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# The Use of Virtual Reality in Studying Complex Interventions in Our Every-Day Food Environment

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Additional information is available at the end of the chapter

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## 1. Introduction

‘An apple a day keeps the doctor away’. This saying illustrates how a healthy diet can contribute to the prevention of some major diseases. Despite the fact that most people are more or less aware of the importance of healthy eating and the fact that most governments and public health organisations make large effort in educating the public about healthy eating, unhealthy population diets are still a major concern. Industrialized countries suffer from the consequences of overconsumption and excessive intakes of sugar, salt, and saturated fatty acids on the one hand and insufficient intakes of fibre, fruits and vegetables on the other. These unhealthy dietary patterns contribute largely to the growing prevalence of non-communicable diseases such as cardiovascular disease, diabetes type 2, obesity and cancer. For example, the prevalence of overweight and obesity in the United States has risen to the massive number of 68% in 2007-2008 [1]. Unhealthy population diets and its consequences put a growing burden on public health, and both the World Health Organization (WHO) and the Federal Agricultural Organization (FAO) have called for action [2, 3]. Moreover, the first-ever High-Level Meeting of the UN General Assembly on non-communicable diseases held in September 2011 demonstrated that one of the major challenges in today’s society is creating healthier population diets [4]. The impact of reaching healthier population diets is well illustrated by a recent UK modelling study which found that 33,000 deaths per year would be prevented as a result of improvements in the population diet to a level that is in line with government recommendations [5].

In the challenge of improving population diets, structural interventions such as lowering fruit and vegetable prices, increasing prices of unhealthy foods, front-of-pack (FOP) nutrient labelling or food reformulation are becoming more frequently mentioned as being promising interventions as opposed to nutrition education (alone). The sustainability and

affordability of educational programmes are key continuing challenges, especially when it is aimed to reach whole populations. Besides, educational programmes do not address the strong societal forces (e.g., food availability, costs, merchandising, etc.) that work against individual behaviour change [6]. These societal forces may be of key relevance since there is a large body of evidence from the field of consumer psychology showing that consumer choices are mostly not rational, but merely unconscious and heavily influenced by environmental factors [7]. This means that, even if people are well educated about what a healthy diets looks like, they still have a great chance of making unhealthy food choices because at the point of purchase they do not consider all options rationally and are instead driven by factors such as price, convenience, branding, etc.

Swinburn and colleagues developed a framework for understanding the role of our food environment in food choice behavior and for prioritizing environmental components for intervention: the ANGELO-Framework (Analysis Grid for Environments Linked to Obesity). The model makes a distinction in the size (e.g., micro level or macro level) and the type of the environment (e.g., physical, economic, political and socio cultural) [8]. The physical environment refers to the presence of food in all settings including supermarkets, vending machines, restaurants and worksites. The political environment refers to laws and regulations that apply for food, for example Value Added Tax (VAT) regimes or food safety standards. The socio-cultural environment includes components such as traditions and religion which have a powerful influence on peoples' dietary rituals and habits. Finally, the economic environment refers to both food costs and income [8].

In large parts of the world, supermarkets are the dominant food environment [9, 10]; this is the place where people buy most of their food [11, 12]. For example, the market share of Dutch supermarkets for food purchases is around 86%. It is therefore interesting to study how changes in the retail environment (such as different prices, products or placing) could be used to stimulate healthier food choices. However, such evidence is currently very small [13]. The main reason for this lack of evidence is that supermarket studies are complex and costly to conduct. This is especially true for randomized controlled trials (imagine that you would have to modify all supermarket food prices). Besides, opposition from the food industry on several intervention strategies is an important reason for the lack of experimental studies. In order to find a solution to this problem, we developed a research tool which can be used to study the effects of interventions in a virtual-reality setting: the Virtual Supermarket. This software tool can be used to study various interventions in a supermarket setting without having to rely on a complex implementation process.

## 1.1. Chapter outline

In this chapter we will go more deeply into: 1) the design of the Virtual Supermarket software; 2) potentials of the Virtual Supermarket in food behaviour research and the importance of this new research; 3) how the Virtual Supermarket has been used in experimental studies and an overview of participant feedback on the software; 4) an overview the newest updates and information about future research; 5) new ideas for the Virtual Supermarket such as modifying the software to a serious game.

## 2. Design of the Virtual Supermarket software

The Virtual Supermarket is a three-dimensional software application in which study participants can shop in a manner comparable to a real supermarket. The application was developed in the Netherlands at the Department of Health Sciences of the VU University Amsterdam in collaboration with SARA Computing and Networking Services Amsterdam. Recently, we published a paper in BMC Public Health about the working, design and development of the software [14]. In this section, we will provide some of the most important features of the application and will give an overview about the working of the program.

The Virtual Supermarket is a computerized web-based supermarket which is very suitable for experimental research on food choice behaviour in a supermarket environment. The program contains a front-end which can be seen by study participants and a back-end that enables researchers to easily manipulate research conditions. The front-end was designed in the image of a real supermarket using an Amsterdam branch of the Dutch market leader supermarket as a model (see Figure 1). When study participants open the Virtual Supermarket on their computer, they see a three-dimensional supermarket model with isles, shelves and a range of food products to choose from. Photographs of real products were used to compose the product models. The current supermarket model contains 512 different food products which form a representation of a normal Dutch supermarket assortment. The program does not include all food products normally present in a supermarket because it was unfeasible to model all these products. In order to make a representative product selection, we used numbers provided by one of the major Dutch supermarket specialist journals and information from the market leader's website [15]. An average Dutch supermarket offers about 7,000 different food products; this number includes, for example, approximately 200 different types of cheese and 250 varieties of wine. The market leader's website categorizes these products in 38 different food categories. These categories comprise, for example, potatoes, vegetables, poultry, fish, soft drinks, confectionary, and bread [15]. Within each product category, a sample representing approximately 10% of the usual stock was selected by choosing popular and frequently consumed products. Since there were no Dutch sales data available showing market shares of individual products and brands, the product selection was conducted by two individual researchers. However, when developing new versions of the Virtual Supermarket, we recommend researchers to use sales data in order to ensure that the program contains the most popular food products. In order to widen the product availability, we created a function by which products in the Virtual Supermarket could represent a number of product varieties. For example, grapes represented red and white grapes and fruit yoghurt represented peach/strawberry/and forest fruit flavours. An overview of the entire product categories as well as the number of products per category in the Virtual Supermarket is given in Table 1.

The 512 food products were placed in three-dimensional supermarket shelves, making a supermarket model which closely resembles a real supermarket. Study participants can download the software on their home computer and start grocery shopping right away. Navigating the virtual supermarket goes easily by using the cursor keys. Participants can select groceries by clicking on them and the product then appears in their shopping cart. After they have finished shopping, participants can move to the cash desks which are

located in a similar position as in a regular supermarket. The shopping procedure is however virtual and not real, meaning that participants do not receive the products they have purchased and do not have to pay with real money. If researchers however have the capability to link the virtual supermarket with a real product delivery system (comparable to online shopping) this would be of great interest. Also, there lies potential in collaborating with supermarkets in order to make the virtual shopping procedure real.



Figure 1. Screenshots of the Virtual Supermarket

	Food Category	Total products (n)	Healthy products (n) <sup>a</sup>
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%)

<sup>a</sup> 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 [16]

**Table 1.** Outline of product categories and number of products in the web-based supermarket

The back-end of the Virtual Supermarket is designed in such a way that it can be used by researchers to change research conditions in the application without the assistance of an expert programmer. Researchers can use the back-end to change for example food prices, food labels, the placement of signs, and to configure questionnaires. The back-end can also be used to create different research conditions. For example, research condition A can be linked to regular food prices and research condition B to a situation where a fat tax is introduced. Participants who log in to the application with login code A (1-1000) will see regular prices and participants who log on with login code B (1-1000) will receive the changed (taxed) prices. Changing the above mentioned aspects works via Excel sheets, using comma-separated values. The application keeps track of all products purchased by a participant, the time at which the products were selected, the allocated budget, total expenditures and answers to configurable questionnaires. When a respondent completes the virtual shopping task, data is automatically sent to a server and stored in a unique comma-separated value file under the respondent's personal code. The individual data can subsequently be transferred to an Excel or SPSS data file using a link which compresses the data of all participants that are available on the server.

