Examining environmental influences on food choice with fake foods

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EXAMINING ENVIRONMENTAL INFLUENCES ON FOOD CHOICE WITH FAKE FOODS

A dissertation submitted to

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presented by

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Chapter 1

General Introduction
1.1 Introduction

Infectious diseases were the leading causes of death for hundreds of years however; recently they have been outranked by overweight and obesity,\(^1\) which have now become the major threats to public health. To date, more than 1.4 billion adults are overweight; of these, more than 400 million are obese \([63]\). Diet-related diseases are now the major causes of death worldwide \([63]\). In Switzerland, 30 percent of the adult population are overweight and another 9 percent are obese \([16]\).

Obesity causes chronic diseases such as type 2 diabetes, contributes to several types of cancer, coronary heart disease and cerebrovascular diseases, and leads to a reduced quality of life and premature death. Overweight is a heavy financial burden on today’s society. It is estimated that obesity and obesity-related dietary patterns cause costs that are higher than 3.6 percent of the Gross National Product\(^2\) \([36]\).

But even more alarming than the rising overweight and obesity rates in adults is the weight increase in children \([28]\). In Switzerland, 15 percent of the children are overweight and another 5 percent are obese. This means that every fifth child is overweight \([16]\). Childhood overweight is of particular concern, because contrary to common belief, it is not just outgrown. Dietary habits, such as the consumption of fruits and vegetables, tend to track into adulthood \([24, 27, 56]\). Overweight children and adolescents have a very high likelihood of becoming overweight adults and, as a consequence, developing chronic diseases \([35, 51]\). Besides risking adverse immediate and long-term effects on the organ system, children who are obese or overweight are also at risk of developing psychological problems caused

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\(^1\)Overweight is defined as a body mass index (BMI) between 25 and 30. Obesity is defined as a BMI higher than 30. The BMI is calculated by an individual’s body mass divided by the square of the height in meters.

\(^2\)The Gross National Product (GNP) is the market value of all products and services produced in one year by labour and property supplied by the residents of a country.
by teasing, discrimination and victimisation [35].

**Eat less, move more**

The biological reason for weight gain is a positive net energy balance. If more energy is consumed than spent, the excess calories are stored. And, vice versa: to lose weight, the energy output must be higher than the energy input. A negative energy balance could be achieved by eating less and moving more. Although this does seem simple, it is not.

Successful and maintained weight loss is extremely hard to achieve. Across studies, only about 20 percent of overweight individuals successfully lose weight and maintain losses over time [64]. Most of the people who try to lose weight do not succeed or regain their lost weight within a one-year period [54, 23]. Only a few behavioural practices have been found to be associated with both weight loss and weight-loss maintenance. Eating plenty of fruits and vegetables was found to be one of these successful strategies [49].

Losing weight is especially tenuous in childhood. Dieting is not particularly recommended for children, because unlike adults, they need energy for growth and development, in addition to the energy that the body requires for metabolism and physical activity. Children who are on a diet are probably at risk for malnutrition. Therefore, the primary goal for the treatment of overweight in children is weight maintenance during linear growth. Weight loss is only recommended in extreme cases [10, 20].

Because dieting seems so difficult and success rates are so low, public health strategies focus on the prevention of overweight and obesity rather than treatment. For this purpose, most public health campaigns attempt to increase people’s nutrition knowledge and promote better dietary behaviour. Educational interventions, though, have had limited success [7]. Research shows that nutrition information is prevalent and well understood by the
Even though knowledge and information about healthy nutrition are present, obesity rates do not decrease. One possible explanation for this seeming contradiction may be that the prevalent type of nutrition knowledge is not helpful. Factual nutrition knowledge, such as information about ingredients, nutrients or portion weights, might not be of much use to the consumer in establishing a healthy diet in everyday life. More applied nutrition knowledge, such as knowing which of two products is the healthier option, might be more useful to the consumer than being able to read complex nutrition tables. This type of nutritional ‘know-how’ is also called *procedural nutrition knowledge* [1, 32, 65, 11]. Procedural knowledge is thought to be related more closely to actual behaviour than factual nutrition knowledge.

It is possible that current dietary guidelines, which contain a lot of ingredient names and figures, do not help consumers in situations where they have to plan a meal. This thesis addresses the question of whether current dietary guidelines improve the food choices of people who aim to compose a healthy, balanced meal.

### 1.2 The Role of the Environment in the Obesity Epidemic

Although there are certain genetic predispositions that influence the individual’s susceptibility to becoming obese, genetic factors are insufficient to explain the worldwide BMI increase. Obesity has become epidemic fast, while our genes have not substantially changed during the last decades. What has changed is the environment [19].

Our current food and eating environment is characterised by an unlimited, all-abundant supply of convenient, relatively inexpensive, energy-
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dense and highly palatable food. Combined with a sedentary lifestyle, in which only a minimal level of physical activity is necessary for subsistence, this leads to a positive energy balance [18, 15, 19]. Family structures have changed, and eating in fast food restaurants has become popular. As a high proportion of meals are consumed out of the home, the nutritional quality of these meals is of special concern. Data suggests that away-from-home meals are higher in energy than at-home meals [5]. Also, away-from-home meals probably encourage higher energy and fat intake because of larger portion sizes [15]. Further, there has been a drastic increase in exposure to adverts that encourage sales and consumption of food. Television watching is related to choice of foods higher in energy and fat and to lower levels of physical activity [15].

The obesogenic environment is defined as the sum of influences that surroundings, opportunities, or conditions of life have on promoting obesity in populations or individuals [55]. Swinburn et al. described the ANGELO (analysis grid for environments linked to obesity) framework, a conceptual model for understanding the obesogenicity of different environments. The basic framework consists of a two by four grid, which dissects the environment by type (physical, economic, political and sociocultural) and environment scale (micro and macro) [55]. In this thesis, the focus lies on physical micro environments.

The Influence of Environmental Cues on Food Choice

Consumer behaviour is the function of the interaction between the individual and the environment [3].

When we think about factors that could determine what and how much we eat, we first think of taste, hunger and satiety. But food choice is a very complex behaviour, which is influenced by numerous determinants. Research in different areas has shown that many factors, such as biologi-
1.2. THE ROLE OF THE ENVIRONMENT IN OBESITY

cal (hunger, satiety, appetite, taste), economical (cost, income, availability),
social (culture, family, meal patterns) or psychological (mood, stress, attitudes, beliefs) interact and influence food choice [14, 50]. Recently though, science has focused on the environment as a major determinant of what and how much is consumed.

In 1988, Meiselman et al. noted the importance of the environment in understanding acceptance and predicting food consumption. However, only recently has the impact of environmental alterations on amounts consumed become evident and gained public attention [31]. Wansink and colleagues conducted a series of experiments that demonstrated the strong unconscious influences of environmental cues on consumption [59]. In one study they gave people who were about to watch a movie a bucket of either fresh-popped popcorn or a bucket of stale, week-old popcorn. Although people under normal conditions would eat very little of the old popcorn, people in the movie theatre consumed equal amounts of fresh and old popcorn. This experiment illustrates how distractions can lead to unconscious overeating [60].

In 1995, Bell and Meiselman laid down a conceptual framework for factors affecting choice. Within this framework, both the state of the individual and the state of the environment can affect behaviour [4]. To investigate environmental influences, it is important to distinguish between food choice decisions (e.g. what to eat) and consumption volume decisions. Wansink therefore further structured the environment into the eating environment and the food environment [59].

The eating environment refers to ambient factors that are independent of food but associated with eating, such as social interactions, the effort of obtaining the food, eating atmospherics or distractions. The food environment refers to factors such as portion size, salience, or food structure, and variety, which directly relate to the way in which foods are provided or presented [59]. Both the food and the eating environments affect consumed
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amounts. See Figure 1.1.

Figure 1.1: Antecedents and mediators of food consumption volume. [59]

The eating environment. Various experimental studies have shown that contextual factors such as social interactions, meal duration, eating atmospheres or distractions influence food consumption [60, 59]. As an example, studies consistently showed a positive relationship between the duration of a meal and food intake. A pleasant atmosphere, such as nice music or enjoyable company, increases the time spent at the table and consequently the amount consumed [60, 4].

The food environment. Besides ambient influences, cues directly related to food or the way in which it is presented can also unconsciously increase consumption volumes. When people were invited to rate a movie, it was shown that they ate more M&M candies from bigger packages than from smaller ones [60]. Factors like food variety and bigger portion sizes of energy-dense foods are believed to be contributors to the obesity epidemic [15].

Several experimental studies demonstrated how environmental cues can cause overconsumption and poor nutrition [22, 40, 60], but very little research has assessed how this knowledge could be implemented to improve consumers’ food choices [42, 61]. To date, most effort to promote healthy eating has focused on food product attributes (food technology) or educating individual eaters (product or nutrition information). However, environmen-
1.3 Nudging People Toward Better Choices

[...] Given the broad potential application of knowledge about eating environments’ effects, it is surprising that we do not know more about these effects. The area is rich with unexamined possibilities, and by conducting research in both laboratory and real-world eating environments, we will uncover new factors underlying the consumers’ choices of food in eating environments.

[...]


The idea that changes in the environment could be used to encourage consumers to make healthier decisions is not new. However, the concept of choice architecture recently gained public attention when two behavioural economists published their book *Nudge - Improving Decisions About Health, Wealth, and Happiness*, in which they make suggestions on how public well-being could be improved by restructuring the environment to make the healthier choices the easier ones.

They define nudging as an environmental change that alters people’s behaviour in a predictable way, without proscribing any options or directly changing economic incentives [57]. The prime example was a simple intervention that improved people’s retirement saving behaviour by changing the default of the saving system. By replacing the opt-in system, in which people save money voluntarily, with an opt-out system, in which savings were made by default, savings were dramatically increased [57].

The same principle can be applied to encourage more healthful food choices and to discourage people from indulging.

The mechanism of how nudging is thought to operate can be explained
by the dual-process model in which human behaviour is shaped by two systems [53]. Behaviour is thought to result as a function of two interacting systems: the reflective system, which generates behavioural decisions based on knowledge about facts and values; and the impulsive system, which elicits behaviour through affective responses. The first system requires cognitive capacity, which is limited. Public health interventions have had little success when attempting behavioural change, which targets this system by providing information to alter motivation, beliefs or attitudes or to help develop self-regulatory skills. The second system requires no cognitive effort and is driven by feelings and immediate response to the environment. The failure to comply with a diet can therefore be explained by a conflict between these two systems. Therefore, although a person might want to lose weight, his or her long-term goal might be overruled by an affective response to hedonic food cues in her environment [29].

Nudging operates through the second, automatic, system and attempts behavioural change by changing environmental stimuli. The approach of guiding decisions by restructuring the environment has recently been recognised as a very powerful tool [58].

In 1971, Schachter predicted in his 'Theory of Obesity’ that obese individuals would reduce energy intake more than normal-weight individuals as effort to obtain food increases [47]. They showed that obese individuals consumed fewer almonds if they were not shelled compared to when they were shelled [48]. Similar studies with water [13], potato chips [4] or chocolate [8] also reported decreased consumption as effort increased. Rozin et al. suggested that minor alterations in a buffet setting may nudge consumers to select foods with a lower energy density and thereby reduce their energy intake [46]. Also, point-of-purchase labelling and increased salience of healthy foods were demonstrated to promote healthy food choices [9, 12, 26]. A study of schoolchildren found that fruit sales at lunchtime were increased
by 70 percent if the fruits were placed directly by the cash register [21]. Manipulations of plate and cutlery size had ambiguous effects [62, 41, 33].

To date, the evidence on how choice architecture can be implemented to change food consumption is weak [52]. Notably, most studies conducted in this research area focus on single food products rather than meal composition. One reason for the lack of research investigating nudging effects on more complex food choices is that experiments with food in real-life settings take great effort and are almost impossible to control. In order to investigate the effect of a single environmental cue, the environment needs to be well controlled. Experiments must be conducted under conditions that are constant for each individual study subject to avoid unwanted environmental fluctuations and group testing effects. This thesis presents an experimental method that allows the study of environmental influences on food choice and meal composition.

