Chapter 8

INTRODUCING TAXES, SUBSIDIES OR BOTH: THE EFFECTS OF VARIOUS FOOD PRICING STRATEGIES IN A WEB-BASED SUPERMARKET RANDOMIZED TRIAL

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Abstract

Objective: Fiscal policies may form a solution in improving dietary intake. This study aimed to examine the effectiveness of varying taxing and subsiding schemes to stimulate healthier food purchases.

Methods: A randomized controlled trial with a three levels of price reduction on healthy foods (no;25%;50%) x three levels of price increase on unhealthy foods (5%;10%;25%) factorial design was used. 150 participants were randomized into one of nine conditions and were asked to purchase groceries at a web-based supermarket. Data were collected in the Netherlands in January-February 2010 and analyzed using analysis of covariance.

Results: Subjects receiving 50% discount purchased significantly more healthy foods than subjects receiving no (B=6.62 items, p<.01) or 25% discount (B=4.87 items, p<.05). Moreover, these subjects purchased more vegetables (B=821 gram; p<.05 compared to no discount). However, participants with the highest discount also purchased significantly more calories. No significant effects of the price increases on unhealthy foods were found.

Conclusion: Price decreases are effective in stimulating healthy food purchases, but the proportion of healthy foods remains unaffected. Price increases up to 25% on unhealthier products do not significantly affect food purchases. Future studies are important to validate these results in real supermarkets and across different countries.

Keywords: Nutrition Policy; Intervention studies; Randomized Controlled Trial; Food; Financial Support; Health Policy; Health Behavior; taxes; economics

Introduction

Overconsumption and excessive intakes of sugar and saturated fats contribute largely to the growing prevalence of non-communicable diseases including cardiovascular disease, type-2 diabetes and obesity [1-3]. Fiscal policies form one solution in improving dietary intake [4-7]. Broadly, three types of strategies can be considered: 1) increasing unhealthy food prices, 2) lowering healthy food prices, and 3) a combination of both.

With respect to taxes on high-calorie foods there is evidence from two experimental studies showing that these are effective in lowering calorie purchases [8, 9]. However, both studies were limited to a restricted food selection making it hard to extrapolate the conclusions into broader food environments. Recently, Nederkoorn and colleagues published a comparable study using a web-based supermarket. They found that a calorie tax was effective in decreasing the purchase of high energy-dense products, but not in decreasing calories from fat. Moreover, they found that people tended to replace more expensive energy-dense products with cheaper alternatives [10]. Also Mytton and colleagues found that reactions to price increases were not linear by showing that fruit purchases tended to fall as a result of taxation on milk and cream [11]. These complex reactions to pricing measures may have important implications for public health outcomes [11, 12].

Similar concerns apply to thin subsidies (lowering the price of healthier products). To date only a couple of experimental studies examining these types of strategies in retail environments are available, including a New Zealand supermarket trial [13] and a Dutch trial in a computerized retail environment [14]. Both studies found that the reduced prices of healthier foods lead to higher purchases of these products. Recently, Andreyeva and colleagues published a review on the price elasticity[21] of food. They concluded that food is elastic and that the highest price elasticity was found for food away from home, soft drinks, juice, meats, and fruit [16]. These results show that thin subsidies are promising to stimulate healthier food purchases. Nevertheless, studies also reported that discounting healthy foods lead to more calorie purchases [9] or are counterproductive because consumers used the saved money to buy unhealthier products [17].

1 Price elasticity of demand is defined as the percentage change in the quantity demanded in response to a given percentage change in price, at a particular point in the demand curve [15].

Previous studies show that both taxing and subsidizing strategies have positive (e.g., more healthy food purchases), but also potentially negative side effects (e.g., more calories, lower fruit purchases). Therefore, the best suggestion may be to combine both strategies [18-20]. Therefore, this study aimed to examine both single and combined effects of lowering the prices of healthier foods and (simultaneously) increasing the prices of unhealthier foods on food purchases. It is hypothesized that the most favourable nutrient purchases will be found when combining the greatest discounts on healthier foods with the greatest tax increase on unhealthier foods.

Methods

The 3-D web-based supermarket

This study used a unique 3-D web-based supermarket (Figure 8.1). The main features are described below; additional information can be found elsewhere [21].

The web-based supermarket was designed in the image of an existent branch of the Dutch market leader supermarket. Photographs of genuine products were used to

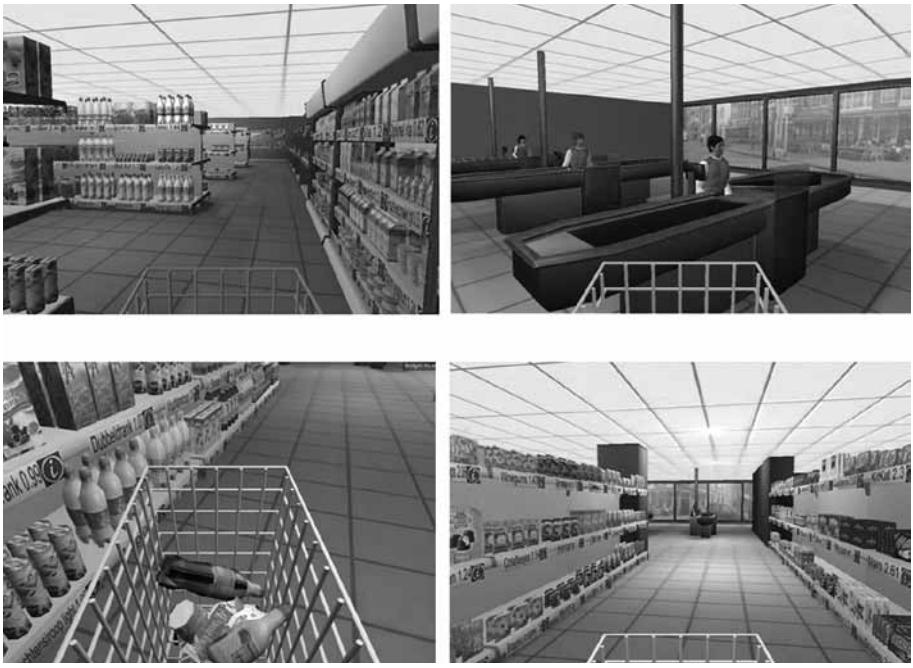

Figure 8.1 Impression of the 3-D web-based supermarket

Table 8.1 Number of healthy food products within the 38 food categories in the web-based supermarket, the Netherlands (2008-2009)