### **2.1. Have a closer look at the software**

The Virtual Supermarket is free to watch and to test for scientific purposes (e.g., non-commercial). The application is available for both MS Windows (Windows 2000 and all newer versions e.g. Windows XP and Windows 7) and Mac (OS10 and all newer versions) and is built to accommodate a wide range of computer arrangements, by allowing the user to choose different screen sizes and graphical quality. Researchers can download the application for free and in a way that preserves their anonymity.

The Virtual Supermarket can be downloaded for:

- Windows: [http://www.falw.vu/boodschappen/Supermarket\\_0027\\_windows.zip](http://www.falw.vu/boodschappen/Supermarket_0027_windows.zip);
- Mac: [http://www.falw.vu/boodschappen/Supermarket\\_0027\\_mac\\_universal.zip](http://www.falw.vu/boodschappen/Supermarket_0027_mac_universal.zip).

The installation consists of unpacking a compressed file to the desired location. When opening the program, it first asks you about the graphic quality you want to use; you can just click on 'play' in this window. Following you have to fill in a participant number, this can be anything starting with an alphabetic letter (A-Z) followed by a number from 2000 (e.g., A2000). Subsequently, the current version asks you to fill in your household composition; you can fill in the appropriate numbers here. After that, you'll find yourselves at the entrance of the Virtual Supermarket. Feel free to try the program out!

### **3. Potentials of the Virtual Supermarket in food behaviour research**

Key strong points of the Virtual Supermarket are that it can be used to test several intervention strategies (such as food pricing strategies, food labelling, shelf spacing) in a highly controlled experimentally design without a complex implementation process. In this section, we will describe why this type of research is so important, what it adds to the

current scientific literature and what the exact potentials of the Virtual Supermarket are in food behaviour research.

### **3.1. Research that is not supported by the food industry**

First, the Virtual Supermarket is very useful to conduct controversial research. During the formation of new pricing, labelling, or other health-stimulating strategies, there is a massive lobby from the food industry aiming to ban new legislations that aim to limit the purchase of certain foods. For example, a recent WHO nutrition report was heavily criticized on its credibility because the draft strategy was delayed for a month in order to give the United States and several small, sugar-producing countries (the so-called G77) an opening to lobby for a softer strategy [17].

David Ludwig and Marion Nestle have published an insightful commentary paper in the Journal of the American Medical Association (JAMA) about the role of the Food Industry in obesity (research) [18]. This paper highlights the problems that occur when academics and governments work together with the food industry when trying to find successful interventions to stimulate healthy eating. The major problem is that food corporates must make the financial return to stockholders their first priority, in other words, they must sell as much food as possible. This goal contradicts the public health goals which focus on increasing the consumption of healthy foods such as fruits and vegetables, and on decreasing the intake of calories from fat and sugar. As highlighted later in this chapter, most of food industries' profit comes from convenience foods such as fast food and snacks which is illustrated by the fact that nearly 70% of the annual \$33 billion spending on food advertisements and promotions goes into these convenience foods [19]. Due to this profit making structure, food producers have no real incentive to participate in health stimulating behaviour and may even contradict this aim. For example, pricing strategies are frequently mentioned as a promising strategy to stimulate healthier food choices. In a Delphi Study, we asked representatives from academia, food industry and government organizations what the most feasible and effective pricing strategies would be. An interesting outcome of this study was that taxing unhealthy food was generally indicated to be an effective strategy, but not feasible, especially from the food producers view point [20]. Brownell and colleagues at the Yale Rudd Centre have argued for the introduction of taxes on sugar-sweetened beverages [21], but encountered some thorough opposition from the sugar sweetened beverage industry stating that such taxes would lead to higher alcohol consumption. Numbers show that PepsiCo, Coca-Cola Co and the American Beverage Association have spent the huge amount of US\$ 70 million on lobbying against proposed soda taxes [22]. Moreover, Vermeer *et al.* concluded in their study on the feasibility of interventions aimed at portion size that "The respondents indicated that, from a perspective of responsible entrepreneurship, their companies were willing to play an active role in combating this social problem. However, that this willingness was subject to the condition that any such intervention would not harm commercial interests" [23]. Finally, in front-of-pack labelling research (see also later in this chapter) there are issues with labels indicating products as being unhealthy. From the public health viewpoint, there is growing consensus that FOP

labels should identify food products both as being healthy or unhealthy where applicable [24]. An example of such a system is the multiple traffic light format [25] using colour schemes to indicate the products healthiness. In general, food producers do not favour this system since it could give their products a clear red mark indicating the product as being unhealthy, which could in turn lower the sales. In general, food producers are willing to think about practices to stimulate healthy eating, as long as their profits are not affected. When truly thinking about successful interventions, we do however might want to achieve lower sales and lower profit making in the food industry sector, especially with regard to unhealthy convenience foods.

Ludwig and Nestle highlight that 'Academia's role is to investigate by rigorous scientific investigation of nutrition and health. To minimize the corrosive effects of financial conflicts of interest, universities should institute systems to ensure independent review of industry-sponsored research, including critical oversight of hypotheses, design, data collection, data analysis, interpretation, and decisions to publish' [18]. However, this level of independence is hard to accomplish when trying to examine the effectiveness of interventions in the real-life food environment. For example, if you want to conduct a trial on shelf spacing in the supermarket, you rely on the willingness of the supermarket to cooperate. Also, testing the effectiveness of interventions that are not favoured or rejected by the food industry (such as traffic light labelling or soft drink taxes) is very complicated to conduct. The Virtual Supermarket does not have to deal with such issues and maintains researcher independence and avoids conflicts of interest that may arise from industry collaboration. In the following paragraphs, we will list some different types of interventions that are interesting to study using the Virtual Supermarket.

### 3.2. Social marketing

Traditional nutrition education interventions are based on social-cognitive models, which assume that behavior change is a rational process. Examples of such models are the 'Theory of Planned Behavior', the 'Health Belief Model' or self-regulation theory [26, 27]. Key elements in these theories are health beliefs, intentions, goal setting et cetera. However, often behavior is unconscious, irrational and driven by other motivators than health. Marketing makes use of this knowledge by nudging people towards a product by using default behaviors (i.e. the tendency to choose the middle size or the one which is labeled as 'normal' or 'medium'), building on human preferences (i.e. to make it easy, convenient and requiring low effort) and by using the 'fun factor'. Social marketing is a process "that applies marketing principles and techniques to create, communicate, and deliver value in order to influence target audience behaviors that benefit society (public health, safety, the environment, and communities) as well as the target audience" [28] Social Marketing is more customer oriented than traditional health education; it uses marketing research to understand market segments; positions the 'product' or behavior in an appealing way to the chosen target market (more appealing than the competing products or behaviors); and uses a marketing mix in which product, place, price and promotion are the key elements. Social marketing differs from commercial marketing in the sense that the main goal of commercial

marketing is to make a financial profit, while the main goal of social marketing is to benefit both the individual and the society. An important principle in both commercial and social marketing is the exchange theory. In order for an exchange to take place, people must perceive benefits greater or at least equal to the perceived costs [28].

Both social marketing and the classic marketing mix use the concept of four p's to describe the determinants that can be used to steer consumer behaviour: product, place, price and promotion [29]. This concept implies that if you want to sell something to a consumer (for example healthy eating) you could intervene on the product (develop a new type of healthy bread); on the place (self-spacing in the supermarket); price (subsidy on fruits); and/or promotion (advertising). Especially, it is important to be aware of the fact that all four p's should be 'correct', for example: if you have a very healthy, tasty new type of bread, which is placed in every supermarket and heavily promoted, it will still not sell if it has not the right price. It is interesting to study these four p's in relation to health promotion since they show potential as primers to steer consumers decision processes [7]. In this section, we will provide an overview of the potentials of the virtual supermarket in research on the use of these four p's.

