bazzano et al., 2002; Van Duyn & Pivonka, 2000). Norwegian four-year olds have a below adequate intake of fruits (Hansen et al., 2017), which is therefore additionally worrisome.

Together, the influence of the parents illustrated an important point: Parents could guide their children to a sweeter preference. It is not only what they exposed their children to, but also their other food behaviours that helped develop their children's sweet preference. What foods parents serve is important in a wider perspective than the diet of the child that day, and the use of rewards not only in that situation: Through their food choices, parents will help shape the preferences of their children, and the children might bring these preferences with them also beyond childhood (Nicklaus et al., 2005). I argue that the adults of today must make healthier food choices for their children, so the adults of tomorrow will have healthier preferences – and thus food choices and habits. As the attitudes of parents moderated behaviours, I argue that it is important to influence these attitudes in a healthier direction.

The influence of parents and sensitivity could together help explain some of the variation in sweet preferences, but by no means the entirety. The increase in sweet preference could also be explained through a different theory, as seen in adolescents (Coldwell, Oswald, & Reed, 2009): Children have a higher sweet preference than adults do because they are growing, and thus have a higher nutritional need. However, the children were growing at both age four, five, and six, and the height of the children at the different data collections did not reveal a much higher growth spurt at any time. Although an increased need for energy could have facilitated an increased preference for high sweet stimuli during the preschool years, it seems unlikely that it would have a much different influence at age four than at age six.

To sum up, the results on sweetness revealed that the preschool children had a general high sweet preference, which increased between the age of four and six. There was a small association between sweet preference and sensitivity, and children that were more sensitive to sweetness had a lower sweet preference. As well, more bitter sensitive children preferred less sweetness. Parental practices through exposing their children to sweet food as well as using food as rewards was in addition associated with a higher preference for sweetness.

### **Bitter preference**

In the drinks provided, bitter preferences were stable within the child during the study (Paper 3). Whereas the percentage of children that preferred the sweetest drink increased dramatically, preference was surprisingly stable in bitter drinks, and only 14% of the children either increased or decreased their bitter preference throughout the study. In total, 40% of the children consistently preferred medium bitterness taste (Paper 3), and the tendency was equally stable for both the most and the least bitter drink.

With chocolates, there was a decrease in preference for more bitter/less sweet chocolate between the age of four and age of six (Paper 3). As there was a change in sweet preference in drink, I postulate that the differences in preference in chocolate was mainly due to the preference for sweetness developing, and not a reduction in preference for bitterness.

Even though the preference for bitterness was stable in the individual, there were differences within the child group. Preference was related to neither sensitivity for bitterness nor any other basic taste. At age four, the children were not better than chance at discriminating for bitterness at any concentration (Paper 1), and 45% of the children showed a low sensitivity for bitterness (Paper 3) throughout the study. Nevertheless, there were still differences in bitterness sensitivity, with between 19% (age four and five) and 16% (age six) of the children consequently discriminating within all four pairs (Paper 3). A proportion of the children was thus very sensitive towards bitterness, but still did not differ in their preference from the rest of the group.

Generally, studies suggest that children reject bitter taste in childhood (Mennella et al., 2013), but a significant proportion of children showed a different relationship to bitterness in this study. As described above, a large proportion of the children preferred the most bitter drink

each year, and 19% of the children had the highest possible bitter score in drink throughout the study (Paper 3). I argue that these children preferred high bitterness intensity.

Additionally, we found high exposure to bitter snacks such as dark chocolate, walnuts, and olives to be related to a higher preference for bitterness in chocolate (Paper 2). As bitter is rejected from birth (Schwartz et al., 2009), and acceptance of bitter taste thus has to be learned, typically in early adulthood, the exposure to bitter foods could have augmented this learned preference. The sweet taste and high energy of chocolate is particularly potent in forming a preference (Prescott, 2013). Repeated exposure to dark chocolate can strengthen the relationship between these taste qualities and the distinct taste of cocoa and thereby condition a preference for darker chocolate. The bitterness is thus linked to something that is both nutritionally rewarding (high energy) and pleasant in taste (sweetness), which can facilitate in overcoming the aversion to bitterness, and instead to actually liking it. This suggests that food exposure might mediate the relationship between sensitivity and preference. It also suggests that bitter preferences can be influenced at an early age, which can have important applications, as healthy foods such as some vegetables can taste bitter. Influencing the bitter preference in preschoolers could be a step in the direction of accepting healthier foods, and thus healthier habits. An important notice is that a heightened bitter preference is always food specific, and not related to the taste itself. Unlike sweetness, where humans actually like the basic taste itself, it seems unlikely that the children have developed a liking for actual bitter taste, but it is rather food-specific.

Together, our results revealed that a) some children did indeed have a high bitter preference throughout the preschool years, b) these children were not less sensitive to quinine than their peers were, and c) the higher preference might be related to a higher exposure to bitter snacks.

### **Sour preference**

We did not find any change in sour preference during the three years (Paper 3). Not only was there not a significant difference, there was no developmental trend towards an increase or decrease, and the preference was remarkably stable within the individual. This is in line with previous results, where preference was not altered by repeated exposure in children aged six to eleven year olds (Liem & De Graaf, 2004).

In general, the children had a very high sensitivity for the sour water presented. The children were better than chance at discriminating for all concentrations of sour at age four (Paper 1), and there was still an increase between the age of four and six (Paper 3). As such, 84% of the children had either a stable high or an increase in sensitivity for sour taste. This suggests that childhood could be a period of a particular sensitivity for sourness, supported by previous results (Liem, Mars, et al., 2004a). However, the high sensitivity was in part due to the ISO-standard concentrations not being comparable across taste (Myhrer, Carlehög, & Hersleth, 2016), but easier to detect for sourness. I do not conclude that the children were more sensitive to sour than the other basic tastes, but that there was an increase in sour sensitivity in the preschool years. Interestingly, even though the sensitivity increases, there was no relationship with sour preference at any stage of the study.

Sour preference is related to consumption of healthy foods such as fruits and vegetables (Liem, 2004), and understanding sour preferences is thus important in a health-perspective. Our findings corroborate previous results that some children have a very high sour preference (Blossfeld et al., 2007; Liem & Mennella, 2003), as 31% of the children had the highest possible sour preference consistently through the study. Additionally, we add that the high preference for sourness seemed to be unrelated to a low sensitivity, but due to an actual high sour preference, as sensitivity could not explain differences in preference for sourness (Paper 3). This indicates that sour sensitivity might not be a barrier to liking fruits and vegetables.

Even in children as young as 18 months, Blossfeld and colleagues (2007) found some children to have a high preference for sourness. Some children could therefore have a higher preference for sour because of factors introduced at an even earlier stage than age four. As an effect of shared environment on sour preferences has been found in adults (Törnwall et al., 2012), I argue that it might be possible to influence sour preference in childhood at a very young age. Supporting this, sour preference of preschoolers is related to the formula they consumed as infants (Mennella & Beauchamp, 2002). Better understanding of what influences sour preferences can thus help modify the preferences in a healthier direction (Liem, 2004). Our research indicates that within the preschool years, sour preference was not affected by sensitivity, gender, or development

Sour preference could be explained by intrinsic factors outside of this thesis, such as personality traits or behaviour. Supporting this, a correlation between preference for intense visual stimuli and strong sour taste has also been found (Liem, Westerbeek, et al., 2004). Additionally, an adult twin study has found a large genetic contribution to sour preferences (Törnwall et al., 2012). However, these results were found with adults, and the genetic contribution could be different in childhood, as genetic variations to taste can have different expressions in adults and children (Mennella et al., 2005). Together, this shows that more research is needed to further investigate the origin of differences in sour preferences.

To sum up, our results revealed that the preference for sourness was stable between the age of four and six, and there were differences between the children in what intensity of sourness they preferred. The preference for sourness was not related to sensitivity for sourness.

