INDIVIDUAL DIFFERENCES IN THE DEVELOPMENT OF GIRLS’ FOOD PREFERENCES ACROSS MIDDLE CHILDHOOD:

TRACKING OF FOOD PREFERENCES, AND THE RELATION BETWEEN FOOD PREFERENCES, ENERGY DENSITY, AND FOOD INTAKE

A Thesis in
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ABSTRACT

**Background:** To date, there is limited research on the study of children’s food preferences using validated measures. Few studies have examined the longitudinal tracking of food preferences and whether energy density is predictive of food preferences in childhood. Only Birch (1979b) has demonstrated that food preferences predict intake in young children using a valid measure of preference, and it is unknown how this relationship changes as children age or whether individual differences emerge with age.

**Objective:** The aims were to 1) examine the tracking of food preferences between ages 5 and 11; 2) assess whether energy density predicts food preferences in childhood; 3) replicate Birch’s (1979b) original finding that preferences predict intake in children; 4) assess the longitudinal change in the preference-intake relationship between ages 5 and 11; and 5) identify individual differences in how the preference-intake relationship changes over time.

**Methods:** Subjects include 197 girls from the Girls’ Needs Study. Girls’ preferences and intake of 10 palatable snack foods were obtained at ages 5, 7, 9 and 11 during a behavioral protocol designed to measure Eating in the Absence of Hunger (EAH; Fisher & Birch, 1999a; Fisher & Birch, 1999c). Girls’ heights and weight were measured and used to calculate BMI z-scores according to CDC 2000 guidelines, dietary restraint was assessed using the Dutch Eating Behavior Questionnaire, and EAH total caloric intake, a measure of disinhibited overeating, was assessed.

**Results:** Average correlation coefficients for the sample indicated that food preferences at age 5 predicted preferences at ages 7 (mean r=34), 9 (mean r=.32), and 11 (mean r=.26). However, energy density did not predict girls’ food preferences at any age. To identify the average predictive relationship between preference and intake, polyserial correlations between
preference rankings and intake were performed separately for each girl. Average preference-intake correlation coefficients (P-ICCs) were $r=.33$, $r=.43$, $r=.52$, and $r=.45$ at ages 5, 7, 9, and 11, respectively. A Repeated Measures ANOVA revealed that the average P-ICC significantly increased over time ($r=.33$ to $r=.43$) and followed a curvilinear shape, peaking at age 9 ($r=.52$). A latent profile analysis revealed three patterns of change in the preference-intake relationship between ages 5 and 11: 1) preferences are consistently significant predictors of intake at all ages (mean $r$ range: .37 to .55); 2) preferences are significant and increasing predictors of intake from 5 (mean $r=.21$) and 9 y (mean $r=.48$), but decline to non-significance at 11 (mean $r=-.05$); 3) preferences are nonsignificant predictors of intake between ages 5 and 9 (mean $r$ range: .07 to .14), but become significant predictors at age 11 (mean $r=.61$). Girls following pattern 2 had higher BMI z-scores and greater increases in dietary restraint over time than girls following patterns 1 and 3.

**Conclusion:** Our findings demonstrate that food preferences track across middle childhood. There was no evidence that, at least for these foods, preferences were predicted by energy density. On average, children’s food preferences predicted intake across middle childhood and became a better predictor over time; however, there were individual differences in this relationship. For most girls, food preferences were a strong predictor of intake throughout childhood; whereas, for some girls, preferences no longer predicted intake as they entered preadolescence. Compared to the former, the latter group was heavier and had greater increases in dietary restraint and EAH in childhood.
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Chapter 1

Introduction

The sense of taste and smell enables humans to navigate their food environment and identify safe, nutritious foods to eat (Galef Jr, 1981). It is evolutionarily adaptive for humans to develop preferences for these safe foods, as well as for foods that are energy-dense and widely available, and aversions to foods that cause illness or nausea (Rozin & Vollmecke, 1986). Humans are predisposed to prefer sweet tastes but dislike bitter tastes which tend to be found in toxic plants and foods. However, because humans have few innate taste predispositions and must learn about foods through tasting them, they are highly dependent on social learning to reduce the costs associated with ingesting new, potentially dangerous foods (Galef Jr, 1981; Rozin & Vollmecke, 1986). Early childhood is a distinctive period when humans learn about the foods in their environment (Cashdan, 1994; Mennella, Griffin, & Beauchamp, 2004). From infancy, children are exposed to a variety of foods and they learn what these foods taste like, and when and how they should be eaten (Birch & Fisher, 1998). Within the context of these experiences and human’s flavor predispositions, food preferences emerge. Such plasticity in food preference development allows humans to alter their predispositions, for example, to come to accept or prefer initially rejected flavors (e.g. bitter) and develop aversions to foods associated with nausea or illness (Galef Jr, 1981; Rozin, 1979).

The first aim of the current review is to discuss how predispositions and the environment work in concert to influence the development of food preferences during infancy and childhood. Social learning plays a role in the ontogeny of food preferences; thus, the bulk of the review is devoted to discussing three learning modalities: familiarization/repeated exposure, associative
learning, and modeling. The second aim is to summarize current findings on the relationship between children’s food preferences and adiposity. The third aim is to discuss the long-term stability of food preferences acquired in early childhood, and the final aim is to discuss issues related to the measurement of children’s food preferences.

**Food Preference: A Definition**

Put simply, a food preference is the choice of one food over another (Rozin, 1979; Rozin & Vollmecke, 1986; Young, 1977). Although a preferred food is generally the most liked, individuals may prefer a food because it is more convenient, healthy, or has positive social consequences (Drewnowski, 1997; Furst, Connors, Bisogni, Sobal, & Falk, 1996; Rozin, 1979). Instead, liking is a part of a paradigm called hedonic affect, which is a set of reactions to tasting a particular food (ranging from like to dislike). Hedonic affect describes the amount of pleasure stimulated by eating a food (Galef Jr, 1981; Young, 1977) and is visually expressed by facial expressions in infants and children (e.g. a smile; Rozin, 1979). Likewise, preference doesn’t equal consumption (Rozin, 1979; Rozin & Vollmecke, 1986). Many factors other than preference can influence the relation between preference and intake, such as social consequences, whereby a child may prefer soda to juice but chose juice because all her friends selected juice (e.g. Hollinger & Roberts, 1929). In general, however, children’s food preferences are a strong predictor of consumption (L. Birch, 1979b), presumably because children are less concerned with external factors such as healthiness or cost.
Epigenetic Theory

Consistent with Gottlieb’s theory of individual development, food preferences emerge through the coaction of the organism and environment—a process referred to as epigenesis. Specifically, Gottlieb (1992) defined epigenesis as,

"individual development [that] is characterized by an increase of complexity of an organism—i.e., the emergence of new structural and functional properties and competencies—at all levels of analysis (molecular, subcellular, cellular, and organismic) as a consequence of horizontal and vertical coactions among its parts, including organism-environment coactions. (p.159-60)

According to epigenetic theory, development is self-organizing and through this process, new patterns of behavior or neo-phenotypes emerge (Kuo, 1967). Along these lines, food preferences emerge through the interaction of the system’s constituents (e.g. genes, biology, etc.) and the environment, and when behaviorally expressed, reciprocally influence the system and environment. This theory is useful in describing human behavior and will be used to frame our discussion of the early ontogeny of human food preferences.

Genetic Predispositions and Postnatal Sensory Development

Humans are predisposed to prefer flavors that are sweet and salty, and dislike those that are bitter and sour (Desor, Maller, & Andrews, 1975; Nisbett & Gurwitz, 1970; Tatzer, Schubert, Timischl, & Simbruner, 1985). Sweet foods naturally contain calories due to their carbohydrate content, making sweet tastes highly adaptive for humans to prefer (Desor, Maller, & Turner, 1973; Galef Jr, 1981; Young, 1977). Similarly, it has been hypothesized that humans innately dislike bitter tastes because this flavor is present in many poisonous plants and foods (Young,
Human newborns also demonstrate an aversion to sour flavors (Desor, Maller et al., 1975). At birth, humans are indifferent to salty flavors despite their physiological need to regulate sodium balance (Desor, Maller et al., 1975). However, a developmental shift occurs at ~4 months such that a preference for salt emerges (Beauchamp, Cowart, Mennella, & Marsh, 1994; Beauchamp, Cowart, & Moran, 1986). It is likely that postnatal neurobiological development in chemical sensory perception causes this shift in salt preference (D. L. Hill & Mistretta, 1990). Postnatal development may also explain the difference in sour, salt, and sweet preference between children and adults, whereby the former displays a greater preference for all three flavors compared to the latter (Desor, Greene, & Maller, 1975; Liem & Mennella, 2003).

Humans are genetically predisposed to reject novel foods, a behavior referred to as food neophobia (Rozin, 1976). Food neophobia is defined as the avoidance of new foods and can include dimensions of disgust (e.g. feces), or fear of danger (e.g. a toxin) and dislike (e.g. unpalatable taste) (Rozin, 1979). Humans must learn which novel foods are safe to eat, thus the initial reaction is to reject or avoid new foods until it is learned that the food is not harmful, a process also referred to as “learned safety” (Kalat & Rozin, 1973). Humans experience very little neophobia in infancy and readily accept new foods until around age 2, when they become increasingly neophobic (see Cooke, 2007); however, neophobia does dissipate with age (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987). Due to infant’s minimal neophobic reactions, many researchers consider infancy a sensitive period for food preferences development (Cashdan, 1994; Mennella & Beauchamp, 2002; Mennella et al., 2004). It is highly adaptive for a sensitive period to occur during infancy—a time when there is low risk for trying new foods because parents are the exclusive food source (Cashdan, 1994). By the end of the second year, children are mobile and must decide what and what not to put in their mouths. It is thought that at this age, neophobia protects children from ingesting possibly toxic foods and substances (Cashdan, 1994; Pliner & Hobden, 1992).
Despite the previously described predispositions, food preferences emerge in human development from the coactions of genetic, biological, and environmental factors (Rozin & Vollmecke, 1986). It is in the presence of these factors that a learning process takes place. For example, previous dietary experiences have been shown to influence infants’ innate preference for sweet flavors (Beauchamp & Moran, 1982). In this study, infants’ preference for a sucrose-sweetened solution was tested at birth and 6-months. At birth, all infants had a high preference for the sucrose solution; however, at 6 months, only infants routinely fed sweetened water by their mothers maintained a high preference for the sucrose solution. Infants who were not fed sweetened water had a decreased preference for the sucrose solution. Thus, through interacting with their environment, infants learned about the sweet flavors of their context and such learning elicited changes in their preferences. Because learning is salient in the ontogeny of food preferences, we will now focus on three modalities of learning: familiarization/repeated exposure, associative learning, and modeling.

**Familiarization or Repeated Exposure**

“Learning is itself a process of the new becoming familiar for, in acquiring familiarity, novelty is being dissipated and rendered familiar” (p. 2, Rheingold, 1985). Through the process of repeated exposure, unfamiliar foods become familiar and children acquire preferences for the familiar. In childhood, familiarity is a salient dimension of food preferences for novel foods (Birch et al., 1987; Pliner & Stallberg-White, 2000). An extensive body of work demonstrates that repeated exposure increases preferences for novel and familiar foods in both infancy and childhood. The aim of the current section is to summarize this literature using an epigenetic perspective. Special focus will be given to discussing biological and developmental factors that may moderate the influence of repeated exposure on food preference development.
Humans first learn about the foods in their environment via their mother’s diet. Similar to other omnivores (Contreras & Ryan, 1990; Hepper, 1988), the human maternal diet flavors her amniotic fluid (Mennella, Johnson, & Beauchamp, 1995) and breastmilk (Mennella & Beauchamp, 1991a, 1991b, 1993). This creates a rich learning environment where humans learn about, and eventually accept and prefer the flavors of the diet of their culture (Mennella et al., 2004). Researchers have referred to perinatal and infant development as a sensitive period when humans undergo intensive flavor programming to familiarize themselves with the safe and nutrient-appropriate foods in their environments (Cashdan, 1994; Mennella & Beauchamp, 2002; Mennella et al., 2004). An experimental study by Mennella and colleagues (2001) provides support for this hypothesis. Pregnant women were assigned to three conditions where they were asked to consume carrot juice daily either 1) during their third trimester, 2) during the first 3 weeks postpartum, or 3) not at all. At weaning (i.e. 5-6 months of age), mothers in the first and second conditions had infants who preferred carrot-flavored cereal compared to infants in the third condition. Other studies examining the impact of breast milk flavors on infants’ food preferences at weaning have corroborated these findings (Forestell & Mennella, 2007; Mennella & Beauchamp, 1997).

Likewise, repeated exposure to novel solid foods increases preferences in infants and young children. In an early study, Sullivan and Birch (1994) found that 10 exposures to two novel green vegetables increased infants’ preference for these foods. Similar findings have been reported in more recent studies with infants (Forestell & Mennella, 2007; Gerrish & Mennella, 2001; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007), preschool children (Wardle, Cooke et al., 2003), and preadolescents (Liem & de Graaf, 2004; Pliner & Stallberg-White, 2000). In addition, Maier et al. (2007) found that ~9 months following an 8-exposure experimental trial, 63% of the infants still preferred the initially disliked vegetable. Several studies suggest that the effect of repeated exposure generalizes to similar foods. Gerrish and
Mennella (2001) reported that infants fed a rotation diet of pureed peas, potatoes, and squash once per day for 8 days, showed greater preference for a novel vegetable (i.e. carrots) compared to infants exposed only to potatoes. While these results have not been replicated, there is evidence that variety does increase acceptance and intake of similar novel foods in both infants (Birch, Gunder, Grimm-Thomas, & Laing, 1998; Mennella, Nicklaus, Jagolino, & Yourshaw, 2008) and rats (Braveman & Jarvis, 1978).

