Appetite 161 (2021) 105140

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Does temperament make children differently susceptible to their home physical food environment? A cross-sectional DAGIS study on 3–6 year old Finnish children's food consumption

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ARTICLE INFO

Keywords:
Negative affectivity
Surgency
Effortful control
Food availability
Food accessibility
Food frequency questionnaire

ABSTRACT

Consistently linked with children's food consumption are food availability and accessibility. However, less is known about potential individual differences among young children in their susceptibility to home food environments. The purpose of the study was to examine whether the association between home food availability and accessibility of sugar-rich foods and drinks (SFD) or fruits and vegetables (FV) and children's consumption of these foods differ according to their temperament. The study used two cross-sectional datasets collected as part of the Increased Health and Wellbeing in Preschools (DAGIS) study: 1) a cross-sectional data of 864 children aged 3–6 years old collected between fall 2015 and spring 2016, and 2) an intervention baseline data of 802 children aged 3–6 collected in fall 2017. Parents reported their children's temperament, consumption of FV and SFD, and home availability and accessibility of SFD and FV. Examination of whether associations between home availability and accessibility of FV and their consumption differ according to children's temperament involved using linear regression models. Similar models were used to examine association between home availability and accessibility of SFD and their consumption, and the moderating role of temperament. The association between home accessibility of SFD and their consumption frequency was dependent on the level of children's negative affectivity. More frequent consumption of SFD was observed with higher home accessibility of SFD. The association was stronger in children with higher scores in negative affectivity. No other interactions were found. Children with higher negative affectivity are possibly more vulnerable to food cues in the home environment than children with lower negative affectivity. Consideration of children's individual characteristics is necessary in supporting their healthy eating.

1. Introduction

Diets including sufficient consumption of vegetables and fruits and moderate consumption of foods with high sugar and saturated fat content are recommended for health promotion and disease prevention (Diet and nutrition and the p, 2003). As food consumption patterns learned in childhood predict diet in adulthood (Mikkilä et al., 2005; Movassagh et al., 2017), promoting healthy eating among young children is of vital importance. The home food environment, which comprises both physical and sociocultural factors, is a major contributor to children's diet (Pearson et al., 2017; Rosenkranz & Dzewaltowski, 2008). The physical home food environment includes availability and accessibility of different foods at home. Availability refers to presence of foods at home, whereas accessibility refers to how easily in terms of forms, location and time the foods can be consumed (Cullen et al., 2003). Sociocultural factors include parents' own food consumption,

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https://doi.org/10.1016/j.appet.2021.105140
Received 8 July 2020; Received in revised form 12 December 2020; Accepted 22 January 2021
Available online 29 January 2021

modelling and practices around mealtimes (Rosenkranz & Dzewaltowski, 2008).

Existing literature links the physical home food environment to children's diets among preschoolers (Boles et al., 2019; Kristiansen et al., 2017; Vepsäläinen et al., 2018; Wyse et al., 2011), primary-school aged children (Couch et al., 2014; Ding et al., 2012; Vepsäläinen et al., 2015) and adolescents (Ding et al., 2012). The availability of unhealthy foods, for example sugar-rich foods and drinks (SFD) and savory foods, has been linked with lower consumption of fruits and vegetables (FV) (Couch et al., 2014), lower overall diet quality (Vepsäläinen et al., 2018) and higher consumption of unhealthy foods (Blaine et al., 2017; Boles et al., 2019; Vepsäläinen et al., 2018). The availability of FV has been positively associated with both higher consumption of FV (Boles et al., 2019; Kristiansen et al., 2017; Wyse et al., 2011) and healthy dietary patterns (Couch et al., 2014; Vepsäläinen et al., 2018). To date, less research has focused on food accessibility at home and its associations with children's food consumption (Gebremariam et al., 2017). However, existing studies indicate a relatively consistent positive association between home food accessibility and food consumption (mainly FV consumption) (Ong et al., 2017).

Home food availability and accessibility play a clear role in children's food consumption. However, research also implies that people may be differently susceptible to food environments based on their individual characteristics. For example, impulsivity (i.e. disposition to react rapidly without forethought to internal/external stimuli) and reward sensitivity (i.e. disposition to anticipate and response positively to reward) positively associates with body mass index (Francis et al., 2013; Van Den Berg et al., 2011). Furthermore, research has found positive links between impulsivity and higher consumption of unhealthy foods (Coumans et al., 2018; Nederkoorn et al., 2015) and external eating (i.e. eating induced by external and environmental food cues) (Farrow, 2012; Leung et al., 2014) among children of different ages. Contrary to impulsivity, self-regulatory abilities (e.g. abilities to focus attention and inhibit prepotent responses) associate negatively with body mass index or risk of obesity (Anzman-Frasca et al., 2012; Bergmeier et al., 2014), and positively with self-regulated eating (Godefroy et al., 2016; Leung et al., 2014) among children and adolescents. Proneness to negative emotionality, in turn, predicts both food approach behavior, such as susceptibility to the hedonistic qualities of food and emotional overeating, and food avoidant behavior, such as food fussiness and emotional undereating (Steinsbekk et al., 2020). Thus, it is possible that interactions between physical home food environments and children's individual characteristics exist; some children may be more susceptible than others.