1.4 Food Variety

Food variety is one factor that affects consumers’ food choice in an unconscious way. Perceived variety correlates highly with satisfaction [4] and consumers seek variety in their choice of food [45]. Unfortunately though, food variety also increases consumption. Studies in animals and humans consistently show that a varied diet or variety within a meal is associated with a higher energy intake, increased body weight and body fat [37]. For example, it has been shown that people who were offered an assortment of yoghurt in different flavours, textures and colours consumed more than when they were offered only one type [44].

The finding that variety increases consumption is referred to as the variety effect. Based on evolution, the effect may have had an advantage, as a varied diet is more likely to cover nutrient needs. In today’s affluent society, where a large variety of food is abundant, the variety effect has instead
become a severe health threat.

The variety effect is very stable, and in general, internal moderators such as gender, weight and dietary restraint [17] do not influence it [39]. However, there is some indication that restrained individuals, who constrain their food intake in order to avoid weight gain, are more prone to the variety effect compared to unrestrained individuals, who worry less about weight and food intake [44]. But another study that assessed the effect of restrained eating and variety did not find different intakes in restrained and non-restrained eaters [34]. In the experiment of Mok et al. restrained eaters did not consume more than unrestrained individuals when they were offered a variety of chocolate; however, they consumed more of their favourite type of chocolate [34].

Age seems to be the only internal moderator of the variety effect, in that the effect is less pronounced in old age [39]. On the other hand, external factors, such as how the consumer perceives the variety, seem to moderate the effect to some extent [22].

The effect of variety on food consumption is commonly explained by a reduction of sensory-specific satiety. Sensory-specific satiety is the state in which the palatability of a food gradually declines as it is eaten. Variety is assumed to overcome sensory-specific satiety and therefore lead to hypephagia [43].

The paradigm of sensory-specific satiety implies that foods are consumed to satiation and that there is a taste experience. However, Kahn and Wansink, showed that even the mere perception of variety increases consumption [22]. In a series of experiments, they demonstrated that perceived variety is influenced by the actual variety (e.g. the number of different options) and by the organisation of the assortment. When jelly beans in 24 different flavours were offered to children, they took more jelly beans if the beans were organised according to colours than when they were scrambled.
1.4. FOOD VARIETY

In their framework, the authors suggested that actual variety together with how the assortment is structured could serve as a consumption rule that suggests a quantity that it is acceptable to consume. For organised assortments, the number of distinct categories might serve as a benchmark of how much should be consumed. As an example, if candies are organised into different colours, participants may assume that it is appropriate to take one piece of each colour.

Using the Variety Effect to Nudge Consumers

As variety is an environmental factor which consistently increases intake, the effect could be used to increase intake of healthy foods, such as fruits and vegetables. To date, few studies have systematically investigated whether it is possible to nudge consumers to choose healthier foods using the variety effect [30, 38]. Also, it is not clear how variety affects the composition of a meal and whether variety within healthy options nudges consumers to select more balanced meals. This thesis addressed these questions.

Fruit and vegetable variety have been suggested as a determinant of healthy eating in children [25] and there is some evidence from an observational study that the percentage of children who ate at least one serving of fruits and vegetables during lunch was higher in schools that offered more fruits and vegetables [21]. However, there is also evidence that younger children are less responsive to food-related environmental cues than adults. Data indicate that young children take internal signals such as hunger and satiety as references for how much they consume [2]. This would suggest that nudging strategies aiming to promote better choices in children would be less effective. This thesis investigates whether food variety is effective to promote healthier choices in children.
1.5 Research Questions and Chapter Overview

The aim of this research was to investigate how the food environment influences consumers’ food choices and how environmental cues can be used to help people compose better meals.

Meiselman stated that “Considering how fundamental and important meals are to eating, research in meal context has not been widely reported…” [50].

Investigating environmental influences on food choice is challenging for two reasons. First, to accurately determine the effect of an environmental factor on choice, all other factors need to be controlled for and kept constant. Most food environments are highly dynamic and complex systems. In a school cafeteria, for example, children eat food from buffets that change not only daily, but also during lunchtime. A bowl of fruit salad might look appealing to the first person who is served from it, but after all the strawberries have been picked out, the following person may decide to have a muffin instead.

Secondly, within cafeteria settings, people choose and eat foods in social contexts. Depending on who the company is, one might decide to go for healthy food or indulge in energy-dense food.

To investigate the specific effects of single factors on choice, the food and eating environments need to be controlled. A buffet in which positional effects on choices are to be examined should appear similarly appealing to the first and last consumer. This presents a problem due to the effort involved. It simply is not possible to offer a perfectly identical choice to many people if real foods are used.

As a result of these constraints, most of the research done in this field so far has been conducted with only single food items (such as candies or milk shakes) or in cafeteria settings where people were tested in groups within a variable environment.
The first study of this thesis presents a new method, using replica foods to overcome these limitations and allow examination of environmental influences under controlled laboratory conditions. Then, this method is used to assess how current nutrition information affects consumers’ choices and whether the information is sufficient to help people compose healthier meals. Further, the fake food buffet (FFB) is used to examine whether vegetable variety can improve the meal composition of adults and children.
Chapter II: The Fake Food Buffet - A New Method in Nutrition Behaviour Research

The first study presents the fake food buffet, a method developed to investigate environmental influences on food choices. This method’s reliability and validity are assessed and results and implications for the research field are discussed.

Chapter III: Fruit for Dessert - How People Compose Healthier Meals

In the second experiment, the fake food buffet was used to investigate whether nutritional knowledge can help consumers compose better meals and also how people change their selections if they aim to choose a healthy, balanced meal.

Chapter IV: Improvement of Meal Composition by Vegetable Variety

The third study assessed whether variety of healthy products is effective to nudge consumers to select healthier meals. A fake food buffet was used in an experimental setting to examine how vegetable variety affects adults’ meal composition.

Chapter V: Vegetable Variety: An Effective Strategy to Increase Vegetable Choice in Children

For preventive reasons, it is of major interest to increase vegetable intake in children. The fourth study investigated whether school-aged children are responsive to food-related environmental cues. Therefore, a fake food buffet was used to assess whether vegetable variety has the potential to improve the food choices of 7–10-year-olds.
Chapter VI: General Discussion

In the last chapter, the main findings of the four studies are summarised and integrated. Methodological limitations are discussed and practical implications derived.
CHAPTER 1. GENERAL INTRODUCTION

Bibliography


Chapter 2

The Fake Food Buffet – A New Method in Nutrition Behaviour Research

Abstract

Experimental research in behavioural nutrition is often limited by practical applicability. In the present study, we assess the reproducibility and validity of a new experimental method using food replicas. A total of fifty-seven people were invited on two separate occasions with an interval of 2 weeks to serve themselves a meal from a fake food buffet (FFB) containing replica carrots, beans, pasta and chicken. The external validity of the FFB was assessed in a second study by comparing meals served from replica foods (beans, pasta, chicken) with meals served from a corresponding real food buffet (RFB). For the second study, forty-eight participants were invited on two separate occasions; first to serve themselves a meal from the FFB or an RFB and 2 weeks later from the other buffet. The amounts of food items served and (theoretical) energy content were compared. Correlation coefficients between the amounts of fake foods served were 0.77 (95 % CI 0.68, 0.86) for chicken, 0.79 (95 % CI 0.68, 0.87) for carrots, 0.81 (95 % CI 0.69, 0.89) for beans and 0.89 (95 % CI 0.82, 0.93) for pasta. For the FFB meal and the RFB meal, the correlations ranged between 0.76 (95 % CI 0.73, 0.91) for chicken and 0.87 (95 % CI 0.77, 0.92) for beans. The theoretical energy of the fake meal was 132 kJ (32 kcal) lower compared to the energy of the real meal. Results suggest that the FFB can be a valuable tool for the experimental assessment of relative effects of environmental influences on portion sizes and food choice under well-controlled conditions.
2.1 Introduction

A balanced diet is essential to maintain good health and involves eating a variety of foods in healthy proportions [16, 8, 24]. A diet rich in fruit and vegetables has been shown to reduce the risk of cancer [13] and cardiovascular disease [3], improve bone health [28, 33] and reduce age-related cognitive decline [23], while eating an unbalanced diet can cause weight gain and poor health [19]. To improve general nutrition, it is important to understand how people compose meals and whether they are able to practically implement current dietary recommendations such as the food pyramid [15].

Most people seem to be aware that a healthy diet requires more than consuming vitamins and minerals [9]. People are able to estimate the number of calories in a meal to a certain extent, but they tend to underestimate the energy content as the meal size increases [38]. Having this knowledge, however, does not suggest that it helps people to make healthy diet choices or that people are able to use this knowledge when composing meals. To make healthy food choices, people should be able to create a balanced meal that consists of enough vegetables, starchy foods and reasonable amounts of meat.

Food choice is influenced not only by explicit decisions. Research has shown that environmental factors play a major role when choosing food. It has been shown that the variety of food presented [29], portion sizes [30], the plate size or even the number of peers at the table can influence consumption [35]. Changes in the food environment, such as increasing the availability of healthy foods, are therefore potential measures for influencing consumers’ food selection towards better nutrition, without affecting the consumers’ freedom of choice.

Investigation of consumers’ abilities to compose balanced meals and investigating environmental influences on food choice are methodological challenges. Methods currently applied in the field of nutrition research range
from detailed individual weight records over several days to FFQ, household survey methods and simple food lists [32, 40]. The appropriateness of a tool depends on the purpose for which the tool is intended. Each method has its merits, associated errors and practical difficulties. Very few methods enable the investigation of procedural nutritional knowledge, which is defined as knowledge of the way in which actions are performed [2, 9].

Experimental methods assessing consumers’ nutritional abilities and influences on food choice are often limited by very practical issues such as high costs, limited availability of suitable infrastructure, the effort of preparing food and its subsequent waste and spoilage. Elaborate experiments investigating food choice were sometimes conducted in cafeteria-like settings [5, 12] or even in specialised infrastructures such as artificial kitchens or restaurants [36]. In those settings, however, participants have usually been tested in big groups [5, 39]. Group testing has the disadvantage that participants may influence each other during experiments. It is for example known that more food is consumed when more people sit at a table [7, 21] or when people are more distracted [35]. Individual testing of participants and standardisation of the environmental influences are desirable, when studying people’s ability to compose healthy meals. Each participant should find the same selection of food, which should look similarly appealing at all times. However, individual testing and keeping the environment constant are two requirements related to high methodological effort with respect to food preparation and cost.

In this study, we present the Fake Food Buffet (FFB) as a new method for experimental nutrition research. Among various other applications, the FFB allows for assessing influences on food choice and consumers’ practical nutritional knowledge under well-controlled conditions. The FFB is a buffet of replica food items, from which consumers are invited to choose. Food replicas, such as the Nasco food models (Nasco International Inc.,
Fort Atkinson, Wisconsin USA), have been used in nutrition research as measurement aids for portion size [25, 10, 26, 34]. Canada was one of the first countries to use a collection of three-dimensional food models in the National Nutrition Survey [20]. The validity of these food models, however, remains questionable [6, 11, 22, 31], and more research assessing the accuracy of portion size measurement aids in controlled testing environments is required [18]. To the best of our knowledge, replica foods have not yet been validated for experimental nutrition research. This is the first study to assess the validity and reproducibility of food replicas in a buffet setting, where consumers compose a meal from replica food items. The reproducibility of the FFB method was assessed in a test-retest reliability study (Study 1), where participants served themselves two meals from the FFB within a 2-week period. The validity was assessed in a second study (Study 2) by comparing meals served from an FFB with meals served from a corresponding real food buffet (RFB).

### 2.2 Experimental Methods

The supplementary material for this article is found on: http://www.journals.cambridge.org/bjn

#### Subjects

Subjects were recruited via the subject pool of the University of Zurich (mainly students and staff). Persons following a medically prescribed diet, vegetarians and people who had previously participated in food studies were excluded from the present study.

A total of fifty-nine persons were recruited for the reproducibility study (Study 1). Data from fifty-seven participants (twenty-nine males and twenty-eight females) were analysed. Two persons were excluded, as they failed to
participate in the retest. A total of fifty-one participants were recruited for the validity study (Study 2). Data from forty-eight subjects (twenty males and twenty-eight females) were analysed. Three people were excluded: two for non-participation and one for not completing the questionnaire.