A few studies have reported null findings for the effect of repeated exposure. Newman and Taylor (1992), and Birch (1979a) reported no change in preferences after young children were exposed to a familiar food only one time and novel food seven times. However, given the findings from previous studies and as these authors acknowledge, a longer exposure period may have been needed. This may be the case for neophobic preschool children and foods with flavors that humans innately dislike such as bitter and sour.

Along these lines, researchers hypothesize that flavor type (e.g. sweet, bitter) moderates the effect of repeated exposure on food preferences (Cooke, 2007; Liem & de Graaf, 2004; Mennella et al., 2008). Because children are predisposed to prefer sweet and salty foods, fewer exposures may be required to induce a preference; whereas, more exposures may be needed for bitter and sour foods. A recent study provides support for this hypothesis. In a laboratory trial, 4 to7-year-old children were split into 2 conditions where they were repeatedly exposed to either a sour or sweet orangeade drink. After 8 exposures, preference for the sweet drink increased whereas no change was observed for the sour drink (Liem & de Graaf, 2004). These findings suggest that a longer exposure length is needed for sour foods; however, it is not clear how many exposures are needed. For bitter tasting foods, research findings suggest 14 exposures is enough to elicit positive changes in preschool children’s preferences (Wardle, Cooke et al., 2003), whereas shorter exposure periods (e.g. 8-10 times) are needed in infancy (Forestell & Mennella, 2007; Maier et al., 2007; S. A. Sullivan & Birch, 1994).
In addition, due to the developmental shift in neophobia that occurs in early childhood, repeated exposure may have a greater impact on food preferences during infancy (Cooke, 2007). It is evolutionary adaptive for familiarization to be more effective during infancy because as food neophobia increases, children are less open to tasting novel foods (Birch et al., 1998). For example, ten or fewer exposures have been shown to increase infant’s preferences (Forestell & Mennella, 2007; Maier et al., 2007; S. A. Sullivan & Birch, 1994); whereas, studies have reported inconsistent findings with a similar exposure length in preschool children (L. Birch, 1979a; Birch & Marlin, 1982; Liem & de Graaf, 2004). Studies in older children that report significant results tend to employ longer exposure lengths. For example, 14 and 20 exposures were used to increase children’s preference for a vegetable (Wardle, Cooke et al., 2003) and novel food (Pliner & Stallberg-White, 2000), respectively. In congruence, Galef and Kennett (1987) found that the effect of familiarization on food preferences was stronger in younger rats than older rats. However, more human research is needed to empirical investigate whether the effect of familiarization changes developmentally.

**Associative Learning**

Associative learning is the process by which a neutral stimulus (conditioned stimulus, CS+; e.g. green beans) is paired with a meaningful stimulus (unconditioned stimulus, CS-; e.g. butter or oil), and the valence from the latter becomes associated with the former even after the latter is no longer present (Bolles, Hayward, & Crandall, 1981; De Houwer, Thomas, & Baeyens, 2001; Elizalde & Sclafani, 1988, 1990). In the case of food preferences, associative learning occurs in response to environmental factors, social contexts, post-ingestive consequences, and food characteristics such as flavor. These forms of associative learning are particularly robust against short-term extinction (De Houwer et al., 2001; Drucker, Ackroff, & Sclafani, 1994;
Elizalde & Sclafani, 1990; Garcia, Kimeldorf, & Koelling, 1955) and thus may cause long-term changes in food preferences. The current section discusses how associative learning influences children’s food preference development from an epigenetic viewpoint. Specifically, associative learning in response to environmental factors (e.g. parental feeding strategies), and in the form of flavor-flavor conditioning, nutrient-flavor conditioning, and aversion learning will be reviewed.

In the home food environment, parents employ controlling feeding strategies like food reward or restriction because they feel that these practices will increase their children’s intake of nutritious foods (Casey & Rozin, 1989; Orrell-Valente et al., 2007); however, these methods can have unexpected effects on children’s food preferences (Birch & Fisher, 1998). For instance, many parents reward children’s consumption of a less preferred food with a desired food (e.g. “If you eat your peas, then you can have ice cream”) (Casey & Rozin, 1989; Tucker, Irwin, He, Bouck, & Pollett, 2006). Because the desired food is presented as a reward or prize, it acquires a positive valance and subsequently becomes preferred (Birch, Zimmerman, & Hind, 1980). In contrast, the less preferred food is presented in a negative context where the child must eat the food (i.e. an instrument) to obtain the reward and thus acquires a negative valence. As a result, preference decreases for the less preferred food (Birch, Birch, Marlin, & Kramer, 1982; Newman & Taylor, 1992; Wardle, Herrera, Cooke, & Gibson, 2003). Similarly, children's preference increases when foods are presented in positive contexts such as when paired with adult attention and verbal praise (Birch, Marlin, & Rotter, 1984; Birch et al., 1980), and may decrease when presented in a negative context such as being labeled nutritious or “healthy” (Murphy, Youatt, Hoerr, Sawyer, & Andrews, 1995).

It remains unclear in the literature how innate predispositions and associative learning interact. For instance, because children are predisposed to prefer sweet and dislike bitter flavors, using a sweet food as a reward is probably more effective than a vegetable. However, more research is needed.
Flavor-flavor conditioning is the association of a neutral flavor with a disliked or preferred flavor (e.g. sweet) that results in a change in preference for the former in the direction of the latter (Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Rozin & Zellner, 1985). To date, only Havermans and Jansen (2007) have investigated the effect of flavor-flavor conditioning on food preferences in children. In this study, children were asked to taste two vegetable purees--sweetened or non-sweetened--in six conditioning trials. Following the conditioning, children were presented with non-sweetened versions of the two vegetable purees and asked to rank-order them according to preference. Children showed greater preference for the vegetable that was previously sweetened compared to the vegetable that was not previously sweetened. Consistent findings have also been reported in adults (Baeyens, Crombez, Hendrickx, & Eelen, 1995; Zellner, Rozin, Aron, & Kulish, 1983).

Flavor-nutrient conditioning occurs when high-calorie macronutrients (e.g. fat, carbohydrates) are paired with a neutral-valance food, and the positive post-ingestive consequences caused by the former become associated with the flavor of the latter (Bolles et al., 1981; Elizalde & Sclafani, 1988; Rozin & Zellner, 1985). As a result, preference for the neutral food increases. In an experimental study, for instance, Birch and colleagues (1990) repeatedly exposed 3- to 5-year-old children to high- and low-calorie versions of two novel drinks, which differed in the amount of carbohydrate. After 8 conditioning sessions over a 4-week period, children’s preference significantly increased for the high-calorie drinks, whereas no change was observed for the low-calorie drinks. Consistent findings have been reported when fat was used instead of carbohydrate (Johnson, McPhee, & Birch, 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993) and in rats (Bolles et al., 1981; Drucker, Ackroff, & Sclafani, 1994; Elizalde & Sclafani, 1988, 1990; Sclafani, 1991; see Young, 1948), and the effect of calorie density on preference may be stronger when hungry (Drucker et al., 1994; Kern et al., 1993). In addition, a recent cross-sectional study found that children liked energy-dense fruits and vegetables (e.g.
banana, on-fried potatoes) more than low energy-dense fruits and vegetables (e.g. melon, cabbage), after adjusting for sugar content. Because children require significant amounts of energy for normal development, this type of associative learning is very adaptive (Birch, 1992).

Along these lines, negative post-ingestive consequences, such as illness or nausea, have been associated with decreases in preference (A. W. Logue, Ophir, & Strauss, 1981), a process termed aversion learning. Specifically, aversion learning occurs when consumption of a food item is followed by illness or nausea, the food item becomes associated with the illness, and the food item is avoided in the future (Bernstein, 1994; J. Garcia, Ervin, & Koelling, 1966; John Garcia & Kimeldorf, 1957; J. Garcia et al., 1955; Kimeldorf, Garcia, & Rubadeau, 1960; A.W. Logue, 1985; Young, 1977). In a rare study, for example, an experimental group of children were offered novel ice cream prior to receiving chemotherapy, whereas a control group was not offered the ice cream prior to chemotherapy. Two weeks following the treatment, all the children were offered the same novel again and former group were less likely to select it again compared to the control (21% vs. 67%) (Bernstein, 1978). Findings from human and animal work suggest that learned aversions are prevalent and long-lasting (A.W. Logue, 1985), more likely to be caused by novel foods (Bernstein, 1978; Braveman & Jarvis, 1978; Revusky & Bedarf, 1967), and serve an adaptive function of preventing future consumption of harmful foods (A.W. Logue, 1985). Developmentally, it is not clear how early in life aversions are able to form; however, animal studies suggest that they can form in infancy (A.W. Logue, 1985; R. M. Sullivan, Landers, Yeaman, & Wilson, 2000).

**Modeling**

According to Bandura’s social cognitive theory, modeling is a process of observational learning in which the behavior of an individual stimulates the same behavior in another individual
Individuals are more likely to copy another's behavior when that person is similar to themselves (e.g. age, gender, race). Observational learning serves as a way to communicate information about novel and familiar objects (e.g. whether they are safe) and situations (Galef & Girardetteau, 2001). This makes modeling salient in human food preference development; although it is not clear at what age children begin to learn via the modeling of food choices. Through observing adults and peers, children learn which foods are safe as well as the appropriate contexts for consuming these foods. Modeling provides children with the opportunity to become familiar with foods, consume them on a regular basis, and develop preferences for them. The current section discusses the impact of both parent/adult and peer modeling on children’s food preferences.

Most adults agree that parental modeling influences children’s preferences (Casey & Rozin, 1989; Cullen, Baranowski, Rittenberry, & Olvera, 2000). This view is in contrast to strong evidence that parent’s and children’s preferences are only weakly related (Birch, 1980b; Cullen et al., 2001; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Galloway, Fiorito, Lee, & Birch, 2005; Skinner, Carruth, Wendy, & Ziegler, 2002). In fact, there is little empirical evidence to suggest that watching a parent or adult consume a food significantly impacts children’s preferences. For example, an early study found that watching a familiar adult choose a preferred food had no effect on which food a child selected as their most liked (Duncker, 1938). Whether a significant result would have been observed with a parent model is unknown. In a later study, Jansen and Tenny (2001) found that the effect of flavor-nutrient conditioning on children’s preferences was strongest when it was paired with parent modeling and teacher verbal praise. However, it cannot be determined whether the modeling, verbal praise, or both caused the change in preferences. It is also worth noting that several studies have investigated the effect of adult and parent models on children’s acceptance and intake of novel and familiar foods. These studies report a positive effect of both adult and parent modeling (Addessi, Galloway, Visalbergh, &
Birch, 2005; Harper & Sanders, 1975; Hendy & Raudenbush, 2000), suggesting that these models do potentially impact children’s preferences. Together, these studies suggest that parent and adult models may have an impact on children’s preferences; however, current findings are inconclusive and further study is warranted.

Based on social cognitive theory, children are more likely to model the behaviors of individuals who are similar to themselves (i.e. age, gender, race) (Bandura, 1997). For example, in a classroom-based study, preschoolers were exposed to 4 consecutive days of peer modeling (Birch, 1980a). The study was designed so that at each table, one targeted child who strongly preferred vegetable A over B was seated with 3-4 other children who preferred vegetable B over A. Nine weeks following the experiment, the targeted child's preference had increased for the initially disliked vegetable (i.e. B). Similar findings have been reported elsewhere for familiar (Duncker, 1938; Marinho, 1942) and novel foods (Hendy, 2002) in children, and for novel foods in rats (B. G. Galef, 1993; B. G. Galef, Jr., 1989; Valsecchi & Galef Jr, 1989). In addition, Marinho (1942) reported that increased preferences were stable 4 weeks post-experiment, and 1 year later for children who displayed a neutral initial preference for the targeted food. Together, these findings suggest that peer models induce both short-term and long-term changes in children's preferences.

In addition, several studies have examined whether age, gender, and personality of the observer and modeler moderates the effect of peer modeling on food preferences. For instance, the food preferences of younger observers were more influenced by peer modeling than older observers (Birch, 1980a), and all children were more influenced when the modeler was an older peer (Duncker, 1938). However, a later study reported no age effects (Hendy, 2002). Contrary to social cognitive theory, one study found that same-sex modeling was no different than opposite-sex modeling in changing preferences (Hendy, 2002). In fact, girls were more effective models, regardless of the observer's gender. The authors hypothesized that girls were more cooperative
and friendly as models compared to boys, and thus created a more positive context for food learning. This is consistent with Marinho's (1942) finding that children who were more friendly and amusing made better peer models than children who used force and teasing. In addition, Hendy (2002) found that girls' preferences were more influenced by peer modeling than teacher modeling compared to boys, whose preferences did not change in response to peer or teacher modeling. However, Birch (1980a) found no moderating effects of gender, thus more research is warranted. Taken together, peer modeling may be more effective in changing food preferences when the observer is young and modeler is older, friendly, and cooperative.

Although discussed separately, it is likely that repeated exposure, associative learning, and modeling co-occur in children's food environments. For instance, parents use multiple feeding strategies to influence children's food choices and intake ranging from modeling, pressure to eat, parental restriction, and simple exposure (Casey & Rozin, 1989). It is reasonable to presume that using multiple learning modalities is more effective in changing children's food preferences; however, very little research has tested this hypothesis. Most studies to date have focused on one learning modality. In a rare multimodal study, Jansen and Tenny (2001) examined the effect of pairing flavor-nutrient conditioning with teacher attention and parental modeling on children's preference for a sweetened drink. Preference increased only when flavor-nutrient conditioning, teacher attention, and parental modeling were used in combination compared to when they were used alone.