Individual characteristics can be examined as a single trait or they can be approached from a broader perspective, such as through temperament, as in the study of Steinsbekk et al. (Steinsbekk et al., 2020) The current study examined children's individual characteristics from a broader perspective by using Rothbart and colleagues' (Rothbart et al., 2001) concept of temperament. According to their model, temperament comprises three higher order dimensions: 1) surgency: characterized by, for example, motor activity, impulsivity, low levels of shyness and desire for reward and sensation seeking, 2) negative affectivity: characterized by, for example, high irritability, anger, frustration and sadness, and 3) effortful control: characterized by, for example, high inhibitory control and attention focusing, representing the regulatory disposition of an individual.

Existing studies on interactions between home availability or accessibility of different foods and children's individual characteristics on children's diet have revealed mixed results. De Decker et al. (De Decker et al., 2017) found that children with high reward sensitivity more frequently ate fast food when unhealthy foods were available at home. Another study by De Cock et al. (De Cock et al., 2016) did not find interaction between reward sensitivity and availability of snacks at home or at school regarding snack consumption among adolescents. Studies on the topic are scarce, and to the best of our knowledge, no studies exist regarding children aged under 6. Further, the existing studies have examined only unhealthy food consumption, specifically considering children's reward sensitivity or impulsivity (De Cock et al., 2016; De Decker et al., 2017). We aimed to address the literature gap and examine whether the association between home availability and accessibility FV or SFD and their consumption frequency is dependent on children's temperament.

2. Methods

2.1. Study design and participants

The present analyses uses two datasets collected in Finland as part of the Increased Health and Wellbeing in Preschools (DAGIS) study: 1) a cross-sectional dataset collected between fall 2015 and spring 2016, and 2) an intervention baseline dataset collected in fall 2017.

In the cross-sectional study, 864 children (25% of the invited children) and their families, from 66 early childhood education and care (ECEC) centers (43% of the invited ECECs) in eight municipalities in southern and western Finland consented to participate in the study. The recruitment took place between August 2015 and February 2016. ECECs were eligible for the survey, if they charged income dependent fees (all public ECECs have reduced fees for low-income families), had at least one group with children aged between 3 and 6, provided childcare in either Finnish or Swedish and provided childcare only during the daytime. Power and sample size calculations provided the grounds for the number of invited ECECs (Määttä et al., 2015). A detailed description of the recruitment process of the cross-sectional study is described elsewhere (Lehto et al., 2018).

In the intervention study, 802 children and their families consented to participate, and 778 families (45% of the invited children) provided at least some data in the baseline measurements. The recruitment took place in August 2017. Families were recruited in two municipalities in southern Finland through ECECs. In one municipality, all eligible ECECs (n = 19) and in the other, three ECECs participated in the study. The municipalities were different from those who participated in the cross-sectional study. Eligibility criteria for the ECECs were: 1) having at least one group with children aged 3 to 6, 2) being Finnish speaking and 3) being a public ECEC. Sample size and power calculations for the intervention data were based on previous results of the DAGIS project (Lehto et al., 2018) and are described elsewhere (Ray et al. et al.). A detailed description of the recruitment process of the intervention study is described elsewhere (Ray et al. et al.).

Analyses of the home availability of FV and SFD utilized combined data from both the studies. Children were included in the analyses with the combined data if they had available complete temperament data, data at least on one of the outcomes (FV, SFD consumption frequency), and on at least one of the availability variables (FV availability, SFD availability) (N = 1216, 74% of the total sample). Analyses of the home accessibility of FV and SFD were conducted using only the intervention baseline data because information on home food accessibility was collected only in the intervention data. Children were included in the analyses with only the intervention baseline data if they had available complete temperament data, data at least on one of the outcomes (FV or SFD consumption frequency) and on at least one of the accessibility variables (FV, SFD accessibility) (N = 479, 62% of the total sample).

Families participating in the cross-sectional and intervention studies signed a written informed consent. The studies were performed in accordance with the Declaration of Helsinki. The Helsinki Ethical Review Board in Humanities and Social and Behavioral Sciences approved the study design and procedures for the cross-sectional survey in February 2015 (#6/2015) and for the intervention in May 2017 (#22/2017).

2.2. Measures

2.2.1. Temperament

To measure children's temperament, one parent in each family completed the very short Children's Behavior Questionnaire (CBQ-VSF) (Putnam & Rothbart, 2006). The CBQ-VSF is developed for children aged 3 to 8 and it includes 36 items with response options ranging from 1 (= extremely untrue) to 7 (= extremely true). The instrument defines three broad temperament dimensions (each measured with 12 items): surgency, negative affectivity and effortful control.

For the analyses, the mean of each dimension was calculated for each participant. The variables were used as continuous variables and mean centered before analyses. The questionnaire demonstrated acceptable internal consistency and criterion validity (Putnam & Rothbart, 2006). In this study's combined data, the Cronbach's alpha values for surgency, negative affectivity and effortful control were 0.81, 0.77 and 0.74, and in the cross-sectional data 0.80, 0.76 and 0.74, and in the intervention data 0.83, 0.79, 0.75, respectively.