### **Sensory Tests with Preschoolers**

Previous studies had methodological challenges when testing the same age-group as in this study (Knof et al., 2011; Liem, Mars, et al., 2004a). We carefully designed protocols that we pre-tested and pilot-tested in several stages, as described both above and in Paper 1. Findings from Paper 1, Paper 2, and Paper 3 together demonstrated that with great consideration, it is possible to undertake valid and reliable testing with children as young as four years old. The following findings support this.

Firstly, the participation rate was generally high: the first year, 5% of the children chose to withdraw from a test (Paper 1), and in the two subsequent years, it was respectively 5% and 3% (Paper 3). This high participation involved children across personality characteristics and presented a nuanced picture. Personality characteristics have been associated with taste preferences (Byrnes & Hayes, 2013; Liem, Westerbeek, et al., 2004; Sagioglou & Greitemeyer, 2016), and involuntarily excluding children of certain characteristics, such as shyness, could skew results. The high participation rate also mirrors an interest in participating in the tests. I, as well as the other experimenters, observed that the children were enthusiastic about the procedures, and generally involved during the testing. Involvement could also have facilitated a better concentration, as the procedures kept the attention of the children, and thus produced more carefully considered answers.

Secondly, the protocol of the sensitivity test (Paper 1) showed a high test-retest reliability, indicating that the children provided reliable responses. A study found low repeatability with 4-5 year old children (Leon, Couronne, Marcuz, & Köster, 1999), and reported that this could be due to the length of the sessions. Because of this, this study employed shorter sessions. Liem, Mars, and de Graaf (2004a) reported that four-year-old children could not reliably discriminate between samples of orangeade, but used protocols that relied on verbal skills, while we used non-verbal protocols for the children.

Thirdly, using the Ages and Stages Questionnaire (ASQ), we controlled for the influence of differences in cognitive development. Cognitive development was not related to neither sensitivity (Paper 1, 3) nor preference (Paper 2, 3). This supports that the tasks were not too cognitively difficult for the age group, and that the results found were not mainly due to cognitive differences between the children. There was also not an influence of age within the year (Paper 1) – i.e. the children who were up to 11 months older at the time of testing did not perform differently from their younger peers. This could be due to the tests being affective, as affective rather than analytical tasks rely less on cognitive encoding (Zajonc, 1980). As described in the introduction, verbal skills have been found to influence test performance, and we therefore designed the protocol to be non-verbal for the children. The experimenters did talk and instruct the children in the task, which could potentially have influenced results, but the instructions did not rely on vocabulary development. Verbal skills are a subset of the ASQ through the measure Communication, and this was not related to performance in any test.

Lastly, we found different developmental trajectories for the basic tastes, regarding both taste sensitivity and preference (Paper 3). This indicates that our test indeed measured differences in sensitivity and preferences – and not a developmental difference in performing the task. If the children only performed the task differently due to age, we would expect the effect of age to be similar on all five tastes.

## **Methodological Considerations**

Careful considerations were taken in designing valid and reliable tests. Nevertheless, several of the methodological choices could have skewed the results. Even though we tried to design naturalistic protocols, the children did participate in an artificial test, and the results could be influenced by how relatable to real-life the tests were. We chose to test the children in their

kindergartens rather than a laboratory setting. One of the reasons for this is that children do consume food in their kindergartens, making this a more naturalistic place to measure preferences. We tried to make the experimenters familiar to the children and provide taste carriers that children were likely to consume also outside of the test. However, there were situational cues that could inform the child that this was in fact not an everyday eating situation, but an artificial one, which could have influenced the results (van't Riet et al., 2011).

In addition, there are five important methodological considerations in this dissertation: generalisability of the participants, the choice of taste carriers in both the preference and sensitivity test, the effect of familiarity in the preference test, and the use of Children vs. Experimenters' Criterion for the sensitivity test. Additionally, there are several constraints with the parental questionnaire. These considerations are all presented below.

### **Generalizability of the participations**

The participants mainly show generalizability. The children themselves seem to be representative of the population regarding the factors we wanted to control for, such as balance of gender. The proportion of breast-fed children was suitable (84% in this sample vs. 82% in the population (A. L. Kristiansen, Lande, Øverby, & Andersen, 2010), which is relevant as being breast-fed is related to later food habits (de Wild et al., 2018; Scott et al., 2012; The World Health Organization, 2001). Body mass index, which is related to taste perception (Bobowski & Mennella, 2015), was also comparable to the population (World Health Organization, 2007). Nevertheless, there are several characteristics we did *not* control for, and these could have influenced the results.

What foods children are exposed to is decided by their parents, but also influenced by innate factors in the children. Several appetite traits, such as amount of food consumed, and speed of consumption, could influence the reported exposure to foods. These factors have a strong heritability (Dubois et al., 2013). Additionally, preterm children can have more eating difficulties (Migraine et al., 2013). Together, this highlights the complex relationships that influence preferences; as these factors will influence the perceived food preferences of a child but might be due to other factors than what food is actually preferred.

The children in this study were influenced by parents who presented a skewed part of the population. Mainly, the parents had a high level of education compared to the rest of the Norwegian population, as described above. Education level of parents was not correlated to either taste preference or sensitivity in the children (data not shown). However, this could be due to the homogenous level of education: Almost no parents had a low education. The high level of education can have influenced the results in several ways as described next.

One, level of education in parent is related to the general healthiness of the diet of the child (Antonogeorgos et al., 2013; Emmett & Jones, 2015; Jones, Steer, Rogers, & Emmett, 2010; North & Emmett, 2000; Ystrom, Niegel, Klepp, & Vollrath, 2008) and adults (Galobardes, Morabia, & Bernstein, 2001). A higher education is also associated with consumption of fruit and vegetables by parents (Vereecken et al., 2004), which relates to higher fruit and vegetable consumption in their children. Thus, food both provided and modelled could be skewed in our sample.

Two, education has been found to correlate with health consciousness (Cho, Park, & Lee, 2014; Girois, Kumanyika, Morabia, & Mauger, 2001). Our results indicate that health and sugar attitudes were associated with what food the parents exposed their children to (Paper 2), and food exposure to taste preferences. The general high level of education could have skewed the preferences through an effect of health and sugar attitudes of the parents.

Three, education level is associated with parental style (Boots, Tiggemann, Corsini, & Mattiske, 2015; Valcke, Bonte, De Wever, & Rots, 2010; Vereecken et al., 2004). The parents in this study generally subscribed to an authoritative parental style, with few parents using either authoritarian or permissive styles. Parents who use authoritative style expose their children to more fruit and vegetables (Patrick et al., 2005), and the children actually consume more of the foods as well, whereas permissive parents expose their children to more sweet foods (Vereecken et al., 2004) and snacks (Boots et al., 2015). Fruit exposure was related to a lower preference for sweet (Paper 2), and high exposure to sweet foods to have the opposite effect, this could clearly have skewed our results.

Together, the high level of education could have influenced several factors that influence taste preferences. A more diverse parental population could have resulted in more diverse preferences in the children.

### **Preference test**

The taste carriers all had the same color, as color can influence preferences (Leon et al., 1999; Walsh, Toma, Tuveson, & Sondhi, 1990). We used cups with exiting colors and fun pictures to engage the children. The cups were randomized for each taste: One child would receive the blue cups for sweet drinks, another for bitter drinks. The color of the cups was randomized to counterbalance the influence of color on the choice of the child: For example, with sweet drink in pink cups, the cups could influence the children to choose the sweetest drink, if the child associated red with sweetness.

The taste carriers were chosen to be, among other things, familiar to the children, as unfamiliarity of a food can induce negative affect towards the food (Tuorila & Mustonen, 2010). The taste carriers provided represented familiar food products to the children. On average, Norwegian four year olds consumed 0.6 dl of sweet beverages and 13 grams of candy and chocolate daily (Hansen et al., 2017). Norwegian four-year olds are thus clearly familiar with the type of products used in this study. This familiarity can however have an additional influence on the results. Typically, the “middle concentration” in preference studies is the one most similar to what can be found in grocery stores (Mojet, Christ-Hazelhof, & Heidema, 2005). This is also the case for the drinks in this study, where the middle concentration for sour, bitter, and sweet taste corresponds most closely to what can be bought by Norwegian consumers. A familiarization effect on this taste carrier could be possible, and thus lead to a higher proportion of children preferring this concentration. However, consumers buy the drink in concentrated form, and dilute it with water. Although there is a recommended mixing ratio of drink to water, consumers may diverge from this, and the drink consumed would differ in intensity. It is impossible to know which of the concentrations used in the study is most similar to what is most familiar for each individual child. This familiarity could as such have an impact on the preference for which we did not control. The chocolates are developed especially for this study and not available in stores. There are however similarities with chocolates offered in stores. As we found children that were exposed to dark chocolate

had a higher preference for the darkest chocolate offered (Paper 2), there seems to be an effect of familiarity on the chocolates.