Another influential feature of the home environment is the television. On average, young children watch 2 hours a television a day (Christakis, Ebel, Rivara, & Zimmerman, 2004), are exposed to 20,000 – 40,000 television commercials annually (Strasburger, 2001), and 90% of food commercials advertise products that are high in fat, sugar, and sodium (Batada, Seitz, Wootan, & Story, 2008; Folta, Goldberg, Economos, Bell, & Meltzer, 2006; Kotz & Story, 1994). Television programs and food advertisements use a variety of learning approaches to impact
children's food choices including fun and exuberant peer models and action heroes, social appealing settings, and up-beat music; overall, creating a positive experience (Folta et al., 2006; Goldberg, Gorn, & Gibson, 1978; Tseng, 2001). Several experimental studies demonstrate that after viewing commercials and programs displaying food products, children express greater preference for the advertised foods compared to non-advertised foods (Borzekowski & Robinson, 2001; Boyland, Harrold, Kirkham, & Halford, 2008; Dixon, Scully, Wakefield, White, & Crawford, 2007; Goldberg et al., 1978; Stoneman & Brody, 1981). Similar findings have been reported for children’s food choices and intake (J. C. Halford, Gillespie, Brown, Pontin, & Dovey, 2004; J. C. G. Halford, Boyland, Hughes, Oliveira, & Dovey, 2007; Hitchings & Moynihan, 1998).

**Stability of Food Preferences**

It has long been thought that food preferences are stable over long periods of time (Galef Jr, 1981; Rozin & Vollmecke, 1986). However, flavor programming via the previous learning modalities as well as developmental changes in chemical sensory perception, neophobia, and access to new food environments with age challenge this assumption. In addition, both cross-sectional and longitudinal studies suggest that there are significant developmental shifts in preference for sweet and sour foods, and vegetables (Desor, Greene, & Maller, 1975; Nicklaus, Boggio, Chabanet, & Issanchou, 2004; von Post-Skagegård et al., 2002). Specifically, children show greater preferences for sour and sweet foods compared to adolescents and adults, whereas, the latter groups report a greater preference for vegetables. Despite these biological, developmental, and contextual changes, there is evidence for a weak tracking of food preferences from childhood into adulthood. Nicklaus et al. (2004) examined the longitudinal change in food preferences from age 2 to 22. At baseline, nursery children's (ages 2-3) food preferences were
measured by recording their food choices during a self-served lunch. At later occasions of measurement, children reported their preference for 80 common foods using a questionnaire. The authors reported a decrease in the concordance of preference rankings between baseline and ages 4-7 (.43), 8-12 (.35), 13-16 (.26) and 17-22 (.24), indicating a weak tracking of food preferences over time. Similarly, a longitudinal study found that preferences for healthy foods tracked across adolescence from 7th grade to 12th grade (Kelder, Perry, Klepp, & Lytle, 1994). Similar findings have been reported in a retrospective study when college students were asked to recall their childhood preferences for a variety of foods (Unusan, 2006).

Preferences may be particularly stable during childhood. This is reasonable considering children’s neophobic response to new foods. In one study, for example, children reported whether they liked or disliked 90 foods at ages 2, 4, and 8 (Skinner, Carruth, Wendy, & Ziegler, 2002). The authors found that children's liking was consistent between time points such that the same foods were liked over time, the number of foods liked increased only 3.7% from age 2 to 8, and most of the foods introduced after age 4 were likely to be disliked. These findings contradict the hypothesis that diet variety increases with age and suggest that preferences may be particularly stable in childhood.

### Preference and Obesity

Studies investigating whether children’s food preferences relate to adiposity have reported inconsistent results. For instance, one study found that BMI in 4- to 7-year-old children was unrelated to preferences for foods low (i.e., high in fat, salt, sugar, low in nutrients), medium (i.e., some fat, salt, sugar, medium in nutrients), or high (i.e., high in nutrients, outweighing any fat, salt, sugar content) in nutrient value (Klesges, Stein, Eck, Isbell, & Klesges, 1991). Another study reported that liking of sweet snack foods, beverages, vegetables or fruits did not correlate to...
BMI (Conner & Booth, 1988). However, only 10 individuals in the sample were overweight or obese and a larger number may have been needed to find significant differences. In addition, analysis was performed on 6-25 year olds as one group, thus providing little understanding of this relationship in early and middle childhood. Despite these null findings, two studies reported more positive findings. According to Fisher and Birch (1995), children’s preferences for high-fat foods were associated with greater fat intake and triceps skinfolds, but not with BMI or subscapular skinfolds. A later study by Ricketts (1997) reported that fat preferences were associated with triceps skinfolds and BMI in children aged 9-12 years, but not with subscapular skinfolds. Although these studies report positive findings, they are cross-sectional and thus causality and directionality cannot be determined. Further research is needed.

Preference Measurement

Studies have employed a variety of strategies to measure children’s food preferences ranging from questionnaires, protocols involving real foods, and observation of food choices. Unfortunately, these different strategies may be associated with varying levels of validity and reliability, which can ultimately influence a study's findings. To date, the Birch preference assessment protocol is considered the gold standard for measuring children’s preferences due to its high predictive validity (L. L. Birch, 1979b) and reliability (L. L. Birch, 1979a; Guthrie, Rapoport, & Wardle, 2000). In this procedure, individual children are presented with several different foods, and asked to taste each food and indicate the most liked food. The selected food is removed, and the procedure is repeated until a rank order is obtained. Birch has demonstrated high predictive validity for this protocol by correlating preference rank-orders with subsequent food intake in a laboratory setting (r = .80) (L. L. Birch, 1979b), and good test-retest reliability (r = .58) over a 2 week period (L. L. Birch, 1979a). A later study by Guthrie, Rapoport, and Wardle
(2000) reported a test-retest reliability of .81 over a 1-week period. Despite the previous strengths, this preference protocol is time consuming, and requires trained staff and food preparation. As a result, many studies have employed other methods for measuring children’s food preferences.

It is common for studies to use questionnaires to measure children’s preferences. Questionnaires without visual stimuli (e.g. pictures) require children to form a mental representation of a particular food and then judge how much that food is liked relative to another food. Because children generally have difficulty recalling their preferences, researchers suggest that these questionnaires have low validity (Birch & Sullivan, 1991). Although it is easier to have parents complete these questionnaires, parents are poor reporters of children's preferences (Birch, 1980b; Weidner, Archer, Healy, & Matarazzo, 1985).

More recently, researchers have incorporated pictures of foods into their questionnaires. Birch and Sullivan (1991) suggest that food preference questionnaires with visual stimuli have greater predictive validity than those that don’t use them; however, this assertion has yet to be tested, and it is not clear whether using pictures produces a high predictive validity similar to the Birch protocol. In terms of reliability, Gutherie, Rapoport, and Wardle (2000) reported similar 1-week test-retest correlation coefficients in preference rankings between the Birch protocol ($r = .81$) and a questionnaire containing pictures of food ($r = .75$), but a lower coefficient for a questionnaire containing no pictures ($r = .52$). More research is needed that experimentally tests the predictive validity of questionnaires containing pictures compared to the Birch protocol.

In addition, many studies measure children's hedonic affect, food selection, or intake as a proxy for measuring food preferences. As mentioned previously, many factors can moderate the relationship between hedonic liking and preference such as time of day. For instance, a child may rate their liking of eggs higher than pizza at breakfast, but prefer the latter over the former during dinner time (Birch, Billman, & Richards, 1984). Similarly, several factors can moderate the
relationship between preference and intake in children such as social consequences. In one experimental trial, for instance, children selected different foods for lunch when a parent was present compared to when a parent was absent (Klesges et al., 1991). Thus, food choice and intake may not always reflect actual preference. This problem becomes especially problematic when food recalls and food frequency questionnaires are used to measure intake. These measures have been shown to be poor measures of food intake in children (McPherson, Hoelscher, Alexander, Scanlon, & Serdula, 2000), and consequently are especially poor measures of food preference.

**Conclusion**

In conclusion, children’s food preferences emerge through the epigenetic co-action of innate predispositions, biology, and environment. Through the continuous interaction of these three domains, children learn about the foods within their culture, and which foods are nutritionally appropriate and safe to consume. Learning is salient in early childhood when humans must transition from a milk-based diet to the diverse world of solid foods, and come to prefer these foods. As discussed, children acquire food preferences through several learning mechanisms including familiarization/repeated exposure, associative learning, and modeling.

Human’s predispositions for certain tastes and to learn food preferences evolved in food environment markedly different than today’s obesigenic context. Currently, most children live in obesigenic environments where energy-dense, unhealthy foods are easily available in homes, schools, and neighborhoods (J. O. Hill & Peters, 1998). In this context, children’s predispositions may promote high energy consumption and excess weight gain. For example, the innate liking of sweet and salty flavors, and predisposition to acquire preferences for energy-dense foods via flavor-nutrient conditioning, encourage children to prefer and consume high-calorie foods. And when we consider the overabundance of peer and adult models who also prefer and consume
high-fat foods, it is likely that children will acquire long-term preferences for unhealthy foods. However, understanding the epigenetic development of children preferences can aid the development of effective prevention strategies. Through understanding how genetic, biological, and contextual factors interact to form children’s food preferences, researchers can better understand how preferences for fatty, sugary, and salty foods emerge in childhood, and more importantly identify malleable factors and critical periods to target for preventive interventions.

To further advance the study of food preferences and inform prevention work, future research must utilize reliable and valid measures of food preferences. Currently, there are few reliable and valid methods of assessing preferences in children, and these methods have several disadvantages including being time-consuming and costly. The field would benefit from developing new, time-saving measures of food preference.
Chapter 2

Food Preferences, Intake, and Energy Density

Today, children grow up in an obesogenic environment where energy-dense foods are widely available (J. O. Hill & Peters, 1998). Not surprisingly, children’s vegetable and fruit intakes are well below the recommended 5 servings a day (Dennison, Rockwell, & Baker, 1998; Knol, Haughton, & Fitzhugh, 2005; Krebs-Smith et al., 1996; Striegel-Moore et al., 2006).

Because children tend to eat foods they like and avoid foods they dislike (L. Birch, 1979b), understanding the development of food preferences is salient for promoting healthier eating behaviors. For this reason, a large effort has been made towards understanding food preference etiology including the long-term stability of food preferences, factors influences the development of foods preferences, and the relation between food preferences and consumption. To date, however, many studies that have aimed to answer pivotal research questions have also suffered from measurement issues in their assessment of children’s food preferences. Specifically, these studies have used preference measures with low or unknown validity and/or reliability. The current study aims to reinvestigate several of these research questions using reliable and valid measures as well as answer new questions related to the developmental trajectory of food preferences and their relation to food consumption.

Tracking of food preferences during childhood and measurement issues

Few studies have examined the longitudinal tracking of food preferences from early childhood into adolescence. Nicklaus et al. (2004) reported that preferences for a variety of foods
at ages 2-3 were in concordance with those reported at ages 4-7 (.43), 8-12 (.35), 13-16 (.26), and 17-22 (.24), thus suggesting a weak tracking of food preferences over time. Similarly, Kelder et al. (1994) reported that preferences for healthy foods tracked across adolescence from 7th grade to 12th grade. Both of these studies used food preference questionnaires with unknown measurement validity, which could have attenuated the magnitude of the reported findings. Thus, the current study aims to replicate the finding that food preferences track across childhood using a reliable and valid measure of food preference: the Birch food preference assessment (L. Birch, 1979a).

The Birch food preference assessment is an established measure of food preferences that is both valid (L. Birch, 1979b; Fisher & Birch, 1995) and reliable (L. Birch, 1979a; Guthrie et al., 2000). In the assessment protocol, an individual child is asked to taste a series of foods and indicate whether he or she thinks each food is “yummy”, “just okay”, or “yucky”. Once all the foods are categorized, the child rank orders the foods within each category by selecting the most liked food, removing that food, and then selecting the most liked food among the remaining foods. This procedure is repeated for each category. Birch (1979b) reported high predictive validity for this assessment by demonstrating in an experimental procedure that children’s preferences predicted their subsequent measured intake (r = .80). In addition, Birch (1979a) and Guthrie, Rapoport, and Wardle (2000) reported test-retest reliabilities of .58 and .81 for the protocol, respectively.

The Birch food preference assessment can be timely and costly to administer. As a result, many studies have employed simpler methods to measure children’s food preferences—often, at the cost of measurement validity and reliability. For instance, it is common for researchers to use questionnaires without visual stimuli (e.g. pictures of foods; e.g. Perez-Rodrigo, Ribas, Serra-Majem, & Aranceta, 2003; Wind et al., 2006) or, to a lesser extent, with visual stimuli (e.g. Harvey-Berino et al., 1997). The former method requires children to form a mental representation
of a particular food, remember how it tastes, and then judge how much it is preferred compared to another food, of which they also have to form a mental representation. Not surprisingly, it has been suggested that these questionnaires have low predictive validity compared to those that incorporate pictures or food tasting (Birch & Sullivan, 1991). In addition, Guthrie et al. (2000) reported a lower test-retest reliability for a questionnaire without pictures \( r = .52 \) compared to the Birch assessment \( r = .81 \). The study also found that a questionnaires containing pictures had a similar reliability \( r = .75 \) to the Birch protocol; however, to date, the validity of the former method has not been experimentally tested.

**Energy Density and Food Preferences**

Children's food preferences are responsive to the energy density of foods. Birch and colleagues (1990), for example, found that when children were repeatedly exposed (8 times) to two different caloric versions of a novel drink varying in carbohydrate content, children's preference increased only for higher calorie drink. The same effect was observed in later studies when fat was used instead of carbohydrate (Johnson, McPhee, & Birch, 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993). However, only one study has examined how energy densities of a variety of foods relate to food preferences. In a cross-sectional study, Gibson and Wardle (2003) found that 4-year-old children preferred fruits and vegetables greater in energy density, after adjusting for sugar content. An objective of the current study was to extend previous research by examining whether the energy densities of a variety of palatable snack foods predict food preferences in childhood and preadolescence.