2.2.2. FV and SFD consumption

To measure children's food consumption, on behalf of their child, one parent completed a food frequency questionnaire (FFQ) developed for the DAGIS project (Korkalo et al., 2019). The FFQ was developed to assess children's dietary quality in general outside preschool hours, with specific attention paid to capturing the consumption patterns of vegetables and fruits as well as sugary foods and beverages. The FFQ of the cross-sectional study inquired about the consumption frequencies of 47 different foods and beverages. Participant families received the FFQs by post roughly one week before data on FV and SFD availability and accessibility was collected. Parents returned the completed FFQs to the preschools, from where they were collected by the research staff. If two or more FFQ items were missing, nutritionists contacted the families and the missing items were completed if possible. For the intervention study, the original FFQ was expanded by four items and transformed into an online version. Hence, intervention families reported consumption frequencies of 51 different foods and beverages, and they administered the FFQs via a link sent to their emails. Links were sent roughly 1–3 weeks after the data on FV and SFD availability and accessibility was collected. Hard copies of FFQs were sent by post to those families who did not fill in the electronic version. The completed FFQs in the intervention study were not further quality checked by the research staff. The consumption frequency was reported by informing the exact number of times (either in times per day or times per week) the child had consumed each food or beverage during the past week when not at preschool. A "not at all" option for each item was available if a child had not consumed that food or beverage during the past week. The FFQ has shown moderate reproducibility (Määttä et al., 2018) and fairly good relative validity when ranking FV and SFD consumption compared to food record data (Korkalo et al., 2019). For the present study, two continuous variables were calculated to sum up the daily consumption frequency of FV and

Table 1
Study variables and their descriptive statistics.

	Construct items	Combined data (n = 1216)	Survey data (n = 707)	Intervention data (n = 509)	*p – value*[a]
Effortful control, mean ± SD	Mean of 12 items: E.g. "My child is good at following instructions", "My child prepares for trips and outings by planning things s/he will need"	5.2 ± 0.7	5.2 ± 0.7	5.3 ± 0.8	.13
Surgency, mean ± SD	Mean of 12 items: E.g. "My child often rushes into a new situation", "My child seems to be at ease with almost anyone"	4.7 ± 0.9	4.7 ± 0.8	4.7 ± 0.9	.55
Negative affectivity, mean ± SD	Mean of 12 items: E.g. "My child gets quite frustrated when prevented from doing something s/he wants to", "My child is very difficult to soothe when upset"	3.7 ± 0.9	3.7 ± 0.9	3.7 ± 0.9	.93
Missing, n (%)		0 (0)	0 (0)	0 (0)	
Daily sugar-rich food and drink consumption frequency, mean ± SD	Sum of 14 items: Flavored yogurt and quark; puddings; sugar-sweetened cereals and muesli; berry, fruit and chocolate porridge with added sugar; berry and fruit soups with added sugar; ice cream; chocolate; sweets; cakes, cupcakes, sweet rolls, Danish pastries, pies and other sweet pastries; sweet biscuits and cereal bars; soft drinks; flavored and sweetened milk- and plant-based drinks; sugar-sweetened juice drinks; and fruit juice	2.4 ± 1.2	2.5 ± 1.2	2.3 ± 1.2	.045
Missing, n (%)		42 (4)	25 (4)	17 (3)	
Daily fruit and vegetable consumption frequency, mean ± SD	Sum of 5 items: Fresh vegetables; cooked and canned vegetables; fresh fruits; canned and frozen fruits; berries	3.0 ± 1.5	2.9 ± 1.4	3.1 ± 1.6	.09
Missing, n (%)		31 (3)	14 (2)	17 (3)	
Availability of fruits and vegetables at home, mean ± SD, (range)	Sum of 4 items: Fresh vegetables; frozen vegetables; fresh fruit; and frozen fruit	16.9 ± 2.5 (7–20)	17.4 ± 2.4 (7–20)	16.2 ± 2.6 (8–20)	.001
Missing, n (%)		5 (0.4)	2 (0.3)	3 (0.6)	
Availability of sugar-rich foods and drinks at home, mean ± SD, (range)	Sum of 8 items: Chocolate and sweets; ice-cream; cookies; soft drinks; sweet pastries; sugar-sweetened juice drinks; sugar-sweetened cereals and muesli; and sugar-sweetened yoghurts and puddings	22.5 ± 4.6 (10–37)	22.7 ± 4.7 (12–36)	22.1 ± 4.5 (10–37)	0.03
Missing, n (%)		2 (0.2)	0 (0)	2 (0.4)	
Accessibility of sugar-rich foods and drinks at home, mean ± SD, (range)	Sum of 6 items: Sugar-rich cereals and muesli; juice with added sugar; soft drinks with added sugar; cookies and cereal bars; cakes, muffins, buns, sweet pies; chocolate and sweets			6.7 ± 2.3 (0–12)	
Missing, n (%)				110 (22)	
Accessibility of fruits and vegetables at home	Sum of 2 items: Fresh vegetables; fresh fruit				
Neither or either one accessible, n (%)				127 (27)	
Both accessible, n (%)				345 (73)	
Missing, n (%)				37 (7)	

[a] Student's t-test, survey data compared to intervention data.

SFD. Table 1 presents foods included in each of the variables.