The drinks and chocolates were made for this study, and corrected through several phases of the preparation, including tests with a sensory panel. Nevertheless, the taste carriers differed between each other on other attributes than only the basic taste investigated. In drinks, it was possible to produce taste carriers that significantly differed on few other attributes, but this was not possible for the more complex chocolates. The chocolates significantly differ in important attributes such as meltability and hardness, and differences in preferences could thus correspond to these attributes. In addition, unlike the drinks, the chocolates significantly differed in several odours. The preference in chocolate could thus be influenced across sensory modalities, with a contribution from the smell.

The results regarding preferences from this study are not necessarily applicable to other stimuli. Different choices of taste carriers provided, and concentrations chosen, might have given quite different results. In addition, larger sips or portions consumed might have yielded different results. What is medium sweet in this study could be the lowest sweet in another study. Studies can therefore only be compared with great caution (Mojet et al., 2005). Particularly for bitter taste, comparing with other studies provides challenges, as bitter is the most complex taste modality. Bitterness has 25 known bitter taste receptors (Wiener, Shudler, Levit, & Niv, 2011). This study employed three different bitter compounds: quinine (sensitivity), isolone (drinks), and theobromine from cocoa (chocolates), but it has been suggested that over 500 bitter compounds exist (Wiener et al., 2011). Different bitter taste compounds in different studies are not necessarily related. Specific for this study, our measure of sensitivity might not explain preferences within basic tastes. Whereas quinine has been found to activate ten different bitter receptors (Meyerhof et al., 2010), isolone is a purified isohumulone (converted from hop alpha acids), and has been suggested to share a common bitter receptor with other bitter stimuli (Guinard, Hong, Zoumas-Morse, Budwig, & Russell, 1994). As mentioned in the introduction, genetic differences will influence bitterness perception, and both quinine (Tepper et al., 2009) and isohumulones (Mela, 1990) are to some degree related to PROP-status in adults. As children can have different gene expression related to PROP than adults (Mennella et al., 2005), the relation between bitter compounds might be different in the present study. Generally, how perception for different bitter

compounds relate to each other in children is not clear, and this is an important limitation of this study.

### **Taste sensitivity**

When tasting several stimuli, the spillover effect from the previously tasted stimulus can influence the taste of the present stimulus. As such, what is previously tasted will desensitize the participants. The desensitization effect may have been particularly strong in this study, as the children never rinsed between beverages, as this would increase the length of the sessions, and we would not be able to control how well they rinsed. This could influence results in the preference test, but is perhaps more important regarding taste sensitivity, where the children started with the pair including the strongest concentration. Starting with the strongest concentration was decided based on results from the pilot-test, as starting with the weakest concentration did not interest the children (Paper 1). A possible spillover effect is therefore an important limitation of the study. However, half the drinks in the sensitivity test were water. Basic tastes diluted in water are often used to study basic tastes (Lawless & Heymann, 2010), but not all taste dilutions are natural to consume (Hartvig, 2013). Salty water, as we used in the present study, is for example rarely consumed in real life. Nevertheless, we decided that water would be the best taste carrier to investigate taste sensitivity. The main reason for this is that a previous study found four years olds to inconsistently discriminate more complex taste carriers (Liem, Mars, et al., 2004a). However, water is not water: It is easier to measure taste sensitivity in untrained personnel with water low in mineral content (Hoehl et al., 2010), highlighting the influence of the taste carrier. We used water from the company Imsdal for all three years, so the water could be as similar as possible. As discussed above, the choice of taste carriers will have influenced the results, particularly for bitterness. Additionally, no correlation between sensitivity for fructose and sucrose have been found in adults (Peng, Hautus, Oey, & Silcock, 2016). This highlights that the findings in this dissertation might only be applicable to sensitivity for the same taste carriers.

One limitation of this study is the lack of transferability between the different basic tastes in the sensitivity test. We wanted to be able to compare not only within one basic taste, but also across tastes, and used the ISO-standard (2003). Alas, this was not possible as the chosen dilutions differed greatly in easiness to detect. Particularly strikingly was the easiness of detecting all four concentrations in sourness, which 57% (CSC)/ 50% (ESC) children were

able to do the first year. Compared to the low result for sensitivity in sweetness (11% with ESC, 19% with CSC) and bitterness (11% with ESC, 19% with CSC), it is important to see the development over the years for each taste individually, and not compare across tastes (all Paper 1). Future studies should aim to improve the comparability across basic tastes.

### **Children vs. Experimenters' Criterion**

Originally, the sensitivity test was designed to use The Experimenters' Criterion – the children should sort the water with added taste on the placemat with a magic character. However, when plotting the data, the trend of some children using a different criterion emerged. A large proportion (ranging from 7% for sourness and 14% for salty taste) differed between all pairs consistently, but not using The Experimenters' Criterion. We assume that these children understand the task, but in a different way than we expected. The concept of "magic water" is indeed an abstract concept, and "regular water" could fit for the cup with added taste, as it is actually water. Defining plain water as "magic water" is thus not actually more wrong than defining water with taste as "magic water".

Additionally, one of the main objectives of this thesis was to tailor the procedures to the children. This is important in all phases of the study: the experimenter should investigate not only *if*, but also *how* the child understands the task. Considering this, The Children's Criterion was included, where the sorting on the first pair sets the blueprint for each taste. The Children's Criterion was compared with The Experimenters' Criterion (i.e. water with taste on place mat with magic character) in Paper 1, and the trends were the same. Before conducting the analyses in Paper 2 and Paper 3, preliminary analyses to compare both criteria revealed that the trends were the same (data not shown), and The Children's Criterion has consequently been used in this dissertation.

One may argue that it is easier for the children to guess correctly for all four pairs with The Children's Criterion, and that is true. However, the children scored equally well when using both criteria for all tastes except for sour (Paper 1), and further investigations revealed that the same was true also at age five and age six (data now shown). I argue that the use of The Children's Criterion put the child in center, which is important in such a task as this, and it is therefore the best fit to our data.

## **Parental questionnaires**

The questionnaires were self-reported by the parents, and could be influenced by social desirability, even though the questionnaires were on-line and anonymous. This is particularly poignant for the items regarding healthiness and food exposure. There is an emphasis on healthiness in today's society, and parents could wish to appear more health-conscious than they really are, and thus underreport exposure to more unhealthy foods. Most parents would by all probabilities be affected by this in the same direction, and though the answers will be skewed, they will be skewed in the same direction.

The goal with the food section of the parental questionnaires was to gain an overview of the food exposure and, more specifically, each child's exposure to foods that are high or low in the basic tastes. In studies such as this one, using less accurate measures on food is common (Schneider et al., 2013) as it is the general diet that is important, not the specifics. The diet data was not collected at the micro level and can therefore not accurately describe each child's diet. Instead, the parents were asked about food exposure and not consumption as it is a more valid measure for parents to report what they serve, and not if the child actually eats it, since the latter is harder to control for (Serdula, Alexander, Scanlon, & Bowman, 2001). The parents answered on frequency of exposure, not the amount their children were exposed to. However, some children could have received large portions infrequently. In Norway, children typically receive "lørdagsgodt", which can be roughly translated as "Saturday candy". As an example, on typical Saturdays, a child could be exposed to large amounts of candy, or just receive a small piece, and the questionnaire cannot differentiate between the two. There were differences between the children based on food exposure (Paper 2), and a more accurate measure on exposure could have revealed additional trends. Future studies could therefore investigate if high quantities of exposure to sweets also relates to increased sweet preference.