### 3.3. The first P: Pricing

Price has been listed as *the* factor to steer consumer behaviour [30]. Indeed, economists state that they have no idea how to change people's preferences; the way to change behaviour is to change the cost [31]. It is true that economic strategies have previously been successful in reducing the use of alcohol and tobacco [32]. Moreover, when thinking about our every-day food environment, it is clear that marketers use price a lot to attract consumers towards their product. Another way to use price is via de-marketing obesity [33]. Social marketing not only focuses on attracting people towards a certain product or behaviour, but also on decreasing their attraction towards unwanted behaviours. With regard to food pricing, one could think about making the relative costs of unhealthy foods more expensive in order to make them less attractive.

Different governments around the world are considering (or have already introduced) food pricing strategies to improve the quality of population diets. In October 2011, Denmark introduced a fat tax. Specifically, the measure consisted of a price increase of around €2.15 on every kilo of saturated fat on any food that contains more than 2.3% saturated fat. Also Hungary introduced a tax on unhealthy food items [34] and France recently introduced a tax on sugary soft drinks (the tax of around one Euro cent per can is expected to bring in tax revenues of €120 million). Moreover, in December 2011, the Dutch Council for Public Health and Health Care (RVZ) advised the government to look at food pricing strategies as a measure in the prevention of welfare diseases. Their particular advice was to explore how a fat tax or a higher Value Added Tax rate for all foods could be realised [35]. Furthermore, also the WHO advises member states to consider fiscal policies to stimulate healthy food choices [34]. Interestingly, however, the effects of these fiscal measures on health are unknown and are some gaps that need to be filled before pricing strategies can be designated as a solution in health promotion [36].

### *3.3.1. Evidence on the effectiveness of food pricing strategies*

One way of studying the effects of food pricing strategies, is the use of simulation modelling studies. These studies simulate the effects of tax reforms using real data on food expenditures such as national household consumption surveys. These data are used to determine the price elasticity of demand of the studied food products. Price elasticity of demand is defined as the responsiveness of the quantity demanded of a certain good due to a price change of this good [37]. If, for example, the demand of hamburgers decreases drastically due to a fat tax (price increase) this is considered an elastic good. A recent review on the price elasticity of food (based on a selection of 160 studies) revealed that food is elastic and that the highest price elasticity was found for food away from home, soft drinks, juice, meats, and fruit and the most inelastic demand for eggs [11].

A second way of studying the potential of food pricing strategies is to ask consumers how they would react to changing food prices using qualitative methods or quantitative surveys. This type of research has shown that price is an important factor in food choice and that consumers expect that they will eat more healthy food if this becomes cheaper [38, 39]. Third, experimental studies are highly relevant to gain insight into consumer responses towards price changes. Well known examples of experimental pricing studies in the field of health promotion is the work by French and colleagues. They conducted experiments in vending machines where prices of low-fat snacks were reduced by 10, 25 and 50 per cent and found that sales of these products raised by 9, 39 and 93 per cent respectively [40]. These results were duplicated in later studies of the same group [41]. Also, they found that reducing prices of fruits and vegetables with 50 per cent in school canteens lead to a two-fold increase in vegetable and four-fold increase in fruit purchases [40]. Other experimental studies are the work by Epstein and colleagues who conducted a study on several pricing schemes in a laboratory supermarket [42], the work by Nederkoorn and colleagues on a high caloric tax in a web-based supermarket [43], and the work by Giesen and colleagues on taxing high caloric university lunch menus [44]. All these studies revealed significant effects of the price changes.

While the previous paragraph illustrates that there is some good scientific evidence to support the effects of food pricing strategies, it still does not give insight into the effectiveness of these measures to stimulate population health. The major issue with the effects of food pricing strategies on health outcomes is the potential side effects of these measures. For example, if fruits become cheaper people may use the money to buy more pizza. Or, if fatty foods become more expensive people may compensate their loss by buying less fruits and vegetables [42, 45]. This side effect of food pricing strategies is known as 'cross price elasticity of demand', e.g., the responsiveness of the demand for a good as a result of a price change of another good [37]. Cross-price elasticity is consequently referred to as being highly complex [45]. The majority of simulation modelling studies have not modelled complete demand systems to estimate the effects of price changes on both targeted foods and non-targeted foods. Moreover, most studies have only modelled through to the effect of fiscal regimens on overall purchases of targeted foods and nutrients; there are very few examples where modelling has been extended to determine effects on health and

disease [36] or across socio-economic groups. The same issue applies to experimental studies. A review on randomized controlled trials on food pricing found that the published trials studied small sample sizes, were of short duration and also only studied a small number of products [46].

### 3.3.2. *What type of research is needed?*

In order to gain insight in the multifaceted effects of food pricing strategies, it is of importance to conduct experiments in larger food environments, where people buy most of their foods, that is retail settings [11, 12, 47]. Randomized controlled trials (RCT's) are especially important to conduct because, in the hierarchy of evidence that influences healthcare policy and practice, this type of research is considered to be the most reliable methodology. For example, the National Health and Medical Research Council of Australia designated "Level I" evidence as that "obtained from a systematic review of all relevant randomised controlled trials" and "Level II" evidence as that "obtained from at least one properly designed randomised controlled trial. Moreover, the results of RCT's form an important input for the data used in simulation modelling studies. A recent review on experimental food pricing research has revealed that only four supermarket food pricing experiments have been published up to date [48]. These trials include for example the New Zealand SHOP study [47] and a recently published French study on the effects of fruit and vegetable vouchers [49]. All four studies focused on the effects of providing discounts on healthier foods and did not contain detailed data on substitution effects [48]. The main reason for the absence of large experimental trials on the effects of food pricing strategies is that those are complex, costly and sometimes even impossible to conduct in real-life. It is hard to change prices in real supermarkets and it also difficult to find good a good control group (that receives regular prices) which is crucial for a randomized controlled trial. Moreover, it is hard to extract the effects of the pricing strategy from other factors that may influence consumer choices (e.g., branding, shelf placement, etc.).

The virtual supermarket offers a great solution to the difficulties surrounding the implementation of RCT's on the effects of food pricing strategies. The software is suitable to experimentally study various pricing interventions in a highly controlled supermarket setting without having to rely on a complex implementation process. Besides, the Virtual Supermarket can be used to study the effects of food pricing strategies that are not favoured by the retail or food sector such as different types of taxes (soda tax, fat tax, etc.). The results of such studies can form a good input for policy and practise and can also be used in subsequent simulation modelling studies.

## 3.4. The second P: Product

A second way of stimulating healthier food choices is by the introduction of new healthy food products or the reformulation of existing food products towards a healthier nutrient composition. One way by which food producers can be encouraged to develop healthier products is by the introduction of a front-of-pack (FOP) nutrition label [50]. FOP labels can roughly be divided into non-directive, semi-directive and directive labels [51] and aim to

provide clear and direct information about the healthiness of a food product and thereby support consumers in making healthier food choices. FOP labels show potential to promote healthier product selection by consumers (as will be explained in section 3.5) but show also potential with regard to food reformulation and the development of new food products with a healthier product composition. Food producers are generally keen to have a healthy food label on their product or just don't want a red traffic light stating that their product is unhealthy. In order to reach this goal, food producers are encouraged by FOP labels towards a healthier product composition.