Both studies were conducted according to the guidelines laid down in the Declaration of Helsinki. Written informed consent was obtained from all subjects. Participants received monetary compensation for participation. All participants were informed about the study’s aim subsequent to study completion.

Reproducibility study protocol (Study 1)

Participants were invited twice, with a 2-week interval between occasions, to serve lunch from the FFB, containing the following replica food items: cooked carrots, cooked green garden beans, pasta and fried chicken breast pieces (see Fig. S1 in the supplementary material for this article for illustration of the FFB used in the reproducibility study). Each person was tested individually. Upon entering the experimental room, the participant was provided with a standard serving plate (27 cm diameter) and instructed to serve himself/herself a meal, such as he/she would normally eat for lunch, from the presented selection. After serving himself/herself, the participant filled out a questionnaire assessing hunger and recent food intake. Meanwhile, the investigator quantified each food component of the meal by weighing it (Shimadzu UW6200H, Swiss Waagen DC GmbH Uster, Switzerland). Two weeks later at the same time of day (±1 h), the participant was again invited to select a meal, as he/she would normally eat for lunch, from the same FFB selection. After serving himself/herself, the participant filled out a questionnaire assessing hunger, recent food intake and anthropometric data. Participants were also asked to rate the authenticity of the replica foods.
2.2. EXPERIMENTAL METHODS

Validity study protocol (Study 2)

Students were invited to participate in a food study twice, with a 2-week interval between sessions. All subjects were tested individually. During the first session, the participant was presented with either an FFB or an RFB (random assignment) containing replica beans, pasta and chicken or the respective real food items (see Fig. S2 in the supplementary material, for an illustrative comparison of replica and real foods). The participant was instructed to serve himself/herself a meal, such as he or she would normally serve for lunch, from the presented buffet (randomly assigned FFB or RFB). Fourteen days later, at the same time of day, the participant was instructed to serve himself/herself a meal from the other buffet; so participants who served themselves first from the FFB would serve themselves from the RFB in the second session and vice versa. Each food component of the replica and the real meal was quantified by weighing it.

**Calculation of energy contents**

The values that were used for the energy (kJ) calculations are summarised in the supplementary material (Table S1). All energy estimates are based on the values for the corresponding raw food items found in the Swissfir database [41]).

**Cooked real food items**

To estimate the energy content of the cooked foods, the beans, pasta and chicken were weighed before and after cooking. The energy content of the cooked food was calculated from the value for the raw product by correcting for the mass change due to processing (cooking/frying).

*Beans.* Approximately 100 g of green garden beans were chopped into pieces comparable to the replica beans and cooked for 20 min. The exact weight of the beans was measured before and after cooking and chilling. One
hundred grams of cooked beans are estimated to correspond to 103 kJ (raw beans (100 g) = 103 kJ [41]).

*Pasta.* A type of pasta was selected that looked similar to the replica pasta in size and shape after cooking. Ninety grams of pasta were cooked for approximately 10–12 min, and the weight was measured before and after cooking and chilling. One hundred grams of cooked pasta are estimated to contain 668 kJ (uncooked egg pasta (100 g) = 1498 kJ [41]).

*Chicken.* Chicken breast was flavoured and subsequently fried in a pan. The weight of the raw and fried meat was measured as well as the frying oil remaining on the chicken. The frying oil was taken into account to calculate the energy content of the fried chicken breast. One hundred grams of fried chicken are estimated to contain 648 kJ (raw chicken breast (100 g) = 456 kJ [41]).

**Fake food items**

To estimate the theoretical energy content of the replica foods, corresponding real foods were prepared, and the weights were measured. This procedure was repeated three times for each food item to calculate an average conversion factor.

*Replica carrots.* Raw carrots were chopped into pieces comparable to the replica carrots. Fifty pieces of replica carrots and 50 pieces of real carrots were selected randomly. The weight of the real and replica carrots was measured. One hundred grams fake carrots were estimated to correspond to a theoretical energy value of 149 kJ (raw carrots (100 g) = 135 kJ [41]).

*Replica beans.* Green garden beans were chopped into pieces comparable to the replica beans. Forty replica beans and 40 real beans were selected randomly. The weight of the real and replica beans was measured. One hundred grams of replica beans have a theoretical energy content of 75 kJ.

*Replica pasta.* A type of pasta was selected that looked similar in size
2.2. EXPERIMENTAL METHODS

and shape after cooking to the replica pasta. Forty pieces of real pasta and
40 pieces of replica pasta were selected randomly. The weight of the real and
replica pasta was measured. One hundred grams of replica pasta correspond
to 455 kJ.

Replica chicken. Chicken breast was flavoured and subsequently fried in a pan. The weight of the raw and fried chicken was measured as well as the frying oil remaining on the chicken. The chicken breasts were then chopped into pieces similar to the replica food. Six similarly shaped pieces of real and replica chicken were selected and measured. The procedure was repeated three times. One hundred grams of replica chicken correspond to 636 kJ. Note that for chicken, the oil remaining on the meat after frying was taken into account, while for all other food items, no addition of fat was assumed.

Measures

The outcome variable, energy fake meal, was established by weighing all served replica food items, multiplying the weight of the individual food items by the corresponding factor and calculating the total energy in kJ. Similarly, the outcome variable energy real meal was determined by weighing all real food items and calculating the total energy content of the meal. The mean energy of the fake meal is the mean energy of the fake meals served in the test and retest study. Participants provided self-reported height, weight and age measurements. These measurements were used to calculate the body mass index (BMI) (weight in kilograms divided by height in metres squared) and the individual’s personal energy need per day (weight multiplied by a calories per kilogram bodyweight factor, which depends on age and gender [14]). The students completed questions about their levels of hunger, recentness of food intake and the authenticity of the replica foods. Hunger was assessed with the question, How hungry are you right now? on a 6-point scale (1 = not
hungry at all; 6 = very hungry). The authenticity of the replica foods was measured with the question, ‘How realistic were the following replica foods?’ on another 6-point scale (1 = not realistic at all; 6 = very realistic). The recentness of the food intake was assessed by asking for the time of the last food intake (any caloric item) as well as the time of the last meal intake.

Statistical analysis

Statistical analysis was performed using Predictive Analytics SoftWare Statistics, version 18.0 (SPSS, Inc., Chicago, IL, USA).

For normal data, mean differences were assessed with the paired sample t-test, and Pearson correlation coefficients were reported. For non-normal data, mean differences were assessed with the Wilcoxon signed-rank test, and Spearman’s correlation coefficients were reported. All tests are based on a 0.05 significance level. For the t-tests, the test values $t$ and Cohen’s $d$ are reported. The EXAMINE SPSS procedure was used to detect outliers or extreme values (values more than 1.5 or 3 interquartile ranges, respectively). Analysis with and without outliers provided virtually identical results. Therefore, only results of the complete sample are reported.

2.3 Results

Reproducibility of the FFB (Study 1)

To measure the reproducibility of the FFB method, 2-week test–retest reliability data of fifty-seven students (twenty-nine males and twenty-eight females) were analysed. Descriptive characteristics of the study population can be found in Table 2.1. The mean amounts (kJ) of individual replica foods served in the test and retest study did not differ significantly (see Table 2.2). The correlation coefficients ranged from .77 for replica chicken to .89 for the amount of replica pasta. Furthermore, the theoretical energy of
the fake meal served in the test and retest study was highly correlated, indicating the good overall reproducibility of the method ($r = .80, P < .001$). A bivariate plot of the total energy (kJ) of the fake meal measured in test and retest is shown in Figure 2.1. Bivariate plots of the energy (kJ) of individual replica food items measured in the test and retest may be found in Fig. S3 of the supplementary material for this article.

Figure 2.1: Reproducibility of the FFB: Bivariate plot of energy served from the fake food buffet (FFB) in test (T1) and retest study (T2). "—": Linear regression $R^2 = 0.63$. "– – –": Ideal line: energy T1 = energy T2.

High overall ratings for the authenticity of the replica food items give an indication of the usefulness of replica foods (Carrots: $M = 4.79, SD = 1.15$; Beans: $M = 4.84, SD = 1.05$; Pasta: $M = 4.86, SD = 1.04$; Chicken: $M = 3.61, SD = 1.42$; All foods in general: $M = 4.81, SD = 0.83$).

Men ($M_{male} = 1574, SD = 325$) served themselves significantly more energy (mean energy test and retest) compared to women ($M_{female} = 1143$, $M_{male} - M_{female} = 431$).
Table 2.1: Descriptive characteristics of reproducibility study subjects (Mean values and standard deviations, \( n = 57 \))

<table>
<thead>
<tr>
<th></th>
<th>Men (( n = 29 ))</th>
<th>Women (( n = 28 ))</th>
<th>Total (( n = 57 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>25.2</td>
<td>24.4</td>
<td>24.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76.2</td>
<td>58.4</td>
<td>67.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180.8</td>
<td>166.8</td>
<td>173.9</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>23.4</td>
<td>20.9</td>
<td>22.2</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>4.1</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>12.3</td>
<td>8.5</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>6.0</td>
<td>5.7</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>2.1</td>
<td>3.6</td>
</tr>
</tbody>
</table>

\( SD = 237 \), \( t(55) = 5.33, P < .001 \). The personal energy need of the study subjects was significantly related to the mean energy of the fake meal served in test and retest \( (r = .53, P < .001, N = 57) \), indicating a natural behaviour. Note that height and weight are self-reported, and therefore, the calculated personal energy needs might be lower than the actual energy needs [27]. Hunger was not related to the amount of energy served in either the test \( (r = .22, P = .106, N = 57) \) or retest \( (r = .18, P = .188, N = 57) \). In addition, the amount of time since the last food intake was not significantly related to the amount of energy served (test: \( r = .23, P = .083 \), retest \( r = .12, P = .376 \)).
Table 2.2: Reproducibility of the FFB. Mean energy fake food served in 14-d test-retest study (Test = T1, retest = T2).
Mean energy and standard deviations, \( n = 57 \) (twenty-nine male/twenty-eight female) subjects.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>d</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrots</td>
<td>71</td>
<td>34</td>
<td>68</td>
<td>36</td>
<td>1.14(^{NS})</td>
<td>0.10</td>
<td>0.79(^{*})</td>
</tr>
<tr>
<td>Beans</td>
<td>48</td>
<td>26</td>
<td>50</td>
<td>32</td>
<td>-0.92(^{NS})</td>
<td>-0.08</td>
<td>0.81(^{*})</td>
</tr>
<tr>
<td>Pasta</td>
<td>644</td>
<td>256</td>
<td>611</td>
<td>280</td>
<td>1.95(^{NS})</td>
<td>0.12</td>
<td>0.89(^{*})</td>
</tr>
<tr>
<td>Chicken(^{†})</td>
<td>596</td>
<td>239</td>
<td>610</td>
<td>273</td>
<td>-0.60(^{NS})(^{‡})</td>
<td>-0.05</td>
<td>0.77(^{*})(^{‡})</td>
</tr>
<tr>
<td>Total energy fake meal</td>
<td>1359</td>
<td>446</td>
<td>1338</td>
<td>389</td>
<td>0.67(^{NS})</td>
<td>0.06</td>
<td>0.80(^{*})</td>
</tr>
</tbody>
</table>

\(^{*}\)P < 0.001.

\(^{†}\)Mean energy fake food served in 14-d T1–T2 study.

\(^{‡}\)Data are non-normal. Therefore, z value of Wilcoxon signed-rank test and Spearman's correlation coefficient are reported.
Validity of the FFB (Study 2)

For the validity study, forty-eight persons (twenty males and twenty-eight females) were recruited over a 2-week period. Descriptive characteristics of the study population can be found in Table 2.3. Participants were instructed to first serve a meal from the FFB or RFB and 2 weeks later from the other buffet. The meals served from the FFB were compared to meals served from the RFB (within-subject comparison). The results are summarised in Table 2.4. Correlations between served amounts of fake and real foods were high and ranged from $r_s=.76$ (chicken) to $r = .87$ (beans). The correlation of the total energy served from the RFB and the FFB is high ($r = .76$).