	Food Category	Total products (n)	Healthy products (n)[a]
1	Potatoes and potato products	10	7
2	Fruits	10	10
3	Vegetables	41	41
4	Ready to eat meals	19	4
5	Meat/ Fish/ Poultry *	29	13
6	Meat products *	18	4
7	Salads (e.g., crab salad, egg salad, etc.)	8	3
8	Appetizers/ snacks	6	1
9	Cheese	19	3
10	Dairy drinks (e.g., milk, yoghurt drink, etc.) *	15	8
11	Desserts *	21	4
12	(Whipped) cream	5	-
13	Butter	6	2
14	Eggs	2	-
15	Bread *	15	6
16	Pastry	14	4
17	Snacks/ refreshments	12	3
18	Frozen snacks	10	-
19	Ice (cream)	8	1
20	Frozen pastry	2	-
21	Coffee	7	-
22	Evaporated milk/ sugar/ sweeteners	9	2
23	Baking products	13	4
24	Sweet sandwich fillings *	10	3
25	Breakfast products	13	6
26	Pasta/ Rice/ Noodles *	12	4
27	Mixes for sauces	12	1
28	Seasonings	9	1
29	Herbs and spices	10	-
30	Oils/ Sauces and pickles	26	9
31	Soups	12	2
32	Canned foods (excluding fruits and vegetables)	10	3
33	Beverages (excluding soda)	6	3
34	Soda *	24	14
35	Alcoholic beverages	19	-
36	Candy	14	3
37	Chocolate	20	-
38	Crisps/ nuts/ toast	16	3
	Total	**512**	**172 (33.6%)**

[a] **Healthy products are defined following the Choices front-of-pack nutrition label criteria which are based on the international WHO recommendations regarding saturated fat, trans fat, sodium, and added sugar** [24]

* **These product categories were selected for *within* category analysis**

compose product images and prices were made available through shelf labelling. Food prices were based on the prices of the two Dutch market leaders, and the stock was also based on an existing supermarket. It was decided to create a representative product selection based on the 38 different food categories as used on the website of the market leader supermarket [22]. Within each product category, a sample representing around 10% of the regular assortment was selected by choosing popular and frequently consumed products. In total, the web-based supermarket contained 512 different food products modeling the actual distribution of store products and categories (Table 8.1). The stock did not take in specific brands or different package sizes.

Study design

A randomized controlled trial with three levels of price reduction on healthy foods and three levels of price increases on unhealthy foods was conducted. Participants were randomly assigned to one of nine conditions by using the Random Number Generator in Excel by three research assistants who were blinded with regard to the contents of each condition. Discount levels were: no discount; 25%; and 50%; and price increases were: 5%; 10%; and 25% (Figure 8.2). This design was chosen to

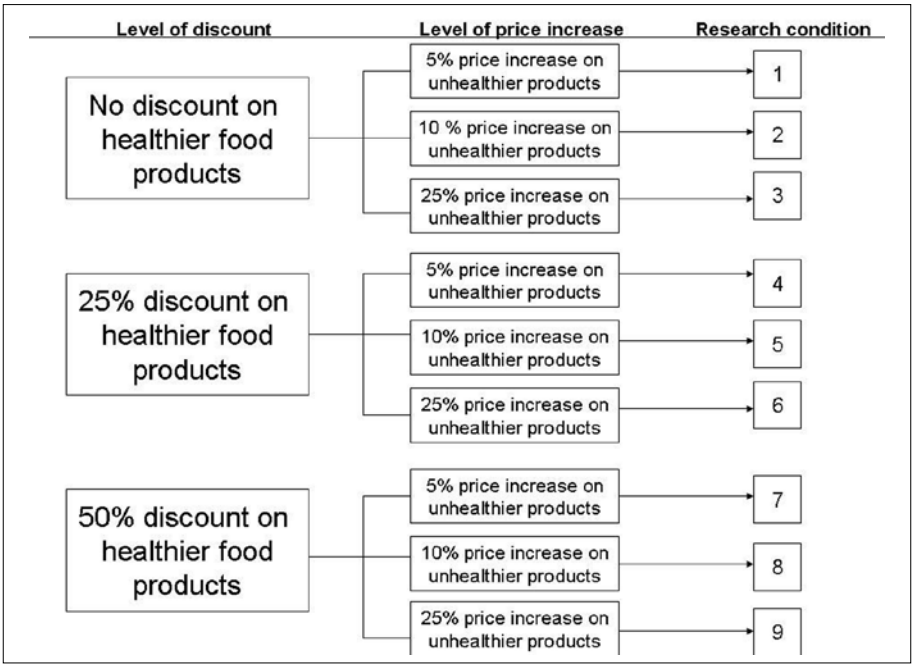

Figure 8.2 Study design

enable studying the effects of smaller and larger price changes, thereby expanding the results of previous experimental [23] and economic modelling studies (Nnoaham et al., 2009). Price increases were kept relatively low, because these have been suggested more feasible to implement [7]. Discount levels up to 50% do seem to be practicable [7] and are frequently used by retailers. The base condition was set on no discount on healthier foods combined with a 5% price increase on unhealthier foods; which could basically be seen as a control condition.

In determining experimental price levels (e.g., in distinguishing healthy and unhealthy products) product criteria of the Choices front of pack nutrition logo were used [24]. These criteria are based on the international World Health Organization (WHO) recommendations regarding saturated fat, trans fat, sodium, and added sugar [25]. The criteria are set separately for different food categories, where the criteria for non-basic foods are generally stricter than for basic foods. All products in the web-based supermarket were judged against these criteria and, if they complied, they were eligible for price reduction. Prices of products not meeting the criteria were increased (Table 8.1).

Participants and recruitment

A sample size was determined using delta-values as effect size. Delta-values are denoted by the difference between the smallest and the largest mean, in units of the within-cell standard deviation. Values of delta = .25, .75 and ≥1.25 correspond to small, medium and large effect sizes respectively [26]. For this study it was determined that a sample size of n=108 would be sufficient to demonstrate an effect size of .50 (level of significance .05, power >.90, fixed effects, equal sizes in all treatment cells assumed).