#### *3.4.1. Evidence on the effect of product interventions*

Research on a FOP label (the Choices Healthy Food Label) revealed that this label stimulated food manufacturers to develop new healthier products and to reformulate existing products towards a healthier nutrient composition [52]. Moreover, a New Zealand study observed that the Pick the Tick logo lead to a reduction in sodium content of a small number of products [53]. When food products are reformulated as a consequence of FOP labels, this could have large implications for public health since people will then automatically select healthier products (because the products became healthier). A Dutch simulation modelling study using national food consumption and food composition data revealed that a diet modelled to contain more products that complied with the Choices FOP label could contribute to cardiovascular risk reduction [54]. Second, a study using a randomized parallel design examining the effects on sodium excretion of dietary education to choose foods identified by either Australia's National Heart Foundation Tick symbol or by the Food Standards Australia and New Zealand's low-salt guideline, revealed that sodium excretion decreased significantly in both groups after 8 weeks [55].

#### *3.4.2. What type of evidence is needed?*

Comparable with food pricing research, large randomized controlled trials on the effects of food reformulation and new product development form a gap in the literature. There is evidence that FOP labels lead to healthier product development and there is evidence that the consumption of healthier products leads to improved health status, but we don't exactly know how consumers react to the introduction of new or improved products. Will consumers indeed buy these new products, or will they stick with their regular purchases? Or will consumers purchase more products if they perceive them as being healthier? The virtual supermarket can be a very useful tool to conduct such research since it allows the placement of new products in the assortment. Therefore, the effects of new products can be studied in a highly controlled environment without other disturbing factors such as pricing or branding. The software enables to link the virtual purchases with food composition data, meaning that the effects of new products on nutrient purchases can be easily calculated. The Virtual Supermarket could be similarly useful to study the introduction of new sustainable, organic or fair-trade products. Different studies have shown that there is a large gap between environmental awareness and conducting actual environmentally friendly behaviour. The same issues apply to health: most people list their health as being one of the

most important factors in their life, but still, they have trouble in taking part in healthy behaviour. While numerous studies have been undertaken to explain this gap, there is no definite answer yet [56]. The Virtual Supermarket has the unique advantage of providing the possibility to study environmental friendly related or health related behaviour experimentally. Will product innovation actually pay off? What is the right price for a new product when it enters the market? How should the new product be positioned and how does it work amongst different types of consumers? There lies great potential in conducting research on these aspects. Later in this chapter, we talk about the possibilities of linking the Virtual Supermarket to eye-tracking research. This technique captures how long consumers look at a certain product and where they look at. The combination of both tools shows great potential in studying the effects of new products in the market place.

### **3.5. The third P: Promotion**

Promotion has great potential in stimulating healthier food choices. Here there are different types of promotion we could consider, for example, promoting the healthiness of a product, promoting the price of a product, promoting a new product, advertisements, etc. The huge amount of money that goes in food promotion each year (in 1999, US food companies spent more than \$33 billion annually on advertising and promoting their products and nearly 70% of this money was spent on advertisements for convenience foods such as fast food and snacks) illustrates that at least food producers expect good results from this marketing strategy [19]. It would be very interesting to study how different type of advertisements would affect consumer food choices and how these could be used to stimulate healthier food choices. The virtual supermarket could be used to display different types of signs or people could be exposed to different types of commercials before entering the supermarket.

#### *3.5.1. Evidence on the effects of promotion*

There is a large body of evidence, especially within the field of marketing and retail research, about the effects of promotions. For example, research showed that people have the tendency to buy a product simply because it is on sale or cheaper now [57, 58]. Going beyond that, there is evidence that people react to a sale sign without an actual price discount. Anderson and Simester found that using the word 'sale' beside a price (without actually varying the price) can increase demand by more than 50% [59]. Also the way of framing the price seems to be important. Research found that the use of \$9/€9 endings increases demand because people link this ending to a promotion price [60]. This extra effort seems important since it was found that people tend to remember prices badly and are dependent on cues to update their expectations about relative prices and future product availability [61].

Besides informing about special offers, it was found that consumers are interested in information telling them about the healthiness of a product [39]. FOP labels form a potential effective strategy to promote healthy products among consumers. As described above, there are generally three different types of FOP labels. First, non-directive labels provide information about the (core) nutrients in a product, but leave the decision about whether

this nutrient content is healthy or not to the consumer (for example the Daily Intake Guide, DIG). Second, semi-directive labels provide some guidance, but leave the final healthiness interpretation to the consumer. An example is the colour-coded multiple traffic lights label (MTL) which ranks total fat, saturated fat, sugar and sodium and codes these with a colour [25]. Finally, directive FOP labels include quality marks – a healthy food logo. Mostly, this logo defines a healthier product within a certain product category. A recent review revealed that consumers are interested in nutrition labeling and favor the idea of a simple label on the front of pack of food products [62]. There is a considerable amount of evidence on consumer understanding of different FOP schemes and also their use in the supermarket [62, 63]. For example, A German study tested consumer understanding (n=420) of different FOP label formats. Results revealed that German adults profit most from the traffic light label [64]. Next, A new Zealand study on use, understanding and preferences among ethnically diverse shoppers revealed that traffic light labels demonstrated high levels of understanding while consumers had more difficulties with the mandatory nutrition information panel [65]. Finally, a Dutch observational study examined the evaluation and use of the Choices front-of-pack logo among supermarket shoppers [66]. This study found that 62% of the study sample was familiar with the logo and that it regularly occurs that shoppers purchase products with the logo unintentionally [66].

### 3.5.2. *What type of evidence is needed?*

There is need for experimental research on the effects of different types of product promotion on food purchases. With regard to FOP labelling it is a problem that most studies are based on self-report; experimental evidence about the effectiveness of FOP labels is roughly absent [62]. The main reason for the absence of experimental studies about the effects of FOP labels on food choices is that, similar to food pricing, these are complex to conduct. FOP labels are mostly introduced nation-wide without the presence of a good control group (that did not receive the new FOP labels). Moreover, different FOP labels already exist in the market place, which makes it hard to extract the effect of the new label only. Finally, it is complex to measure the pure effects of FOP labels apart from other influencing factors such as food packages, branding and price. It is highly important to get more insight into the effects of FOP labels on actual purchases, both for research and policy purposes. First objective measures are needed because these effects may differ largely from reported behaviour. Moreover, it is important to carefully monitor the effects of FOP labels because they may result in negative side effects. For example, it is expected that consumers eat more of a product when they think the product is healthy and also there are also indications that health messages may be counteractive because people link health with a bad taste [67]. Stakeholder views are polarized with regard to the best FOP label format [24]. For example, most food producers do not favour the traffic light system [25] because it will give their products a clear red mark indicating the product as being unhealthy. Most public health workers, on the other side, do favour such a system [24]. Without the presence of solid experimental evidence it is hard to inform policy makers about the best format. If we aim for stringent food labels (such as the traffic light system) solid evidence is needed to work against the strong lobby of the food industry.

Also for other type of promotion strategies more experimental research is warranted. Most marketing and retail research has not focused on public health outcomes, but instead measured the effects of promotion on a couple of single products. The effects found in such studies cannot be directly related to the effects of promotion on public health nutrition. For example, the effects of increased sales due to a promotion could work via different mechanisms being “product substitution”, “forward buying”, “purchase acceleration”, “brand switching”, “product testing”, or “repeat purchasing” which all are expected to have different effects on the definite consumption pattern [30]. Similar concerns apply to the effects of the communication of pricing strategies. As mentioned before, it may be more important to tell people that a product is discounted than to actually discount it. The effects of communicating pricing information (promotion) also seems relevant in relation to price increases; it may be more important to tell people that products are taxed than to actually tax it [68, 69]. 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 [70]. Nevertheless, the evidence is currently limited to theoretical analysis [70] and experimental studies are needed to gain insight into this topic.

The virtual supermarket could be a useful tool in conducting experiments on different promotion strategies and in finding out how taxing, subsidizing or FOP label schemes should best be addressed to consumers. For example, researchers can design an experiment with different sales labels (‘two for the price of one’ versus ‘50% discount’) and the effects of communicating new taxing measures (for example placing signs stating ‘warning: this product has been taxed’).