**Food Preferences and Intake**

Birch (1979b) initially demonstrated that food preferences predict intake in childhood using valid and reliable experimental measures. More recently, a variety of cross-sectional studies
have shown this association in children of different ages and from diverse backgrounds, and
across food groups (Cullen, Eagan, Baranowski, Owens, & de Moor, 2000; Cullen et al., 2004;
Harvey-Berino et al., 1997; Jaramillo et al., 2006; Perez-Rodrigo, Ribas, Serra-Majem, &
Aranceta, 2003; Wind et al., 2006). However, to our knowledge, all of these later studies have
used measures of preference and intake with low or unknown validity and/or reliability. Most
often these studies used questionnaires without pictures (e.g. Perez-Rodrigo et al., 2003; Wind et
al., 2006) or, to a less extent, with pictures (e.g. Harvey-Berino et al., 1997). In addition, none of
these studies used accurate measures of food intake, but instead relied on child-reported food
frequency questionnaires (FFQs), food records, or 24-hour food recalls. These measures of intake
rely on children’s memory and limited cognitive abilities, and thus are subject to errors and
misreporting (Livingstone & Robson, 2007). According to an extensive review by McPherson
and colleagues (2000), FFQs tend to overestimate energy intake, food records tend to
underestimated energy intake, and 24-hour food recalls are only moderately related to energy
intake. In light of the previous measurement issues, no study to date has replicated Birch (1979b)
original finding that preference is a strong predictor of intake. The current study aims to replicate
this finding by using the Birch food preference assessment protocol and measuring food intake in
a laboratory setting.

Current knowledge on the developmental change in the preference-intake relation is
based on cross-sectional data. In childhood, food preferences strongly predict intake (L. L. Birch,
1979b), whereas, they are weakly associated with intake in adolescence and adulthood
(Drewnowski & Hann, 1999; Drewnowski, Hann, Henderson, & Gorenflo, 2000; Drewnowski,
Henderson, Driscoll, & Rolls, 1996; Iglesias-Gutierrez, Garcia-Roves, Garcia, & Patterson,
2008). Often adults avoid foods they prefer for reasons related to health and nutrition, weight
concerns, food costs, and convenience (Drewnowski, 1997; Furst et al., 1996). Although many of
these factors do not concern children, weight-related behaviors such as dietary restraint (Carper,
Orlet Fisher, & Birch, 2000; Shunk & Birch, 2004b), weight concerns (Davison, Markey, & Birch, 2000; Gustafson-Larson & Terry, 1992), and disinhibited overeating (Carper et al., 2000; Fisher & Birch, 2002) are present in girls as young as 5. Abramovitz and Birch (2000) found that 5-year-old girls already had ideas and beliefs about dieting. Due to developing cognitive and self-regulation skills, however, girls may not actually begin restricting their food intake until preadolescence (Shunk & Birch, 2004b). Because young children do not yet possess the self-regulatory skills to resist the impulse for immediate gratification (e.g. a snack or toy; Mischel, Shoda, & Rodriguez, 1989), it is likely that they will eat the foods they prefer even in the presence of weight-related concerns. However, as self-regulation increases from early childhood into middle childhood (Raffaelli, Crockett, & Shen, 2005), the ability to resist preferred foods may improve. The motivation to restrict consumption of preferred foods may become especially powerful during adolescence when girls experience the normative weight gain associated with puberty (Herman-Giddens et al., 1997). To determine the age at which the relation between preferences and intake begins to change, longitudinal research is needed. Such information would inform prevention work aiming to modify children’s food preferences by indicating when preferences are a strong or weak predictor of intake. In the present study, we will build upon current literature by examining the developmental change in the preference-intake relation from early childhood into adolescents using longitudinal data.

Limited research is available on the presence of individual differences in the food preference-intake relationship in childhood. In a cross-sectional study of 5-year-old girls, three different patterns in the preference-intake relationship were observed: most girls (64%) only ate the foods they liked, some (34%) ate the foods they moderately liked more often, and few (2%) ate the foods they disliked more often (Rollins & Birch, 2007). To date, no other study has been conducted and it is unknown whether there are similar patterns in how preferences predict intake over time. Do children who eat foods they prefer continue to do so years later? Understanding the
proportion of children for whom and the age period when preferences strongly predict intake would inform prevention strategies. The current study aims to identify individual differences in the longitudinal preference-intake relation between early childhood and preadolescence. As seen in adults, individual differences may be associated with weight-related behaviors such that some girls begin to avoid foods they prefer for weight-related reasons (e.g. fear of gaining weight or eating too much). Thus, the current study will also examine whether individual differences in the preference-intake association are related to girls’ weight status, dietary restraint, and disinhibited eating.

Specific Aims

The present study investigated the evolving nature of food preferences in childhood and its developmental association with energy density and food intake. First, we examined the tracking of preferences for palatable snack foods between ages 5 to 11. Second, we assessed whether energy density predicted food preferences between ages 5 to 11. In addition, the study extended Birch’s original study (1979b) by aiming to replicate the main finding that food preferences predict intake in a larger sample and wider age range, and assessed whether individual differences in the relation between preference and intake were related to weight status, dietary restraint, and disinhibited overeating. Lastly, we examined the longitudinal relationship between preference and intake across middle childhood, investigated patterns in girls’ longitudinal trajectories, and assessed whether these patterns were related to weight status, dietary restraint, and disinhibited overeating.

Specific aim 1: Long-term tracking of food preferences

The first aim was to assess whether girls’ food preferences for 10 palatable snack foods tracked between ages 5 and 11. We specifically tested whether food preferences at age 5
predicted preferences at ages 7, 9, and 11, and adjacent times of measurement (i.e., 7 and 9, 9 and
11). Food preferences for the 10 snack foods were measured using the Birch food preference
assessment in a laboratory setting (L. Birch, 1979a).

**Hypothesis 1.** As mentioned, longitudinal studies have shown that food preferences track
across childhood and into adolescence (Skinner et al., 2002) and adulthood (Nicklaus et al.,
2004). In this study, we hypothesized that food preferences would track across childhood such
that preferences at age 5 would predict later preferences at ages 7, 9, and 11. A strong association
would suggest that girls’ preferences for a variety of snack foods were highly stable across
childhood, whereas a weak association would suggest a low stability in food preferences.

**Specific aim 2: Energy density as a predictor of food preferences**

The second aim was to examine the relationship between energy density and food
preferences in childhood. Specifically, we investigated whether energy density was a predictor of
girls’ preferences for palatable snack foods between the ages 5 and 11.

**Hypothesis 2.** As previously discussed, children’s food preferences are sensitive to the
calorie density of foods such that they tend to acquire preferences for high-calorie foods (Birch et
link between energy density and food preferences has even been shown in young children for
vegetables and fruits, foods that are very low in energy density (Gibson & Wardle, 2003). Thus,
we hypothesized in the current study that energy density would predict preferences for snack
foods between ages 5 and 11.
Specific aim 3: Food preferences as a predictor of food intake

The third aim of the present study was to assess whether girls’ preferences was predictive of their food intake at ages 5, 7, 9, and 11. The current aim extends Birch (1979b) by examining the predictive relationship between preference and intake in a large sample and wider age range. In post hoc analyses, we examined whether individual differences in the preference-intake relationship were related to concurrent BMI, dietary restraint, and disinhibited overeating. In this study, disinhibited overeating, or excessive caloric intake, was operationalized as eating in the absence of hunger (EAH; Birch & Fisher, 2000).

Hypothesis 3. Together, Birch’s (1979b) original findings in 3- to 4-year-old children and later cross-sectional work in children ranging from 2 to 13 years old (Cullen, Eagan, Baranowski, Owens, & de Moor, 2000; Gibson, Wardle, & Watts, 1998; Grimm, Harnack, & Story, 2004; Perez-Rodrigo et al., 2003; Wind et al., 2006) suggest that food preferences predict intake during childhood and early adolescence. Thus, in this study we hypothesized that food preferences would be a strong predictor of intake in girls’ between the ages 5 and 11.

As mentioned, girls as young as 5 years old report weight-related behaviors including dietary restraint (Carper et al., 2000; Shunk & Birch, 2004b), weight concerns (Davison et al., 2000; Gustafson-Larson & Terry, 1992), and disinhibited overeating (Carper et al., 2000; Fisher & Birch, 2002); however, they may not begin to restrict their intake of high calorie foods until preadolescence (Shunk & Birch, 2004b). As these factors emerge during development, these factors may begin to explain more variance in girls’ food intake than preferences; thus, the predictive power of preferences declines. As such, there will be no individual differences in how the preference-intake relation relates to BMI, dietary restraint, and disinhibited overeating in early childhood. When the girls are older, however, food preferences will be a weaker predictor of intake in girls’ with higher dietary restraint, BMIs, and EAH.
Specific aim 4: Longitudinal change in preference-intake relationship

The fourth aim was to explore the longitudinal change in the preference-intake relationship between ages 5 and 11. In other words, does the magnitude in how well food preferences predict intake change from early childhood into preadolescence?

Hypothesis 4. As discussed, food preferences are a strong predictor of intake in childhood (Birch, 1979b) and become a weaker predictor of intake in adolescence and adulthood (Drewnowski & Hann, 1999; Drewnowski et al., 2000; Drewnowski et al., 1996; Iglesias-Gutierrez et al., 2008). Adults and adolescents tend to avoid the foods they prefer because of external factors such weight concerns, health, convenience, and costs (Drewnowski, 1997; Furst et al., 1996). A weaker relationship between preferences and intake may began to emerge during preadolescence—a developmental period when girls experience greater fat deposition due puberty onset (Herman-Giddens et al., 1997) and are better equipped with self-regulation skills to delay immediate gratification (e.g. palatable foods; Raffaelli et al., 2005). Thus, other factors such as dietary restraint and weight concerns began to replace food preference as a predictor of intake. In this study we hypothesized that girls’ food preferences would be a strong predictor of intake during early childhood and become a weaker predictor as girls entered preadolescence.

Specific aim 5: Individual differences in the longitudinal preference-intake relationship

The fifth aim was to identify individual differences in the longitudinal change of the preference-intake relationship. Specifically, we investigated whether there were different patterns of change in how food preferences predicted intake between the ages 5 and 11. Next, we conducted post hoc analyses to assess whether girls’ BMI scores, dietary restraint, and disinhibited overeating were associated with these different patterns of change.
Hypothesis 5. As discussed, Rollins and Birch (2007) reported individual differences in food preference-intake association in 5-year-old girls where preferences were a strong predictor in most and a weaker predictor in some. However, this was a cross-sectional study and it is unknown whether there are patterns in how the preference-intake relationship changes over time. In other words, do girls who eat what they prefer at age 5 do so at ages 7, 9, and 11? Perhaps another developmental pattern emerges where food preference becomes a weaker predictor of intake over time for a subset of girls. As discussed in aims 3 and 4, girls who report dietary restraint in early childhood may begin to actually practice these strategies in adolescence by restricting their intakes of palatable foods. In addition, the normative weight gain associated with puberty may be a powerful impetus for many girls to practice dietary restraint as well. Thus, we hypothesized that for most girls, food preference would be a strong predictor of intake between the ages 5 and 11; whereas, for a subset of girls, preference would become a weaker predictor of intake as they entered preadolescence.

In the post hoc analysis, we expected certain longitudinal patterns in the preference-intake association to relate to girls’ BMI, dietary restraint, and EAH. Due to reasons previously discussed, girls for whom preference becomes a weaker predictor of intake may have greater BMIs and dietary restraint compared to girls who eat the foods they preference at all ages. It is unclear how EAH will relate to these longitudinal patterns. One study found that female adolescents who practice high dietary restraint also report either low or high disinhibited overeating (Williams, Michela, Contento, Gladis, & Pierce, 1996). In other words, girls with high dietary restraint and high disinhibited eating were unsuccessful in restricting their food intake, whereas girls with high dietary restraint and low disinhibited overeating were successful in restraining their intake.
Chapter 3

Methods

Participants

Participants were from central Pennsylvania and were part of a longitudinal study of the health and development of young girls. At entry into the study, participants included 197 5-year-old girls (mean age 5.4 ± 0.4) and their parents, of whom 192 families were reassessed 2 years later when girls were 7 years old (mean age 7.3 ± 0.3). A third assessment with 183 families was conducted 2 years later when girls were 9 years old (mean age 9.34, ± 0.3), followed by a fourth assessment with 177 families when girls were age 11 (mean age 11.34 ± 0.3). Eligibility criteria for girls’ participation at the time of recruitment included living with two biological parents, the absence of severe food allergies or chronic medical problems affecting food intake, and the absence of dietary restrictions involving animal products. Families were recruited using flyers and newspaper advertisements. In addition, families with age-eligible female children within a 5-county radius received mailings and follow-up phone calls (Metromail Inc.). Refer to Table 3-1 for background characteristics of the participants at study entry. The Pennsylvania State University Institutional Review Board approved all study procedures, and parents provided consent for their family’s participation.
BMI percentiles were calculated using the CDC growth charts.

Girls with BMI percentiles equal to or greater than 85 but less than 95 were considered overweight; girls with BMI percentiles greater than 95 were considered obese.

BMI = \text{kg/m}^2.