The study was conducted in the Netherlands. Participants were recruited as part of a broader range of studies by using newspapers in October – November 2009. N=658 people signed up and were checked for eligibility (Figure 8.3). For this study, the main interest was in participants with a lower socio-economic status (SES) since they have the largest burden of diet-related disease and financial barriers in taking up a healthy diet mainly applies to them [27-29]. Because Dutch people are reluctant in providing their income, inclusion criteria were set on having completed a medium secondary vocational education or lower and/or being unemployed. Furthermore, participants had to be ≥18 years, speaking the Dutch language, and running an own household.

Participants were not aware of the research aims and were blinded with regard to assignment of the research conditions. The study procedures were in accordance with the standards of the institutional medical ethical committee.

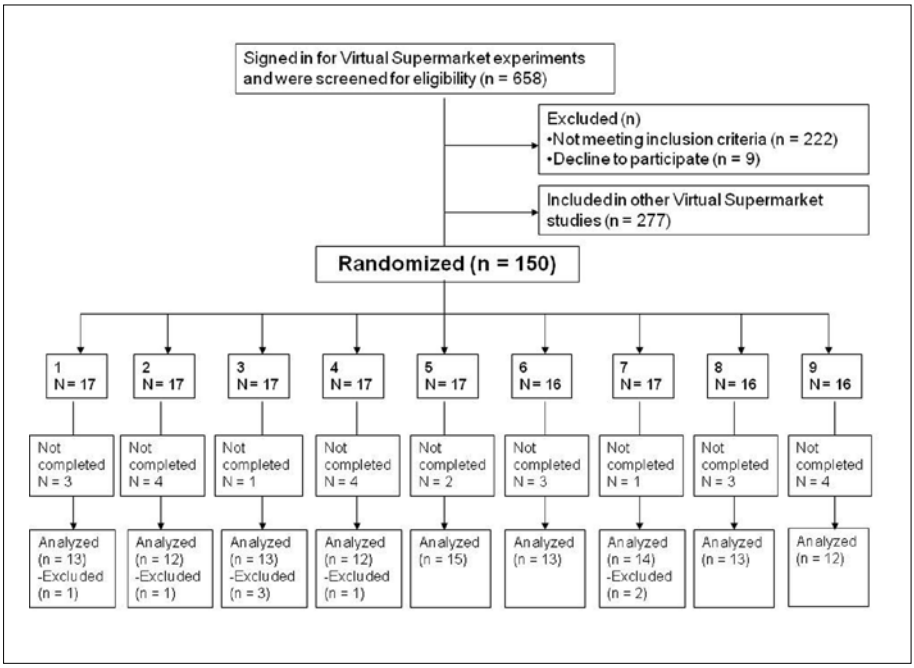

Figure 8.3 CONSORT Flow Diagram

Procedure

Participants were sent an USB-device with the web-based supermarket software, instructions and a personal log-in code by post. Every participant was asked to conduct a typical shop for their household for one week. The shopping procedure was experimental and participants did not receive their groceries for real. After logging on to the application, participants were asked about their household composition which was used to allocate a specific shopping budget. Next, participants were able to walk around the web-based supermarket and purchase products by a single mouse click. Also, participants could obtain nutritional information about each product; see also ([21]. When finished shopping, participants moved to the cash register and, if the budget was not exceeded, they were directed to a closing questionnaire.

Measures

Main outcome measures were purchases of healthy and unhealthy food items (number and percentage); fruit and vegetables (gram); healthy products outside fruits and vegetables (number and percentage); budget spending and calories. As secondary outcome measure we calculated the proportion of healthier products purchased within specific product categories (Table 8.1). In addition, some background variables were assessed (Table 8.2). Finally, participants were asked to complete several questionnaires after shopping assessing price perception [30]; habit strength [31]; understanding and rewarding of the web-based supermarket and notice of prices (Table 8.2). Answers were all measured on a 7-point Likert Scale, and total scores were calculated from summing up the individual items.

Statistical analysis

First, outcome measures were tested for an adequately normal distribution. Second, mean values for the main outcomes measures were analyzed. Next, differences between conditions were tested using two-way factorial ANCOVA, where factor 1 indicated the level of discount and level 2 the level of price increase. Analysis were conducted by including standard factors (e.g., sex, education level, spending budget (low/high) and grocery responsibility) and theoretically expected strong predictors of the outcomes (e.g., score on price perception, habit strength, appreciation of the web-based supermarket and notice of prices) in the model. These covariates were included because they explained a major part of the error variance and enlarged the power of the model. For each outcome measure it was then tested whether the interaction between the level of discount and price increase was significant, whereby the level of significance was set at .10. Non-significant interaction terms were then removed from the model. For significant interaction terms it was planned to present the results separately for every discount and price increase combination. Analyses were conducted using SPSS statistical software (version 17.00, SPSS Inc, Chicago, IL).

Results

Participant characteristics

N=125 (83%) participants completed the study. Compared to the final study sample, non-responders were older (Δ=7.42 years) and had a smaller household size (Δ =.82 persons). From this sample, participants who were barely responsible for groceries in real life (n=1) or with a low appreciation score of the Virtual Supermarket (n=6) were

Table 8.2 Participant Characteristics, the Netherlands (2010)

		Total n = 117 n (%)	p[a]
Sex	Female	100 (85.5)	.81
Age	18 – 31	13 (11.1)	.85
	32 – 46	34 (29.1)	
	47 – 61	52 (44.4)	
	62 +	18 (15.4)	
Grocery responsibility	Totally responsible	74 (63.2)	.80
	Largely responsible	24 (20.5)	
	Partly responsible	19 (16.2)	
Education level	Low (primary / lower secondary)	21 (17.9)	.75
	Medium (higher secondary/ intermediate vocational)	66 (56.4)	
	High (high vocational/ University)	30 (25.7)	
Employment status	Employed	55 (47.0)	.66
	Other	62 (53.0)	
Household income	Low (0 – 2000)	23 (19.7)	.88
(€ gross monthly)[b]	Medium (2000 – 3000)	31 (26.5)	
	High (3000+)	63 (53.8)	
Household weekly food expenditures (€)	20 – 60	36 (30.8)	.39
	60 – 100	65 (55.6)	
	100 +	16 (13.6)	
		Mean (SD)	
Household size		2.9 (1.5)	.53
Price perception [c]		63.3 (11.9)	.72
Habit score [d]		52.5 (10.1)	.27
Appreciation score Virtual Supermarket [e]		58.8 (8.6)	.36
Attention to prices in Virtual Supermarket [f]		17.4 (6.8)	.92
Budget in Virtual Supermarket		72.4 (24.6)	.41
% Of budget spent		93.0 (12.3)	.08