### 3.6. The fourth P: Place

There is growing recognition that our food environment is obesogenic, that is defined as “the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations”[6, 8]. Another interesting area for investigation would therefore be product placement and the amount of shelf space that is awarded to a certain product. What happens if healthy foods form 90% of the supermarket assortment and unhealthy food is more difficult to locate?

#### 3.6.1. Evidence on the effects of place

The effects of shelf spacing and product placement have not been heavily studied, but there are some studies that show promising results. For example, a study found that the sales of fruits and vegetables increased by 40% after doubling the shelf space [71]. Moreover it has been observed that all store types (supermarkets, convenience stores, specialty shops, etc.) devote more shelf space to unhealthy items compared to healthy items [72]. Finally, a group at Deakin University (Australia) has done some work on the shelf spacing aspect and found that supermarkets in lower socio-economic areas dedicate significantly more shelf space to unhealthier products (soft drinks, snacks) compared to supermarkets in higher socio-economic areas. Besides shelf spacing, also the location of products in the supermarket is expected to have a large influence on food purchases. This includes for example the location of products near the entrance, or placing products on eye-level [73].

### 3.6.2. *What type of evidence is needed?*

Altogether, there are indications that changes in shelf spacing of healthier and unhealthier foods can be an effective intervention to stimulate healthier food choices. However, up to date, there are no published experimental studies that have examined the effects of interventions with regard to product place on food purchases [73]. Moreover, there are roughly no studies on the effects of the placement of products on eye level, the placement of products near the cash desk area, the placement of products in special eye-catching locations (including for children); changing the proportion of healthy versus unhealthy products; or changing the total amount of products available [73]. We expect that one of the main reasons for the absence of such studies is that those are very complicated to conduct. This would require the adjustment of a whole supermarket layout which is very complex and costly. The virtual supermarket has potential in studying such interventions. Besides, we do expect that the retail industry has some useful data on the effects of product placement in the supermarket; however, this information has not been published or provided to public health researchers so far. We are therefore dependent on other types of data collection to get insight into these effects.

### **3.7. Summary of the main potentials of the virtual supermarket in food behaviour research**

This section revealed that the Virtual Supermarket has great potential for experimental research about the effects of interventions in a retail setting on food purchases. The virtual supermarket provides a highly controlled environment and makes it easy for researchers to change research conditions such as price, product place, promotion or other strategies. Besides the four P's from the marketing mix, researchers could use the Virtual Supermarket for various other intervention studies. For example, what is the influence of music? Work by North and colleagues revealed that French music played in a store led to higher sales of French wine whereas German music led to higher German wine sales [74]. Researchers could also think of the influence of colour schemes, lighting, adding extra service, providing consumers with a clear map of the supermarket (or via a smartphone application), the influence of hunger and thirst, impulsivity, stress and many other things. For example, Nederkoorn *et al* have used a virtual supermarket in the form of 640 food products that could be chosen via drop down lists (comparable to the current form of most online stores) to examine the effects of impulsivity and hunger on calorie purchases [75]. Moreover, Giesen *et al.*, have used this similar type of virtual supermarket to examine the role of impulsivity on the effects of calorie taxes and subsidies [76].

## **4. Results of experimental research with the Virtual Supermarket**

The development of the Dutch Virtual Supermarket software has been completed in 2010. Since then, the software has been pilot tested among 66 consumers and it has been successfully used in five scientific experiments among 557 study participants. In the sections below, we will provide an overview of the experiments that have been conducted with the

Virtual Supermarket so far. These experiments were mainly focused around the effects of food pricing strategies and give an indication about how virtual reality can be used in behavioural research. Besides, during the pilot phase and as part of the experiments, we asked consumer feedback about the software and requested them to judge the validity of the tool on several quality indicators. The results of these quality observations will be presented at the end of this chapter.

#### **4.1. The effects of a 25% price discount on fruits and vegetables**

The first experiment in the virtual supermarket examined the effects of a 25% price discount on fruits and vegetables. The results have been published in the International Journal of Behavioral Nutrition and Physical Activity [77]. In this experiment, 115 Dutch adults from the general population shopped one time in the virtual supermarket. Half of the sample was randomized to a condition with normal food prices and the other half of the sample was randomized to a condition with a 25% price discount on fruits and vegetables. Most participants completed the experiment at home and they were instructed to undertake a typical shop for their household for one week. The main outcome measure was fruit and vegetable purchases (in grams and items). Next, also purchased calories (kcal) and expenditures in unhealthier food categories were measured (e.g., desserts, soda, crisps, candy, and chocolate). Before entering the Virtual Supermarket, participants were asked some background variables including: sex; age; ethnicity; household composition; degree of being responsible for the groceries; weekly food budget; education level; employment status; and household income. Results of this experiment revealed that the group in the 25% price discount condition purchased nearly 1 kilogram of fruits plus vegetables more for their household for one week compared to the group that received normal food prices ( $p < .05$ ). Differences between both research conditions for fruit ( $B=481$ ; 95% CI: -69, 1,030;  $p=.09$ ) and vegetable purchases ( $B=504$ ; 95%CI: -64, 1071;  $p=.08$ ) separately also showed large differences, but these were not statistically significant.

Furthermore, both groups purchased an equal number of food items and an equal amount of calories, indicating that participants in the discount condition did not spend the money they saved from the discounts on other foods than fruits and vegetables. More details of the results can be found in Figure 2.

While it is important that future studies expand and validate these findings to a real supermarket setting, the results were the first to report the effects of discounting fruits and vegetables in a retail setting and found that this measure is effective in stimulating purchases of those products which could have major implications for public health.

#### **4.2. The effects of price discounts combined with price increases**

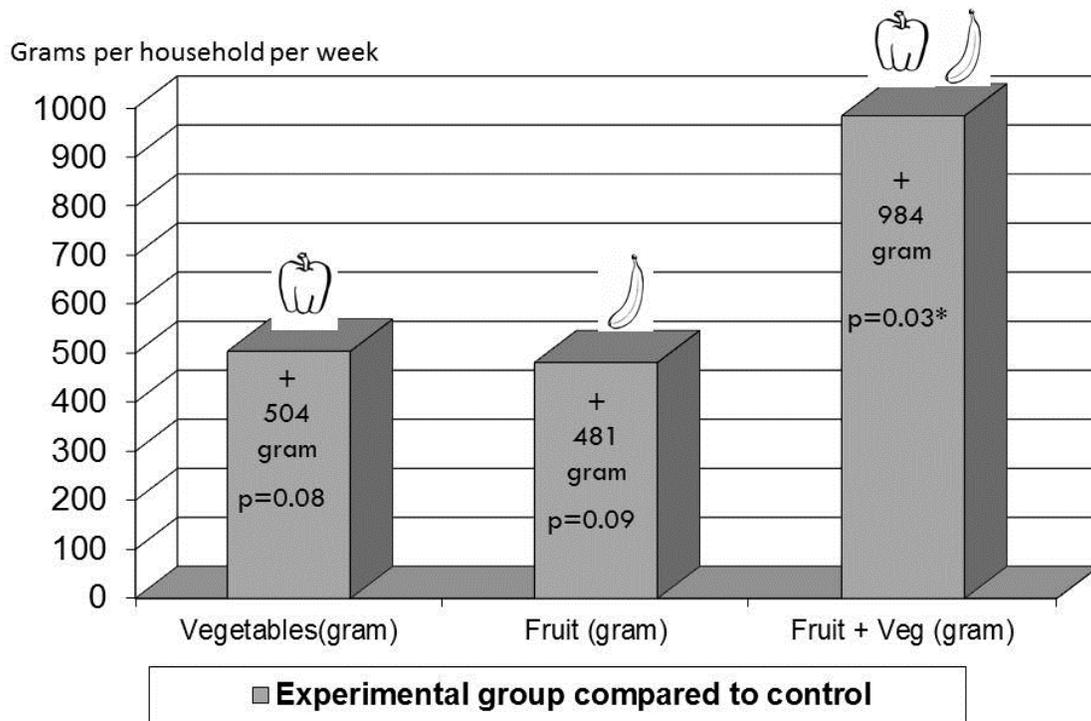
The second experiment in the Virtual Supermarket concerned the effects of combining discounts on healthier food products (no discount; 25% discount or 50% discount) with price increases on unhealthy products (5%; 10%; 25% price increase) on food purchases. The results of this experiment have been recently published in Preventive Medicine [69]. The