### Table 3-1

Background Characteristics at Study Entry (N=197)

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls’ characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>5.4 (.3)</td>
<td>4.7 - 6.0</td>
</tr>
<tr>
<td>BMI percentile(^1)</td>
<td>61.9 (25.9)</td>
<td>6.4 - 99.8</td>
</tr>
<tr>
<td>% overweight(^1,2)</td>
<td>19.8%</td>
<td></td>
</tr>
<tr>
<td>% obese(^1,2)</td>
<td>6.1%</td>
<td></td>
</tr>
<tr>
<td>Parent characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moms’ age (years)</td>
<td>35.4 (4.8)</td>
<td>24.1 - 46.6</td>
</tr>
<tr>
<td>Dads’ age (years)</td>
<td>37.4 (5.4)</td>
<td>26.1 - 66.4</td>
</tr>
<tr>
<td>Moms’ BMI(^3)</td>
<td>26.4 (6.1)</td>
<td>17.7 - 56.2</td>
</tr>
<tr>
<td>Dads’ BMI(^3)</td>
<td>28.1 (4.4)</td>
<td>18.7 - 42.0</td>
</tr>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family income</td>
<td>$35-50,000</td>
<td>&gt;$20,000 - &lt;$50,000</td>
</tr>
<tr>
<td>Mom's education (years)</td>
<td>14.5 (2.3)</td>
<td>12.0 - 20.0</td>
</tr>
<tr>
<td>Dad's education (years)</td>
<td>14.7 (2.6)</td>
<td>12.0 - 20.0</td>
</tr>
</tbody>
</table>

\(^1\) BMI percentiles were calculated using the CDC growth charts.

\(^2\) Girls with BMI percentiles equal to or greater than 85 but less than 95 were considered overweight; girls with BMI percentiles greater than 95 were considered obese.

\(^3\) BMI = \text{kg/m}^2.

### Procedures

Food energy density, intake, and eating in the absence of hunger (EAH)

Girls’ food intake and responsiveness to the presence of palatable foods in the absence of hunger was measured using a procedure developed in our laboratory, which has been previously described elsewhere (Fisher & Birch, 1999a; 1999b; see Appendix A). Approximately 20 minutes
after a self-selected lunch, each girl was interviewed one-on-one by a trained interviewer in a quiet room. Girls first indicated the extent to which they were hungry using three cartoon figures depicting an empty stomach, half empty/half full stomach, and full stomach. To minimize the influence of hunger on the assessment of snack food intake, cases where girls indicated they were still hungry after lunch were not included in these analyses. Next, a rank-order food preference assessment was performed to measure girls’ food preferences (procedure is described below). Following the preference assessment, the girl was shown various toys that were available for a play session. Generous portions of the same 10 sweet, salty and savory snack foods varying in sugar and fat content were presented during the procedure (see Table 3-2). The girl was told that she could play with the toys or eat any of the foods, while the experimenter did some work in the adjacent room. The experimenter then left the room for 10 minutes, returning after 5 minutes to tell the girl that she would be busy for a few more minutes. Caloric intake was calculated from gram weights obtained by pre- and post-weighing girls’ food intake; energy density of each food was calculated by dividing the amount of calories per serving by the amount of grams per serving; manufacturers’ information on energy content and gram weight was used to determine total energy intake and energy density. Due to differences in the energy density of the snack foods, percentage of calories consumed was calculated (i.e., the proportion of energy consumed from the total energy available) for each snack food. EAH was obtained by summing the energy intake of all the snack foods eaten during the period in which the girl had free access to the snack foods.
Table 3-2

*Snack Foods Served at Baseline (Age 5)*

<table>
<thead>
<tr>
<th>Snack Food</th>
<th>Grams</th>
<th>Total Calories</th>
<th>Energy Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popcorn</td>
<td>15</td>
<td>18.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Peanuts</td>
<td>44</td>
<td>251.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Chips</td>
<td>58</td>
<td>331.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Pretzels</td>
<td>39</td>
<td>144.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Skittles</td>
<td>66</td>
<td>267.3</td>
<td>4.1</td>
</tr>
<tr>
<td>Chocolate</td>
<td>66</td>
<td>346.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Cookies</td>
<td>66</td>
<td>330.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Fig Newtons</td>
<td>51</td>
<td>181.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>168</td>
<td>356.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Frozen Yogurt</td>
<td>168</td>
<td>233.5</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>732</td>
<td>2460.1</td>
<td></td>
</tr>
</tbody>
</table>

*aAmount served increased to 15 grams at ages 7, 9, and 11.*

*bChocolate Chip Cookies.
Food preference assessment.

Girls’ preferences for 10 snack foods (see Table 3-2) were measured using a rank-order food preference assessment protocol created by Birch (1979a; see Appendix B). Three non-gendered faces were presented: “really yummy”, “really yucky”, or “just okay.” In a self-selected order, girls’ categorized each food by first tasting it and then placing it in front of the face that best represented their preference for that food. After all foods were categorized, the girls’ sequentially rank-ordered the foods within each category by picking the yummiest in the “really yummy” category, removing that food, and then selecting the yummiest amongst the remaining foods. This procedure was repeated for the “just okay” foods and “really yucky” foods. Rank-order scores for the foods ranged from 1 (least preferred) to 10 (most preferred). In an early study, Birch (1979a) reported mean test-retest reliability of .58 in sample of 3- to 4-year-old children. Moreover, Birch (1979b) found that food preferences predicted subsequent intake in 3 to 4-year-olds (r=.80), thus demonstrating predictive validity of the measure.

Measures

Anthropometric measurements

Children’s height and weight measurements were obtained in order to determine weight-for-height values. Height and weight were measured in triplicate by a trained staff member. Children were dressed in light clothing and measured without shoes. Height was measured to the nearest 10\textsuperscript{th} of a cm using a Shorr Productions stadiometer (Irwin Shorr, Olney MD). Weight was measured to the nearest 10th of a kg using a Seca Electronic Scale (Seca Corp., Burmingham, UK). BMI scores were generated based on height and weight measurements using the following formula: \( \text{kg/m}^2 \). BMI scores were converted to z-scores as recommended by the U.S. Centers for
Disease Control and Prevention (2000). BMI percentiles were calculated using the 2000 CDC Growth Charts (Kuczmarski et al., 2000).

*Dietary restraint*

Children’s dietary restraint was measured using a modified version of the original Dutch Eating Behavior Questionnaire (DEBQ) created by Van Strien, Frijters, Bergers, and Defares (1986). The measure consists of 33 items on a five point scale (never - often) and 3 subscales: restrained eating (10 items), emotional eating (13 items), and external eating (10 items). Participants are also given the option to choose whether the item is not relevant. At ages 5, 7, and 9, the DEBQ was amended to be age appropriate for participants in this study by changing the response options from a 5 point scale to a 3 point scale (yes, sometimes, no). Girls could also indicate not having experienced the situation or emotion in question. At age 11, the original version of the DEBQ was used. At age 5, a confirmatory factor analysis indicated a three factor model with a Goodness of Fit Index (GFI) of .90 (see Appendix C). For this study, only the restraint scale was used. The restraint scale measures cognitive control of eating (e.g. “Do you watch exactly what you eat?”). A total restraint score was created by taking the average score for the items. The psychometric properties of this scale were similar to those reported by Halvarsson and Sjoden (1998) who also used the DEBQ in a sample of young girls and reported an internal consistency of 0.84 for restrained eating. The reliability and validity of the DEBQ have also been tested and reported in several studies (Allison, Kalinsky, & Gorman, 1992; Laessle, Tuschl, Kotthaus, & Pirke, 1989; van Strien et al., 1986). For this sample, internal consistency scores at ages 5, 7, 9, and 11 were 0.64, 0.78, 0.87, and 0.93 for restrained eating.
Statistical Analysis

Except where noted, all descriptives and data analysis were completed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). Descriptives were computed for EAH, BMI percentiles, and dietary restraint. In subsequent analysis, children were excluded if they had missing preference ranking or intake data, did not consume any foods, were hungry prior to the preference protocol, or had difficulties completing the preference procedure. This slightly reduced the sample size for each occasion of measurement to 186 (age 5), 176 (age 7), 168 (age 9), and 156 (age 11).

Specific aim 1: Long-term tracking of food preferences

Average preference rank by food item for each wave of measurement was computed. To statistically examine the stability of girls’ preferences over time, inter-correlation coefficients were computed separately for each girl between all pairs of measurement times using Spearman correlation. To obtain a mean intercorrelation coefficient for the sample at a particular age, girls’ coefficients were averaged. Medians were computed as well because they are more robust in the presence of skewed data. To evaluate the significance of these mean correlation coefficients, the following steps were taken: 1) 100 pairs of preference rank-orders for 10 items were randomly generated using a random seed, 2) each pair was correlated using Spearman correlation, and 3) the average coefficient was computed across pairs. The expected average correlation coefficient between any random preference rankings was .00 with a standard deviation of .03, suggesting that average coefficients exceeding .03 were likely to be significantly different than .00. As suggested by Cohen (1992), correlation coefficients with magnitudes of .10, .30, and .50 were interpreted as small, medium, and large, respectively.
Specific aim 2: Energy density as a predictor of food preferences

Mean energy density by preference rank (i.e. 1-10) was computed for each occasion of measurement to descriptively examine the relationship between the energy density and children's food preferences. Next, LISREL 8.80 (Scientific Software International Inc., Lincolnwood, IL, USA) was used to statistically evaluate this relationship. Specifically, polyserial correlation coefficients were computed between preference rank-order scores and energy density of the snack foods. Polyserial correlation is a method used to correlate rank-order data with continuous data. Correlation coefficients were computed separately for each girl at each age. For the remainder of the paper, P-EDCC will represent the food preference-energy density correlation coefficient, or the predictive relationship between energy density and food preferences.

Specific aim 3: Food preferences as a predictor of food intake

To descriptively examine the relationship between children’s food preferences and food intake, mean calorie intake and % of total calories consumed by preference rank (i.e. 1-10) were computed for each time of measurement. Next, polyserial correlation coefficients were computed between preference rank-order scores and calorie intake using LISREL 8.80. Polyserial correlation coefficients were obtained for each girl per wave of measurement. The same procedures were repeated to generate polyserial correlation coefficients for the association between preference rank-order scores and % of calories consumed. For the remainder of the paper, P-ICC will refer to the food preference and calorie intake correlation coefficient, representing the predictive relationship between food preferences and calorie intake; and, P-%ICC will refer to the food preference and % of calories consumed correlation coefficient, representing the predictive relationship between food preferences and % of calories consumed. A post hoc t-test was conducted to test whether mean P-ICCs and P-%ICCs at age 9 and 11 were
statistically different. Lastly, Pearson correlation was used to assess the relationship between P-ICCs and P-%ICCs, and girls’ BMI z-scores, dietary restraint, and EAH scores.

**Specific aim 4: Longitudinal change in the preference-intake relationship**

To assess the longitudinal change in the preference-intake relationship between ages 5 to 11, separate one-way, within-subjects repeated measures ANOVAs (PROC GLM) were conducted using P-ICCs and Pr-%ICCs. The repeated measures ANOVA method is appropriate for longitudinal analysis, and accounts for the intra-class correlation between individuals. Polynomial contrasts were included to test whether the trend was linear and/or quadratic. Only girls with complete data for all four waves were included in this procedure (n=127).

**Specific aim 5: Individual differences in the longitudinal preference-intake relationship**

To identify patterns in the change over time, Latent Profile Analysis (LPA) was performed in MPLUS (Muthen and Muthen, Los Angeles, CA) using the P-ICCs as indicators (Muthen & Muthen, 2004). Similar to Latent Class Analysis (LCA), LPA is a mixture modeling technique that employs maximum likelihood algorithms to identify underlying subgroups in the data that are qualitatively distinct (McLachlan & Peel, 2000; Vermunt & Magidson, 2002). However, LPA can accommodate continuous, ordinal, and nominal data whereas categorical data is only appropriate for LCA. Solutions were identified for models containing one, two, three, four, and five classes. Each model was run with 100 random starting values to find the best-fitting model. Model fit was assessed using the Akaike information criterion (AIC), Bayesian information criterion (BIC), and Lo-Mendell-Rubin Likelihood Ratio Test (LMR LRT) (Lo, Mendell, & Rubin, 2001; Schwarz, 1978). The lowest AIC and BIC indicate the best model fit. The LMR tests the parsimony of the current model against a model with one less class (e.g. 3 classes versus 2). A significant p-value indicates that the current model is a significant
improvement on the model containing one less class. Based on these three test statistics, a three class model was the best-fitting. LPA was also run using P-%ICCs as indicators; a 3 class model had the best fit as well.

Next, the sample was classified into 3 classes using posterior probabilities. Average posterior probabilities were .89, .92, and .86, respectively. Classes were then compared on change in BMI z-score, dietary restraint, and disinhibited overeating between ages 5 and 11 using random coefficient models (PROC MIXED). This type analysis was selected to account for intra-class correlation between individuals. A separate model was conducted for each outcome variable: change in BMI z-score, dietary restraint, and EAH. In all models, covariates were age (5, 7, 9, 11), class status (1-3), and an age-by-class interaction. When the interaction term was significant, Tukey adjusted paired comparisons were performed to test for mean differences.
Chapter 4

Results

Descriptive statistics for EAH, BMI percentiles, and dietary restraint for the total sample are provided in Table 4-1. The percentage of girls classified as overweight and obese were similar to national estimates (Ogden, Carroll, & Flegal, 2008) and tended to increase over time. As shown in Table 3-2, girls were from middle-income, highly educated households. At age 5, 52.3% and 17.8% of mothers were overweight and obese, respectively; and, 73.3% and 27.2% of fathers were overweight and obese, respectively.
BMI percentiles were calculated using the CDC growth charts.

Girls with BMI percentiles equal to or greater than 85 but less than 95 were considered overweight; girls with BMI percentiles greater than 95 were considered obese.