Data on exposure to food was not completely accurate, as it is a challenging measure to report for parents. Additionally, the children are exposed to foods in several arenas outside of the family home, such as visiting friends or grandparents. Most importantly for the children in this study is the influence of the kindergartens, which is important for the majority of all other Norwegian children as well, as 96.8% of children between the ages of three and five attend kindergarten (Statistics Norway, 2017a). A large proportion of preschoolers' meals are consumed in kindergartens, and in the present study the children consumed between one and

three meals there every weekday. However, in the majority of the kindergartens, several of these meals consist of prepacked meals made by the parents. Additionally, there was no differences in taste sensitivity and preference based on which kindergarten was attended (data now shown), even though there were differences in what foods the kindergartens served.

To measure parental style, a translated French questionnaire was used as described above. We assumed that parental style could be an important factor to explain parental differences in their attitudes and behaviours regarding food. However, there was very little spread in the data regarding parental style. Almost all the parents reported an authoritative parental style. There could exist cultural differences in parental style between Norway and France, as has been shown between African-American and Hispanic parents (Hughes et al., 2006). Future studies could therefore investigate how parenting style of Norwegian parents differ from that of parents from other countries, and how it relates to food. The lack of spread in parental style could also be due to the homogenous parental sample, as discussed above.

To help explain why some children did not want to participate in tasting the beverages and chocolates, a measure of neophobia and pickiness was employed. More specifically, we wanted to investigate if the children that did not want to participate in the study did so because they were neophobic and/or picky, or if it was due to other reasons. There were however few children that withdrew from testing (at most, 5%), and it was not possible to investigate if this group differed from the other children.

The parents received a quite long questionnaire three times during the study, as there were many factors we were interested in investigating. There was a decrease in answers from the first to the third years. Shorter questionnaires might have yielded more questionnaires returned. As discussed above, several of the measures investigated could not be used to differentiate between the children, and a shorter questionnaire might have been possible with more careful piloting. When piloting the questionnaires, we investigated if they were easy to understand and fill out and included measures that capture what we wanted to measure. We did not investigate if the questionnaires used would uncover differences between Norwegian parents. In addition, the software we used was not compatible with answering from a smartphone or tablet at the time of designing the questionnaires. Parents with small children

are generally under time constraint, and it might have been easier for them to answer on these devices as compared to the computer.

## **Conclusions, Implications and Perspectives**

One reason for investigating taste preference and sensitivity is the relationship with real-life food choices. If these qualities were not related, our taste preferences and sensitivity would have no practical implications. The results from this dissertation corroborate previous studies associating taste preferences and sensitivity with actual food experiences and shows that taste preferences might be influenced by food exposure.

Sweet preferences significantly increased during the span of the study and were related to parental attitudes and use of rewards, food exposure (both to sweet foods and fruit), and taste sensitivity to bitter and sweet. Both bitter and sour preferences were consistent throughout the study, and either weakly or not related to taste sensitivity. Bitter preference seemed to be related to exposure to bitter snacks but was only investigated with chocolate. Neither sensitivity nor preference for any taste at any time was related to cognitive development.

Our results indicate that parental influence can modulate the preferences in their children, at least for bitterness and sweetness. Even though children generally reject bitterness, some of the children in this study had a high bitter preference. Bitter preference in drinks was not related to bitter sensitivity but did however use different bitter compounds. Bitter preference in chocolate was related to bitter food exposure. This implicates that humans can overcome innate preferences even in childhood through learned association. The bitter foods are thus associated with other factors than its unpleasant bitterness. The real-life implication of this is that high bitter sensitive children can also readily consume bitter foods, such as vegetables. For sweetness, the children with high exposure to sweet foods and parental use of foods as a reward had a higher preference for intense sweetness. Those with exposure to fruits had a lower preference. Together, this has important health implications, as it means that parents can influence the taste preferences of their children in either a healthy or an unhealthy direction. This is particularly important as the foundation for food habits is laid in childhood, and unhealthy food preferences might follow the children throughout their lifespan. Taste preferences that correspond to an unhealthier diet might therefore be adverse both for the individual, and in a wider societal perspective. I propose that more resources are needed to guide which foods parents expose their children to. As parental choice of foods seems to be partly modulated by their attitudes, changing the attitudes of parents might lead the children to taste preferences corresponding to healthier food preferences. The majority of the

questionnaires were answered by the mothers, and new research could focus on both gaining more knowledge on the paternal influence, and whether maternal and paternal influences pull in the same direction.

The research presented indicates that food exposure can serve as a mediator between preference and sensitivity. The lack of development and influence of sensitivity on sour preference indicates that preference for this taste was shaped even before the age of four. This implicates that future research should investigate sour preference in a longitudinal perspective, starting at an even earlier age. Unlike for sweet and to some degree bitter preference, this dissertation did not investigate the relationship between sour preference and any food exposure. As food exposure seems to mediate the relationship between taste sensitivity and preferences, it would be interesting to investigate the effect of food exposure on sourness in a longitudinal perspective from the time of weaning to the age of six. Preferences and perception for other basic tastes, such as salty, and taste sensations, such as astringency and fattiness, might be influenced by the same relationship. As preferences for these taste qualities also relate to food choices and diet, more knowledge about how these factors relate, and develop in childhood, could be beneficial.

The test protocols of both sensitivity and preference seem to be both valid and reliable with children between the years they turn four and six. This indicates that with careful considerations and thorough test design in accordance to their age, children can participate in sensory testing at a very young age.

This dissertation has both corroborated previous research in cross-sectional studies and revealed new knowledge. This highlights the importance of longitudinal studies to understand factors that undergo development. Tracking the preferences for sourness, sweetness, and bitterness as well as other taste modalities in an even longer longitudinal perspective could facilitate a deeper understanding of factors that influence every human being.

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## Appendix 1: Fairy Tale Used in Introduction to Test

Nå skal jeg fortelle historien om alle de magiske slurkene med vann!

En gang var det en gutt og en jente som gikk tur i skogen. De het Hans og Lotte.

De gikk og de gikk, de gikk lengre enn langt, og enda lengre enn det igjen.

De gikk til de var midt inne i den mørke, store skogen.

«Jeg skulle ønske vi hadde tatt med oss noe å drikke!» sa Lotte

«Ja, vi burde fylt opp drikkeflaskene våre før vi dro» sa Hans.

«Jeg er så tørst i halsen min» sa Lotte.

«Jeg også» sa Hans.

Og akkurat da, nesten som om det var magisk, så de en fe! Og dette var hvordan feen så ut.

(VIS BILDET AV FEEN MENS DU SIER NESTE SETNING)

Hun hadde store vinger, og barna så med en gang at det var den snille feen.

Henne hadde de møtt mange ganger når de var ute og gikk tur med foreldrene sine.

«Er dere tørste?» spurte feen. «Ja, vi er kjempetørste!» sa barna.

«Vil dere smake på det magiske vannet mitt? Det er annerledes enn sånt vann dere pleier å drikke, sånn som kommer fra vasken. Dette vannet er magisk». Fortalte feen. Barna ville gjerne smake, og det fikk de. De smakte at vannet var magisk.

«Tusen takk for vannet, nå må vi gå videre! Ha det bra, snille fe!» sa Lotte og Hans i kor.

De gikk videre, og så på alle de store trærne. Til slutt hadde de gått så lenge at de var tørste igjen. Og akkurat da, som om det var magisk, så de en alv. Og alven, han så slik ut.

(VIS BILDET AV ALVEN MENS DU SIER NESTE SETNING)

Han hadde spisse ører, og barna så med en gang at det var den snille alven.

Han hadde de møtt mange ganger når de var ute og gikk tur med foreldrene sine.

«Møtte dere søsteren min, den snille feen, i sted?» spurte den snille alven. «Ja, hun ga oss magisk vann!» svarte Hans.