experiment contained nine study (three x three) conditions and study participants shopped once in the virtual supermarket. 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. Data of in total 117 participants were included in the statistical analysis. Results revealed that the discounts were effective in stimulating healthier food purchases; participants that received a 50% discount purchased significantly more healthy foods than participants with no discount (mean difference was 6.62 items) or a 25% discount (mean difference was 4.87 items). However, higher price discounts were also associated with more food purchases overall (including unhealthier products). Participants that received a 50% price discount purchased in total 10.4 more food items compared to the participants that received no discount. Moreover, the 50% discount group purchased 10,505 more calories (kcal) for their household for one week compared to the group with no discount ( $p=.001$ ). We did not find an effect of the price increases on food purchases. Also we did not find that participants in the study conditions with price increases on unhealthy foods purchased less food products, nor that the effects of the discounts (extra calories) were balanced by the price increases. 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 [11, 12]. This study therefore provides important new evidence into the effectiveness of varying price discount and price increase schemes on food purchases. An important aspect to consider is that our results may be an underestimation of price strategies in practice, because the pricing strategies were silent. As mentioned earlier in this chapter; it may be more important to tell people that a price has changed (either increased or decreased) than actually changing the price [57, 58, 68]. It is therefore important to validate our results in a real supermarket setting and to include the effects of communication strategies. Finally, it would be interesting to study the effects of higher tax levels (25% onwards) since different studies have revealed that such high levels are required to result in behaviour change [42, 76]. The virtual supermarket could also be a useful instrument to study such effects as well.

### **4.3. The effects of price discounts in combination with sales and promotion signs**

The third virtual supermarket experiment studied the effects of different signs ('healthy choice', 'sale' and 'sale & healthy choice') in combination with price discounts (10%; 25% and 50%) on healthy foods on food purchases. The results of this experiment have been submitted for publication [78]. The experiment contained nine study conditions (three x three) and study participants shopped once in the virtual supermarket. The types of signs were chosen to segregate the effects of pointing out that a product was either on sale, healthy, or both. The signs were placed noticeably next to the healthier products in the web-based supermarket (Figure 3). Healthy products were 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 [16]. Main outcome measures were: healthy and unhealthy food items (number and proportion); fruit and vegetables (gram); and calories (kcal). All outcomes were measured per household per week. The final study sample included  $n=109$

participants and differences between conditions were tested using two-way factorial ANCOVA, where factor 1 indicated the level of discount and level 2 the promotion sign. In line with the previous experiments, the results of this experiment showed that discounts are effective in stimulating healthy food purchases. We did however not observe significant differences between the effects of the sales signs. A limitation of this study was that it did not include a condition with no promotion sign, which makes it hard to separate the pricing and the promotion effects. It is interesting to examine this in more detail in future studies.



**Figure 2.** Results of experiment 1 in the virtual supermarket: difference in purchased amounts of fruit and vegetables (in grams per household per week) between the experimental group (25% discount on fruits and vegetables) and the control group (normal food prices)



**Figure 3.** Sales signs in the Virtual Supermarket

#### 4.4. Unpublished results

The results of the fourth and fifth experiment in the virtual supermarket have not been published and fully analysed yet. The first of these experiments studied the effects of a tax measure on sugar-sweetened beverages. This pricing measure has particular interest in the United States and also France recently implemented a soda tax. The experiment we conducted contained two study conditions: one with normal prices and one with a tax increase on sugar-sweetened beverages from the regular 6% to the high tax level of 19% (which is the same as the Dutch tax level for alcohol). Table 2 gives an overview of the control and experimental prices. 94 Participants were included in statistical analysis. Results of initial analysis showed promising effects of such a tax on the purchase of sugar sweetened beverages and are expected to be published next year. The second of these experiments studied how different discount percentages on healthier foods affected food purchases. In this experiment we asked participants to shop four times in the virtual supermarket. During every shopping event participants were provided with different prices on healthier food products (no discount; 10% discount; 25% discount and 50% discount). Participants received the price discounts in different orders and were not informed about the price changes. The data of this experiment have not been analysed yet, but they promise to provide valuable new information because they can give insight into the effects of price changes both within and between consumers and also show which discount percentage is needed to find significant results.

	Control Group (price in €)	Experimental group (price in €)
<b>Lemonade/ syrup</b>	1.53	1.71
<b>Cola</b>	1.14	1.28
<b>Orange</b>	1.14	1.28
<b>7-up/ soft drink</b>	1.14	1.28
<b>Spa fruit drink</b>	1.09	1.21
<b>Cassis soft drink</b>	1.09	1.21
<b>Ice tea</b>	0.64	0.71
<b>Tonic</b>	1.35	1.51
<b>Energy drinks</b>	1.72	1.98
<b>Red-bull</b>	4.32	4.83
<b>Ice coffee</b>	1.05	1.17
<b>Apple juice</b>	1.06	1.19
<b>Orange juice</b>	1.25	1.40
<b>Grape juice</b>	0.95	1.06
<b>Multi fruit juice</b>	1.21	1.35
<b>Chocolate milk</b>	0.86	0.96

**Table 2.** Overview of the control and experimental prices in the soda tax experiment

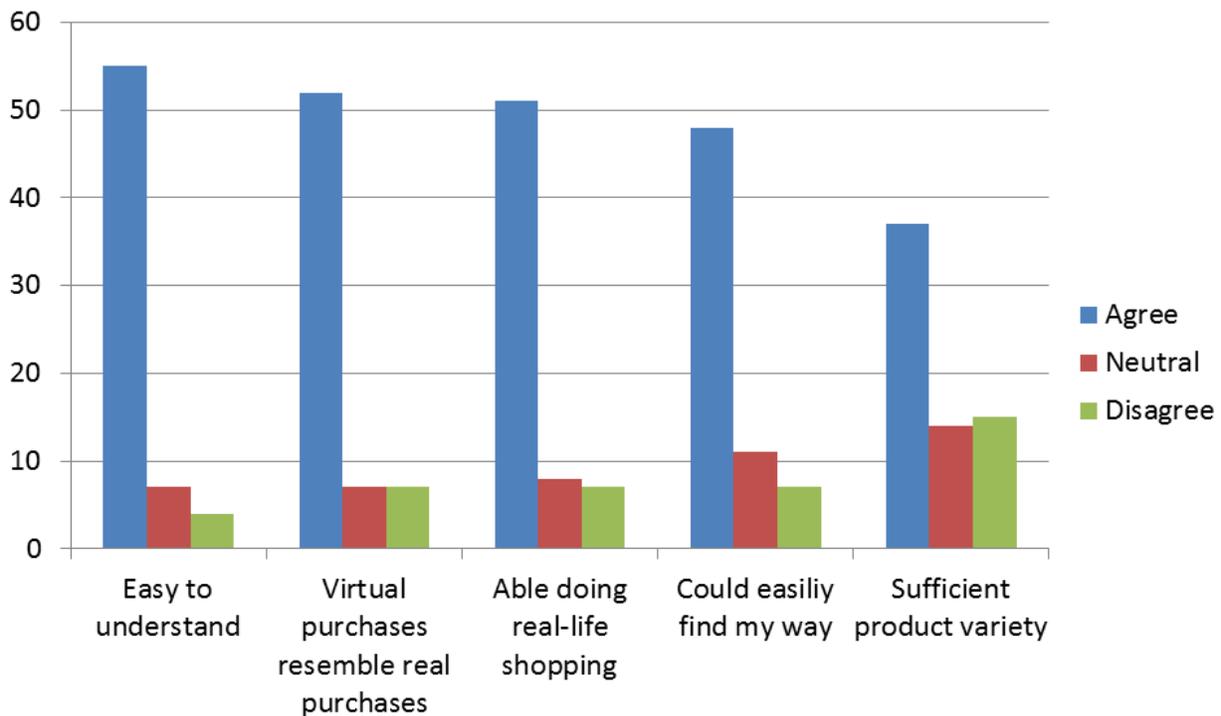
## 5. Participant feedback on the Virtual Supermarket software