Eating in the Absence of Hunger, a measure of disinhibited overeating.

The range for possible scores is 1 to 3.

Table 4-1

<table>
<thead>
<tr>
<th></th>
<th>Girls' age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BMI percentile$^1$</td>
<td>60.3 (26.47)</td>
</tr>
<tr>
<td>Overweight, $^1,2$</td>
<td>6.1</td>
</tr>
<tr>
<td>Obese, $^1,2$</td>
<td>13.7</td>
</tr>
<tr>
<td>EAH, kcal$^3$</td>
<td>123.0 (94.4)</td>
</tr>
<tr>
<td>Dietary restraint$^4$</td>
<td>1.69 (.45)</td>
</tr>
</tbody>
</table>

$^1$BMI percentiles were calculated using the CDC growth charts.

$^2$Girls with BMI percentiles equal to or greater than 85 but less than 95 were considered overweight; girls with BMI percentiles greater than 95 were considered obese.

$^3$Eating in the Absence of Hunger, a measure of disinhibited overeating.

$^4$The range for possible scores is 1 to 3.
Specific aim 1: Long-term tracking of food preferences

Average preference rankings by snack food at ages 5, 7, 9, and 11 are provided in Table 4-2. On average, girls preferred skittles, chocolate, and ice cream the most and fig newtons and peanuts the least at all ages. Table 4-3 displays mean intercorrelation coefficients and standard deviations between preference ranking scores at ages 5 to 11. Median intercorrelation coefficients are presented in Table 4-4. Overall, the effect size for the tracking of girls’ food preferences between ages 5 and 11 was medium to large, indicating that girls’ early preferences strongly predicted their later preferences. Mean coefficients were greater between adjacent times of measurement (e.g. 5 and 7), and lower between distal times of measurement (e.g. 5 and 11). In addition, mean coefficients were greater when the girls were older compared to when they were younger, suggesting that preferences tracked better when the girls were older than when they were younger.
Table 4.2

*Mean (Standard Deviation) Preference Rank* by Snack Food between Ages 5 and 11, in Order of Most Preferred at Age 5.

<table>
<thead>
<tr>
<th>Snack Food</th>
<th>Age 5</th>
<th>Age 7</th>
<th>Age 9</th>
<th>Age 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skittles</td>
<td>7.3 (2.9)</td>
<td>7.0 (2.8)</td>
<td>6.9 (2.6)</td>
<td>6.8 (2.5)</td>
</tr>
<tr>
<td>Chocolate</td>
<td>6.8 (2.6)</td>
<td>6.8 (2.7)</td>
<td>6.7 (3.0)</td>
<td>6.4 (2.7)</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>6.1 (2.6)</td>
<td>6.5 (2.8)</td>
<td>6.8 (2.5)</td>
<td>7.8 (2.3)</td>
</tr>
<tr>
<td>Chips</td>
<td>5.8 (2.6)</td>
<td>6.1 (2.5)</td>
<td>6.3 (2.5)</td>
<td>5.4 (2.6)</td>
</tr>
<tr>
<td>Cookies</td>
<td>5.6 (2.4)</td>
<td>5.7 (2.4)</td>
<td>5.4 (2.2)</td>
<td>5.4 (2.2)</td>
</tr>
<tr>
<td>Popcorn</td>
<td>5.6 (2.9)</td>
<td>5.9 (2.5)</td>
<td>6.4 (2.6)</td>
<td>5.2 (2.6)</td>
</tr>
<tr>
<td>Pretzels</td>
<td>5.3 (2.5)</td>
<td>4.8 (2.5)</td>
<td>5.0 (2.4)</td>
<td>5.0 (2.3)</td>
</tr>
<tr>
<td>Frozen Yogurt</td>
<td>5.1 (2.8)</td>
<td>4.9 (3.0)</td>
<td>4.8 (2.8)</td>
<td>6.2 (3.0)</td>
</tr>
<tr>
<td>Peanuts</td>
<td>4.2 (2.8)</td>
<td>4.1 (2.6)</td>
<td>4.1 (2.6)</td>
<td>3.8 (2.7)</td>
</tr>
<tr>
<td>Fig Newtons</td>
<td>3.4 (2.3)</td>
<td>3.3 (2.5)</td>
<td>2.8 (2.3)</td>
<td>3.1 (2.5)</td>
</tr>
</tbody>
</table>

*aFoods were ranked from 1=least preferred to 10=most preferred.*

*bChocolate Chip Cookies.
Table 4-3. Mean (Standard Deviation) Intercorrelations\(^1\) between Girls’ Preference Rank-Order Scores (1-10) between Ages 5 and 11.

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age 5</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age 7</td>
<td>.34 (.36)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Age 9</td>
<td>.32 (.33)</td>
<td>.45 (.31)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4. Age 11</td>
<td>.26 (.34)</td>
<td>.35 (.35)</td>
<td>.47 (.30)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

\(^1\)Mean correlation coefficients represent average food preference stability between any two time points. Coefficients were obtained by correlating preference rank-order scores for each individual.
Coefficients were obtained by correlating preference rank-order scores for each individual.

**Specific aim 2: Energy density as a predictor of food preferences**

Figure 4-1 illustrates average energy density by preference rank separately at ages 5, 7, 9, and 11. As shown in Table 4-5, P-EDCCs ranged from -.14 to .04 between ages 5 and 11, indicating that energy density did not predict preference rankings at any age.

*Table 4-4. Median Intercorrelations$^1$ between Girls’ Preference Rank-Order Scores (1-10) between Ages 5 and 11.*

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age 5</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age 7</td>
<td>.38</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Age 9</td>
<td>.35</td>
<td>.47</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4. Age 11</td>
<td>.27</td>
<td>.41</td>
<td>.53</td>
<td>1.00</td>
</tr>
</tbody>
</table>

$^1$Coefficients were obtained by correlating preference rank-order scores for each individual.
Snack foods were peanuts, skittles, pretzels, popcorn, chocolate, potato chips, ice cream, frozen yogurt, chocolate chip cookies, and fig newtons.

Figure 4-1. Descriptive relationship between energy density and girls’ preference rankings of 10 palatable snack foods. The relationship was non-linear and there was a tendency for girls to prefer low energy dense foods at age 11. Plotted values are mean energy density ± standard errors.

Snack foods were peanuts, skittles, pretzels, popcorn, chocolate, potato chips, ice cream, frozen yogurt, chocolate chip cookies, and fig newtons.
Table 4-5
Means, Standard Deviations, and Medians of Girls’ P-EDCCs\(^1\) between Ages 5 to 11.

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>.02</td>
<td>.35</td>
<td>-.01</td>
</tr>
<tr>
<td>7</td>
<td>.04</td>
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<td>.07</td>
</tr>
<tr>
<td>11</td>
<td>-.14</td>
<td>.35</td>
<td>-.18</td>
</tr>
</tbody>
</table>

\(^1\)P-EDCCs refers to preference-energy density correlation coefficients. Coefficients were computed between food preference rank-orders and energy density separately for each individual.
Specific aim 3: Food preferences as a predictor of intake

Figure 4-2 displays mean calorie intake by preference rank separately at ages 5, 7, 9, and 11. Similar charts were obtained for mean % of calories consumed by preference rank (data not shown). As shown in Table 4-6, food preferences predicted girls’ intake of snack foods at all ages; however, there was wide individual variability in how well preference predicted intake. The large standard deviations suggest that preference was a strong predictor in some girls and a weak predictor in others. Similar results were observed for mean P-%ICCs by age (see Table 4-7).

At age 11, P-ICCs were correlated with BMI z-scores (r=-.25, p<.01) and dietary restraint (r=-.16, p<.05), meaning that girls’ whose preferences were weakly related to intake also weighed more and reported higher dietary restraint. In addition, P-ICCs were positively related to EAH at age 9 (r=.23, p<.01), but not at ages 5, 7, and 11. This finding indicates that at age 9, girls who ate foods they prefer also ate more calories in the absence of hunger. No other significant findings were observed. Similar results were obtained between P-%ICCs and BMI z-scores, dietary restraint, and EAH (data not shown).
Snack foods were peanuts, skittles, pretzels, popcorn, chocolate, potato chips, ice cream, frozen yogurt, chocolate chip cookies, and fig newtons.

Figure 4-2. Descriptive relationship between girls’ food preference rankings and calorie intake of 10 palatable snack foods\(^1\). At each age, girls’ calorie intake was greater in foods that were ranked higher. Plotted values are mean energy density ± standard errors.

\(^1\)Snack foods were peanuts, skittles, pretzels, popcorn, chocolate, potato chips, ice cream, frozen yogurt, chocolate chip cookies, and fig newtons.
Table 4-6

*Means, Standard Deviations, and Medians of Girls’ P-ICC’s*\(^1\) between Ages 5 and 11.

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>.33</td>
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<td>.42</td>
</tr>
<tr>
<td>7</td>
<td>.43</td>
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<td>.57</td>
</tr>
<tr>
<td>11</td>
<td>.45</td>
<td>.29</td>
<td>.54</td>
</tr>
</tbody>
</table>

\(^1\)P-ICC refers to preference-calorie intake correlation coefficients. Coefficients were computed between food preference rank-orders and calorie intake separately for each individual.
Specific aim 4: Longitudinal change in preference-intake relationship

As shown in Table 4-6, average P-ICC$s$ increased between ages 5 and 11 from .33 to .45, indicating that as girls aged they ate more of the foods they preferred, $F(1,126)=21.65$, $p<.0001$. However, the preference-intake relationship at age 11 was significantly lower than at age 9, indicating that preferences became a weaker predictor of intake, $t(126)=2.49$, $p=.01$. The same longitudinal trend was observed for average P-%ICC$s$ (see Table 4-6).

### Table 4-7
Means, Standard Deviations, and Medians of Girls’ P-%ICCs$^1$ between Ages 5 and 11.

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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<td>.57</td>
</tr>
<tr>
<td>11</td>
<td>.46</td>
<td>.30</td>
<td>.56</td>
</tr>
</tbody>
</table>

$^1$P-ICC refers to preference-% of calories consumed correlation coefficients. Coefficients were computed between food preference rank-orders and % of calories consumed of each food separately for each individual.
Specific aim 5: Individual differences in the longitudinal preference-intake relationship

Model fit statistics for the one, two, three, four, and five class solutions using P-ICCs as indicators are presented in Table 4-8. The best-fitting model was selected according to the fit statistics (Lo et al., 2001; Schwarz, 1978). The LMR test statistic indicated the two class model was better than the one class model, but a three, four, and five class model was not better than a two class model. The AIC continued to decrease as the number of classes increased. The BIC, a more conservative test than the AIC, indicated a three class model. Although the BIC was similar for the three and four latent class models, the former was selected because it produced a more parsimonious and interpretable solution. When P-%ICCs were used as indicators, similar model fit statistics and classes were produced, and the 3 class model was the best fitting as well (data not shown). The classes represent longitudinal change in the preference-intake relationship and will be referred to as patterns of change.

Figure 4-3 shows the three distinct patterns in the mean preference-intake correlation coefficients between ages 5 and 11. The majority of girls followed pattern 1 (n=143). These girls had a mean P-ICC of ~.40 at age 5 and P-ICCs exceeding .50 at ages 7 to 11, indicating that preferences became a stronger predictor of intake and were a moderate predictor of intake between ages 7 and 11. Girls following pattern 2 (n=27) had mean P-ICCs that increased from .21 to .48 between ages 5 to 9 and then dropped to -.05 at 11. In other words, girls in class 2 increasingly ate foods they preferred until age 11 when their preference rankings no longer predicted their caloric intake. Girls following pattern 3 (n=17) had low mean P-ICCs between ages 5 and 9 and then experienced a large increase in mean P-ICCs of .61 at age 11, suggesting that preferences were not a predictor of intake until age 11.

Figures 4-4, 4-5, and 4-6 illustrate differences in the patterns of change between ages 5 and 11 among the latent classes on BMI z-scores, dietary restraint, and EAH, respectively. On
average, BMI z-scores increased between ages 5 and 11 for all girls, $F(1,534)=24.82$, $p<.0001$.

Regardless of pattern, average BMI percentiles increased from 57.2% to 60.8% from age 5 to 11. Girls following pattern 2 had significantly greater BMI z-scores than girls having pattern 1 at all ages, $F(2,534)=3.57$, $p<.05$; whereas girls following pattern 3 were not significant different than girls within pattern 1 and 2 at any age. BMI percentiles of girls having pattern 2 were 75.1% to 80.7% at ages 5 and 11 compared to 57.2% and 60.8% in girls having pattern 1 and 62.7% and 70.4% having pattern 3. In addition, the change in dietary restraint between ages 5 and 11 was greater for girls following pattern 2 compared to girls having pattern 1 ($B=.06$, $p=.012$) and pattern 3 ($B=.10$, $p=.002$). Overall, EAH increased between ages 5 and 11 for all girls ($F(1,524)=294.74$, $p<.0001$). Girls following pattern 2 had significantly greater increases in EAH between ages 5 and 11 compared to girls having pattern 1 ($B=16.34$, $p=.05$) and 3 ($B=13.69$, $p=.01$).
Table 4-8

*Fit Statistics for Latent Profile Solutions Fitting One, Two, Three, Four, and Five classes.*

<table>
<thead>
<tr>
<th>Number of Classes</th>
<th>LMR&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Likelihood</th>
<th>AIC&lt;sup&gt;a&lt;/sup&gt;</th>
<th>BIC&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>166.951</td>
<td>192.809</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>115.966</td>
<td>157.970</td>
<td>58.749</td>
<td>.0044</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>89.816</td>
<td>147.976</td>
<td>34.819</td>
<td>.3200</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>73.614</td>
<td>147.930</td>
<td>25.237</td>
<td>.3027</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>62.527</td>
<td>152.998</td>
<td>20.311</td>
<td>.7497</td>
</tr>
</tbody>
</table>

<sup>a</sup>Akaike Information Criterion.