Data were measured in January – February 2010 in the Netherlands. Participants included a community sample (n=117)

[a] **Indicates the p-value for chi² tests and ANOVA analysis comparing the nine research conditions**

[b] **The standard gross monthly income in the Netherlands (2010) was € 2,508** [45]

[c] **Measured by fifteen items on a 7-point Likert scale (min = 15; max = 105) from the seven "price perception construct scale items" (Lichtenstein et al., 1993).**

[d] **Measured by twelve items on a 7-point Likert scale (min = 12; max = 84) self-report index of habit strength (Verplanken et al., 2003)**

[e] **Measured by eleven items on a 7-point Likert scale (min = 11; max = 77) on the Virtual Supermarket software**

[f] **Measured by four items on a 7-point Likert scale concerning attention to prices in the Virtual Supermarket (min = 4; max = 28)**

excluded. A low appreciation score was set on the fifth percentile, which included participants with a score ≤42 (range=27-77; mean=58, SD=9.6). Also, n=1 person was excluded due to missing data. The final study sample included n=117 participants (Figure 8.3; Table 8.2).

Understanding and appreciation of the 3-D web-based supermarket

Ninety-one percent of the participants scored ≥5 (1=lowest; 7=highest) on comprehension of the software. Furthermore, 85% scored ≥5 on the question asking whether their experimental groceries corresponded with their regular groceries and 94% scored ≥5 on the question asking whether the products in the web-based supermarket were good recognizable.

Description of differences in food purchases

Participants with the highest discount on healthier foods purchased the most products within this category (32.0 items), compared to the other discount conditions (27.2 and 24.6 items respectively) and also purchased the most fruits and vegetables. However, this group also purchased the highest number of calories. This was especially apparent in the conditions with the lowest price increase on unhealthier foods (Table 8.3).

Table 8.3 Purchased amounts of (un)healthier food items within the nine research conditions, the Netherlands (2010) [a]

Item		5% increase		10% increase		25% increase		**Total per discount**	
		Mean	SD	Mean	SD	Mean	SD	**Mean**	**SD**
Healthy food items (n)	No discount	23.9	7.0	23.8	5.7	26.2	8.1	**24.6**	**6.9**
	25% discount	29.4	12.1	24.9	9.7	27.7	10.4	**27.2**	**10.6**
	50% discount	30.4	11.9	33.5	9.0	32.3	15,0	**32.0**	**11.9**
	Total per price increase	**27.9**	**10.7**	**27.3**	**9.3**	**28.6**	**11.4**	-	-
Unhealthy food items (n)	No discount	23.8	10.9	22.7	12.7	20.8	9.5	**22.4**	**10.9**
	25% discount	24.9	12.1	22.9	11.5	26.5	11.6	**24.7**	**11.5**
	50% discount	32.1	14.3	24.6	9.0	25.4	8.8	**27.5**	**11.4**
	Total per price increase	**27.1**	**12.8**	**23.4**	**10.9**	**24.2**	**10.1**	-	-
Total products (n)	No discount	47.7	16.0	46.4	16.0	47.0	9.6	**47.1**	**13.8**
	25% discount	54.3	23.1	47.8	18.0	54.2	18.1	**51.8**	**19.4**
	50% discount	62.5	20.2	58.1	12.4	57.8	9.7	**59.6**	**18.3**
	Total per price increase	**55.1**	**20.4**	**50.7**	**16.2**	**52.8**	**17.4**	-	-

Healthy exl. food items (n) [b]	No discount	14.8	6.8	13.9	3.8	16.8	6.4	**15.2**	**5.8**
	25% discount	19.3	8.3	15.6	6.4	18.5	7.1	**17.2**	**7.3**
	50% discount	19.9	9.5	21.6	6.6	19.8	9.7	**20.4**	**8.5**
	Total per price increase	**18.1**	**8.4**	**17.1**	**6.6**	**18.3**	**7.7**	-	-
Purchased Calories (kcal)	No discount	34,936	16,467	38,091	16,611	38,027	10,645	**36,990**	**14,456**
	25% discount	43,874	20,358	38,328	15,692	46,913	21,338	**42,782**	**18,949**
	50% discount	52,805	18,255	47,835	13,180	47,081	18,741	**49,387**	**16,654**
	Total per price increase	**44,101**	**19,398**	**41,347**	**15,507**	**43,926**	**17,533**	-	-
Vegetables (gram)	No discount	3,682	1,021	3,433	1,268	3,771	1,765	**3,634**	**1,359**
	25% discount	3,625	1,977	3,353	1,363	4,196	2,236	**3,708**	**1,854**
	50% discount	4,491	1,481	4,646	1,470	4,853	2,561	**4,654**	**1,831**
	Total per price increase	**3,955**	**1,542**	**3,797**	**1,463**	**4,258**	**2,187**	-	-
Fruit (gram)	No discount	2,308	1,066	2,583	907	2,748	1,940	**2,545**	**1,367**
	25% discount	2,685	1,775	2,200	1,536	1,692	1,575	**2,181**	**1,630**
	50% discount	2,654	1,314	3,442	1,225	3,396	2,535	**3,145**	**1,750**
	Total per price increase	**2,548**	**1,375**	**2,719**	**1,351**	**2,591**	**2,107**	-	-
% of budget spent	No discount	97.2	4.9	96.4	4.9	95.0	10.8	**96.2**	**7.3**
	25% discount	88.6	22.2	94.3	9.8	95.2	4.9	**92.9**	**13.7**
	50% discount	83.3	18.4	94.6	7.3	92.8	11.5	**90.0**	**14.1**
	Total per price increase	**89.5**	**17.3**	**95.0**	**7.7**	**94.4**	**9.3**	-	-
Total expenditures (€)	No discount	65.9	18.0	66.0	23.2	70.0	13.7	**67.3**	**18.2**
	25% discount	66.5	29.2	58.3	20.8	69.6	20.5	**64.4**	**23.5**
	50% discount	67.1	24.4	62.8	13.7	69.2	24.2	**66.3**	**21.0**
	Total per price increase	**66.5**	**23.3**	**62.1**	**19.4**	**69.6**	**19.3**	-	-

Data were measured in January – February 2010 in the Netherlands. Participants included a community sample (n=117)

[a.] **Crude effects.**

[b] **Healthy excl. means amount of healthy products excluding fruits and vegetables**

Effects of price discount x price increase

There were no significant interactions between price increase and discount level for any outcome measure. This means that the effects of the discounts were irrespective of price increase level and vice versa. This could however be due to our small sample size. Interaction terms were therefore removed from the model, and results of the ANCOVA will be presented at discount and price increase level of separately.