«Jeg har også magisk vann som jeg drikker, men det er magisk på en annen måte enn vannet til søsteren min, den snille feen. Det smaker annerledes. Vil dere smake på det magiske vannet mitt også?» Fortalte alven. Barna ville gjerne smake, og det fikk de. De smakte at vannet hadde en helt annen magisk smak.

«Tusen takk for vannet, nå må vi gå videre! Ha det bra, snille alv!» sa Lotte og Hans i kor.

Og så gikk de videre, til de var kommet enda lengre i skogen, og begynte å bli tørste igjen.

Og da tittet den snille trollmannen bak frem et tre.

(VIS BILDET AV TROLLMANNEN MENS DU SIER NESTE SETNING)

«Hei snille trollmann!» sa Hans og Lotte, for de hadde møtt den snille trollmannen mange ganger før sammen med foreldrene sine.

«Hei, Hans og Lotte! Er dere tørste?» spurte han

«Ja, vi er veldig tørste!» sa Hans og Lotte.

«Jeg vet at dere har møtt barnebarna mine, den snille alven og den snille feen, og at dere smakte på det magiske vannet deres. Jeg har også magisk vann. Men det er magisk på en annen måte. Vil dere smake på det magiske vannet mitt? Det smaker helt annerledes enn det magiske vannet dere allerede har smakt.» sa Trollmannen.

Hans og Lotte ville smake, og det fikk de. De smakte at vannet hadde en annen magisk smak.

«Tusen takk for vannet, nå må vi gå videre! Ha det bra, snille trollmann!» sa Lotte og Hans i kor.

Så gikk de lengre enn langt, helt til de ikke lenger var i skogen. De kom frem til et vann hvor de pleide å bade med foreldrene sine. Og der i vannet, det var både den snille havmannen og den snille havfruen. Og de så slik ut:

(VIS BILDENE AV HAVMANNEN OG HAVFRUEN)

Både havmannen og havfruen hadde lange fiskehaler, og kunne svømme lenge under vann.

«Hei havmannen og havfruen!» sa Hans og Lotte i kor, for de hadde møtt havmannen og havfruen mange ganger når de badet med foreldrene sine.

«Hei Hans og Lotte!» sa havmannen og havfruen tilbake.

«Nå har dere smakt på det magiske vannet til den snille feen, og det magiske vannet til den snille alven, og det magiske vannet til den snille trollmannen. Kanskje dere vil smake på det magiske vannet mitt også? Det er også magisk, men det er magisk på en annen måte, så det smaker ikke likt som det dere allerede har smakt.» sa den snille havfruen.

«Ja, det vil vi gjerne!» sa Hans og Lotte. Og de fikk smake på det magiske vannet til den snille havfruen, og det vannet smakte helt annerledes enn noe av det de hadde smakt tidligere på dagen.

«Jeg har også magisk vann» sa havmannen. «Men mitt vann har en annen magisk smak enn vannet dere har drukket før, og det smaker helt annerledes. Kanskje dere vil smake på det vannet også?» sa han.

«Ja, det vil vi gjerne!» sa Hans og Lotte. Og de smakte at vannet var annerledes enn det magiske vannet de hadde smakt før.

«Nå må vi gå hjem! Ha det bra, og takk for vannet!» sa Hans og Lotte.

Så gikk de hjem til foreldrene sine.

«Hva har dere gjort i dag?» spurte foreldrene.

«Vi har drukket magisk vann!» sa Hans.

«Vi fikk magisk vann av den snille feen, og den snille alven, og den snille trollmannen, og den snille havfruen, og den snille havmannen.» sa Lotte.

«Og det smakte helt forskjellige, alt det magiske vannet. Ingenting smakte likt, for det var magisk på forskjellige måter» fortalte Hans.

«Det høstes ut som en veldig fin dag!» sa foreldrene. «Kanskje har dere lyst til å smake på vannet vårt her hjemme?» Det ville barna gjerne, så det fikk de.

De smakte av vannet var godt, og helt vanlig.

«Det var jo ikke magisk i det hele tatt, men det var godt likevel!» sa Lotte, og lo.

## Appendix 2: Parental Practices and Food habits

### Questionnaire

*Dette er et spørreskjema til deg som foresatt i forbindelse med smaksopplevelsene ditt barn har vært med på i barnehagen.*

*Vi er svært takknemlige for hjelpen - tusen takk for at du tar deg tid slik at vi kan lære mer om barns smakssans.*

*Noen av spørsmålene svarte du kanskje også på i fjor. Vi spør igjen i år siden det kan ha forandret seg.*

*Dette spørreskjemaet gjelder ditt barn født i 2011.*

#### ***Hva er barnets ID- nummer?***

*Se ID-nummer opplyst i mailen du fikk dette spørreskjemaet i.*

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#### ***Når er barnet født - dag og måned?***

---

#### ***Hva er barnets kjønn?***

- Jente*
- Gutt*

#### ***Hvem fyller ut dette skjemaet?***

- Kvinnelig foresatt*
- Mannlig foresatt*
- Annen person:*

#### ***Har barnet søsken?***

- Nei*
- Ja.*

***Spesifiser antall yngre og antall eldre søsken her:***

---

***Hvor mye bor du med barnet?***

- Hele tiden*
- Mer enn halve (50%) tiden*
- Halve (50%) tiden*
- Mindre enn halve (50%) tiden*
- Aldri*

***Spiser barnet hovedsakelig samme mat til middag som de voksne?***

- Ja*
- Ja, men bare i hverdagene*
- Ja, men bare i helgene*
- Nei*

***Når ble barnet født i forhold til ultralydstermin?***

- Før uke 38*
- I eller etter uke 38*
- Vet ikke*

***Hvor gammelt var barnet ditt da det sluttet å få morsmelk? (i måneder)***

---

***Hvor gammelt var barnet ditt da fast føde ble introdusert? (i måneder)***

---

***Hvor mye veier barnet ditt? (i kg)***

---

***Hvor høyt er barnet ditt? (i cm)***

Du vil nå få noen spørsmål om ditt barns kosthold.

Dette er for å kartlegge ditt barns eksponering til forskjellige typer smak.

**Hvor ofte har ditt barn blitt servert følgende matvarer:**

	<i>Aldri</i>	<i>Sjeldent</i>	<i>Månedlig</i>	<i>Ukentlig</i>	<i>Daglig</i>
<i>Kokt skinke</i>	<input type="radio"/>				
<i>Bacon</i>	<input type="radio"/>				
<i>Spekemat</i>	<input type="radio"/>				
<i>Kalkun- eller kyllingpålegg</i>	<input type="radio"/>				
<i>Pølse</i>	<input type="radio"/>				
<i>Røkelaks</i>	<input type="radio"/>				
<i>Torsk</i>	<input type="radio"/>				
<i>Leverpostei</i>	<input type="radio"/>				
<i>Makrell i tomat</i>	<input type="radio"/>				
<i>Laks, grillet eller kokt osv.</i>	<input type="radio"/>				
<i>Kylling</i>	<input type="radio"/>				
<i>Pasta</i>	<input type="radio"/>				
<i>Pizza</i>	<input type="radio"/>				
<i>Potet, kokt eller most</i>	<input type="radio"/>				
<i>Potet, stekt eller fritert</i>	<input type="radio"/>				

	<i>Aldri</i>	<i>Sjeldent</i>	<i>Månedlig</i>	<i>Ukentlig</i>	<i>Daglig</i>
<i>Mango</i>	<input type="radio"/>				
<i>Kiwi</i>	<input type="radio"/>				
<i>Sopp</i>	<input type="radio"/>				
<i>Gulrot</i>	<input type="radio"/>				
<i>Blomkål</i>	<input type="radio"/>				
<i>Brokkoli</i>	<input type="radio"/>				
<i>Ananas</i>	<input type="radio"/>				
<i>Klementin/mandarin</i>	<input type="radio"/>				