2.2.3. FV and SFD availability and accessibility

Parents reported the availability of fruits and vegetables and sugar-rich foods and drinks by answering the question "How often do you have the following foods and drinks at home?" and giving the response on a scale from 1 (=never) to 5 (=always). For the intervention study, the tool was further modified so that after reporting the availability of different foods, parents also indicated the accessibility of FV and SFD that are kept in sight of children by answering a follow-up question "If you have had the food at home, have you kept it in sight of the child (yes/no)?" Accessibility was not inquired of foods and drinks usually kept in the refrigerator or freezer. The accessibility variables were formed by combining information from the availability and accessibility questions as follows: If a parent indicated they did not have the food available at home, its accessibility was coded as 0 (=not available at home), foods that were available at home were coded either as 1 (=available, not accessible) or 2(=available and accessible) as per the answers to the accessibility question. The measure for home food availability was based on a previously published tool (Couch et al., 2014; Ding et al., 2012) that has demonstrated acceptable to good test-retest reliability for scales of FV, unhealthful and healthful foods (Ding et al., 2012). The tool was modified for the present study by adding foods and drinks commonly eaten in Finnish families with children and removing those considered unnecessary in the context of present study. For the intervention study, follow-up questions about the accessibility of the foods and drinks were added after each item. Määttä et al. (Määttä et al., 2018) have examined the test-retest reliability of the modified tool, and they found that most availability and accessibility items demonstrate moderate to good intraclass correlations (ICC) or Kappa values. However, three availability items (sweet pastries, chocolate and sweets, and ice cream) and three accessibility items (fresh fruit, cookies, and sweet pastries) had ICCs/Kappa values under 0.40 and thus did not reach the moderate level of test-retest reliability.

For the analyses, two continuous variables were calculated to sum up the home availability of FV and SFD. Table 1 presents the foods included in each variable. The variables were mean centered before analyses. Home accessibility of FV was calculated by summing up the accessibility of fresh vegetables and fresh fruit. The formed categorical variable with three categories was dichotomized (1 = both fresh vegetables and fresh fruits accessible, 0 = either one or neither accessible) as only a few children (N = 19, 4%) belonged to the group "neither accessible". A continuous variable of home accessibility of SFD was calculated by summing up accessibility of sugar-rich foods at home (Table 1). The variable was mean centered before analyses.

2.2.4. Confounding variables

Children's age (continuous), gender and mother's highest education were considered as confounders in the study because existing literature has indicated their relevance to children's temperament (Bornstein et al., 2019; Sanson et al., 1994) and food consumption (Kyttälä et al., 2013). Parents reported children's age and gender. A mother's education was established by a questionnaire and categorized as low (comprehensive, high school or vocational school), middle (bachelor's degree or equivalent) or high (master's degree or licentiate/doctor). In addition, a mother's age, number of days in ECEC per week and the source of the data (cross-sectional study vs. intervention) were examined as potential confounders in preliminary analyses; however these variables were not included in final models because they did not demonstrate considerable effects on the models.

2.3. Statistical analyses

First examined were means, standard deviations and distributions. Prior to the analyses, outliers in the distance of three standard deviations or more from the mean were excluded in the dependent variables (consumption frequency of SFD n = 21, consumption frequency of FV n = 17). In addition, differences between the two datasets (cross-sectional vs. intervention baseline) were examined by using Student's t-test for continuous and Chi-squared test for categorical variables. Further examined were differences between the participants regarding socio-demographic variables that were included in the analyses and those excluded because of missing data in one or more of the core variables (temperament, food consumption, food availability/accessibility). These examinations used Student's t-test for continuous and Chi-squared test to categorical variables. All the preliminary analyses were performed in SPSS (IBM SPSS version 25.0, Armonk, NY, USA).

Interactions of the home food environment by each temperament dimension were examined in linear models with R version 3.5.3 and RStudio (R Core Team, 2019). The models included one temperament dimension at a time, availability/accessibility of FV or SFD, availability and accessibility by temperament interaction; the models were adjusted for children's age, gender and mother's highest education. We also examined models that simultaneously included all three temperament dimensions. However, the results did not change significantly and therefore, are not further presented in this article.

The model residuals indicated non-constant variance and some children (21%) had one or more siblings in the study, causing clustering of the data on family-level; therefore, covariance matrices accounting for heteroscedasticity (with heteroscedasticity-consistent standard errors (HC3)) and clustering were estimated (package "sandwich" (Berger et al., 2017; Zeileis, 2004)). Model coefficients and 95% confidence intervals were estimated using the model-robust covariance matrices (package "lmtest" (Zeileis & Hothorn, 2002)). Significant interactions were further examined through Johnson-Neyman significance regions and simple slopes at mean and in the distance of one standard deviation from the mean (package "interactions" (Long, 2019)). In all analyses, participants providing sufficient data were included in the analysis (complete case analysis). All associations used a confidence level of 95 percent.

3. Results

Table 2 presents the descriptive statistics of the participants. The average age of children in the combined data was 4.9 (±1.0). Children in the cross-sectional data were on average slightly younger than children in the intervention data (4.7 ± 0.9 vs. 5.2 ± 1.0, respectively). Furthermore, a greater proportion of mothers in the cross-sectional data were highly educated (had at least a master's degree) compared to the intervention data (30% vs. 17% in the highest education groups, respectively) (Table 2). Small differences were found in the home availability of FV and SFD between children in the two datasets (Table 1). The children who were excluded from the analyses because of missing data in temperament, food consumption and/or food availability/accessibility were slightly older (Student's t-test, $p = 0.017$) and had younger mothers (Student's t-test, $p = 0.018$) than children with available data. Also, among the excluded children, a greater proportion of mothers had a low education level (Chi-Squared test, $p = 0.021$). No differences in gender distribution were found.

Table 3 presents the results for associations between home food availability and FV and SFD consumption according to children's temperament. None of the three temperament dimensions moderated the association between home FV availability and FV consumption or the association between home SFD availability and their consumption. Associations existed, however, between the availability of both FV and SFD alone, and consumption frequencies of those foods.