Effects of the discounts

Participants with a 50% discount purchased significantly more healthy foods than participants with no discount (Δ=6.62, p=.002) or a 25% discount (Δ=4.87, p=.02) (Table 8.4a). Furthermore, participants with a 50% discount purchased 821 grams more vegetables for their household for a week (p=.03) compared to no discount and 768 gram more compared to the 25% discount conditions (p=.04). However, participants in the highest discount condition also purchased significantly more items in total (Δ=10.40, p=.001) compared to no discount, and significantly more calories

Table 8.4a Effects of varying price *discount* levels on food purchases in the web-based supermarket, the Netherlands (2010) [a]

Discount		*Level 1 = No*			*Level 2 = 25%*			*Level 3 = 50%*		
	Ref. level	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
N Unhealthy	1	-	-	-	1.75	-2.06	5.55	3.78‡	-.12	7.68
	3	-3.78‡	-7.68	.12	-2.03	-5.91	1.84	-	-	-
N Healthy	1	-	-	-	1.75	-2.30	5.80	6.62**	2.47	10.78
	3	-6.62**	-10.78	-2.47	-4.87*	-9.00	-.75	-	-	-
Total items	1	-	-	-	3.50	-2.32	9.31	10.40**	4.44	16.37
	3	-10.40**	-16.37	-4.44	-6.91*	-12.83	-.99	-	-	-
N healthy excl. [b]	1	-	-	-	1.87	-1.08	4.82	4.94**	1.91	7.96
	3	-4.94**	-7.69	-1.91	-3.07*	-6.07	-.06	-	-	-
Purchased Calories(kcal)	1	-	-	-	4,669	-1,305	10,642	10,505**	4,376	16,635
	3	-10,505**	-16,635	-4,376	-5,836	-11,920	247	-	-	-
% Healthy	1	-	-	-	-1.07	-6.09	3.94	.59	-4.55	5.74
	3	-.59	-5.74	4.55	-1.66	-6.77	3.44	-	-	-
% Healthy excl. [b]	1	-	-	-	1.02	-2.83	4.87	2.04	-1.92	5.99
	3	-2.04	-5.99	1.92	-1.01	-4.94	2.91	-	-	-
Vegetables (gram)	1	-	-	-	52	-665	769	821*	85.1	1,556
	3	-821*	-1,556	-85.1	-768*	-1,498	38.2	-	-	-
Fruit (gram)	1	-	-	-	-382	-1,105	341	420	-322	1,163
	3	-420	-1,163	322	-803*	-1,539	-66.4	-	-	-
% of budget spent	1	-	-	-	-3.67	-8.95	1.60	-5.20‡	-10.61	.22
	3	5.20‡	-.22	10.61	1.52	-3.85	6.90	-	-	-

Data were measured in January – February 2010 in the Netherlands. Participants included a community sample (n=117)

[a] Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices

[b] Healthy excl. means amount of healthy products excluding fruits and vegetables

‡ Borderline significant at p = .06

*** Significant at p<.05**

**** Significant at p<.01**

(Δ=10,505 kcal, p=.001) compared to no discount. The discounts had no statistically significant effects on the proportion of healthier products purchased within each of the eight most popular food categories (Table 8.1 and Table Appendix 8.1), but effects were generally in the same direction as for the overall analyses.

Effects of the price increases

Participants with higher taxes purchased somewhat fewer unhealthy food items than participants presented with a lower tax, but this was not statistically significant (Table 8.4b). Furthermore, the price increases did not significantly limit the total number of products or calories bought. Within specific food categories, including soda, dairy drinks, or desserts, no significant effects of the price increases on unhealthier food

Table 8.4b Effects of varying price *increase* levels on food purchases in the web-based supermarket, the Netherlands (2010) [a]

Price increase		*Level 1 = 5%*			*Level 2 = 10%*			*Level 3 = 25%*		
	Ref. level	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
N Unhealthy	1	-	-	-	-1.66	-5.47	2.15	-1.99	-5.82	1.85
	3	1.99	-1.85	5.82	.33	-3.51	4.17	-	-	-
N Healthy	1	-	-	-	.48	-3.58	4.54	1.03	-3.05	5.11
	3	-1.03	-5.11	3.05	-.55	-4.63	3.54	-	-	-
Total items	1	-	-	-	-1.18	-7.00	4.65	-.96	-6.82	4.90
	3	.96	-4.90	6.82	-.22	-6.08	5.65	-	-	-
N healthy	1	-	-	-	-.42	-3.38	2.53	.45	-2.53	3.42
excl.[b]	3	-.45	-3.42	2.53	-.87	-3.85	2.10	-	-	-
Purchased	1	-	-	-	313	-5,676	6,302	816	-5,209	6,841
Calories(kcal)	3	-816	-6,841	5,209	-503	-6,530	5,524	-	-	-
% Healthy	1	-	-	-	2.17	-2.85	7.20	1.93	-3.12	6.99
	3	-1.93	-6.99	3.12	.24	-4.82	5.30	-	-	-
% healthy	1	-	-	-	.74	-3.12	4.60	1.89	-2.00	5.77
excl.[b]	3	-1.89	-5.77	2.00	-1.15	-5.04	2.74	-	-	-
vegetables	1	-	-	-	121	-598	840	368	-355	1,091
(gram)	3	-368	-1,091	355	-247	-970	477	-	-	-
Fruit (gram)	1	-	-	-	304	-421	1,029	83.2	-646	813
	3	-83.2	-813	646	221	-508	951	-	-	-
% of budget	1	-	-	-	4.43	-.86	9.72	4.21	-1.11	9.53
spent	3	-4.21	-9.53	1.11	.23	-5.10	5.55	-	-	-

Data were measured in January – February 2010 in the Netherlands. Participants included a community sample (n=117)

[a] **Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices**

[b] **Healthy excl. means amount of healthy products excluding fruits and vegetables**

purchases were found either (Table Appendix 8.2). The only statistically significant effect was observed within the category 'meat products' where participants in the 10% price increase group purchased a higher percentage of healthier products compared to the 5% price increase group (Table Appendix 8.2).