Besides the primary outcome measures on food purchases, the Virtual Supermarket also enables to review how participants experienced the software. In all five experiments, we measured participant feedback with a list of questions. It was observed that this feedback was generally very good. For example, in experiment 1, it was observed that 91% of the participants scored  $\geq 4$  (scale 1-5) on comprehension of the software. Furthermore, 87% scored  $\geq 4$  on the question asking whether they could envision doing their normal groceries using the web-based supermarket. Finally, 80% scored  $\geq 4$  on the question asking whether their purchases at the web-based supermarket gave a good indication for their normal groceries [77]. In experiment 3, we found comparable results showing that ninety-one percent of the participants scored  $\geq 5$  (1=lowest; 7=highest) on comprehension of the software. Furthermore, 85% scored  $\geq 5$  on the question asking whether their experimental groceries corresponded with their regular groceries and 94% scored  $\geq 5$  on the question asking whether the products in the web-based supermarket were good recognizable [69].

The virtual supermarket was also pilot-tested among 66 consumers as described in our paper in BMC Public Health [14]. Results (see also Figure 4) of this pilot study revealed that the majority of respondents considered the Virtual Supermarket easy to understand ( $n = 55$  agree,  $n = 7$  neutral,  $n = 4$  disagree) and could easily find their way around the Virtual Supermarket ( $n = 48$  agree,  $n = 11$  neutral,  $n = 7$  disagree). Around half of the respondents agreed that the Virtual Supermarket had a sufficient variety of products in stock ( $n = 37$  agree,  $n = 14$  neutral,  $n = 15$  disagree), and thought that the stock of the Virtual Supermarket resembled the stock of a real supermarket ( $n = 34$  agree,  $n = 11$  neutral,  $n = 21$  disagree). Moreover, most respondents indicated that the products they selected in the Virtual Supermarket corresponded to their normal weekly groceries ( $n = 52$  agree,  $n = 7$  neutral,  $n = 7$  disagree).

The experimental results and the results from the pilot study show that the Virtual Supermarket is a good-quality tool to measure shopping behaviour. Study participants state that they can envision doing a typical grocery shop using the software and most participants indicate that their virtual groceries correspond well with their regular groceries. Especially when combined with other methodologies to unravel the effects of interventions in the supermarket environment (simulation studies, questionnaires, experiments in smaller settings), the results can provide imperative insight in the effects of different intervention strategies. Especially since electronic shopping is becoming increasingly common these days. Moreover, there is evidence that peoples' virtual behavior largely corresponds with their actual behavior. Sharpe et al. (2008) validated food and beverage choices made in a virtual road trip survey by comparing those choices with choices made in a real McDonalds a week later. The authors concluded that peoples' simulated purchasing behavior is highly predictive of their real behavior [79]. Virtual shopping behaviour may thus also be fairly comparable to real-life shopping behaviour. A point for improvement would be the number of products that is available in the Virtual Supermarket since some participants indicated that the product variety was low. Besides, it could be valuable to provide participants with a

map of the supermarket showing them which products are available and where they are located; more than half of the participants in the pilot study indicated that they could not easily find all products [14].



**Figure 4.** Participant feedbacks from 66 consumers on the Virtual Supermarket software. Each bar represents the number of participants that fitted in that category. For a more detailed overview see [14]

## 6. What's next: Upcoming research and an English language version of the Virtual Supermarket

The virtual supermarket has successfully been used in several experimental studies and shows great potential for further food choice studies. In order to ensure that the quality of the software is high and to enable the use of the software outside the Netherlands, we are currently working on new research. This research encompasses the validation of the software and the development of a New Zealand version of the virtual supermarket.

### 6.1. Validation of the virtual supermarket

An important limitation of the virtual supermarket in food choice research is that the found effects may be different compared to a real supermarket. Behaviour in a real setting may differ from a virtual setting because real life concerns real money and real products and this may lead virtual shopping to be taken less seriously. It is therefore of major importance to validate the Virtual Supermarket against real-life food purchases.

In the Netherlands, we are conducting a virtual supermarket validation study at this moment. In this study, we have asked study participants to conduct a typical weekly shop at the Virtual Supermarket and subsequently to collect their (real) grocery receipts from the following week. We aim to collect data for around 100 study participants. The data from this study will be used to analyse to what extent the virtual and the real purchases overlap and how this varies across different food categories. Next, we will measure which products were purchased in real life but for which no good alternative was available in the virtual supermarket. Moreover, participants will be given a set of questions asking about the quality of the software and whether or not they missed any products. We aim to finish data collection in April 2012 and expect the results to be published early 2013. We aim to update the software based on the results of this validation study.

## 6.2. New Zealand Virtual Supermarket

At the National Institute for Health Innovation (NIHI), the University of Auckland, New Zealand we are working on a New Zealand version of the Virtual Supermarket at this moment. This version will contain more product items compared to the Dutch version and will contain many new features.

The New Zealand version will enclose an assortment that is representative for an average New Zealand supermarket. The product selection will be based on the products that are available in a regular supermarket and we aim to enclose around 1,500 products (this is three times more than the Dutch version). In contrast to the Dutch version, The New Zealand Virtual Supermarket will contain different brands. In order to select the most popular products from each product category we use data from the Australian Grocery Guide. This guide gives an overview of market sizes and market shares of all retail products in Australia. While Australian data may differ somewhat from New Zealand, the guide does provide a good starting point for product selection. Other features of the New Zealand version include that it will have signs at each aisle indicating what product categories are located there. Moreover, we will incorporate a function that enables to select fruits and vegetables per gram (instead of per package) and we will enable participants to set their own shopping budget based on their normal expenditures.

After finishing the virtual supermarket software, we will initially test it among the University staff. Based on this internal feedback, we will create an updated version of the software. The next step is to validate the New Zealand virtual supermarket and test it among New Zealand consumers. For this purpose we will conduct a study in which we ask a selection of study participants to conduct a typical shop at the virtual supermarket. After their shop, they will be asked a set of questions about the software, for example, about the product assortment or the easiness of navigation. Besides, we will use insights from previous work on perceptions of virtual environments by measuring level of presence and realism (e.g., the feeling of being there). Also, we will ask participants to collect their grocery receipts from the past week and compare their real groceries with the virtual ones. The software will be updated based on the results of this validation study. We aim to finalize the

New Zealand Virtual Supermarket software by the end of 2012 and we have planned an experiment on the effects of front-of-pack labelling using this new application.

## 7. The virtual supermarket as a serious game

All the above sections describe the use of the Virtual Supermarket as a research instrument, e.g., an innovative way to measure here food choice behaviour in the retail setting. A final very promising aspect of the software that we would like to mention is modifying the application to an intervention tool. Here one could think of the Virtual Supermarket as a serious game or eHealth instrument.