The theoretical energy of the fake meal was 132 kJ lower compared to the energy of the real meal. For the individual food items, we found a significant difference between the energy from the fake and real beans ($t = 4.44, P < 0.01, d = 0.51$) as well as the fake and real pasta ($t = 5.79, P < 0.01, d = 0.61$). The energy from the chicken did not differ between the real and fake food ($t = 0.13, P = .90, d = 0.20$). Overall, participants served themselves slightly more energy (Mean difference =132 kJ) from the RFB than from the FFB.

We found that if pasta is cooked for 12 instead of 8 min, the weight of the pasta increased by 20 %, which in turn led to an energy reduction of 15 % /100 g. When the foods cool down, they again lose humidity and decrease in volume.

A bivariate plot of the total energy of the fake meal and energy of the real meal is shown in Figure 2.2a. Bivariate plots of the amounts of individual fake and real food items may be found in Fig. S4 of the supplementary material for this article (http : //www.journals.cambridge.org/bjn). The agreement of the FFB and the RFB was assessed with the Bland-Altman method [1]. The percentage energy differences between the meals served from the FFB and the RFB were plotted against the mean energy of those two meals.
2.3. RESULTS

Figure 2.2: Agreement of energy served from replica foods and real foods between the Fake Food Buffet (FFB) and a corresponding real food buffet [1].

a) Bivariate plot of energy served from FFB (kJ) and RFB (kJ). "—": Linear regression $R^2=0.74$. "- - -": Ideal line: energy FFB = energy RFB.

b). Bland-Altman plot of percentage energy difference of the meals served from RFB and FFB against mean energy served from both FFB and RFB. The dotted lines indicate the mean relative difference and the 95 % boundaries of true significance (Mean ± 1.96 $SD$).
Table 2.3: Descriptive characteristics of validity study subjects.

(Mean values and standard deviations, $n = 48$)

<table>
<thead>
<tr>
<th></th>
<th>Men ($n = 20$)</th>
<th>Women ($n = 28$)</th>
<th>Total ($n = 48$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.3</td>
<td>22.7</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76.2</td>
<td>58.5</td>
<td>65.9</td>
</tr>
<tr>
<td></td>
<td>8.5</td>
<td>6.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>179.8</td>
<td>168.0</td>
<td>172.9</td>
</tr>
<tr>
<td></td>
<td>5.6</td>
<td>6.3</td>
<td>8.4</td>
</tr>
<tr>
<td>BMI ($\text{kg/m}^2$)</td>
<td>23.6</td>
<td>20.7</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>1.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The Bland-Altman plot shows that there was no systematic variation between the amounts of food served from an FFB or an RFB (Fig. 2.2B). There is, however, a slight bias to serve more energy from the RFB compared to the FFB. Bland–Altman plots of individual food items (Fig. S5, supplementary material for this article, http://www.journals.cambridge.org/bjn) as well as a sample picture of a plate served by participant number 33 (Fig. S6) may be found in the supplementary material.

2.4 Conclusion

Environmental influences on food choice are an important area of investigation, as changes in the food environment are potential measures to subconsciously influence consumers into selecting more nutritious foods [37]. To examine the influence on food behaviour and consumers’ practical skills, experimental studies are needed. Controlling environmental influences is essential in such experiments. However, current methods to study food choice and meal composition are limited by practical problems, such as the effort of food handling and individual testing under a constant or experimentally manipulated environment. In this study, we present the FFB, an innovative method in nutrition research. The results in this study show that the
2.4. CONCLUSION

Table 2.4: Validity of the fake food buffet (FFB) method.

(Mean values and standard deviations served from fake food buffet and real food buffet, n = 48 (twenty male/twenty-eight female))

<table>
<thead>
<tr>
<th></th>
<th>Replica food served(kJ)</th>
<th>Real food served(kJ)</th>
<th>Correlation food served from FFB and RFB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, SD</td>
<td>Mean, SD</td>
<td>r</td>
</tr>
<tr>
<td>Beans</td>
<td>78, 35</td>
<td>92, 43</td>
<td>0.87*</td>
</tr>
<tr>
<td>Pasta</td>
<td>660, 223</td>
<td>781, 252</td>
<td>0.82*</td>
</tr>
<tr>
<td>Chicken†</td>
<td>587, 250</td>
<td>584, 224</td>
<td>0.76*†</td>
</tr>
<tr>
<td>Total energy meal</td>
<td>1325, 369</td>
<td>1457, 373</td>
<td>0.86*</td>
</tr>
</tbody>
</table>

RFB, real food buffet.

*P < 0.001.

†Data are non-normal. Therefore, the Spearman’s correlation coefficient is reported.

The FFB method is reproducible, as high correlations were found for test-retest reliability. Further, we found that women serve less energy from fake foods compared to men. The energy served correlates with the actual personal energy requirement. Furthermore, students rated the appearance of the replica food items as very realistic. Altogether, these findings indicate that participants behaved naturally when serving the replica food (face validity). The participants chose a meal related to their energy need rather than momentary feelings of hunger or recentness of food intake. This indicates that participants indeed followed the instruction to serve a meal similar to one they would normally eat for lunch, rather than just serving a meal they would have chosen at that moment.

The amounts of food served from the FFB were highly correlated to the amounts of food served from a corresponding real food buffet. Absolute amounts of energy are somewhat lower for fake beans and pasta, compared to real beans and pasta. The theoretical energy of the fake meal was 132
kJ (32 kcal) lower compared to the energy of the real meal. This difference is significant, but rather small when compared to the potential changes in the energy content of the real food due to processing (cooking). When fake foods are used in experimental designs, the small underestimation of energy served from fake foods will be present in all experimental groups, and is therefore not very likely to affect the results. Real foods are susceptible to compositional changes such as water and energy content and to changes in pleasantness to the consumer. Fake foods on the other hand are stable over time, enabling food experiments without the variability due to processing foods.

Limitations

Although of outstanding quality, the replica foods were fake. An important limitation of using replica foods is that served theoretical energy may not be identical to consumed energy. Even though it is known from previous research that people tend to empty their plates [35] and take single portions as units for consumption, rather than compensating by eating more portions [17], parts of meals might be left over or a second serving eaten. Also, fake foods have certain limitations when it comes to liquids such as sauces or dressings. A Fake Food Buffet will never represent a complete choice but will always be a selection. An important limitation of the FFB was found in the validity study (study 2), as there exists a tendency of people to serve themselves slightly more energy from fake foods compared to real foods. The method is therefore only suitable to assess relative differences in serving sizes but not absolute differences. The comparability in terms of energy depends on the similarity of the individual food replicas to the corresponding real food, as well as the accuracy of theoretical energy estimated for replica food items. Other limitations are that the study was conducted with only a small range of food items, and the participants of this study were mainly students.
2.4. CONCLUSION

Practical implications

Food replicas have numerous advantages over real food in experimental nutrition research. Fake foods do not spoil and do not require preparation. For FFB experiments, there is no need for specialised infrastructure, such as a kitchen. FFB experiments can be conducted in a normal experimental room, where temperature, light, noise level or other factors might be kept constant or varied systematically. The fake foods can be used repeatedly, which makes the method inexpensive and avoids food waste. The FFB method allows for the study of practical nutritional knowledge and environmental influences on food choice under well-controlled laboratory conditions. Experiments to investigate the comprehensibility of dietary guidelines such as the food pyramid require minimal effort. Furthermore, interesting FFB studies could be carried out to assess the dietary behaviour and nutritional knowledge of children. In young children, issues such as literacy, writing skills or limited food recognition skills from pictures might be overcome by using fake foods. The FFB also facilitates studying environmental influences such as ambiance, plate size or the serving order on consumers’ meal composition.

In a recent study, we used fake foods to investigate the effect of vegetable variety on meal composition [4]. To our knowledge, this is the only study that has used fake foods for experimental nutrition research. We found that consumers chose a higher percentage of energy from vegetables if they are offered two instead of only one vegetable in a buffet setting. The overall energy of the served meal, however, did not increase, indicating that participants chose a more balanced meal when offered a higher variety of vegetables. The reliability and validity studies together with the above-mentioned study on variety show that the fake food buffet is a practical and appropriate method for investigating environmental influences. We suggest application of the FFB for experimental assessment of relative effects on portion sizes and
food choice, but not for quantification of absolute amounts of energy.

Acknowledgments

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Bibliography


Chapter 3

Fruit for Dessert: How People Compose Healthier Meals

Bucher, T., van der Horst, K. and Siegrist, M. In: Appetite, 60(1), 74-80.
Abstract

The present study assessed whether factual nutritional information on portion sizes helps consumers to select healthier meals. 124 people were invited to serve themselves lunch from a ‘fake food buffet’ containing 55 replica food items. Participants in the control group were instructed to serve themselves a meal, as they would normally eat from the given selections (control). Participants in the second condition were asked to select a healthy, balanced meal (instruction). People in the third group were also instructed to select a healthy meal, but in addition, they received nutrition information (instruction + information). The results suggest that participants in the instruction and instruction + information condition chose fewer sweets and desserts ($F_{(2,121)} = 6.91, P<.05$) but more fruits ($F_{(2,121)} = 5.16, P<.05$). This led to overall healthier meals than in the control group. All other food categories, including vegetables, were not altered. No difference was found between the two experimental groups. The results indicate that factual nutrition information does not help consumers compose healthier meals.
3.1 Introduction

To obtain healthy eating patterns, people should choose a diet that consists of a variety of foods in balanced proportions [9, 18]. Environmental opportunity, motivation and ability have been suggested as the three main determinants of healthy or unhealthy eating [4]. Environmental opportunity refers to the fact that the present-day food environment is characterised by abundant availability and accessibility of energy-rich foods that strongly appeal to our instinctive preferences for sweet, salty and fatty foods. This influence of food with high energy density is thought to promote overeating and consequent weight gain [4].

Food choices have long-term effects, for instance, on bodyweight, but also short-term effects, such as satiety. The most important motivational drivers for food choices are short-term outcome expectations, such as taste, satiety and pleasure [7]. Even though health as a long-term outcome expectation can also be an important motivational factor, the majority of people are not willing to compromise on taste to improve the healthfulness of their diets [21, 22].

Ability, such as nutrition knowledge, is a third predictor of healthy food choice [4]. Abilities, which are necessary for healthy food choices, comprise self-efficacy (Do I have confidence in my abilities and skills to choose healthy?), awareness (Are my intake levels adequate?), knowledge (Which are the healthiest choices?) and skills (How do I compose a healthy meal?) [4].

A certain level of nutrition knowledge is a prerequisite to making healthy choices, and studies have shown that better nutrition knowledge is linked to better eating habits [8, 10, 11]. However, nutrition knowledge neither strongly correlates to good dietary habits nor to behavioural changes [12]. Although educational interventions have had limited success, nutrition education is common practise for preventing diet-related diseases [3].
Many nutrition education campaigns attempt to support people in consciously adopting better eating habits by propagating factual information about healthy and unhealthy eating. Findings from the FLABEL project (Food Labelling to Advance Better Education for Life) indicate that in general, nutrition information is prevalent and well understood by consumers [2]. The FLABEL project also showed that when information was provided, most consumers were able to correctly rank products according to their healthiness [2].

Consumers seem to be aware that a balanced diet requires more than just consuming vitamins and minerals, and they are well informed about how to follow a healthy eating pattern [10]. However, whether people can compose a healthy, balanced meal or how people compose healthy meals is not known. It has been shown that consumers are able to estimate calories in meals to a certain extent, but consumers tend to underestimate the energy content as the size of the meal increases [24]. Still, having this knowledge does not imply that it helps people to make healthy dietary choices.

It is also unclear whether people are able to use this knowledge when composing meals. Counting calories and evaluating meals based on their composition is only a small part of making healthy food choices. To eat healthy, consumers should be able to create a balanced meal consisting of reasonable proportions of starchy foods, such as pasta or rice, reasonable amounts of meat, fish or other sources of protein and a high proportion of vegetables. Food-based dietary guidelines, such as the food pyramid, contain recommendations about reasonable portions. These dietary recommendations should provide consumers with the necessary skills to choose better diets and increase their nutrition ‘know-how’.