Discussion

This study examined the effects of varying combinations of price increases on unhealthy products and price discounts on healthy products on food purchases. Results indicate that higher discount levels were associated with higher purchases of fruit and vegetables and a higher number of healthy foods overall. However, the discounts also lead to a higher *total* number of items purchased, meaning that the proportion of healthy products was not higher. Furthermore, higher price discounts were associated with a higher number of calories purchased. The effects of the discounts were found on the product range in general and not within specific food categories including meat products, bread or soda. There were no significant effects of price increases. Also, the rise in total food items purchased due to the discounts was not significantly balanced by the price increases. The results apply specifically to the Dutch situation and the generalizability to other settings is unknown.

To our knowledge, this is the first study examining both separate and simultaneous effects of multiple price discounts and price increases in a retail environment. Different authors have emphasized the importance of such studies [16, 18]. Results revealed that the effects of price changes are multifaceted. Firstly, it was found that discounts are effective in stimulating healthy food purchases in general and also specifically in stimulating fruit and vegetable purchases. At the 50% discount level an average increase of 821 grams in vegetable and 420 gram in fruit purchases was found compared to the no discount level. This indicates a difference of 40 grams and 21 grams per person per day respectively. As the Dutch Food Consumption Survey showed that people consumed on average 121 grams of vegetables and 77 grams of fruit per day [32], this would implicate a major shift in fruit and vegetable purchases which seems very relevant for public health.

Secondly, however, it was found that the discounts also lead to higher food purchases in total and to higher calorie purchases. Therefore, the proportion of healthy foods was not higher due to the discounts. These results are in line with a laboratory experiment by Epstein and colleagues [9] and a simulation modeling study on the effects of tax

reforms designed to increase whole grain consumption [33]. One suggested solution is combining lowering prices of healthier products with tax increases on unhealthier food products [33].

Epstein found that a price increase of high-caloric foods was effective in decreasing the purchase of these items while increasing the purchase of low-caloric foods. Giessen and colleagues also concluded that a >25% tax rise on high-caloric foods is effective in decreasing the demand for calories [8]. The current study, however, does not provide support for increasing unhealthier food prices. In addition, results of the study could not confirm the hypothesis that discounts on healthier food products are most effective when supported by price increases of unhealthier products, nor that higher energy purchases may be prevented using such a combination of strategies. Nordström et al. found similar results in a simulation modelling study where the increase in fat consumption remained prevalent in simulations combining a subsidizing measure with a tax on unhealthier products [34]. Nevertheless, the current study found that price increases lowered the amount of unhealthy food purchases to some extent. The absence of significant interaction effects may be due to a power problem; our sample size was not specifically powered for these interaction effects. Moreover, our power calculations were based on quite large effect sizes, meaning that our sample size was likely too small to detect smaller effects of the price increases. It is therefore important to study the combined effects of taxes and subsidies further in larger populations. Moreover, the price increase levels in this study were relatively low whereas the price discounts ran up to 50%. We opted for these levels based on the results of a previously conducted Delphi study where it was found that subsidies are more politically feasible than taxes [7]. Nevertheless, higher tax increases can be feasible when considering the revenue they bring, especially given the current budget deficits many governments are facing. We therefore propose that increased taxes on unhealthier food products could be effective when they are high and prevent shifting to cheaper (unhealthier) alternatives.

Another important aspect to consider is that our results may be an underestimation of price strategies in practice, because the pricing strategies were silent. Normally, when products are sold at lower prices, effort is made in drawing people's attention towards this by using signs or advertisements [35,36]. This may apply to price increases; it may be more important to tell people that products are taxed than to actually tax it [37]. This discussion is referred to as 'tax salience' in the economic literature; in which

salience has indeed been found to have large effects on behavioral responses on tax changes [38]. Nevertheless, the evidence is currently limited to theoretical analysis [38] and experimental studies are needed to gain insight into this topic. The web-based supermarket could be a useful tool in conducting such experiments and in finding out how taxing schemes should best be addressed to consumers.

Alongside the effectiveness of price manipulations, it is of importance to consider practical issues as well. A recent study found that an expert panel was uniformly in favor of a subsidy on fruits and vegetables, which is promising [39]. Nevertheless, the discounts in the current study were found to be most effective in stimulating healthy food purchases when these were set at 50%. Such high levels of price change may not be realistic and there seems to be little consensus on who should pay for that [7]. One potential solution lies in designing subsidizing schemes specifically targeting the lower socio-economic groups (who are most in need for such interventions), for example by providing discount coupons within food assistance programs. A focus at specific target groups is also relevant with regard to the distributional effects of food pricing strategies. A population wide fiscal policy could worsen economic inequality wherefore strategies that target specific vulnerable populations are more appropriate [40]

A merit of this study is the use of the 3-D web-based supermarket which closely images a real shopping experience. Still, the assortment is not as extensive as a real supermarket. Also, this supermarket does not provide insight into how people may shift to non-food items as a consequence of the price changes. The results do not give insight into effects at other point of purchase settings. Nevertheless, people buy most of their food at supermarkets [41] which thus seems the most obvious environment for interventions [42, 43]. Another limitation is that people may behave differently in an authentic shopping situation, involving real money. However, a large majority of the participants stated that their web-based purchases resembled their regular food purchases accurately. Moreover, there is evidence showing that peoples' virtual behavior images their actual behavior very well [44]. Finally, compared to previous studies where a supermarket environment was modeled using 60 products [9] or using online drop-down lists [10], our application is regarded a high-quality research instrument. Nevertheless, it remains important to validate the results in a real shopping environment. Another limitation is that the price changes in our study applied to a wide product range (healthy versus unhealthy). At this time, various governments are considering more specific strategies such as a fat tax or a tax on sugar sweetened beverages. Our results

do not provide insight into the effects of such specific measures. Finally, it should be mentioned that our study population had a relatively high income level and also that it is unknown whether our results are generalizable outside the Dutch setting. Future research is warranted to validate our results in real supermarkets and among different populations.