Associations between home food accessibility and FV and SFD consumption according to children's temperament are presented in Table 4. Negative affectivity significantly moderated ($p < 0.01$) the association between accessibility and SFD consumption frequency. Fig. 1 describes the conditional effects of home accessibility of SFD on SFD consumption frequency at different levels (mean and ±1 standard deviations from the

Table 2
Descriptive statistics of study participants.

		Combined data (n = 1216)	Survey data (n = 707)	Intervention data (n = 509)	
Children's age, years, mean ± SD		4.9 ± 1.0	4.7 ± 0.9	5.2 ± 1.0	<.001[a]
Missing, n (%)		0 (0)	0 (0)	(0)	
Mothers' age, years, mean ± SD		35.7 ± 4.8	35.7 ± 4.7	35.7 ± 5.1	.82[a]
Missing, n (%)		24 (2)	13 (2)	11 (2)	
Child's gender, n (%)	girl	576 (47)	346 (49)	230 (45)	.20[b]
	boy	640 (53)	361 (51)	279 (55)	
	missing, n (%)	0 (0)	0 (0)	0 (0)	
Mothers' education level, n (%)	low	377 (32)	202 (29)	175 (36)	<.001[b]
	middle	519 (44)	286 (41)	233 (47)	
	high	296 (25)	211 (30)	85 (17)	
	missing, n (%)	24 (2)	8 (1)	16 (3)	
Who reported the home food availability and accessibility, n (%)	mother	1083 (90)	626 (89)	457 (91)	0.57[b]
	father	120 (10)	76 (11)	44 (9)	
	other guardian	6 (0.5)	3 (0.4)	3 (0.6)	
	missing, n (%)	7 (0.6)	2 (0.3)	5 (1)	

[a] Student's t-test, survey data compared to intervention data.
[b] Chi-Squared test, survey data compared to intervention data.

mean) of children's negative affectivity. The association was stronger when children scored high in negative affectivity. Fig. 2 displays the values of negative affectivity with a statistically significant association between home accessibility of SFD and SFD consumption frequency (i.e. Johnson-Neyman significance regions). When children score very low in negative affectivity (score < 2.60, 14% of the study children), no significant association exists between the home accessibility of SFD and consumption of these foods based on the Johnson-Neyman significance regions. No interactions were found according to surgency or effortful control for the associations between accessibility and consumption frequency of FV or SFD. The accessibility of both FV and SFD alone, however, were associated with consumption frequencies of those foods.

4. Discussion

This study aimed to examine whether the association between physical home food environment and food consumption differs according children's temperament. Neither the association between the availability of FV and FV consumption frequency nor the availability of SFD and SFD consumption frequency was dependent on any of the examined temperament dimensions. Accessibility of SFD, however, was differently associated with SFD consumption frequency depending on the level of children's negative affectivity. Children with high scores in negative affectivity consumed SFD more often when plenty of these foods were accessible at home. No other interactions were found.

An explanation for the lack of interactions between home availability of FV or SFD and any of the temperament dimensions could relate to 'home food availability' only meaning that the foods are present at home but not necessarily kept in places where children can see or reach them. Previous research has shown that the presence of foods in their direct environment can trigger people to start eating (Bilman et al., 2017). However, available foods at home may not actually be present in the direct environment of children if the foods are kept in cupboards and children are not aware of their presence.

Two previous studies (De Cock et al., 2016; De Decker et al., 2017) reported different results regarding the moderating effect of the home

Table 3
Linear regression models on associations between home availability, temperament and consumption frequency of fruits and vegetables and sugar-rich foods and drinks.

	Fruits and vegetables[a]						Sugar-rich foods and drinks[b]					
	Unadjusted (n = 1180)			Adjusted[c] (n = 1157)			Unadjusted (n = 1172)			Adjusted[c] (n = 1150)		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
Negative affectivity[d]	**−0.10**	**0.05**	**−0.20, -0.01**	−0.10	0.05	−0.19, 0.01	0.01	0.04	−0.07, 0.08	−0.01	0.04	−0.09, 0.06
Availability[d]	**0.16**	**0.02**	**0.13, 0.19**	**0.16**	**0.02**	**0.13, 0.20**	**0.09**	**0.01**	**0.07, 0.10**	**0.09**	**0.01**	**0.07, 0.10**
Negative affectivity x availability	0.02	0.02	−0.01, 0.06	0.02	0.02	−0.01, 0.06	0.00	0.01	−0.02, 0.01	0.00	0.01	−0.02, 0.01
R^2			0.09			0.09			0.11			0.12
ΔR^2			0.00			0.00			0.00			0.00
Constant			3.01			2.79			2.40			1.99
Surgency[d]	0.06	0.05	−0.03, 0.15	0.07	0.05	−0.02, 0.17	0.04	0.04	−0.04, 0.11	0.03	0.04	−0.05, 0.10
Availability[d]	**0.17**	**0.02**	**0.14, 0.20**	**0.17**	**0.02**	**0.13, 0.20**	**0.09**	**0.01**	**0.07, 0.10**	**0.09**	**0.01**	**0.07, 0.10**
Surgency x availability	0.03	0.02	−0.01, 0.07	0.03	0.02	−0.01, 0.07	0.00	0.01	−0.02, 0.02	0.00	0.01	−0.02, 0.02
R^2			0.09			0.09			0.11			0.12
ΔR^2			0.00			0.00			0.00			0.00
Constant			3.00			2.76			2.40			1.99
Effortful control[d]	**0.14**	**0.06**	**0.03, 0.25**	0.10	0.06	−0.01, 0.22	−0.07	0.05	−0.15, 0.02	−0.08	0.05	−0.17, 0.02
Availability[d]	**0.17**	**0.02**	**0.13, 0.20**	**0.17**	**0.02**	**0.13, 0.20**	0.09	**0.01**	**0.07, 0.10**	**0.09**	**0.01**	**0.07, 0.10**
Effortful control x availability	0.01	0.02	−0.03, 0.05	0.01	0.02	−0.04, 0.05	−0.01	0.01	−0.02, 0.01	−0.00	0.01	−0.02, 0.01
R^2			0.09			0.09			0.11			0.12
ΔR^2			0.00			0.00			0.00			0.00
Constant			3.00			2.80			2.40			1.97