Psychological literature uses the term procedural knowledge, to refer to the knowledge about the ways in which actions are performed or ‘know-how’ [1]. In contrast to factual knowledge, or ‘knowing that’, which is defined
3.1. INTRODUCTION

as the knowledge about facts and things, procedural knowledge is thought to be in closer relationship to actual behaviour. Lately, the distinction of procedural and factual knowledge has also been applied to the field of nutrition knowledge [17, 25]. An example of factual nutrition knowledge would be that fruits and vegetables contain dietary fibres, while knowing how to choose a balanced meal represents an example of procedural nutrition knowledge. Although, it seems apparent that food-based dietary guidelines (FBDGs) should increase nutrition knowledge, it is entirely unclear whether FBDGs also increase consumers’ procedural knowledge and their ability to choose healthier meals. To the best of our knowledge, there is a lack of studies examining how people compose meals and how they make meals healthier when they are asked to do so.

Studying meal composition is methodologically challenging. To overcome the limitations of a canteen setting, such as environmental influences and group testing, we recently developed and validated a method using replica food items – the fake food buffet (FFB) [5, 6]. In this experimental setting, participants are invited separately to serve themselves food from a canteen-like buffet of selected replica food items. Using fake foods instead of real foods for experiments offers the advantage of testing individuals separately in a controlled environment. In addition, fake food experiments require comparatively little effort as the foods do not need to be cooked and can be utilised repeatedly.

The FFB has been suggested as a useful method for assessment of nutritional knowledge. The method has been shown to be reliable and valid for assessing food choice under well-controlled conditions [6]. Researchers have shown that the amounts of food served from a fake food buffet are strongly correlated to the amounts of food selected from a buffet containing the corresponding real food items. Furthermore, participants tend to serve themselves portions that are related to their individual energy needs [6].
In the present study, we examined how the instruction to select a healthy meal (instruction condition) influenced participants’ food choices and meal composition compared with participants who were asked to choose a meal that they wanted to (control condition). In a third condition (instruction + information condition), participants were asked to compose a healthy meal after they had received information about the food pyramid and current dietary recommendations. The third group received information as well as the explicit task to compose a healthy meal because such a design allowed to test whether the information material helps consumers composing healthier meals.

3.2 Methods

Study subjects

One hundred twenty-five persons were recruited via the subject pool of the University of Zurich. People following a medically prescribed diet, vegetarians, students who had taken classes in nutrition or health and persons who had previously participated in other food studies were excluded from participating. Data from 124 participants (59 male, 65 female) were analysed. One person was excluded as she failed to read the information brochure.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki. Written informed consent was obtained from all subjects. Students received monetary compensation for participating. All participants were informed about the study’s aim subsequent to the study’s completion.

Experimental procedure

Before the experimental study, a fake food buffet (FFB) containing 55 different replica food items was prepared (see Figure 3.1), and the energy content
was estimated for all items. The buffet contained a selection of common food items suitable for a lunch meal. Liquids (cream for coffee, French and Italian salad dressing, ketchup and mayonnaise) were offered as single packet portions. All items were labelled. The energy contents of the fake food items were estimated by comparison with each corresponding real food item. For methodological details, see Bucher et al. [5, 6].
Figure 3.1: Fake food buffet containing 55 replica products.
3.2. METHODS

The corresponding real food items were purchased from local retailers (Migros Genossenschaft and Coop). The calculations on energy content were based on energy values in the Swissfir database [26] or on retailer information for more processed products, such as meatloaf. The full list of products, energy contents and details on how estimates were derived for each food product can be found in the appendix of the publication.

Participants were individually invited to select a lunch from the FFB. An equal number of male and female volunteers were randomly assigned to one of three experimental conditions. Participants in the control condition were instructed to serve themselves a meal as they would normally eat for lunch if they were provided the given selection of food. Participants assigned to the instruction condition were instructed to serve themselves a meal that they thought would be healthy and balanced for them. People in the instruction + information condition were asked to read a brochure on the current dietary recommendations and portion sizes, which are meant to assist consumers in making healthy choices.

The brochure contained a picture of the Swiss food guide pyramid. The food guide pyramid visualizes which food groups should be consumed more (base of the pyramid) and which foods should be consumed in smaller amounts (top of the pyramid). The foods are grouped into 6 categories (top to bottom): 1) sweets, salty snacks, energy-dense beverages; 2) oils and fats; 3) protein sources; 4) starchy food items; 5) fruits and vegetables, and 6) unsweetened beverages. In addition, it contained detailed descriptions of reasonable portion sizes and suggested consumption frequencies. For example:

One starch-containing side dish should be consumed with each main meal. Two portions should be whole grains. One portion corresponds to 75–125g of bread, 60–100g of legumes (raw weight), 180–300g of potatoes or 45–75g of flakes, pasta, maize, rice or other cereals (raw weight).
Furthermore, the information material provided recommendations for a healthy lifestyle and healthy eating, such as: “Keep your bodyweight and reduce overweight,” or “Abstain from smoking and excessive alcohol consumption.” The brochure also contained specific dietary recommendations, such as: “Sweets and snacks should be consumed in moderation,” “Drink sufficient drinks that do not contain calories,” or “Eat fruit and vegetables in different colours daily” [14].

Participants were given sufficient time to read all of the material. When participants had completed reading the information, they received the same instructions as participants in the instruction condition. They were told to serve themselves a meal that they thought would be healthy and balanced for them.

For lunch, participants could freely choose from a range of tableware (IKEA, Switzerland): plates in different sizes (two of each: 32 cm, 27 cm, 21 cm and 16 cm diameter) and bowels (two pieces, each with a 14 cm diameter) were provided for self-service. The participants were instructed to arrange their meal on a serving tablet (38 x 58 cm). After serving the meal, each participant filled out a survey. Meanwhile, the experimenter analysed the meal in another room by weighing components (continuous items, such as rice) or counting pieces of fake food (slices of bread, fruits).

Measures

In the subsequent survey, participants used a 6-point scale to rate the perceived tastiness for all of the food items presented at the buffet (1 = not tasty at all to 6 = very tasty) as well as the perceived healthiness of these food items (1 = not healthy at all to 6 = very healthy). The participants also answered a 14-item single-choice questionnaire to test their nutrition knowledge, Cronbach’s $\alpha = 0.76$. The following two sample questions were asked: 1) How many portions of fruits and vegetables should you eat daily?
3.2. METHODS

Answer options: three portions (false), four portions (false), five portions (true), I don’t know (false); 2) A portion of starch containing side dish corresponds to...? Answer options: 75–125g of bread (true), 200–250g of bread (false), 500g of bread (false), 30g of bread (false), I don’t know (false).

Further, participants rated their hunger (1 = not hungry at all to 6 = very hungry) and provided anthropometric data. Self-reported height, weight and age measurements were used to calculate the body mass index (BMI) (weight in kilograms divided by height in meters squared) and the individual’s personal energy need per day (weight multiplied by calories per kilogram bodyweight factor, which depends on age and gender) [13].

The outcome variable, total meal energy, was established by weighing all served replica food items, multiplying the weight of the individual food items by the corresponding conversion factor and calculating the total energy in kJ. According to the food pyramid, the food items were grouped into the following five categories: 1) sweets, salty snacks, energy-dense beverages; 2) oils and fats; 3) protein sources; 4) starchy food items, and 5) fruits and vegetables. Note that according to the Swiss food pyramid, there is a sixth category comprising unsweetened beverages. This category was ignored for the analysis as it is not a source of energy. Furthermore, a distinction between fruits (5a) and vegetables (5b) was made. The energy per food category was calculated from the total energy of all food products in this category chosen by each participant. The perceived tastiness of a meal (T_{meal}) was calculated by multiplying the individual perceived tastiness rating (T_n) of the products with the energy derived from the corresponding products (kJ_n), and then divided by the total energy of the meal (kJ_{meal}) (see Formula(3.1)). Similarly, the perceived healthiness of a meal (H_{meal}) was computed by multiplying the individual health (H_n) score for all items with the energy derived from the corresponding items (kJ_n), and then di-
vided by the total energy of the meal (kJ\text{meal}) (see Formula (3.2)).

\[
T_{\text{meal}} = \frac{\sum_{i=1}^{n} (T_n \cdot kJ_n)}{kJ_{\text{meal}}}
\]  

\[
H_{\text{meal}} = \frac{\sum_{i=1}^{n} (H_n \cdot kJ_n)}{kJ_{\text{meal}}}
\]  

(3.1)
(3.2)

**Statistical analysis**

Statistical analysis was performed using SPSS Statistics, version 19.0 (SPSS Inc, Chicago, IL). One hundred twenty-four participants were included in the final sample. Data were analysed using one-way ANOVA. All tests are based on a 0.05 significance level. In case of a significant omnibus F–test, planned group comparisons were made using Tukey’s HSD (Honestly Significant Difference) test. Means (\(M\)), standard deviations (\(SD\)) and effect sizes \(\eta^2\) are reported. Note that the response variables for energy per food category and total meal energy were log-transformed, as the data are positively skewed.

**Manipulation check**

To assess whether the experimental manipulation was successful and the information brochure increased factual nutrition knowledge, participants’ knowledge was measured with a 14-item questionnaire after the experiment. The one-way ANOVA result indicates that there are significant differences among the three groups (\(F(2,121) = 36.66, P < .001, \eta^2 = 0.304\)). Participants in the instruction + information condition (\(M = 10.6, SD = 2.4\)) had a higher level of nutrition knowledge compared with participants in the control condition (\(M = 6.5, SD = 2.7, P < .001\)), or in the instruction condition (\(M = 7.4, SD = 2.9, P < .001\)), who did not receive any information. The mean score in the control condition and the instruction condition did not significantly differ (\(P = .378\)). One-way ANOVAs did not detect any
significant differences between the groups in terms of age, weight, height, BMI or levels of hunger (see Table 3.1).
Table 3.1: Descriptive characteristics of study subjects \((n = 124)\). Characteristics did not differ between experimental conditions.

<table>
<thead>
<tr>
<th></th>
<th>Total ((n = 124))</th>
<th>Control ((n = 42; 19) male)</th>
<th>Instruction ((n = 40; 21) male)</th>
<th>Instruction + information ((n = 40; 19) male)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean: 26.7</td>
<td>25.5</td>
<td>26.3</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td>SD: 6.0</td>
<td>5.3</td>
<td>5.4</td>
<td>7.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>Mean: 67.3</td>
<td>67.4</td>
<td>66.2</td>
<td>68.3</td>
</tr>
<tr>
<td></td>
<td>SD: 12.4</td>
<td>13.5</td>
<td>11.9</td>
<td>12.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>Mean: 174.3</td>
<td>174.9</td>
<td>173.9</td>
<td>174.1</td>
</tr>
<tr>
<td></td>
<td>SD: 9.4</td>
<td>10.4</td>
<td>8.5</td>
<td>9.7</td>
</tr>
<tr>
<td>BMI (\text{kg/m}^2)</td>
<td>Mean: 22.0</td>
<td>21.8</td>
<td>21.8</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>SD: 2.8</td>
<td>2.6</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Hunger(^*)</td>
<td>Mean: 3.1</td>
<td>3.3</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>SD: 1.4</td>
<td>1.4</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>F: 0.427</td>
<td>0.762</td>
<td>0.721</td>
<td>2.429</td>
</tr>
<tr>
<td></td>
<td>P: .427</td>
<td>.878</td>
<td>.721</td>
<td>.092</td>
</tr>
<tr>
<td></td>
<td>(\eta^2): 0.007</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Hunger levels were measured on a 6-point scale \((1 = \text{not hungry at all}; 6 = \text{very hungry})\).

Note. BMI = body mass index \((\text{weight in kilograms divided by height in meters squared})\).
3.3 Results

The amount of energy chosen from the different food categories in the three conditions was analysed with one-way ANOVAs. The analysis revealed that the amounts of sweets and sweetened beverages as well as the amounts of fruits were significantly different between the groups (see Table 3.2). Tukey’s HSD tests suggest that participants in the instruction condition ($M = 361, SD = 575$) and the instruction + information condition ($M = 306, SD = 412$) served themselves significantly less energy from sweets and sweetened beverages compared to people in the control group ($M = 873, SD = 1127$). In addition, participants in the instruction condition ($M = 397, SD = 346$) and in the instruction + information condition ($M = 364, SD = 206$) served significantly more energy from fruits compared to participants in the control group ($M = 215, SD = 214$). There were no significant differences between the instruction and the instruction + information conditions.