Conclusion

This study provides new evidence into the effectiveness of varying price discount and price increase schemes on food purchases within a Dutch web-based supermarket. Results revealed that decreasing healthy food prices is effective in stimulating the purchase of these products. However, these manipulations also resulted in higher food and calorie purchases overall. This effect was not equilibrated by supplementing the price decreases with taxing unhealthier foods up to 25%. Also, these increased taxes did not significantly discourage unhealthier food purchases. This implicates that the studied pricing strategies do not improve overall diet quality. Future research is required to examine the effects of the studied pricing strategies outside the Dutch situation.

References

1. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: WHO; 2009.
2. Schmidhuber J, Traill WB. The changing structure of diets in the European Union in relation to healthy eating guidelines. *Public Health Nutr* 2006;9(5):584-95.
3. Joint WHO/ FAO Expert Consultation. Diet, nutrition and the prevention of chronic diseases. WHO. Geneva: WHO; 2003.
4. Caraher M, Cowburn G. Taxing food: implications for public health nutrition. *Public Health Nutr* 2005;8(8):1242-9.
5. Finkelstein E, French S, Variyam JN, Haines PS. Pros and cons of proposed interventions to promote healthy eating. *Am J Prev Med* 2004;27(3 Suppl):163-71.
6. Leicester A, Windmeijer F. The 'fat tax'" economic incentives to reduce obesity, Briefing note no.49. In: The institute for fiscal studies - London; 2004.
7. Waterlander WE, Steenhuis IH, de Vet E, Schuit AJ, Seidell JC. Expert views on most suitable monetary incentives on food to stimulate healthy eating. *Eur J Public Health* 2010;20(3):325-331.
8. Giesen JC, Payne CR, Havermans RC, Jansen A. Exploring how calorie information and taxes on high-calorie foods influence lunch decisions. *Am J Clin Nutr* 2011;doi: 10.3945/ajcn.110.008193.
9. Epstein LH, Dearing KK, Roba LG, Finkelstein E. The Influence of Taxes and Subsidies on Energy Purchased in an Experimental Purchasing Study. *Psychological Science* 2010;21:406-414.
10. Nederkoorn C, Havermans RC, Giesen JC, Jansen A. High tax on high energy dense foods and its effects on the purchase of calories in a supermarket: An experiment. *Appetite* 2011;56(3):760-765.
11. Mytton O, Gray A, Rayner M, Rutter H. Could targeted food taxes improve health? *J Epidemiol Community Health* 2007;61(8):689-94.
12. Tiffin R, Arnoult M. The public health impacts of a fat tax. *Eur J Clin Nutr* 2011;doi:10.1038/ejcn.2010.281.
13. Ni Mhurchu C, Blakely T, Jiang Y, Eyles HC, Rodgers A. Effects of price discounts and tailored nutrition education on supermarket purchases: a randomized controlled trial. *Am J Clin Nutr* 2010;91(3):736-47.
14. Waterlander WE, Steenhuis IHM, Schuit AJ, Seidell JC. The effects of a 25% discount on fruits and vegetables: results of a randomized trial in a three-dimensional web-based supermarket *Int J Behav Nutr Phys Act* 2012: 9(1): doi: 10.1186/1479.5868-9-11
15. Perloff JM. Microeconomics. 4 ed. Boston: Pearson Education; 2007.
16. Andreyeva T, Long MW, Brownell KD. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health* 2010;100(2):216-22.
17. Giesen JCAH, Havermans RC, Nederkoorn C, Jansen A. Impulsivity in the Supermarket: Responses to Calorie Taxes and Subsidies in Healthy Weight Undergraduates. *Appetite* 2011;doi:10.1016/j.

appet.2011.09.026.
18. Ni Mhurchu C. Food costs and healthful diets: the need for solution-oriented research and policies. *Am J Clin Nutr* 2010;92:1007-8.
19. Nnoaham KE, Sacks G, Rayner M, Mytton O, Gray A. Modelling income group differences in the health and economic impacts of targeted food taxes and subsidies. *Int J Epidemiol* 2009;38(5):1324-1333.
20. Powell LM, Chaloupka FJ. Food prices and obesity: evidence and policy implications for taxes and subsidies. *The Milbank Quarterly* 2009;87(1):229-257.
21. Waterlander WE, Scarpa M, Lentz D, Steenhuis IH. The Virtual Supermarket: An Innovative Research Tool to Study Consumer Food Purchasing Behaviour. *BMC Public Health* 2011;11(1):589.
22. Albert Heijn Online Shop (AH Webwinkel). Groceries (boodschappen). URL:http://webwinkel.ah.nl/ Available at: http://webwinkel.ah.nl/. Accessed 12 November 2010.
23. French SA. Pricing effects on food choices. *J Nutr* 2003;133(3):841S-843S.
24. Roodenburg AJC, Popkin BM, Seidell JC. Development of international criteria for a front of package food labelling system: the international Choices Programme. *Eur J Clin Nutr* 2011;65:1190-1200.
25. Dotsch-Klerk M, Jansen L. The Choices programme: a simple, front-of-pack stamp making healthy choices easy. *Asia Pac J Clin Nutr* 2008;17 Suppl 1:383-6.
26. Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2nd Edition. 2nd Edition ed. Hillsdale, New Jersey: Lawrence Erlbaum Associates 1988.
27. Darmon N, Drewnowski, A. Does social class predict diet quality? *Am J Clin Nutr.* 2008;87(5):1107-1117.
28. Waterlander WE, de Mul A, Schuit AJ, Seidell JC, Steenhuis IHM. Perceptions on the use of Pricing Strategies to stimulate Healthy Eating among Residents of deprived Neighbourhoods: a Focus Group Study *Int J Beh Nutr Phys Act* 2010;7(44):doi:10.1186/1479-5868-7-44.
29. Steenhuis IH, Waterlander WE, de Mul A. Consumer food choices: the role of price and pricing strategies. *Public Health Nutr* 2011; 14(12): 2220-2226.
30. Lichtenstein DR, Ridgway, N.M., Netemeyer, R.G. Price perceptions and consumer shopping behavior: a field study. *Journal of Marketing Research* 1993;30:234-245.
31. Verplanken B, Orbell, S. Reflections on past behavior: A self-report index of habit strength. *Journal of Applied Social Psychology* 2003;33(6):1313-1330.
32. van Rossum CT, Fransen HP, Verkaik-Kloosterman H, Buurma-Rethans EJM, Ocke MC. Dutch National Food Consumption Survey 2007-2010. Bilthoven: National Institute for Public Health and the Environment; 2011.
33. Nordstrom J, Thunstrom L. The impact of tax reforms designed to encourage healthier grain consumption. *J Health Econ* 2009;28(3):622-34.