<i>Spinat</i>	<input type="radio"/>								
<i>Pære</i>	<input type="radio"/>								
<i>Appelsin</i>	<input type="radio"/>								
<i>Appelsinjuice</i>	<input type="radio"/>								
<i>Eple</i>	<input type="radio"/>								
<i>Eplejuice</i>	<input type="radio"/>								
<i>Rosiner</i>	<input type="radio"/>								
<i>Bjørnebær</i>	<input type="radio"/>								
<i>Rosenkål</i>	<input type="radio"/>								
<i>Sitron (f.eks. til fisk eller i vann)</i>	<input type="radio"/>								
<i>Grapefrukt</i>	<input type="radio"/>								
<i>Pasjonsfrukt</i>	<input type="radio"/>								
<i>Asparges</i>	<input type="radio"/>								
<i>Tomatsuppe</i>	<input type="radio"/>								
<i>Rabarbra</i>	<input type="radio"/>								
<i>Jordbær</i>	<input type="radio"/>								
<i>Blåbær</i>	<input type="radio"/>								
<i>Avokado</i>	<input type="radio"/>								
<i>Banan</i>	<input type="radio"/>								

*Aldri*

*Sjeldent*

*Månedlig*

*Ukentlig*

*Daglig*

<i>Syltetøy</i>	<input type="radio"/>								
<i>Gulost</i>	<input type="radio"/>								
<i>Brunost</i>	<input type="radio"/>								
<i>Sjokoladepålegg</i>	<input type="radio"/>								
<i>Yoghurt naturell</i>	<input type="radio"/>								
<i>Fruktyoghurt</i>	<input type="radio"/>								
<i>Frokostblanding</i>	<input type="radio"/>								
<i>Havregryn</i>	<input type="radio"/>								
<i>Melk</i>	<input type="radio"/>								
<i>Sjokolademelk</i>	<input type="radio"/>								
<i>Smøreost</i>	<input type="radio"/>								
<i>Kaviar</i>	<input type="radio"/>								
<i>Ketchup</i>	<input type="radio"/>								
<i>Kneippbrød</i>	<input type="radio"/>								
<i>Fint brød, loff og rundstykker</i>	<input type="radio"/>								

Grovbrød, over  
to på  
brødskalaen

	Aldri	Sjeldent	Månedlig	Ukentlig	Daglig
Potetgull	<input type="radio"/>				
Iskrem	<input type="radio"/>				
Melkesjokolade	<input type="radio"/>				
Mørk sjokolade	<input type="radio"/>				
Annet godteri	<input type="radio"/>				
Kake, alle slags	<input type="radio"/>				
Gjærbakst	<input type="radio"/>				
Valnøtter	<input type="radio"/>				
Oliven	<input type="radio"/>				
Brus med sukker	<input type="radio"/>				
Brus, sukkerfri	<input type="radio"/>				

Du vil nå få se noen påstander for forskjellige situasjoner. Kryss av for det alternativet som passer best for deg og din familie.

**Barnet vil ha pasta når jeg har planlagt grønnsaker**

- Jeg lager grønnsaker uten å diskutere det med barnet
- Jeg lager grønnsaker, og sier at barnet mitt får pasta dagen etter
- Jeg lager pasta

**Dette gjør jeg for å få barnet mitt til å prøve annen mat**

- Jeg får barnet mitt til å spise maten som serveres, uansett
- Jeg oppfordrer ham/henne til å prøve alle matvarer, men tvinger ham/henne ikke
- Jeg prøver ikke å få ham/henne til å spise mat han/hun ikke vil

**Når barnet mitt ikke vil smake på mat, pleier jeg å**

- Bli sint, kjeft på ham/henne, eller tvinge ham/henne til å smake
- Få ham/henne til å smake på andre måter - for eksempel forklare hvorfor han/hun burde smake
- Ikke gjøre noe

**Barnet mitt sier at han/hun ikke er mer sulten på middagsmat, men vil ha dessert eller annet søtt**

- Jeg nekter å gi ham/henne dessert eller annet søtt*
- Jeg prøver å forhandle så han/hun spiser litt mer av middagen sin*
- Serverer dessert eller annet søtt med en gang*

***Når det kommer til variasjon i kosthold, synes jeg barnet mitt***

- Må spise alt, uansett hva han/hun liker*
- Må spise variert, men hva han/hun liker burde bli tatt hensyn til*
- Kan spise hva han/hun liker, uansett om det ikke er noen variasjon*

***Barnet mitt vil ikke prøve en matrett han/hun ikke har prøvd før***

- Jeg sier at han/hun må smake, han/hun har ikke noe valg*
- Får ham/henne til å smake, for eksempel ved triks*
- Aksepterer at han/hun ikke vil smake*

***Barnet mitt sier at maten som er servert ikke er god***

- Jeg tvinger ham/henne til å smake*
- Jeg kommer med forklaringer, så han/hun vil smake*
- Jeg tilbyr ham/henne noe annet å spise*

***Kryss av for hvor enig du er i påstanden, fra helt enig til helt uenig.***

*Jeg gir barnet mitt det han/hun liker, og bryr meg ikke mye om hvor sunn maten er*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Det er naturlig for meg å velge produkter med redusert saltinnhold til barnet mitt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg unngår å belønne barnet mitt med noe som er godt å spise*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg unngår ikke matvarer til barnet mitt selv om de inneholder mye sukker*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Hvor sunn maten er har liten innflytelse på mitt valg av mat til barnet mitt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

<input type="radio"/>				
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*Jeg tenker ikke over hvor mye sukker barnet mitt får i seg i sitt daglige kosthold*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg belønner barnet mitt med noe som er riktig godt å spise*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg synes det er få sunne matvarer som smaker godt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg er bevisst på saltinnholdet i mat barnet mitt spiser*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg synes det er galt å skjemme bort barn med godterier*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg unner ofte barnet mitt noe ekstra godt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Det er viktig for meg at maten barnet mitt spiser inneholder lite sukker*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Sunnhetsaspektet har lite å si for mitt valg av matvarer til barnet mitt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Smaken er uvesentlig når jeg velger matvarer til barnet mitt*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg tenker ikke over hvor mye salt barnet mitt får i seg i sitt daglige kosthold*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Jeg er veldig opptatt av at barnet mitt spiser sunn mat*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
------------------	-------------	----------------------	--------------	-------------------

<input type="radio"/>				
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

*Barnet mitt er umiddelbart villig til å prøve ny mat*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Barnet mitt liker ikke å få servert ny mat*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Barnet mitt avviser ny mat ved første blick*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Barnet mitt elsker noen matvarer, og avslår tvert andre*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Barnet mitt spiser bare noen få matvarer*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

*Barnet mitt aksepterer en stor variasjon av grønnsaker*

<i>Helt enig</i>	<i>Enig</i>	<i>Hverken eller</i>	<i>Uenig</i>	<i>Helt uenig</i>
<input type="radio"/>				

**Hvilken utdanning har du som fyller ut skjemaet?**

- 9/10-årig grunnskole eller kortere
- Videregående opplæring (Videregående skole/gymnas/fagbrev)
- Høyskole- eller universitetsutdanning på 1-4 år
- Høyskole- eller universitetsutdanning på mer enn 4 år
- Vet ikke/ikke relevant

**Hvilken utdanning har barnets andre foresatte?**

- 9/10-årig grunnskole eller kortere
- Videregående opplæring (Videregående skole/gymnas/fagbrev)
- Høyskole- eller universitetsutdanning på 1-4 år
- Høyskole- eller universitetsutdanning på mer enn 4 år
- Vet ikke/ikke relevant

**Er du som fyller ut spørreskjemaet født i Norge?**

- Ja

Nei - hvor?

**Er barnets andre foresatte født i Norge?**

Ja

Nei - hvor?

*Har du noen tilleggsopplysninger om ditt barn,  
eller bemerkelser om spørreskjemaet?*

---

*Tusen takk for at du og ditt barn deltok i prosjektet!*

*Dette er siste år med prosjektet, og vi setter utrolig stor pris på hjelpen.*

*God sommer!*

*Med vennlig hilsen,*

*Frida Felicia Vennerød*

## **Appendix 3: Questionnaire to Kindergartens**

### **Til pedagogisk leder/avdelingsleder**

Vi takker for at din avdeling/base/gruppe deltar i Barn og Smak-studien, og håper du er villig til å besvare dette spørreskjemaet.