Further, the total energy of the meal was analysed. Although participants in the instruction + information condition ($M = 2742, SD = 893$) and the instruction condition ($M = 3044, SD = 1137$) chose slightly less energy compared to participants in the control condition ($M = 3589, SD = 1817$), the effect was small ($F_{(2,121)} = 3.019, P = .053, \eta^2 = 0.048$). The results are summarised in Table 3.2.
Figure 3.2: Examples of meals selected by participants in each condition. Top: control condition; middle: instruction condition; and bottom: instruction + information condition.
Table 3.2: The energy per food category chosen compared among the experimental conditions.

<table>
<thead>
<tr>
<th></th>
<th>Total (n 124)</th>
<th>Control (n 42; 19 male)</th>
<th>Instruction (n 40; 21 male)</th>
<th>Instruction + information (n 40; 19 male)</th>
<th>F</th>
<th>P</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweets/energy dense beverages (kJ)</td>
<td>Mean = 517, SD = 808</td>
<td>Mean = 873, SD = 1127</td>
<td>Mean = 361, SD = 575</td>
<td>Mean = 306, SD = 412</td>
<td>6.905</td>
<td>.001**</td>
<td>.102</td>
</tr>
<tr>
<td>Oils and fats (kJ)</td>
<td>Mean = 491, SD = 387</td>
<td>Mean = 580, SD = 483</td>
<td>Mean = 476, SD = 292</td>
<td>Mean = 414, SD = 350</td>
<td>1.083</td>
<td>.342</td>
<td>.018</td>
</tr>
<tr>
<td>Protein sources (kJ)</td>
<td>Mean = 826, SD = 419</td>
<td>Mean = 886, SD = 561</td>
<td>Mean = 829, SD = 422</td>
<td>Mean = 760, SD = 331</td>
<td>0.046</td>
<td>.955</td>
<td>.018</td>
</tr>
<tr>
<td>Starchy foods (kJ)</td>
<td>Mean = 784, SD = 387</td>
<td>Mean = 856, SD = 442</td>
<td>Mean = 790, SD = 364</td>
<td>Mean = 701, SD = 339</td>
<td>0.046</td>
<td>.955</td>
<td>.018</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>Fruits (kJ) Mean = 325, SD = 274</td>
<td>Mean = 215, SD = 214</td>
<td>Mean = 397, SD = 346</td>
<td>Mean = 364, SD = 206</td>
<td>5.164</td>
<td>.007**</td>
<td>.079</td>
</tr>
<tr>
<td></td>
<td>Vegetables (kJ) Mean = 189, SD = 71</td>
<td>Mean = 179, SD = 76</td>
<td>Mean = 192, SD = 65</td>
<td>Mean = 197, SD = 71</td>
<td>1.051</td>
<td>.535</td>
<td>.017</td>
</tr>
<tr>
<td></td>
<td>Total meal energy (kJ) Mean = 3131, SD = 1381</td>
<td>Mean = 3589, SD = 1817</td>
<td>Mean = 3044, SD = 1137</td>
<td>Mean = 2742, SD = 893</td>
<td>3.019</td>
<td>.053</td>
<td>.048</td>
</tr>
</tbody>
</table>

** Significant at $P < .01$. Note that ANOVA was conducted on log-transformed data.
To ensure natural behaviour in the experimental setting with the fake foods, the total energy of the meals was analysed. The energy ranged from 922 kJ to 8669 kJ ($M = 3131$, $SD = 1381$). Men served significantly more energy ($M = 3786$, $SD = 1586$) compared to women ($M = 2537$, $SD = 796$, $t(122) = 5.74$, $P < .001$). The energy of the meal was significantly related to each individual’s personal energy need ($r = .27$, $P = .003$, $N = 124$).

Furthermore, the participants rated the appearance of the fake foods on a scale ranging from 1 (the fake food items look very unrealistic) to 6 (the fake food items look very realistic). People found the fake food to be authentic ($M = 4.91$, $SD = 0.96$). Sample meals chosen by participants in each condition are shown in Fig. 3.2.

After serving from the FFB, the participants rated the tastiness of all 55 food items presented. Subsequently, each participant also judged the healthiness of the food items. From these ratings, a perceived healthiness score as well as a perceived tastiness score for each meal was calculated (Eqs. (3.1) and (3.2)).

To evaluate whether the mean perceived healthiness of the meal differed among the experimental groups, mean differences were compared. A one-way ANOVA indicated significant differences in perceived healthiness scores between the conditions ($F_{(2,121)} = 28.393$, $P < .001$, $\eta^2 = .319$). Tukey’s HSD test revealed that the perceived healthiness of the meals served by participants in the instruction condition ($M = 4.5$, $SD = 0.6$) and in the instruction + information condition ($M = 4.6$, $SD = 0.6$) were significantly higher compared to the perceived healthiness of the meals served by participants in the control condition ($M = 3.5$, $SD = 0.9$). The perceived healthiness of the meals served by participants in the instruction condition and the instruction + information condition did not significantly differ.

The one-way ANOVA results suggest that the perceived tastiness scores of the meals did not differ across groups ($F_{(2,121)} = 0.834$, $P = .437$, $\eta^2$...
3.4 DISCUSSION

The mean scores were $M = 5.4$, $SD = 0.6$ for the control condition, $M = 5.3$, $SD = 0.5$ for the instruction condition and $M = 5.3$, $SD = 0.5$ for the instruction + information. These results indicate that even though participants in the instruction condition and the instruction + information condition subjectively chose a healthier meal than participants in the control group, they all chose equally tasty meals.

3.4 Discussion

The nutrition information brochure containing factual knowledge on current dietary recommendations and on reasonable portion sizes had no effect on the selected meal. Although nutrition knowledge related to portion sizes and other dietary recommendations was significantly increased in the group that received the information material, their meals did not differ from the meals selected by participants who did not receive the information and were only instructed to serve themselves a healthy meal.

Consumers seem to be able to compose healthier meals to a certain extent. The results of this study clearly show that participants who were instructed to choose a healthy, balanced meal (the instruction and information + instruction conditions) served themselves more energy from fruits and less energy from sweets and sweetened beverages compared to people who were instructed to select a meal they would normally eat. The other food groups, which usually constitute the main course (starchy foods, meat and other types of protein, oils and fats as well as vegetables), remained unaffected by the experimental manipulation. In addition, participants in both instruction conditions perceived their meal as healthier compared to participants in the control condition. Therefore, instructed participants chose objectively, as indicated by the energy from different food groups, as well as subjectively, as indicated by a higher perceived healthiness score and healthier meals. Nevertheless, people who selected healthier meals did not
This finding shows that consumers are able to compose healthier meals, which are perceived as equally tasty. This is an essential finding as taste is still the most important aspect attributing for consumers’ choices.

It is interesting that the amount of vegetables was not altered by the instruction or providing information and instructing people to compose a healthy and balanced meal. If consumers are asked to select a healthy meal, they do not seem to implement nutritional information regarding portion sizes to directly improve their meals, such as increasing the amount of vegetables and decreasing the amount of meat on the plate. It appears that if people aim to select a healthy meal, they use the ‘painless’ strategy of replacing desserts and sweets with a fruit, while the other food groups, which constitute the main course on the plate, remain unchanged. Although the amount of energy for the entire meal was decreased to some extent in the instruction and the instruction + information condition, the effect was rather weak.

Food-based dietary guidelines (FBDGs) such as the food pyramid were designed to encourage healthy eating. The evidence of their effectiveness, however, is limited, and few studies have assessed the direct effect on meal composition. Our results suggest that this relatively comprehensive factual knowledge on portion sizes does not directly help the consumer in the process of composing single meals. It seems that consumers have difficulty transferring the information on portions presented in the food pyramid into food choices.

When consumers aim to compose a healthy meal, most people seem to follow a heuristic approach of choosing fewer sweets and desserts and taking a fruit instead. This strategy may be simple yet smart as healthiness can be increased while the perceived tastiness of the meal is not reduced. Because fruits are perceived as relatively tasty (see the food perceived tasti-
ness scores in Appendix), consumers do not need to compromise on taste when choosing a healthier meal. However, neither the instruction to choose healthy nor providing extra information increased the amount of vegetables served. It seems that participants are either unmotivated to increase the amount of vegetables on the plate, or they are not aware that for a healthy diet, more vegetables should be consumed. They also might be less willing to increase vegetable servings because they are simply not willing to compromise on taste. Since the consumption of vegetables does not meet the recommendations in many countries, this issue should be investigated further.

There are some limitations in the present study that need to be addressed. First, the replica foods used in this study were fake. Served theoretical, this energy may not be identical to consumed energy. Nevertheless, it is known from previous research that people tend to empty their plates [23]. Furthermore, past research indicates that the FFB is a reliable and valid method [6].

Second, the perceived healthiness of the foods and the perceived tastiness of the items were rated after participants had chosen their meals. It is possible that ratings were biased by the experimental manipulation or the choices participants had made before. The participants in this study consisted mainly of university students and staff. The sample might have more baseline knowledge regarding nutrition compared with the general population. It should be noted, however, that the knowledge of participants who received the information improved considerably. A condition where participants would have received information without the instruction to choose healthy was not included in the experimental design, as we aimed to investigate whether information can be helpful if consumers aim to select a healthy meal.

Despite the limitations, the results of the present research have several
practical implications. The findings suggest that the experimental manipulation resulted in a substitution of sweets and desserts by fruits. Furthermore, the task to choose a healthy meal did not result in serving more vegetables or fewer calories. Even though the information about the food pyramid significantly increased consumers’ knowledge, this type of knowledge was not used to improve meal composition. This could be due to a lack of motivation and/or unwillingness to compromise on taste in both groups, and it may be that the type of knowledge is too difficult to translate to menu changes or the composition of single meals. Further research is needed to examine possible explanations, but also to examine whether these brochures have the intended effect to promote healthy eating.

For repeated choice tasks, such as deciding which daily menu to select in the cafeteria, it is possible that elaboration of information is of minor importance. In these situations, environmental cues such as the attractiveness of the information source or the catchiness of a slogan may be more important, and short statements reminding people about how they can simply, yet effectively, change their meal to increase healthiness might be more effective [16, 19].

Previous research shows that although information at the point of purchase increases consumers’ nutrition knowledge, complex nutrient lists do not alter product purchases [20]. The authors suggest that effort-reducing displays, which minimise information collection, computation and comprehension effort, could be a successful strategy to improve point-of-purchase choices [20]. Similarly, reducing the complexity of nutritional advice on portion sizes may be effective in helping consumers compose healthier meals. As people tend to serve themselves units as portions [15], information on portion sizes in grams might be especially difficult to transfer on product items, which can be served in continuous amounts (such as rice or pasta).

To compose a balanced meal, consumers need not only to be motivated
to make healthy choices, but also have the necessary skills to make such decisions. Results of the present study suggest that simply providing extensive factual knowledge on portion sizes does not result in the desired outcomes. Future guidelines should be developed based on scientific evidence in order to increase the effectiveness in helping consumers to develop the necessary skills to compose a healthy meal in practice. Recommendations such as FBDGs should be carefully tested for their applicability and their effect on consumers’ diets. Simple dietary guidelines, such as the plate model in which proportions of different food groups are represented, may facilitate the transfer to real food choices. More research is needed to find out how knowledge needs to be communicated to help people in choosing better diets.
CHAPTER 3. FRUIT FOR DESSERT

Bibliography


CHAPTER 3.  FRUIT FOR DESSERT
Chapter 4

Improvement of Meal Composition by Vegetable Variety

Abstract

Objective: Our physical environment influences our daily food choices unconsciously. Strategic changes in the food environment might therefore be potential measures to influence consumers’ food selection towards better nutrition, without affecting the consumers’ freedom of choice. The present study aimed to examine whether increased vegetable variety enhances healthy food choices and improves meal composition.

Design: A randomised experiment.