34. Nordstrom J, Thunstrom L. Can targeted food taxes and subsidies improve the diet? Distributional effects among income groups. *Food Policy* 2011;36:259-271.
35. Anderson ET, Simester DI. The role of sale signs. *Marketing Science* 1998;17(2):139-155.
36. Blattberg RC, Briesch, R, Fox EJ. How promotions work. *Marketing Science* 1995;14(3):G122-G132.
37. Lacaniloa RD, Cash SB, Adamowisz WL. Heterogneous consumer responses to snack food taxes and warning labels. *The Journal of Consumer Affairs* 2011;45(1):108-122.
38. Chetty R, Looney A, Kroft K. Salience and Taxation: Theory and Evidence. *American Economic Review* 2009;99(4):1145-1177.
39. Faulkner G, Grootendorst P, Nguyen VH, et al. Economic instruments for Obesity Prevention: Results of a Scoping Review and Modified Delphi Survey. *Int J Behav Nutr Phys Act* 2011;8(109):doi:10.1186/1479-5868-8-109.
40. Tiffin R, Salois M. Inequalities in diet and nutrition. *Proc Nutr Soc* 2011:1-7.
41. Main Trading Organisation Retail Trade (Hoofdbedrijfschap detailhandel). Spending and market share supermarkets. Available at: http://www.hbd.nl/pages/14/Bestedingen-en-marktaandelen/Supermarkten.html?branche_id=30&hoofdonderwerp_id=14. Accessed April 14th 2011.
42. Hawkes C. Dietary implications of supermarket development: a global perspective. *Development Policy Review.* 2008;26(6):657-692.
43. Vorley B. Food, Inc.: Corporate Concentration from Farm to Consumer. In. London: International Institute for Environment and Development.; 2003.
44. Sharpe KM, Staelin R, Huber J. Using extremeness aversion to fight obesity: Policy implications of contaxt dependent demand. *Journal of Consumer Research* 2008;35:406-422.
45. Central Planning Office (Centraal Planbureau (CPB)). Standard Income (Modaal inkomen). Available at: http://www.cpb.nl/nl/prognoses/nlinfo.html. Accessed 04-06-2010.

Table Appendix 8.1 Effects of varying price *discount* levels on the percentage of healthy food products purchased within eight different product categories, the Netherlands (2010) [a]

Discount		*Level 1 = No*			*Level 2 = 25%*			*Level 3 = 50%*		
	Ref. level	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
Meat/Fish/ Poultry	1	-	-	-	-7.08	-20.3	6.17	5.45	-7.82	18.7
	3	-5.45	-18.7	7.82	-12.5	-26.1	1.07	-	-	-
Meat products	1	-	-	-	0.83	-15.3	17.0	14.2	-1.67	30.0
	3	-14.2	-30.0	1.67	-13.3	-29.4	2.77	-	-	-
Dairy drinks	1	-	-	-	1.12	-6.87	9.12	2.50	-5.77	10.8
	3	-2.50	-10.8	5.77	-1.38	-9.36	6.60	-	-	-
Desserts	1	-	-	-	7.05	-14.0	28.1	7.91	-13.4	29.2
	3	-7.91	-29.2	13.4	-0.86	-22.1	20.4	-	-	-
Bread	1	-	-	-	0.46	-10.8	11.7	0.10	-11.3	11.7
	3	-0.10	-11.7	11.3	0.36	-10.9	11.7	-	-	-
Sweet sandwich fillings	1	-	-	-	-3.93	-18.1	10.2	9.85	-4.55	24.2
	3	-9.85	-24.2	4.55	-13.8	-28.3	0.77	-	-	-
Pasta/ rice/ noodles	1	-	-	-	-10.5	-30.1	9.21	7.23	-11.8	26.3
	3	-7.23	-26.3	11.8	-17.7	-36.9	1.54	-	-	-
Soda	1	-	-	-	-5.77	-29.8	18.3	7.84	-16.7	32.4
	3	-7.8	-32.4	16.7	-13.6	-38.1	10.9	-	-	-

Data were measured in January – February 2010 in the Netherlands. Participants included a community sample (n=117)

[a] **Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices**

Table Appendix 8.2 Effects of varying price *increase* levels on the percentage of healthy food products purchased within eight different product categories, the Netherlands (2010) [a]

Price increase		*Level 1 = 5%*			*Level 2 = 10%*			*Level 3 = 25%*		
	Ref. level	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
Meat/Fish/ Poultry	1	-	-	-	11.7	-1.62	25.0	10.9	-2.25	24.0
	3	-10.9	-24.0	2.25	0.77	-12.6	14.1	-	-	-
Meat products	1	-	-	-	6.75	-8.86	22.4	-9.49	-25.2	6.25
	3	9.49	-6.25	25.2	16.2*	0.20	32.3	-	-	-
Dairy drinks	1	-	-	-	-0.12	-8.21	7.96	-3.87	-11.9	4.14
	3	3.87	-4.14	11.9	3.74	-4.23	11.7	-	-	-
Desserts	1	-	-	-	-11.1	-32.3	10.0	-8.50	-30.3	13.3
	3	8.50	-13.3	30.3	-2.62	-24.0	18.8	-	-	-
Bread	1	-	-	-	4.61	-6.52	15.7	3.98	-7.40	15.3
	3	-3.98	-15.3	7.40	0.63	-10.8	12.1	-	-	-
Sweet sandwich fillings	1	-	-	-	10.6	-3.69	24.9	3.93	-10.4	18.3
	3	-3.93	-18.3	10.4	6.66	-8.24	21.6	-	-	-
Pasta/ rice/ noodles	1	-	-	-	0.25	-18.6	19.1	-6.74	-25.6	12.1
	3	6.74	-12.1	25.6	6.99	-11.9	25.9	-	-	-
Soda	1	-	-	-	-19.0	-42.9	4.90	-3.07	-26.5	20.3
	3	3.07	-20.3	26.5	-15.9	-42.1	10.2	-	-	-

Data were measured in January – February 2010 in the Netherlands Participants included a community sample (n=117)

[a] **Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices**

*** Significant at p<.05**