Vi vil gjerne at du besvarer alle spørsmålene. Er det spørsmål du ikke kan eller vil svare på, kan disse stå ubesvart. Som hovedregel skal du svare ved å sette ett kryss for hvert spørsmål eller påstand. Hvis du kan sette flere kryss står det spesifisert.

Ferdig utfylt spørreskjema legges tilbake i konvolutten, og returneres til oss i Barn&smak-prosjektet neste gang vi er i barnehagen.

Hvis du har noen spørsmål om spørreskjemaet, kan du rette dem til [frida.vennerod@nofima.no](mailto:frida.vennerod@nofima.no)

På forhånd, tusen takk for at du tar deg tid til å fylle ut dette skjemaet!

Vi er også veldig glade og takknemlige for at vi får lov til å teste barna i deres barnehage.

Med vennlig hilsen

Frida Felicia Vennerød, stipendiat

Prosjektansvarlig

Barn og Smak



Du vil nå få noen spørsmål om kosthold i barnehagen. Dette er ikke for å kartlegge hva dere spiser i barnehagen, men for å få svar på spørsmål i samsvar med studiens formål.

Hvor ofte har barna medbrakt mat til de følgende måltidene i barnehagen?

Frokost	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Lunsj	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Ettermiddagsmat	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Hvor ofte får barna servert brødmatt til de følgende måltidene i barnehagen?

Frokost	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Lunsj	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Ettermiddagsmat	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Hvor ofte får barna servert varm mat til de følgende måltidene i barnehagen?

Frokost	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					
Lunsj	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					
Ettermiddagsmat	5 dager i uken	4 dager i uken	3 dager i uken	2-1 dager i uken	1-3 ganger per måned	Aldri
	<input type="checkbox"/>					

Når det er bursdager på din avdeling, hva er det da som spises?

Sett ett kryss for hver linje

	Ofte	I blant	Sjelden	Aldri	Vet ikke
Is/kjeks/muffins/gele	<input type="checkbox"/>				
Boller/søt gjærbakst/vafler	<input type="checkbox"/>				
Pølser/pizza	<input type="checkbox"/>				
Frukt/bær, smoothie	<input type="checkbox"/>				
Grønnsaker	<input type="checkbox"/>				
Godteri/sjokolade	<input type="checkbox"/>				
Popcorn	<input type="checkbox"/>				
Annen mat	<input type="checkbox"/>				

Hvor ofte tilbyr din avdeling/base/gruppe følgende frisk frukt/bær og grønnsaker til frokosten?

Sett ett kryss for hver linje

	5 dager i uken	4-3 dager i uken	2-1 i uker i uken	1-3 ganger per måned	Aldri
Bær	<input type="checkbox"/>				
Banan	<input type="checkbox"/>				
Druer	<input type="checkbox"/>				
Eple	<input type="checkbox"/>				
Pære	<input type="checkbox"/>				
Sitrusfrukter	<input type="checkbox"/>				
Mango/ananas	<input type="checkbox"/>				

<b>Annen frukt</b>	<input type="checkbox"/>				
<b>Agurk</b>	<input type="checkbox"/>				
<b>Tomat</b>	<input type="checkbox"/>				
<b>Paprika</b>	<input type="checkbox"/>				
<b>Sukkererter</b>	<input type="checkbox"/>				
<b>Salat</b>	<input type="checkbox"/>				
<b>Gulrot</b>	<input type="checkbox"/>				
<b>Andre grønnsaker</b>	<input type="checkbox"/>				

Hvor ofte tilbyr din avdeling/base/gruppe følgende frisk frukt/bær og grønnsaker til lunsjen?

Sett ett kryss for hver linje

	5 dager i uken	4-3 dager i uken	2-1 i uker i uken	1-3 ganger per måned	Aldri
<b>Bær</b>	<input type="checkbox"/>				
<b>Banan</b>	<input type="checkbox"/>				
<b>Druer</b>	<input type="checkbox"/>				
<b>Eple</b>	<input type="checkbox"/>				
<b>Pære</b>	<input type="checkbox"/>				
<b>Sitrusfrukter</b>	<input type="checkbox"/>				
<b>Mango/ananas</b>	<input type="checkbox"/>				
<b>Annen frukt</b>	<input type="checkbox"/>				
<b>Agurk</b>	<input type="checkbox"/>				
<b>Tomat</b>	<input type="checkbox"/>				
<b>Paprika</b>	<input type="checkbox"/>				
<b>Sukkererter</b>	<input type="checkbox"/>				
<b>Salat</b>	<input type="checkbox"/>				
<b>Gulrot</b>	<input type="checkbox"/>				
<b>Mais</b>	<input type="checkbox"/>				
<b>Brokkoli</b>	<input type="checkbox"/>				
<b>Blomkål</b>	<input type="checkbox"/>				
<b>Kålrot</b>	<input type="checkbox"/>				
<b>Hodekål</b>	<input type="checkbox"/>				
<b>Erter</b>	<input type="checkbox"/>				
<b>Andre grønnsaker</b>	<input type="checkbox"/>				

Hvor ofte tilbyr din avdeling/base/gruppe følgende frisk frukt/bær og grønnsaker til mellommåltider?

Sett ett kryss for hver linje

	5 dager i uken	4-3 dager i uken	2-1 i uker i uken	1-3 ganger per måned	Aldri
<b>Bær</b>	<input type="checkbox"/>				
<b>Banan</b>	<input type="checkbox"/>				
<b>Druer</b>	<input type="checkbox"/>				
<b>Eple</b>	<input type="checkbox"/>				
<b>Pære</b>	<input type="checkbox"/>				

Sitrusfrukter	<input type="checkbox"/>				
Mango/ananas	<input type="checkbox"/>				
Annen frukt	<input type="checkbox"/>				
Agurk	<input type="checkbox"/>				
Tomat	<input type="checkbox"/>				
Paprika	<input type="checkbox"/>				
Sukkererter	<input type="checkbox"/>				
Salat	<input type="checkbox"/>				
Gulrot	<input type="checkbox"/>				
Mais	<input type="checkbox"/>				
Brokkoli	<input type="checkbox"/>				
Blomkål	<input type="checkbox"/>				
Kålrot	<input type="checkbox"/>				
Hodekål	<input type="checkbox"/>				
Erter	<input type="checkbox"/>				
Andre grønsaker	<input type="checkbox"/>				

### I hvilken grad..?

Sett ett kryss for hver linje

... mener du at barnehagen har et ansvar for å bidra til at barna i barnehagen innarbeider gode mat-

I svært liten grad	I liten grad	Hverken eller	I stor grad	I svært stor grad
<input type="checkbox"/>				

... mener du at det er behov for å forbedre praksis rundt måltider, mat og drikke i din

I svært liten grad	I liten grad	Hverken eller	I stor grad	I svært stor grad
<input type="checkbox"/>				

... føler du deg trygg i å veilede de ansatte i hva som er et sunt kosthold for barna i

I svært liten grad	I liten grad	Hverken eller	I stor grad	I svært stor grad
<input type="checkbox"/>				

... mener du det er viktig for deg som pedagogisk leder å kunne veilede de ansatte i hva som er et sunt kosthold for

I svært liten grad	I liten grad	Hverken eller	I stor grad	I svært stor grad
<input type="checkbox"/>				

Noen faktorer kan hindre dere i handle inn eller servere grønnsaker i barnehagen. Hvor enig eller uenig er du i at følgende forhold påvirker hvorvidt det kjøpes inn/brukes grønnsaker i barnehagen?