Abbreviations: CI, confidence interval; SE, standard error, statistically significant results in bold.
[a] Fruits and vegetables include: fresh, cooked and canned vegetables; fresh, canned and frozen fruit; berries.
[b] Sugar-rich foods and drinks include: flavored yogurt and quark; puddings; sugar-sweetened cereals and muesli; berry, fruit and chocolate porridge with added sugar; berry and fruit soups with added sugar; ice cream; chocolate; sweets; cakes, cupcakes, sweet rolls, Danish pastries, pies and other sweet pastries; and sweet biscuits and cereal bars; soft drinks; flavored and sweetened milk- and plant-based drinks; and sugar-sweetened juice drinks.
[c] Adjusted for: child's age and gender, mother's education.
[d] Variable continuous and mean centered before analysis.

Table 4
Linear regression models on associations between home accessibility, temperament and consumption frequency of fruits and vegetables and sugar-rich foods and drinks.

	Fruits and vegetables[a]						Sugar-rich foods and drinks[b]					
	Unadjusted (n = 455)			Adjusted[c] (n = 439)			Unadjusted (n = 386)			Adjusted[c] (n = 374)		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
Negative affectivity[d]	−0.19	0.12	−0.48, 0.10	−0.19	0.13	−0.48, 0.11	0.05	0.06	−0.07, 0.17	0.05	0.06	−0.07, 0.18
Accessibility[e]	**0.71**	**0.15**	**0.39, 1.02**	**0.73**	**0.15**	**0.41, 1.05**	**0.14**	**0.03**	**0.09, 0.19**	**0.15**	**0.03**	**0.10, 0.20**
Negative affectivity x accessibility	−0.02	0.16	−0.36, 0.33	0.04	0.16	−0.31, 0.38	**0.08**	**0.03**	**0.04, 0.13**	**0.08**	**0.03**	**0.03, 0.13**
R^2			0.05			0.08			0.09			0.11
ΔR^2			0.00			0.00			0.03			0.03
Constant			2.58			1.66			2.29			1.64
Surgency[d]	−0.11	0.14	−0.39, 0.18	−0.09	0.16	−0.38, 0.20	0.03	0.07	−0.09, 0.15	0.01	0.07	−0.11, 0.14
Accessibility[e]	**0.68**	**0.15**	**0.36, 1.00**	**0.71**	**0.15**	**0.39, 1.03**	**0.13**	**0.03**	**0.08, 0.18**	**0.13**	**0.03**	**0.08, 0.18**
Surgency x accessibility	0.20	0.17	−0.14, 0.54	0.17	0.18	0.17, 0.51	−0.01	0.03	−0.06, 0.04	−0.01	0.03	−0.06, 0.04
R^2			0.03			0.07			0.06			0.08
ΔR^2			0.00			0.00			0.00			0.00
Constant			2.60			2.45			2.30			1.63
Effortful control[d]	0.26	0.16	−0.10, 0.61	0.20	0.17	−0.17, 0.57	−0.07	0.08	−0.22, 0.07	−0.07	0.08	−0.22, 0.09
Accessibility[e]	**0.66**	**0.15**	**0.35, 0.98**	**0.71**	**0.15**	**0.39, 1.03**	**0.13**	**0.03**	**0.08, 0.18**	**0.13**	**0.03**	**0.08, 0.18**
Effortful control x accessibility	−0.03	0.20	−0.45, 0.38	−0.01	0.20	−0.43, 0.41	−0.04	0.04	−0.10, 0.03	−0.03	0.04	−0.10, 0.04
R^2			0.04			0.08			0.06			0.09
ΔR^2			0.00			0.00			0.00			0.00
Constant			2.60			2.48			2.29			1.62

Abbreviations: B, unstandardized coefficient; CI, confidence interval; SE, standard error, statistically significant results in bold.
[a] Fruits and vegetables include: Fresh vegetables; cooked and canned vegetables; fresh fruit; canned and frozen fruit; berries.
[b] Sugar-rich foods and drinks include: flavored yogurt and quark; puddings; sugar-sweetened cereals and muesli; berry, fruit and chocolate porridge with added sugar; berry and fruit soups with added sugar; ice cream; chocolate; sweets; cakes, cupcakes, sweet rolls, Danish pastries, pies and other sweet pastries; and sweet biscuits and cereal bars; soft drinks; flavored and sweetened milk- and plant-based drinks; and sugar-sweetened juice drinks.
[c] Adjusted for: child's age and gender, mother's education.
[d] Variable continuous and mean centered before analysis.
[e] Fruits and vegetables accessibility dichotomous, Sugar-rich food and drinks accessibility continuous and mean centered before analyses.