Serious games form a very promising approach in the stimulation of health behaviours [80], especially among children and young adults. Today's children and young adults spend a great deal of their time on video games and video games can attract and maintain attention, which form key components for effective behaviour change [80]. A review on the use of games for health related behaviour change indicated 25 different serious games available in the literature and revealed that these studies mostly showed significant effects on knowledge, attitude, behaviour, and other health-related changes [80]. The review showed that there are two primary methods by which video games can influence behaviour. The first involves the insertion of behaviour-change procedures (e.g., goal setting) into the process of playing the game. The second involves the use of story (narrative series of events) and inserting behaviour-change concepts in the story [80]. A good example of a serious game focused on improving nutrition intakes is *Squire's Quest!* The design of this American game was an interactive multimedia game for elementary school children [81]. This game used the concept of a story line. The story was about a kingdom that was invaded by enemies and who were attempting to destroy the kingdom by destroying the fruit and vegetable crops. The children had to defend the kingdom and defeat the invaders. In order to succeed this, the child had to take on some challenges which involved skills and goals related to eating more fruit, 100% fruit juice, and vegetables [81]. This example shows that it is important to include a game element in the intervention tool in order to make it successful. It would be possible to do something similar with the Virtual Supermarket. Possible ideas include to let people make their own supermarket empire and letting them get higher scores if their product selection is healthy; develop some kind of supermarket shopping race; or letting people try to see through marketing tricks. There lies also potential of distributing the virtual supermarket game through social media such as Facebook. Finally, there lies potential in the use of the Virtual Supermarket by dieticians or other public health workers. There is some good evidence showing that guided tours through the supermarket by a dietician are effective in stimulating healthy food purchases. Within this approach, a dietician accompanies a consumer during grocery shopping and shows him/her how he/she could make healthier food choices. A limitation of this approach is that it is very costly and time consuming and it is not feasible to reach a whole population with this method. It is therefore potentially a good idea to use the virtual supermarket for these type of guided tours. For example, researchers could make a video with a dietician in the virtual supermarket or it would be possible to let people shop and show health messages by the choices they make.

The modification of the Virtual Supermarket into a serious game would require some serious software changes, but it is definitely an idea worth considering. We are happy to engage in this type of research in the future.

## 8. The Virtual Supermarket one step further

Technology is developing rapidly and recently some interesting tools have been introduced in the market which could be linked with the Virtual Supermarket. For example the 'Carl Zeiss Cinemizer OLED' are video glasses which can be placed in front of the eyes. The device contains head tracking and can be used to 'walk' through three-dimensional virtual rooms. The new device shows great potential for the gaming industry, but could also be used for scientific research and could be linked with the virtual supermarket software. Another example of new technology is the use of a virtual supermarket model by the retail industry. For example, Woolworths (Australia) is currently running a trial on its virtual supermarket concept in the Town Hall railway station in central Sydney. They have created a virtual wall of labels representing available groceries online from the company. Shoppers can use the Woolworth's smartphone application to select products from this wall, which will be subsequently ordered online. The wall features 120 product lines from Woolworths' online catalogue. Also, the Korean branch of Tesco has recently installed billboards in train stations around the country which show all the products one would expect to find in its traditional stores. The model is similar to the Australian one and people can purchase the products by scanning them with their smart phone. The order will then be delivered to the consumers' home address. The Korean billboards have been evaluated and concluded that the project is very popular; more than 10,000 customers have used the virtual stores so far, while the online sales of the store have increased by 130 per cent.

A final possibility for the Virtual Supermarket lies in the combination with eye-tracking research. Eye-tracking technology tracks where a person is looking by using either light or dark spot eye trackers. The eye-tracking device works via shining low levels of infrared light on to the participants face to identify the pupil location. Eye-tracking devices can be accurate to 5mm and allow great latitude for movement [82]. The underlying hypothesis in eye-tracking research is that 'we look at what we like', and 'we like what we look at' [82]. So far, most eye-tracking research has focused on showing study participants with some samples of pictures and testing where the participants look at. For example, eye-tracking could be used to examine how much time consumers spend reading the different sections of information on a nutrient information panel (which is normally provided at the back of pack of food products) and also in which order they look at the information. A limitation of current eye-tracking research however is that it is mostly laboratory based and has not been implemented in real life situations such as for example making product selections in the supermarket. An important reason for this is that most devices do not work well outside the laboratory. The Virtual Supermarket shows therefore great potential. It could serve as a balanced mix between using eye-tracking in real life and in a (controlled) laboratory

environment, especially since eye-tracking works better when working with objects on a computer screen as opposed to real objects [82]. Examples of eye-tracking research in combination with the Virtual Supermarket include experiments on the notice of FOP labels, prices, different types of promotions or shelf spacing.

## 9. Conclusion

The Virtual Supermarket is an innovative and unique research tool with great potential in the study of food choice behaviour. This type of research is of significant importance since the prevalence of several non-communicable diseases such as diabetes type 2, obesity and cancer is growing rapidly. Creating healthier population diets could bring a major contribution in the prevention of these chronic diseases. However, food choice behaviour is highly complex and traditional approaches to stimulate healthy eating (such as education) have shown little effectiveness so far. Traditional nutrition education interventions are based on social-cognitive models, which assume that behavior change is a rational process. However, often behavior is unconscious, irrational and driven by other motivators than health such as convenience or habit. Marketing makes use of this knowledge by nudging people towards a product by using default behaviors (i.e. the tendency to choose the middle size or the one which is labeled as 'normal' or 'medium'), building on human preferences (i.e. to make it easy, convenient and requiring low effort) and by using the 'fun factor' and the effects of interventions. Most importantly, the four P's from the marketing mix e.g., price, product, place and promotion show potential to stimulate healthier food behaviour.

One of the best ways to study the effects of interventions on product, price, place or promotion is by the use of randomized controlled trials (RCT's) in retail environments. Supermarkets form the dominant food environment and are the place where people buy most of their food. However, the design and implementation of supermarket intervention studies is complicated. First, such studies require the modification of supermarkets which is costly and complex, second it is hard to find a good control group (people that do not receive the intervention) and third it is hard to extract the intervention effects from other disturbing factors (e.g., if a new product is introduced, this comes with a certain price, promotion and place). Finally, conducting experiments in the food environment often requires corporation with the food industry which could threaten researcher independence and could lead to conflicts of interest. Virtual Reality can bring a great solution to this complexity by designing environments comparable to real life and using these for experimental research. The virtual supermarket is a great example of how virtual reality can be used in food choice research.

The Virtual Supermarket is a three-dimensional software application in the image of a real supermarket. The program contains a front-end which can be seen by study participants and a back-end that enables researchers to easily manipulate research conditions. The front-end was designed in the image of a real supermarket using an Amsterdam branch of the Dutch market leader supermarket as a model. Study participants can do grocery shopping using

this application comparable to real-life grocery shopping. Researchers can use the tool to easily manipulate research conditions, such as changing food prices or shelf placement. Such interventions show great potential to stimulate healthier food choices, but are very difficult to conduct in real life.

Up to date, the virtual supermarket has been successfully used in multiple experiments and has shown to be a valuable research instrument. The Virtual Supermarket is a valuable tool precisely because it offers high levels of controllability, it allows prices to be easily be manipulated, and because a complex implementation in a real-life setting is avoided. Moreover, participant feedback indicated that consumers view the Virtual Supermarket as a reliable research tool and are able envisioning doing their groceries in it comparable to the real-life situation.

Limitations of the Virtual Supermarket include that it has not been validated against real purchases, that the product selection is not based on sales data, that the product selection is relatively small and that the current version is only available in Dutch. We are however working on improving all these aspects. First, we are currently conducting a validating study in the Netherlands among around 100 participants aiming to test the compatibility of the virtual purchases against real purchases. Second, we are working on the development of a New Zealand version of the Virtual Supermarket. This version will include around 1500 products and the product selection will be based on sales data and market shares. This version will also be validated against real purchases and is expected to be launched by the end of 2012.

The Virtual Supermarket is a good-quality research tool and has great potential to become a multifunctional, well-used and valid instrument. There is interest for the software from around the globe (including the United States and Switzerland) and there are a great number of ways in which the software could be used. Examples include studies on the effects of pricing, food labelling, place, location in the supermarket, and even the modification of the program into a serious game. While the current software requires further validation, the possibilities are endless and it is expected that the software can grow into a high-quality research instrument in a close period of time.

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