Setting: Participants were instructed to serve themselves a lunch from a buffet of food replicas. Individuals were randomly assigned to one of three food combinations: condition A – cooked carrots, pasta and chicken; condition B – cooked green garden beans, pasta and chicken; condition AB – carrot sticks, green garden beans, pasta and chicken. Two one-vegetable conditions were compared with one two-vegetable condition. Data from Zurich, Switzerland, were analysed using one-way ANOVA.

Subjects: Ninety-eight students (fifty-three men; mean age 22.8 (SD = 2.2) years, minimum = 19 years, maximum = 29 years).

Results: Participants who could choose from two vegetables derived significantly more energy (141 kJ) from vegetables compared with participants in the one-vegetable condition (104 and 84 kJ, respectively). Furthermore, in the two-vegetable condition, the relative energy of the meal derived from vegetables (10.9 %) increased significantly compared with the one-vegetable condition (8 % and 6.1 %, respectively). The total energy content of the meal ($M = 1472$, ($SD = 468$) kJ) was not affected by the experimental manipulation.

Conclusions: Having a choice of vegetables increases a person’s tendency to choose vegetables and leads to the selection of a more balanced meal. Serving an assortment of vegetables as side dishes might be a simple and effective strategy to improve food selection.
4.1 Introduction

A balanced diet means eating a variety of foods in healthy proportions. A healthy balanced diet should be based on fruits, vegetables, and whole foods high in nutrients [17, 4]. Eating an unbalanced diet can cause weight gain and poor health [15, 9], while consumption of high amounts of fruits and vegetables has been suggested as a potential dietary strategy for optimizing health [23]. A diet rich in fruits and vegetables has been shown to reduce the risk for cancer [6] and cardiovascular disease [1], improve bone health [21, 30], and reduce age-related cognitive decline [16]. Such a diet even may result in weight loss [5, 14]. To increase people’s fruit and vegetable intake, it is important to understand the factors influencing human food choice and meal composition. Previous research has shown that, in addition to psychological factors such as cognition and social influences [28], environmental factors affect food choice [11, 31, 13]. Therefore, changes in the food environment, such as increasing the availability of healthy foods, are potential measures to influence consumers’ food selection toward better nutrition, without affecting the consumers’ freedom of choice. Environmental measures within public eating areas are of importance, as modern living has led to an increase in the frequency and variety of meals and snacks consumed away from home [18, 19].

To classify environmental influences on food choice, Herman and Polivy [10] introduced the distinction between normative and external (sensory) cues. While sensory cues refer to the hedonic appeal of the food (e.g., palatability and odour), normative cues refer to indicators of appropriate intake such as portion sizes. The authors argue that sensory cues are especially powerful for certain groups such as obese or dieting/restraint individuals, while normative cues exert control over food selection for all. It was shown that the variety of the foods presented [22], portion sizes, [24] the plate size, or even the number of peers at the table can influence consumption [31].
While several studies have shown how these cues can cause overconsumption and poor nutrition [12, 24, 32], little is known about implementation of this knowledge to actually improve consumers’ food choice [26, 33].

In the present study, the focus lies on how variety might be strategically used to improve meal composition. In general, variety in a meal is thought to enhance food intake [22]. Consumers offered an assortment with three different flavours of yoghurt consume on average 23% more than when offered only one flavor [27]. Kahn and Wansink have shown that people eat more M&M candies if they come in more colors [12]. Therefore, it does not matter whether the variety is real (e.g., food tastes very different) or just perceived (e.g., food structures differ, but tastes are identical). Both increase consumed quantities. The effect of variety on food consumption is commonly explained by reduction of sensory-specific satiety. Sensory-specific satiety refers to the finding that as a food is eaten, its palatability gradually declines. Higher variety is assumed to overcome sensory-specific satiety and therefore lead to increased food intake. The variety effect might have been advantageous during human evolution, as a varied diet is more likely to cover all essential nutrients. In today’s affluent society, though, the effect has rather become a threat to human health.

Past studies have mainly focused on single foods instead of examining the influence of a variety in healthy foods on consumers’ meal composition. The focus of this study lies on variety as a modifiable normative cue to improve consumers’ food choice. The hypothesis is that by increasing the variety of healthy foods, namely vegetables, consumers can be manipulated toward a healthier and more balanced diet. This might be explained by the so-called 1/N equality heuristic, suggested by DeMiguel et al. [3] The heuristic originates in economics and addresses the question how money is invested in N assets. It states the tendency of people to allocate money equally to each of N funds. Similarly, people might allocate limited space on a serving plate
equally to different foods offered. If this hypothesis is true for food choice, people offered more vegetables should not just choose more vegetables but also improve the composition of the overall meal. In summary, we expect participants with a higher variety of vegetables available to choose a higher proportion of vegetables and reduce the selection of other foods at the same time.

4.2 Methods

To accurately investigate the influence of vegetable availability on the serving amounts and meal composition, a fake food buffet (FFB) was used. Therefore, a buffet of food replicas cast from polyvinylchloride (Döring GmbH Munich, Germany) was prepared. Four foods commonly eaten for a warm meal in Switzerland were selected: carrots (vegetable A), green beans (vegetable B), pasta, and fried skinless chicken breast. All items were placed in aluminium serving dishes to remind students of the local university cafeteria.

Subjects

An invitation to participate in the experiment was sent to the subject pool of the University of Zürich. Students taking classes in nutrition science, following a medically prescribed diet, or following a vegetarian diet were excluded from study participation. Persons older than 30 years were also excluded from the experiment, as age is a potential modifier of the variety effect [22]. Ninety-eight persons (53 men and 45 women) completed the experiment.

Experimental Procedure

Each person was randomly assigned to one of three replica food selections. The buffet for group 1 ($n = 29$, 17 men) consisted of cooked carrots, pasta,
and chicken (condition A). Group 2 \((n = 35, 19 \text{ men})\) could serve themselves beans, pasta, and chicken (condition B), and group 3 \((n = 34, 17 \text{ men})\) had both vegetables in addition to pasta and chicken (condition AB) (Figure 4.1). Participants were provided with a standard serving plate (27 cm diameter) and asked to serve themselves a meal such as they would normally eat for lunch from the presented selection. After serving, the participants filled out a food questionnaire. Meanwhile, the investigator quantified each food component of the meal by weighing it (Shimadzu UW6200H, Swiss Waagen DC GmbH Uster, Switzerland). Students were compensated with CHF 15 for participation. Subsequent to study completion, participants were informed about the study aim. Data were collected and analysed in Zürich, 2010.

**Calculation Theoretical Energy Content of Replica Food Items**

To estimate the theoretical energy content of the replica foods, corresponding real foods were prepared, and weights were measured (Comparison real and replica food see figure 4.2).

*Carrots.* Carrots (vegetable A) were chopped into pieces comparable to the replica carrots. Equal volumes of replica carrots and real carrots were selected. The weight of real and replica carrots was measured, and a factor was calculated. This procedure was repeated three times. The average conversion factor was used for energy estimation of 100 g of replica carrots. The conversion factor from carrots to replica carrots is 1.10 \((M = 1.10, SD = 0.06)\). Therefore, 100 g of replica carrots have a theoretical energy content of 149 kJ (fresh carrots (100 g) = 135 kJ [34]).

*Beans.* Green garden beans (vegetable B) were chopped into pieces comparable to the replica beans. Forty replica beans and 40 real beans were selected randomly. The weight of real and replica beans was measured, and a factor was calculated. This procedure was repeated three times. Average
Figure 4.1: Experimental conditions. A) Condition A. Carrots were offered along with pasta and chicken. B) Condition B. Beans were offered along with pasta and chicken. AB) Condition AB. Both vegetables were offered in addition to chicken and pasta.
CHAPTER 4. VEGETABLE VARIETY

Figure 4.2: Food replica and real foods in comparison. A) Raw beans (lower panel) and replica beans (upper panel). B) Raw carrots (lower panel) and replica carrot sticks (upper panel). C) Cooked pasta (right) and replica pasta (right). D) Fried chicken breast (upper panel) and replica chicken (lower panel).

conversion factor beans to replica beans: 0.73 \((M = 0.73, SD = 0.01)\). 100 g replica beans have a theoretical energy content of 75 kJ (fresh beans (100 g) = 103 kJ [34]).

Pasta. A type of pasta was selected that looked similar in size and shape to the replica pasta after cooking. Forty pieces of real pasta and 40 pieces of replica pasta were selected randomly. The weight of the real
and replica pasta was measured, and the conversion factor was calculated. The procedure was repeated three times. Average conversion factor from pasta to replica pasta: $0.30$ ($M = 0.30$, $SD = 0.01$). 100 g of replica pasta correspond to 455 kJ (egg pasta (100 g) = 1498 kJ [34]).

*Chicken.* Chicken breast was flavoured and subsequently fried in a pan. The weight of the raw and fried meat was measured as well as the frying oil remaining on the chicken. The chicken breasts were then chopped into pieces similar to the replica food. Six similarly shaped pieces of real and replica meat were selected and measured to calculate a conversion factor. The procedure was repeated three times. Average conversion factor from fried chicken breast to replica chicken breast: $0.73$ ($M = 0.98$, $SD = 0.03$). 100 g of replica chicken correspond to 636 kJ (fried chicken breast (100 g) = 456 kJ [34]). Note that for chicken, the oil remaining on the meat after frying was taken into account, while for all other food items, no addition of fat was assumed.

**Measures**

The first outcome variable, *total energy from vegetable* was measured by weighing the replica vegetables that were served. The weights of the replica vegetables were multiplied by the conversion factors and summed up to compute the theoretical energy content from the vegetables served. Similarly, the second outcome variable, *total energy meal* was established by weighing all food items. The weight of the individual food items was multiplied by the corresponding conversion factor and added up to compute the theoretical energy content of the meal. The third outcome variable, *percent energy from vegetables* was determined by computing the relative energy served from vegetables compared to total energy served. The inverse variable, percent energy from non-vegetables, was calculated the same way.

After the participants served themselves a meal, they provided self-
reported height, weight, and age measures. These measures were used to calculate the body mass index (BMI) (weight in kilograms divided by height in meters squared) and the individual’s daily energy need (weight multiplied by a calories per kilogram bodyweight factor, which depends on age and gender [7]). Note, that calculated energy needs might be lower than true energy needs, as there is a general tendency to underreport weight and over-report height [20]. The students completed questions about their levels of hunger, food frequency questions on offered food items, food preferences, and the authenticity of the replica foods. Hunger was assessed with the question, “How hungry are you right now,” on a 6-point scale (1 = not hungry at all; 6 = very hungry). Food frequency was measured with the question, How often do you eat the following food items, (1 = daily, 2 = several times per week, 3 = several times per month, 4 = several times per year, 5 = less or never). Food preferences were assessed with the question, “How much do you like the following food items,” on a 6-point scale (1 = I don’t like it at all; 6 = I like it very much). The authenticity of the replica foods was measured with the question, “How realistic were the following replica foods,” on another 6-point scale (1 = not realistic at all; 6 = very realistic).