<sup>b</sup>Bayesian Information Criterion.

<sup>c</sup>Lo-Mendell-Rubin Likelihood Ratio Test.
P-ICC refers to preference-calorie intake correlation coefficients. Coefficients were computed between food preference rank-orders and calorie intake separately for each individual.

In pattern 1 (n=143), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 (n = 27), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 (n = 17), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

Figure 4-3. Patterns² of change in how food preferences predict intake in girls between ages 5 and 11. Plotted values are mean P-ICCs ± standard errors. Age 5 (n=186), age 7 (n=176), age 9 (n=168), age 11 (n=156).

¹P-ICC refers to preference-calorie intake correlation coefficients. Coefficients were computed between food preference rank-orders and calorie intake separately for each individual.

²In pattern 1 (n=143), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 (n = 27), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 (n = 17), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.
BMI percentiles were calculated using the CDC growth chart.

Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 (n=143), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 (n = 27), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 (n = 17), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

Average BMI increased over time for all girls (p<.05); girls following pattern 2 were heavier than girls following pattern 1 at all ages (p<.05); girls having pattern 3 were not significantly different than girls having patterns 1 or 2.

Figure 4-4. Girls’ BMI trajectories between ages 5 and 11 by pattern in the food preference-intake relationship, plotted using BMI percentiles. Plotted values are mean BMI percentiles ± standard errors. Age 5 (n=186), age 7 (n=176), age 9 (n=168), age 11 (n=156).

1 BMI percentiles were calculated using the CDC growth charts.

2 Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 (n=143), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 (n = 27), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 (n = 17), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

3 Average BMI increased over time for all girls (p<.05); girls following pattern 2 were heavier than girls following pattern 1 at all ages (p<.05); girls having pattern 3 were not significantly different than girls having patterns 1 or 2.
Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 \((n=143)\), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 \((n=27)\), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 \((n=17)\), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

Girls following pattern 2 had a greater increase in dietary restraint between ages 5 and 11 than girls having patterns 1 \((p<.05)\) and 3 \((p<.05)\).

---

Figure 4-5. Girls’ dietary restraint from 5 to 11 years of age by pattern in the food preference-intake relationship.\(^1\) Plotted values are mean dietary restraint ± standard errors. The letters represent significant differences \((p<.05, \text{adjusted})\) in dietary restraint among the classes within each age of measurement. Age 5 \((n=186)\), age 7 \((n=176)\), age 9 \((n=168)\), age 11 \((n=156)\).

\(^1\)Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 \((n=143)\), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 \((n = 27)\), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 \((n = 17)\), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

\(^2\)Girls following pattern 2 had a greater increase in dietary restraint between ages 5 and 11 than girls having patterns 1 \((p<.05)\) and 3 \((p<.05)\).
Eating in the Absence of Hunger, a measure of disinhibited overeating.

Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 \((n=143)\), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 \((n=27)\), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 \((n=17)\), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

Mean EAH scores increased with age for all girls \((p<.05)\). Girls with pattern 2 had a greater increase in EAH between ages 5 to 11 than girls following patterns 1 \((p<.05)\) and 3 \((p=.05)\).

Figure 4-6. Girls’ disinhibited eating from 5 to 11 years of age in the EAH\(^1\) protocol by pattern in the food preference-intake relationship.\(^2\) Plotted values are mean EAH ± standard errors. The letters represent significant differences \((p<.05, \text{ adjusted})\) in EAH among the classes within each age of measurement. Age 5 \((n=186)\), age 7 \((n=176)\), age 9 \((n=168)\), age 11 \((n=156)\).

\(^1\)Eating in the Absence of Hunger, a measure of disinhibited overeating.

\(^2\) Three patterns in how food preferences predict intake from age 5 to 11: pattern 1 \((n=143)\), preferences predicted intake at all ages and became a stronger predictor with age; pattern 2 \((n = 27)\), preferences predicted intake at ages 7 and 9, but did not at ages 5 and 11; and pattern 3 \((n = 17)\), preferences did not predict intake between ages 5 and 9, but became a strong predictor at age 11.

\(^3\)Mean EAH scores increased with age for all girls \((p<.05)\). Girls with pattern 2 had a greater increase in EAH between ages 5 to 11 than girls following patterns 1 \((p<.05)\) and 3 \((p=.05)\).
Chapter 5

Discussion

On average, food preferences tracked between ages 5 and 11 such that preferences in early childhood predicted preferences in preadolescence. Energy density did not predict girls’ preferences for snack foods between ages 5 and 11. On average, girls’ food preferences predicted intake at ages 5, 7, 9, and 11; thus providing supportive evidence that food preferences predict intake throughout early and middle childhood. Between ages 5 and 9, food preferences became a stronger predictor of intake, but was a slightly weaker predictor of intake between ages 9 and 11. There were individual differences in how the preference-intake association changed between ages 5 and 11. Three patterns of change emerged: 1) preferences were a good predictor of intake at all ages, 2) preferences became an increasing good predictor of intake and then declined at age 11, when the relationship became non-significant, and, 3) preferences were not a predictor of intake until age 11. Girls who had a decline in the preference-intake relationship between ages 9 and 11 were heavier compared girls for whom preferences predicted intake at all ages. In addition, girls following pattern 2 had greater increases in dietary restraint and EAH between ages 5 and 11 than girls having the other 2 patterns.

Food preferences track from early childhood into preadolescence

The first aim of the study was to assess whether girls’ preferences for palatable snack foods tracked across middle childhood. It was hypothesized that girls’ food preferences would track between ages 5 and 11. As hypothesized, a moderate to strong tracking of food preferences
was observed between ages 5 and 7, 5 and 9, and 5 and 11. These findings are consistent with previous studies demonstrating that food preferences in early childhood predict preferences in later childhood and adolescence (Nicklaus et al., 2004; Skinner et al., 2002).

Energy density: Not a predictor of food preferences in childhood

The second aim of the study was to assess whether energy density predicted girls’ preferences for palatable snack foods between ages 5 to 11. We hypothesized that energy density would predict girls’ food preferences at all ages. Contrary to our hypothesis, energy density did not predict food preferences at any age. These findings contradict Gibson and Wardle (2003) who showed that 4-year-old children reported greater preference for fruits and vegetables that were energy dense. However, in the current study, palatable snack foods were used that were similar in energy density and were mostly liked by all girls. In contrast, the Gibson and Wardle study had fruits and vegetables widely ranging in energy density as well as children’s hedonic ratings for the foods. Earlier experimental works also indicate that children’s food preferences are responsive to the calorie density of foods. For example, Birch, McPhee, Steinberg, and Sullivan (1990) repeatedly exposure (8 times) 3 to 5-year-old children to novel flavored drinks varying in calorie density, and found that children developed a greater preference for the more calorie dense drink. However, this study differs from the current study in that children were hungry when preferences were assessed. In the current study, children were not hungry when preferences were measured. A later study following a similar experimental procedure to the Birch et al (1990) paper found that preferences for a hi-fat and non-fat food were not significant different when children were full whereas they were significantly different when they were hungry (Kern et al., 1993).

Food preferences: A predictor of food intake in childhood
The third aim of this study was to replicate and extend the findings presented in Birch (1979b) that food preferences strongly predict children’s consumption. We hypothesized that children’s food preferences would be a strong predictor of intake between ages 5 and 11. Our findings partially support our hypothesis, showing that food preferences are a moderate predictor of intake in childhood. Compared to the magnitude of the preference-intake relationship reported in Birch ($r = .80$; L. Birch, 1979b), the current study produced lower coefficients at ages 5 (mean $r = .33$), 7 (mean $r = .43$), 9 (mean $r = .52$), and 11 (mean $r = .45$). However, these findings are similar or stronger than the associations that have been reported in cross-sectional studies (Cullen, Eagan et al., 2000; Gibson et al., 1998; Wind et al., 2006).

Post hoc analyses examined whether individual differences in the preference-intake relationship relate to girls’ BMI, dietary restraint, and EAH. Between ages 5 and 9, these weight-related variables were not related to the preference-intake relationship. However, at age 11, girls with inverse association between preferences and intake had greater BMIs and dietary restraint. As mentioned, the cognitive ability to self-regulate behaviors develops significantly between early childhood and middle childhood (Raffaelli et al., 2005), thus children may not be able to resist the impulse for immediate gratification of palatable snack foods until preadolescence. As a consequence, we may not have been able to observe a relationship between the preference-intake relationship and dietary restraint in early childhood because girls who reported dietary restraint at young ages were still eating the foods they preferred despite their desire to control their intake. Girls as young as 5 years old report dietary restraint and ideas about dieting, but it may not be until preadolescence when they begin to restrict their food intake (Abramovitz & Birch, 2000). In addition, girls who report dietary restraint tend to be overweight (Braet & Van Strien, 1997; Braet & Wydhooge, 2000), and being heavier at age 5 predicts later dietary restraint at ages 7 and 9 (Shunk & Birch, 2004a). Thus, our finding that heavier girls ate less of the foods they preferred is not surprising. These girls may have been attempting to control their intake in response to their
Changes in the food preference-intake from childhood into preadolescence

The fourth aim of the current study was to assess the longitudinal change in how food preferences predict food intake from early childhood into preadolescence. We hypothesized that food preferences would be a strong predictor of intake in early childhood and become a weaker predictor as girls entered preadolescence. We found that food preferences were a strong predictor at ages 7 and 9, but not at age 5. This finding is surprising because Birch (1979b) reported a strong correlation between preference and intake in 3- to 4-year olds. It is unclear why the relationship between preferences and intake is weaker among this sample at age 5. Nevertheless, our findings suggest that food preferences are important predictors of intake throughout childhood, and may even become more important in middle childhood.

As hypothesized, food preferences became a weaker predictor of intake between ages 9 and 11. Previous studies show that preferences are a strong predictor of intake in childhood (L. Birch, 1979b), but are a weak predictor during adolescence and adulthood (Drewnowski & Hann, 1999; Drewnowski et al., 2000; Drewnowski et al., 1996; Iglesias-Gutierrez et al., 2008). Adolescents and adults are less likely to eat the foods they prefer due to concerns for nutrition and health, convenience, and costs (Drewnowski, 1997; Furst et al., 1996). A similar pattern may have emerged in our study. As discussed, we observed that girls who ate less of the foods they preferred also reported greater dietary restraint at age 11, and perhaps this finding was not observed at earlier ages because girls did not have had the self-regulatory abilities to resist the immediate gratification of palatable foods (Mischel et al., 1989; Raffaelli et al., 2005).

Patterns in change of preference-intake relation from childhood into preadolescence
The fifth aim of the study was to examine individual differences in how the preference-intake relationship changed between ages 5 and 11. It was hypothesized that food preferences would be a strong predictor of intake in most girls at all ages, and would become a weaker predictor of intake in some girls during preadolescence. As hypothesized, separate classes or groups emerged that represented different patterns of change over time. Most girls (class 1) ate primarily the foods they preferred at all ages, some (class 2) ate the foods they preferred until age 11, when preference no longer predicted intake (mean $r = -.05$), and a few (class 3) did not eat the foods they preferred until age 11. The first pattern is consistent with Birch (1979b) and other cross-sectional studies (Cullen, Eagan et al., 2000; Gibson et al., 1998; Wind et al., 2006) showing that preferences are good predictor of intake in a wide age range of children. Because most girls comprised this class, this pattern may best represent the relationship between preference and intake in most children.

The post hoc analysis revealed that girls in class 2 differed from girls in the other classes on dietary restraint. While there were no differences in dietary restraint at ages 5, girls in class 2 experienced greater increases in dietary restraint over time and had significantly higher levels at ages 9 and 11 than the other 2 classes. At 11, the preference-intake correlation coefficient decreased to -.05, suggesting that preferences no longer predicted intake in this group. This coefficient suggests that girls were not avoiding their preferred foods completely. If girls were completely avoiding the foods they preferred and instead ate the foods they least preferred, the coefficient would have been strong and negative. Further investigation revealed that girls in class 2 tended to eat some of the preferred foods and more of the least preferred foods. For instance, girls in class 2 ranked ice cream, skittles, and chocolate as their most preferred foods and fig newtons and peanuts as their least preferred foods. However, they consumed 18%, 8.1%, 11.4% of available calories of their preferred foods compared to 18.7% and 20.0% of available calories of their least preferred foods, respectively. Overall, this suggests that the girls ate some of their
preferred foods, but ate more of the foods they least preferred, possibly in an attempt to avoid eating too much of the foods they preferred. Yet, despite the attempt to control their intake of preferred foods, girls in this class had greater calorie intake in the EAH protocol at age 11, and greater increases in EAH over time compared to girls in the other classes. Our findings are consistent with patterns observed in adolescents and adults where attempts at dietary restraint tend to fail, and individuals become at risk for disinhibited overeating (Stice, 2002).

In addition, the current study found that all classes gained weight over time and girls in class 2 consistently weighed more than the other classes between ages 5 and 11. Being heavier earlier on may have put these girls at risk for EAH and dietary restraint later at later ages. Shunk and Birch (2004a) found that being overweight at age 5 predicted dietary restraint and EAH at ages 7 and 9 in girls. Other studies show that overweight girls report greater dietary restraint (Braet & Van Strien, 1997; Braet & Wydhooge, 2000) and show greater EAH (Cutting, Fisher, Grimm-Thomas, & Birch, 1999; Francis & Birch, 2005b; Shunk & Birch, 2004a) as well. It was initially thought that girls increasingly practice dietary restraint in response to the normative weight gain associated with puberty (Striegel-Moore, Silberstein, & Rodin, 1986); however, in our study BMI did not change between ages 9 and 11 in class 2 relative to the other classes. Further investigation revealed that girls in class 2 remained at the ~80th BMI percentile at ages 9 and 11.