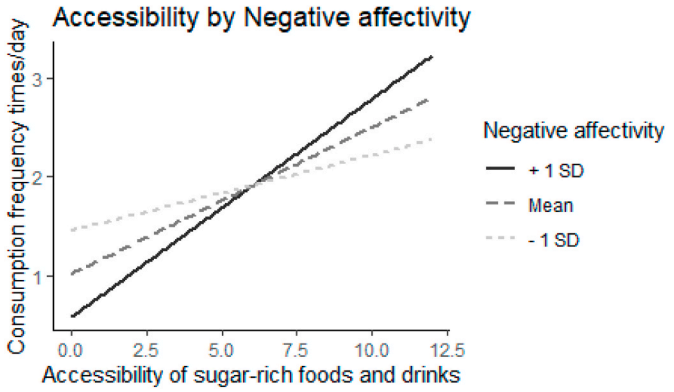

Fig. 1. The moderating role of negative affectivity in the association between home accessibility of sugar-rich foods and drinks and consumption frequency of these foods.

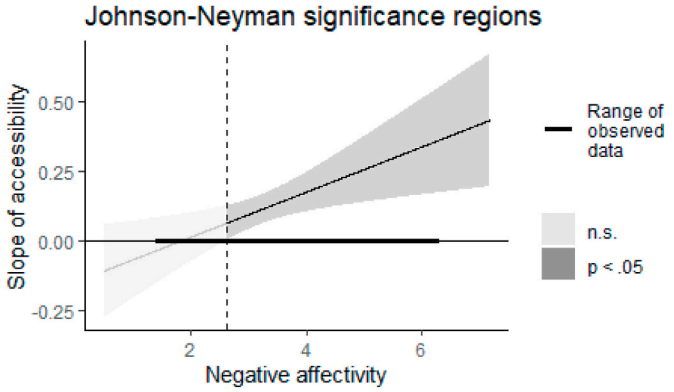

Fig. 2. Values of negative affectivity from which the association between home accessibility of sugar-rich foods and drinks and consumption frequency of these foods is statistically significant.

availability of unhealthy foods on the association between children's individual characteristics and diet. De Decker et al. (De Decker et al., 2017) found that home availability of unhealthy foods moderated the association between reward sensitivity and fast food consumption in children with an average age of 10. De Cock et al. (De Cock et al., 2016), however, did not find interaction between external or emotional eating and availability of unhealthy food at home in adolescents with an average age of 15. The discrepancy between the studies could result from the different ages of the studied children. In our study, the average age of children was 5; their parents might have more control over their eating (e.g., what and how easily the children find different foods from kitchen cabinets or refrigerator and whether the children spend time alone at home or not) than the eating of the older children De Decker et al.'s study (De Decker et al., 2017). In the study by De Cock et al. (De Cock et al., 2016), in turn, dealt with older and more independent adolescents; the study's result of no interactions could relate to adolescents more often eating elsewhere than at home. De Decker et al. (De Decker et al., 2017) suggest that adolescents have more pocket money and may eat more fast-food outside home, which could have substantial effect on their food consumption. Furthermore, in our study and in the study by De Decker et al. (De Decker et al., 2017) parents reported their children's food consumption, and the measure was based on consumption frequencies, whereas in the study by De Cock et al. (De Cock et al., 2016) adolescents self-reported their consumption frequencies along with estimation of portion sizes, which may also explain the different results.

In light of the existing literature, we consider plausible our finding of the moderating effect of negative affectivity on the association between SFD accessibility and SFD consumption frequency. For example, Steinsbekk et al. (Steinsbekk et al., 2020) have recently shown that, over

time, children's proneness to negative emotionality predicts both food approach behavior, such as susceptibility to the hedonistic qualities of food and emotional overeating, and food avoidant behavior. Yet to be determined is which factors cause negative emotionality leading to food approach and emotional overeating, and which to food avoidant behavior and emotional undereating. Environment is one potential factor. Our results suggest that children with high scores in negative affectivity may be more susceptible to food environments having plenty of food cues, resulting in more frequent consumption of palatable foods; however, the cross-sectional study design prevents making conclusions about causality. SFD accessibility by negative affectivity interaction explained three percent of the model variance, which is a modest portion. This was expected, as children's food consumption is the result of multiple factors, such as parental modelling, parental food intake, family rules, children's eating behaviors and parental practices around eating and mealtimes (Scaglioni et al., 2018; Yee et al., 2017), many of which are more proximal to food consumption than temperament.

We did not find interaction between accessibility of SFD and children's surgency or effortful control, which was surprising. Previous studies have specifically linked children's impulsivity and reward sensitivity (characteristics linked with temperamental surgency) and low inhibitory or self-regulatory abilities (characteristics linked with temperamental effortful control) with different kinds of undesirable eating or weight outcomes (Berger et al., 2017; Francis et al., 2013; Gebremariam et al., 2017; Leung et al., 2014; Van Den Berg et al., 2011). Furthermore, De Decker et al. (De Decker et al., 2017) found that children with high reward sensitivity more frequently ate fast food when unhealthy foods were available at home. Guerrieri et al. (Guerrieri et al., 2008) in turn found that children with high reward sensitivity ate more than children with low reward sensitivity when a high variety of different foods were available, but consumption was similar across groups when only monotonous foods were available. Our contradictory finding could be explained by measures used in the study. We measured temperamental surgency and effortful control, with both including many different aspects (surgency including activity level, low shyness, impulsivity; effortful control including perceptual sensitivity, low intensity pleasure, inhibitory control) instead of specifically measuring only reward sensitivity, impulsivity or inhibitory control.