	Helt uenig	Litt uenig	Hverken uenig eller enig	Litt enig	Helt enig
<b>Grønnsaker er for dyre</b>	<input type="checkbox"/>				
<b>Grønnsaker ser ikke ferske ut i butikken</b>	<input type="checkbox"/>				
<b>Grønnsaker blir fort dårlig ved lagring</b>	<input type="checkbox"/>				
<b>Det er for tidkrevende å bruke grønnsaker</b>	<input type="checkbox"/>				
<b>Det er vanskelig å bruke grønnsaker</b>	<input type="checkbox"/>				

**Hvor enig eller uenig er du i følgende påstander?**

*Sett ett kryss for hver linje*

	Helt uenig	Litt uenig	Hverken uenig eller enig	Litt enig	Helt enig
<b>Jeg er et forbilde for barna ved selv å spise grønnsaker</b>	<input type="checkbox"/>				
<b>Jeg prøver å spise ekstra mye grønnsaker når jeg er sammen med barna</b>	<input type="checkbox"/>				
<b>Jeg prøver å vise entusiasme når jeg spiser grønnsaker</b>	<input type="checkbox"/>				
<b>Jeg lar barna delta i å tilberede</b>	<input type="checkbox"/>				

<b>grønnsaker som skal serveres</b>					
<b>Når jeg gir barna grønnsaker må de spise opp hele porsjonen</b>	<input type="checkbox"/>				
<b>Jeg er streng på at barna må spise opp grønnsaker</b>	<input type="checkbox"/>				

### Hvor enig eller uenig er du i følgende påstand?

Sett ett kryss for hver linje

	Helt uenig	Litt uenig	Hverken uenig eller enig	Litt enig	Helt enig
<b>Vi spiser vanligvis grønnsaker til varm mat</b>	<input type="checkbox"/>				
<b>Vi varierer type grønnsaker som serveres</b>	<input type="checkbox"/>				
<b>Vi varierer tilberedningen av grønnsaker</b>	<input type="checkbox"/>				
<b>Jeg minner barna på å spise grønnsaker i løpet av måltidet</b>	<input type="checkbox"/>				
<b>Vi kutter opp grønnsaker barna kan spise mellom måltidene</b>	<input type="checkbox"/>				
<b>Vi inkluderer grønnsaker i de fleste måltidene</b>	<input type="checkbox"/>				

### Hvor enig eller uenig er du i følgende påstand?

Sett ett kryss for hver linje

	Helt uenig	Litt uenig	Hverken uenig eller enig	Litt enig	Helt enig
<b>Jeg forteller barna om hvilke grønnsaker vi skal spise</b>	<input type="checkbox"/>				

Jeg beskriver smaken på nye grønnsaker for barna	<input type="checkbox"/>				
Jeg sier til barna at de må være like flinke som andre til å spise grønnsaker	<input type="checkbox"/>				
Jeg lover barna andre typer mat de liker mot å spise grønnsaker	<input type="checkbox"/>				
Jeg oppmuntrer barna til å spise grønnsaker for å bli sterke ol.	<input type="checkbox"/>				
Jeg skryter av barna når jeg ser at de spiser grønnsaker	<input type="checkbox"/>				
Jeg forteller barna at grønnsaker smaker godt	<input type="checkbox"/>				
Jeg oppmuntrer barna til å prøve et par biter av en grønnsak	<input type="checkbox"/>				
Jeg gir barna grønnsaker de liker	<input type="checkbox"/>				
Jeg spør barna om hjelp til å velge grønnsaker	<input type="checkbox"/>				

**Hvor ofte er barna med i tilberedning av grønnsaker?**

- Daglig
- Ukentlig
- Månedlig
- Aldri/sjelden

**Hva beskriver best det du vanligvis gjør under måltider i barnehagen?**

- 
- Går inn og ut av rommet
- Er i rommet, men sitter ikke ved bordet
- Sitter ved bordet sammen med barna i deler av måltidet
- Sitter ved bordet sammen med barna i den største delen av måltidet

**Til de måltider barnehagen serverer mat, hva beskriver best det du vanligvis spiser?**

- 
- Spiser det samme som barna
- Spiser annen mat enn barna
- Spiser ikke sammen med barn

**Har du noen kommentarer eller tilleggsopplysninger?**

**Tusen takk for at dere deltar i prosjektet!  
Vi sees igjen til neste år - god sommer!**

**Hilsen alle oss på Barn og Smak-prosjektet**



Harald Hårfagres gate 29  
N-5007 Bergen  
Norway  
Tel: +47-55 58 21 17  
Fax: +47-55 58 96 50  
nsd@nsd.uib.no  
www.nsd.uib.no  
Org.nr. 985 321 884

## Appendix 4: Approval from NSD

Frida Vennerød  
Nofima AS  
Osloveien 1  
1430 ÅS

Vår dato: 06.01.2015

Vår ref: 41293 / 3 / JSL

Deres dato:

Deres ref:

### TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 18.12.2014. Meldingen gjelder prosjektet:

41293 *Utviklingen av grunnsmakspreferanser*

*Behandlingsansvarlig* *Nofima, ved institusjonens øverste*

*Daglig ansvarlig* *Frida Vennerød*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, <http://www.nsd.uib.no/personvern/meldeplikt/skjema.html>. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, <http://pvo.nsd.no/prosjekt>.

Personvernombudet vil ved prosjektets avslutning, 31.12.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen  
Katrine Utaaker Segadal

Juni Skjold Lexau

Kontaktperson: Juni Skjold Lexau tlf: 55 58 36 01

Vedlegg: Prosjektvurdering

*Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.*

*Avdelingskontorer / District Offices:*

*OSLO:* NSD, Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. [nsd@uio.no](mailto:nsd@uio.no)

*TRONDHEIM:* NSD, Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim. Tel: +47-73 59 19 07. [kyrre.svarva@svt.ntnu.no](mailto:kyrre.svarva@svt.ntnu.no)

*TROMSØ:* NSD, SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. [nsdmaa@sv.uit.no](mailto:nsdmaa@sv.uit.no)



Formålet med prosjektet er å utforske utviklingen av grunnsmakspreferanser hos 4-6 åringer med et tre-årig longitudinelt studie. Alle fem basal smaker (søtt, surt, salt, umami og bittert) ønskes undersøkt. Studien ønsker å kartlegge hvordan barns preferanser for grunnsmakene utvikler seg. Utviklingen vil sees i lys av hvordan barnas sensorisk sensitivitet for grunnsmakene forandrer seg. I tillegg vil barnets matvaner og matmiljø kartlegges, for å undersøke hvordan dette påvirker både preferanse og sensorisk sensitivitet. Formålet med prosjektet er altså å bedre forstå både hvordan preferanser for grunnsmakene utvikler seg, og også hva som påvirker denne utviklingen.

Vi legger til grunn at forsker har gjort en vurdering av om prosjektet burde vært meldt til REK. Hvis det vurderes slik at prosjektet har som formål å finne "ny kunnskap om helse eller sykdom" skal prosjektet sendes for vurdering til REK. Hvis REK vurderer prosjektet til å falle innenfor helseforskningsloven, kan dere se bort fra vår vurdering.

Barnas foreldre informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er godt utformet. Vi ber likevel om at følgende endres/tilføyes:

- Setningen endres som følger: "Ditt barn INVITERES TIL Å få smake på...." (dette for å understreke at det er frivillig).
- Legg til informasjon som klargjør at dere ikke vil tvinge barn som ikke ønsker å smake eller ikke ønsker å delta, og at dere vil være oppmerksom på slike signaler fra barnet.
- Legg til mer informasjon om hvor mange ganger dere vil besøke barnehagen for testing. Det kan med fordel også legges til litt informasjon om at dere vil benytte en eventyrfortelling som ramme for barnas smakstesting. Hvis det ikke er metodiske grunner til å la være, bør dere legge ved dokumentet som beskriver opplegget, slik at foreldrene er klar over hva de samtykker til på vegne av barnet.

Revidert informasjonsskriv skal sendes til [personvernombudet@nsd.uib.no](mailto:personvernombudet@nsd.uib.no) før utvalget kontaktes.

Det behandles sensitive personopplysninger om helseforhold.

Personvernombudet legger til grunn at forsker etterfølger Nofima AS sine interne rutiner for datasikkerhet. Dersom personopplysninger skal sendes elektronisk eller lagres på mobile enheter, bør opplysningene krypteres tilstrekkelig.

Forventet prosjektslutt er 31.12.2017. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:

- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)