Contrary to our hypothesis, there was a third pattern in the preference-intake relationship; that is, for a small number of girls preference did not predict intake until age 11. It may be that for some girls preferences do not predict intake. Similarly, Rollins and Birch (2007) found that preferences were a weak predictor in some 5-year-old girls. In addition, girls in this class did not show increasing EAH over time, instead, they consumed a similar amount of calories between ages 7 and 11 (i.e. 197 to 189 kcal). It is possible that a lower overall liking for all the snack foods used in the study could have contributed to the lower preference-intake relationship or
stable EAH intake. If girls didn’t like most of the foods they may have had trouble ranking them and their intakes of the foods would have been very low. However, further investigation of girls’ hedonic ratings for each food revealed that girls in this class liked just as many foods as the other classes at all ages, and in some cases liked the foods slightly more. Thus, it is unclear why preference did not predict intake in these girls between ages 5 and 9, and then emerged as a strong predictor at age 11.

Study Limitations and Strengths

The current study has several limitations. Preference and intake data were collected in a laboratory setting, and thus may not fully reflect real world eating behaviors. This may explain the weaker relationship between preference and intake observed in the current study compared to the Birch study. In the Birch study preference and intake data were collected in a familiar setting (i.e. preschool classroom) where children may have been more comfortable. In addition, the current study used a small number of snack foods that were similar in palatability. Because differences in girls’ liking of the foods could have been small, it may have been difficult for girls to rank order the foods. In the Birch study, there was a wide range of foods ranging from peanut butter and jelly to cream cheese and caviar, differing in palatability and familiarity. In addition, the small number of foods may have interfered with our ability to see a relationship between energy density and food preference. In Gibson and Wardle’s (2003) study on energy density and food preferences, 21 vegetables and fruits were used, ranging in taste and texture. In addition, in the current study the girls were fed lunch prior to completing the preference assessment and measuring intake. However, it is unlikely that this would have impacted girls preference rankings as a previous study showed that satiety did not impact 3- to 4-year-old children’s rankings of foods during the Birch preference assessment (L. Birch, 1979b). In addition, girls’ consumed on average 100-300 calories at each time of measurement making it unlikely that satiety reduced
girls’ consumption to where a relationship between preference and intake was unobservable. In addition, the study was limited to girls. It is unknown whether the results differ for boys. The sample is homogenous—white and from middle-class families—and thus may not generalize to other populations. However, this sample represents the demographic of central Pennsylvania.

Despite the previous limitations, the current study has many strengths. This study contributes to the small body of literature showing that food preferences track across childhood. Compared to previous studies, this was the first study to measure food preferences using valid and reliable measures of preference, and to report effect sizes for the magnitude of the tracking of food preferences. In addition, this was the first study to examine whether energy density predicts preferences in childhood using a variety of palatable foods, and valid and reliable measures of food preferences. No other study to date has assessed how weight status, EAH, and dietary restraint relate to preferences for energy dense foods. Also, this was the first replication of the Birch (1979) study to show that preferences predict intake in childhood. By using highly valid and reliable laboratory measures for children’s food preferences and intake, we optimized the chance of observing the true relationship between preference and intake. This study was the first to examine the developmental change in the preference-intake relationship across middle childhood and to identify individual differences in such change. Because previous studies were limited to one time point of measurement, it wasn’t clear at which age preferences become a weaker predictor of intake—an association typically found in adolescents and adults (Drewnowski & Hann, 1999; Drewnowski et al., 2000; Drewnowski et al., 1996; Iglesias-Gutierrez et al., 2008). This study contributes to the literature on dietary restraint by helping to understand when girls began restricting their food intake, and how BMI may interact with this change.

Conclusion
In summary, this study suggests that food preferences track from early childhood into preadolescence and are not associated with energy density. This study also provides strong evidence that food preferences predict intake across childhood, and suggests that this relation may change for some girls as they enter adolescence. For some girls, external factors such as dietary restraint and weight status may become more influential determinants of consumption patterns than food preferences.

In light of the current obesity epidemic (Ogden et al., 2008) and children’s low consumption of fruits and vegetables (Knol, Haughton, & FitzHugh, 2005; Krebs-Smith et al., 1996), future prevention work should consider targeting children’s food preferences. In our study, we found that food preferences explained approximately 25% of the variance in most girls’ intake and were stable over a 6- to 7-year period. In addition, foods preferences are responsive to environmental factors such as parent’s child feeding strategies. Prevention strategies can include educating parents on effective child feeding methods such as repeated exposure, presenting foods in a positive context, and/or serving as role-models for healthy eating. Similar strategies can even be implemented in schools; for example, principals and teachers can work together to repeatedly exposed children to nutritious foods via vending machines and cafeteria lunches, teachers can be taught how to serve as influential role-models for healthy eating, and simple changes can be made to the school environment to make it more supportive for the consumption of healthy foods such as price reductions for fruits and vegetables.

Future prevention work should also consider that the relationship between preference and intake may be weaker in preadolescence for some girls. In preadolescence, other factors may begin to exert a greater influence on intake, thus younger girls may be more a responsive group for changing food preferences. Future prevention programs may need to target other malleable factors to successfully influence eating behaviors of older girls.
Chapter 6

References


Appendix A

Birch Food Preference Assessment

(Interviewer) “I have three faces here. Do you see a face that looks like the face you make when you eat something that tastes really yummy?’ Point to the face that you would make if you ate something that tasted really yummy?”

Faces used in the Preference test

The interviewer should either point to the yummy face or reinforce the child for picking the correct face.
“This is the yummy face, see how she’s smiling and licking her lips with her tongue like she’s thinking Ohhh yummy!!? OK, now, do you see a face up here that looks like the face that you make when you eat something that tastes really yucky?”

Again, either point to the yucky face or reinforce the child for picking the correct one.

“This is our yucky face. See how she’s frowning and sticking out her tongue like she’s saying Ohhh yucky!!? Ok, now this other face this is our just OK face. This is the face that you make when you eat something and it doesn’t taste really yummy, but it doesn’t taste really yucky, it tastes just kind of OK.

Now, I really like . I think that tastes really yummy. Show me the face that I would make if I ate .”

Again, either reinforce the child for the correct choice or show them the correct face.

Ok, now, I don’t like. I think that tastes really yucky, Show me the face that I would make if I ate .”

Again, either reinforce the child for the correct choice or show them the correct face.

Ok, now, I think that are just OK. I think that tastes just OK, it’s not really yummy like , but it’s not really yucky like . Show me the face that I would make if I ate .”

Again, either reinforce the child for the correct choice or show them the correct face.

“OK, now I’d like to play the game with real food. I have some snacks here and I’d like to know whether you think they taste really yummy, really yucky, or if they taste just OK. I’d like you to taste each one and then put the cup in front of the face that you make when you eat it.

OK? Eat the food that you would like to taste first"

Allow the child to take a taste. When the child is finished, point to each face and ask:

“What do you think? Did that taste really yummy, really yucky, or did it taste just OK?

Put the cup in front of the face that you just made when you tasted the .”
Wait for the child to place the cup in front of one of the faces. When the child is finished mark the response on the preference sheet and respond:

“You thought that one was appropriate face!!! OK, what would you like to taste next?”

Allow the child to take a taste of the 2nd food. Again, pointing to the appropriate faces ask the child

“What do you think? Did that taste really yummy, really yucky, or did it taste just OK?

Put the cup in front of the face that you just made when you tasted the .”

Again, wait for the child to place the cup in front of a face. When the child is finished mark the response on the preference sheet and repeat this step for the remaining foods. Periodically reinforce the child. Be careful to reinforce the child for playing the game, not for the actual choices that she makes. Avoid reinforcement directly after the child places a food into a category and use phrases such as:

“You are really good at this game!”

“I’m having so much fun playing this game with you!”

When the child has tasted all 10 foods and placed the cups in front of the appropriate faces, begin the rank order preference.

"Good job! You are so good at playing this game. OK, let's look at the yummy face”.

Move the yummy face and all cups in front of it forward and place them directly in front of the child.

“These are all of the foods that you thought tasted really yummy. (Repeat the names of each food) Now, I'd like you to take a look at all of these foods and take a taste of the one that tasted the very yummiest.”

You may need to set up a context for the child to think in. If the child seems to be having problems say:
“Let’s pretend that it’s snack time, and these are the foods that I have for snack. You can pick anyone that you want, but you can only pick one. Which food would you like to have for snack? Which one is the yummiest?”

Wait for the child to select one of the foods. When the child tastes a food, mark it as 1 for most preferred on the rank order sheet and remove that cup from in front of the child (place it back on the tray).

"OK, you picked say appropriate food!! Now, I'm going to take that away and these are the foods that you told me were really yummy (again, repeat the names of the remaining foods). Take a taste of the one that tasted the yummiest now."

Wait for the child to select one of the foods. When the child tastes a food, mark it as 2 on the rank order sheet and remove that cup from in front of the child. Repeat this procedure for all of the foods that the child has placed in front of the yummy face remembering to repeat the names of the remaining foods each time. When this is completed, move the yummy face out of the child's view and bring the just OK face and foods forward.

"You told me that you thought that all of these foods tasted just OK (repeat the names of the foods). Now, I'd like you to take a taste of the food that tasted the yummiest out of all of these foods."

Wait for the child to select one of the foods. When the child tastes a food, mark it with the appropriate number on the rank order sheet and remove the cup from in front of the child. Repeat this procedure for all of the foods that the child has placed in front of the just OK face remembering to repeat the names of the remaining foods each time. When this is completed, move the just OK face out of the child's immediate view and bring the yucky face and foods forward.

"You told me that you thought that these foodstasted yucky (repeat names of each food). Now, I'd like you to take a taste of the food that you think tastes the yuckiest out of these foods."
Again, wait for the child to select one of the foods. When the food is selected, mark it with the appropriate number on the rank order sheet (below) and remove the cup from in front of the child (Note that the order is reversed and that the food picked should receive a ranking of 10!). Repeat this procedure with the remaining foods remembering to repeat the names of the remaining foods each time. When this is completed, remove the faces and bring in the foods for the disinhibition procedure.

<table>
<thead>
<tr>
<th>Food</th>
<th>Order</th>
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<th>Rank</th>
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<tr>
<td></td>
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<td>Vanilla Frozen Yogurt</td>
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Comments:
Appendix B

Food Intake Protocol

Place the bowls with the 10 snack items in front of the child and tell them:

(Interviewer) "Next, we are going to have 10 minutes of quiet free time before we finish. I have a timer that I am going to set for 10 minutes. There are some books and other stuff that you can do until the timer goes off. You can go ahead and eat whatever you would like - we have to throw away the leftover food. I am going to go do some work in the other room. You can come and get me if you need anything. When the timer goes off, I will come back. OK?

Remember, I'll just be in the next room.

Make sure that this is OK with the child. If the child is not overly bothered by this, leave the room and shut the door. Observe the child through the observation mirror. At the five minute mark, check on the child's progress.

"How are you doing? I have about 5 more minutes of work left. OK?"

When the timer goes off, return to the room and conduct the exit interview with the child. Starting with the first food, ask the child each of the questions in the exit interview.
Appendix C

Dutch Eating Behavior Questionnaire (DEBQ) - Confirmatory Factor Analysis

Confirmatory factor analysis was performed on the DEBQ at Wave 1, cohorts 1 and 2 data (1996/1997). Because the questionnaire contained non-applicable responses (in particular, see items involving emotionally-based eating), only those cases with >50% of responses present were included in the analysis. A total of 89 cases were used for factor analysis.

Confirmatory Analyses

The factor structure of the adult questionnaire was used as the basis for the first confirmatory factor model tested. Confirmatory factor analysis was performed to test the hypothesis that the questionnaire measured children’s restrained, emotional and external eating. To reduce the total number of items being subject to factor analysis, some items within each subscale with similar variances were averaged. The following model was tested: Restraint, containing averaged (AV) items AV(2,3), AV (4,6), AV(5,7), AV(8,9), AV (1,10); Emotional eating AV(11,16), AV(12,23), AV(13,15,21), AV(17,18,20),AV(19,22) and single item #14; and External eating, AV (24,25), AV(28,29), AV(26,27,31), AV(30,32,33). Modification indices for the first model suggested the removal of 1 items: AV(1, 10). A second model was tested, showing high error covariance between AV(28,29) and AV(30,32) in the TD matrix. The final model
estimated the error covariance between the aforementioned items tested and contained 32 variables, represented in 13 composites, and 1 single item t-tests for each item in the final model indicated that each variable provided a meaningful contribution to the factor on which it loaded. The goodness of fit indices for the final model were slightly below the accepted level of 0.95 as shown below, indicating that the model had a fair fit with the observed data structure. The loadings are as follows: Restraint, AV(2,3) 0.29, AV (4,6) 0.38, AV(5,7) 0.32, AV(8,9) 0.53; Emotional eating AV(11,16) 0.39, AV(12,23) 0.33, AV(13,15,21) 0.38, AV(17,18,20) 0.36, AV(19,22) 0.50 and single item #14--0.41; and External eating, AV(24,25) 0.59, AV(28,29) 0.18, AV(26,27,31) 0.38, AV(30,32,33) 0.27. The correlation between restraint and emotional was r=.58, between restraint and external, r=-.09, and r=.29 between emotional and external eating.

**Model Fit Statistics**

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</table>

**Scoring**

Items for each factor (as indicated above in final model) are summed to obtain factor scores for restriction and encouragement. Aggregate items do not have to be averaged before summing.