The lack of interaction between home accessibility of FV and temperament dimensions on FV consumption frequency could stem from potentially different hedonic and reward value of palatable foods versus fruit and vegetables. People are naturally inclined to like and want foods that are high in fat or sugar, or both (Drewnowski, 1997; Ganchrow et al., 1983); the reinforcing value of food (i.e. the effort one is willing to make to obtain food) may be higher for palatable foods than healthier options (Temple, 2014; Vervoort et al. et al.). Thus, children might be more attracted to palatable food cues at home than cues of FV. Some studies have demonstrated that social media influencer marketing of unhealthy foods leads to their increased consumption, however, the same effect is not demonstrated regarding healthy foods (Coates et al., 2019). Furthermore, unhealthy food cues embedded in cartoons seem to attract children more than healthy food cues (Spielvogel et al., 2018). Moreover, Nederkoorn et al. (Nederkoorn et al., 2015) found associations between low inhibitory control and an increased consumption of energy-dense snacks, but not with changes in the consumption of medium or low-energy snacks.

The strengths of this study are its large sample size and a valid, widely used measure of temperament. Also, the FFQ used in the study was specifically designed for the DAGIS project, Finnish context and examined age group, having known validity and reliability (Korkalo et al., 2019; Määttä et al., 2018). Furthermore, only a few studies (De Cock et al., 2016; De Decker et al., 2017; Guerrieri et al., 2008) have previously examined the topic, and to the best of our knowledge none has included both healthy and unhealthy indicators of home food availability and accessibility.

This study also has limitations that should be acknowledged. Importantly, the study had a cross-sectional design that does not allow drawing any conclusions about causality of the associations. Furthermore, parents reported all measures, which may have caused response bias. For example, some of the parents' own characteristics affect their ratings on their child's temperament (Bayly & Gartstein, 2013; Rothbart et al., 2001), which we were unable to control for. We measured temperament with a very short form of the CBQ; consequently, we could examine only three broad dimensions. As these dimensions comprise many sub dimensions that could be of importance independently, a deeper understanding could be achieved by broader measures. In addition, specifically reports on food consumption and food availability and accessibility may be shaped by social desirability bias (Hebert et al., 1995). Since the data was collected at a single time point, the measures for availability and accessibility of foods as well as the FFQ do not capture fluctuations in food consumption and the home food environment due to, for example, time or seasonality. However, the test-retest reliability for most items was moderate or good with ICCs ranging between 0.355 and 0.796 and Kappa values ranging between 0.308 and 0.661 (Määttä et al., 2018). Noteworthy also is that the data on home food accessibility was available only for the intervention participants reducing the sample size available for those analyses and potentially limiting the generalizability of the results. Finally, the participation rate was relatively low (24% in the cross-sectional data and 45% in the intervention baseline data) and the number of excluded participants due to missing data fairly high, which could have led to somewhat selected data. A comparison of children included in the analyses with those excluded because of missing data revealed that children in the analyzed data were slightly younger, and had older and more educated mothers than those who were excluded because of missing data.

5. Conclusions

In conclusion, children's temperament did not moderate the association between home availability of FV or SFD and the consumption frequency of these foods. In terms of home accessibility of SFD, we found conditional effects on SFD consumption frequency depending on the level of children's negative affectivity. More frequent consumption of SFD was observed with higher home accessibility of SFD. The association was stronger in children with higher scores in negative affectivity. No other interactions were found between home accessibility of SFD or FV and temperament dimensions. The results suggest that the physical home food environment may be more important for some individuals than others depending on their individual characteristics. These characteristics should be considered in efforts to support children's healthy eating.

Availability of data and materials

Researchers interested in the study data and materials may contact the principal investigator Eva Roos, eva.roos@folkhalsan.fi.

Funding

This study was financially supported by the Folkhälsan Research Center, the University of Helsinki, the Ministry of Education and Culture in Finland, the Ministry of Social Affairs and Health, the Academy of Finland (Grants: 285439, 287288, 288038), the Juho Vainio Foundation, the Signe and Ane Gyllenberg Foundation, the Finnish Cultural Foundation/South Ostrobothnia Regional Fund, the Päivikki and Sakari Sohlberg foundation, the Medicinska Föreningen Liv och Hälsa, the Finnish Foundation for Nutrition Research and the Finnish Food Research Foundation. None of the authors had a conflict of interest.

Authors' contributions

ER is the principal investigator for the DAGIS project. ER, ME and NS

are responsible for the funding of the project and collected data. RP, CR, KSA and ME conceived and designed the present study. RP, CR, RL, EL, ES, HV, KN collected the data or conducted data management, or both. RP, KSA, CR and ME contributed to the statistical analyses. RP drafted the manuscript. ER, CR, KSA, ME, NS, RL, ES, EL, HV, KS and KN provided subsequent comments and feedback. All authors read and approved the final manuscript.

Ethical statement

Families participating in the cross-sectional and intervention studies signed a written informed consent. The studies were performed in accordance with the Declaration of Helsinki. The Helsinki Ethical Review Board in Humanities and Social and Behavioral Sciences approved the study design and procedures for the cross-sectional survey in February 2015 (#6/2015) and for the intervention in May 2017 (#22/2017).

Declaration of competing interest

The authors declare that they have no competing interests.

Acknowledgements

The authors thank the early childhood education and care centers and the families for their participation in the DAGIS study, as well as the members of the research team for their efforts in recruitment, data collection and management. The authors also thank the collaborating partners of the DAGIS study for providing assistance in designing the study.

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