Statistical Analysis

Data were analysed by PASW Statistics, version 18.0 (SPSS Inc, Chicago, IL). To assess whether the three study conditions were successfully randomised by age, BMI, hunger, and food preference, one-way analysis of variance (ANOVA) was performed. Three univariate ANOVAs were conducted to determine whether the buffet conditions were associated with the three outcome variables, and the effect sizes $\eta^2$ are reported. Gender × condition interactions were analysed with two-way ANOVA. In case of a significant omnibus $F$ test, planned group comparisons were conducted using the Bonferroni correction. Mean differences ($D$) and standard errors
4.3. RESULTS

A total of 98 persons participated in this study, 45.9 % female ($n = 45$) and 54.1 % male ($n = 53$). One-way ANOVA did not detect any significant differences between the experimental groups in terms of age ($22.8 \pm 2.25$ years), BMI ($22.0 \pm 2.5$), or hunger levels ($2.9 \pm 1.3$) (Table 4.1). There is a slight difference in food preference for carrots (vegetable A) between the groups. Participants who were not presented any carrots stated liking them slightly more than participants who could actually serve themselves carrots. The effect, however, is negligible ($F_{(2,95)} = 3.1$, $P = .048$, $\eta^2 = .062$). High ratings for the authenticity of replica food items give an indication of the usefulness of replica foods (carrots: $M = 4.43$, $SD = 1.06$, beans: $M = 4.34$, $SD = 1.18$, chicken: $M = 3.33$, $SD = 1.54$, pasta: $M = 4.61$, $SD = 1.18$).
Table 4.1: Differences in background and demographic variables of participants in the three experimental conditions (one-way ANOVA)

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 98)</th>
<th>Condition A (n = 29; carrots)</th>
<th>Condition B (n = 34; beans)</th>
<th>Condition AB (n = 35; both vegetables)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Age (years)</td>
<td>22.80</td>
<td>2.25</td>
<td>23.07</td>
<td>2.62</td>
</tr>
<tr>
<td><strong>(range: 19-29)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²; range: 17.2-30.0)</td>
<td>21.98</td>
<td>2.51</td>
<td>22.00</td>
<td>2.96</td>
</tr>
<tr>
<td>Hunger level (range: 1-6)</td>
<td>2.91</td>
<td>1.29</td>
<td>2.79</td>
<td>1.32</td>
</tr>
<tr>
<td>Food preference (range: 1-6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable A</td>
<td>4.81</td>
<td>1.32</td>
<td>4.31</td>
<td>1.30</td>
</tr>
<tr>
<td>Vegetable B</td>
<td>4.79</td>
<td>1.28</td>
<td>4.55</td>
<td>1.30</td>
</tr>
<tr>
<td>Pasta</td>
<td>5.16</td>
<td>0.95</td>
<td>5.21</td>
<td>1.05</td>
</tr>
<tr>
<td>Chicken</td>
<td>5.17</td>
<td>1.06</td>
<td>5.21</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Vegetable A, cooked carrots; vegetable B cooked beans.

*One individual refused to state her weight. Total n for BMI is therefore 97.

†Hunger levels were measured on a 6-point scale (1 = not hungry at all; 6 = very hungry)

‡Food preference was measured on a 6-point scale (1 = I don’t like it at all; 6 = I like it very much)
To test whether vegetable variety affects the total energy from vegetables (kJ), the means of the energy derived from vegetables were compared between experimental groups (Table 4.2). ANOVA revealed a significant main effect of vegetable variety ($F_{(2,95)} = 23.776$, $P < .00$, $\eta^2 = 0.334$) on the total energy derived from vegetables. The energy derived from vegetables significantly increased when two vegetables were offered instead of only one. Planned contrasts with Bonferroni correction showed statistically significant differences between condition AB (carrots and beans) and condition A (carrots only) ($D = 8.87$, $SE = 2.11$, $P < .001$) and condition B (beans only) ($D = 13.71$, $SE = 2.11$, $P < .001$). To exclude interactions of gender with experimental conditions, a two-way ANOVA was performed. No significant interaction was found ($F_{(2,95)} = .047$, $P = .954$, $\eta^2 = 0.001$).
Table 4.2: Differences in meal composition depending on the experimental conditions (one-way ANOVA).

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 98)</th>
<th>Condition A (n = 29; carrots)</th>
<th>Condition B (n = 34; beans)</th>
<th>Condition AB (n = 35; both vegetables)</th>
<th>( F )</th>
<th>( P )</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy from vegetables (kJ)</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>42</td>
<td>104(^b)</td>
<td>32</td>
<td>84(^b)</td>
<td>32</td>
<td>141(^a)</td>
</tr>
<tr>
<td>Total energy from meal (kJ)</td>
<td>1472</td>
<td>468</td>
<td>1452</td>
<td>402</td>
<td>1561</td>
<td>562</td>
<td>1399</td>
</tr>
<tr>
<td>Percentage energy from vegetables</td>
<td>8.3</td>
<td>4.4</td>
<td>8.0(^b)</td>
<td>4.4</td>
<td>6.1(^b)</td>
<td>2.4</td>
<td>10.9(^a)</td>
</tr>
</tbody>
</table>

\(^{a,b}\): Means values within rows with unlike superscript letters were significantly different using the Bonferroni tests (\( \alpha = 0.05 \)).
A significant main effect of vegetable variety on the percent energy from vegetables was found ($F_{(2, 95)} = 12.229$, $P < .001$, $\eta^2 = 0.205$). The percent energy from vegetables was significantly larger in condition AB compared to condition A ($D = 2.83\%$, $SE = 1.01$, $P = .018$) as well as compared to condition B ($D = 4.74\%$, $SE = .96$, $P < .001$). No significant interaction of the experimental condition with gender was found ($F_{(2, 95)} = .335$, $P = .716$, $\eta^2 = 0.007$). Few people in the AB condition chose only one vegetable ($n = 2, 5.9\%$). We can therefore rule out that people offered two vegetables served more vegetables because they had a better chance of finding their favourite vegetable.

Further, the variety of vegetables presented did not influence the total energy of the meal ($F_{(2, 95)} = 1.071$, $P = .347$, $\eta^2 = 0.022$). There are, however, significant differences in total energy (kJ) served between genders. Men ($M = 1699$, $SE = 66$) served themselves on average 494 kJ more compared to women ($M = 1205$, $SE = 40$), ($t[96] = 6.11$, $P < 0.001$, $r = .42$). The total amount of energy served from the buffet correlated with the individual daily energy requirement ($r = .35$, $P < .001$).

### 4.4 Discussion

This experiment shows that, by increasing the vegetable variety, consumers’ food selection can successfully be influenced toward a healthier food choice. An increase in vegetable variety results in a change in meal composition. Giving participants one additional vegetable to choose from increases the total as well as the relative energy served from vegetables. Vice versa, the relative energy deriving from non-vegetables (e.g., pasta and chicken) is significantly decreased. This indicates that participants choose a more balanced meal containing a higher proportion of vegetables.

Interestingly, the increase in the variety of vegetables did not affect the total energy served, even though the variety effect is in general known to
CHAPTER 4. VEGETABLE VARIETY

increase consumption [22]. This finding might be explained by limiting plate space. The plate restricts the maximal amount of food that can be served. Even though more food items are served once variety increases, plate space is limited at one point. Here, relative energy differences between food items are suspected to play a role. Foods relatively low in energy were chosen for the experiment. It is possible that, by substituting the relatively low-energy-dense chicken and pasta with foods higher in energy density such as pork and fries, the total energy of the meal might even be reduced, when offering two vegetables instead of one. For the variety effect within a meal, however, it seems important in which food items the variety lays. If there is a higher variety of low-energy-dense foods such as vegetables, the total energy of the meal does not necessarily increase. On the contrary, it even might be strategically used to reduce energy intake.

The limited plate space forced participants to decide which foods to serve in what quantity. We assume that participants allocate the available space of the plate equally to chosen food items, which might be explained by the 1/N equality heuristic. People may also be likely to allocate space on the plate equally to N food items. We name this observed tendency the “plate space equality heuristic.” Future studies should quantify the relationship between the number of foods offered and the plate space available. It would also be of interest to know how preferences and aversions influence plate space allocation.

Even though the food replicas were of outstanding quality, the foods were fake. However, we found high correlations between served amounts of replica foods from a Fake Food Buffet and a buffet of corresponding real foods [2]. Using replica food has numerous advantages over real food. Most important, the replicas allow studying food choice under well-controlled laboratory conditions and each individually tested participant finds an identical food buffet. A limitation of using replica foods might be that served theo-
retical energy may not be identical with consumed energy from an identical buffet of real foods. In a real-life situation, parts of meals might be left over or a second serving eaten [25]. It is known from previous research, however, that people tend to empty their plates [31] and take single portions as units for consumption, rather than compensating by eating more portions [8]. No sauces were offered along with the replica food items, and minimal fat was assumed for meal preparation and calculation of weight factors. A meal from replica foods might therefore seem lower in calories when compared to the same meal composed from real foods. The study population included students only and hence might not represent the general population.

To verify whether participants behaved naturally in the experiment, gender differences in total energy served were quantified. It was found that women serve less energy compared to men. In addition, the energy served correlates with the actual personal energy requirement. Also, students rated the appearance of the replica food items as very realistic. Together, these findings indicate that participants behaved naturally when serving the replica food.

Eating a balanced diet high in fruit and vegetables is common advice for maintaining good health. However, human food selection is not driven only by individual decision. Food and eating environments are likely to influence food choice, over and even above individual factors such as knowledge, skills, or even motivation [29]. The present findings show that a simple and inexpensive environmental measure, i.e., increasing the selection of healthy foods, can improve consumers’ food choices. This finding might be of interest for public health authorities to promote adapting out-of-home eating environments. Consumers themselves could profit from this measure at home. We suggest that serving an assortment of vegetables as side dishes might be a simple and effective strategy to improve meal composition.
CHAPTER 4. VEGETABLE VARIETY

Bibliography


Chapter 5

Vegetable Variety: An Effective Strategy to Increase Vegetable Choice in Children

Abstract

Background: Most children do not meet the recommended intake of fruit and vegetables. Variety was identified as a potential factor to increase children’s intake of these foods, as it was shown that variety was effective in improving meal composition in adults. Because younger children are suggested to be more responsive to internal satiation signals than to external food-related cues compared to adults, it is not clear whether variety is effective to improve meal composition in children. Findings: To investigate whether vegetable variety is effective in increasing vegetable choice, we conducted a randomised experiment with 100 children aged 7 to 10 years. Children were assigned one of three different fake food buffets containing pasta, chicken, and either one vegetable (carrots or beans) or two vegetables (carrots & beans). The children were asked to serve themselves a meal, that they would like to eat for lunch from the given selection. Children given the two-vegetable choice served themselves significantly more energy from vegetables ($M = 10.9$ ($SD = 9.4$) %) compared to children who were only offered either carrots ($M = 5.9$ ($SD = 6.5$) %) or beans ($M = 5.6$ ($SD = 6.3$) %). The total energy of the meal was not reduced, indicating that children chose a more balanced lunch when offered more vegetables. Conclusions: School-aged children are responsive to food-related cues and variety is effective in increasing their vegetable choice. Serving an assortment of vegetables in school cafeterias might be a simple and effective strategy to improve children’s nutrition.
5.1 Background

As the evidence for the health benefits of a diet rich in fruit and vegetables is substantial [11], the World Health Organisation (WHO) recommends a daily intake of at least 400 grams of these foods which, unfortunately, most children do not meet [12]. As low intakes of fruit and vegetables track into adolescence and adulthood [5, 10], many campaigns are trying to increase the intake of these healthy foods in children. Fruit and vegetable variety was suggested as a potential factor that may increase choice of these foods in school children [6]. Vegetable variety was shown to improve meal composition in adults [2]. If two vegetables were offered instead of one, people served themselves a higher proportion of energy from vegetables while the overall energy of the meal was not altered [2]. A similar result was found by Meengs et al. [7].

A possible mechanism for how variety could increase amounts consumed, is sensory-specific satiety, which refers to the declining satisfaction generated by the consumption of a certain type of food and subsequent renewal of appetite upon exposure to another still-palatable food. [9, 8]. Recent studies, demonstrate, that variety is also effective when people select meals from fake foods [2] without actually consuming the foods. However, even though vegetable variety was shown to be effective in improving the composition of adults’ meals, it is not clear, whether vegetable variety also improves the composition of children’s meals. A randomised controlled trial, that examined the effect of choice-offering on consumption of vegetables in 4–to–6 year-olds, did not show an increased intake [14]. When younger children select a meal, food-related cues such as variety might be of minor importance, while the responsiveness to liking or signals such as hunger and satiety might be more important [1]. Recently, an observational study found that the fraction of children that ate at least one serving of fruit and vegetables during lunch was higher in schools that offered more fruit and vegetables.
In the present study, we use a fake food buffet to assess how vegetable variety affects 7-to-10 year-old children’s meal composition. The fake food buffet method has been shown to be reliable and valid to investigate external influences on food choice [3]. We used the same experimental setting, that was applied in our previous study, where we showed that vegetable variety is effective to improve adult’s meal composition [2].

5.2 Methods

The Fake Food Buffet

We use a fake food buffet for the experiment. The method was validated by comparison of meals served from fake foods and from the corresponding real foods in adults [3]. For this study, a buffet was prepared with four replicas of foods commonly eaten for a hot meal in Switzerland: carrots, green garden beans, pasta and fried skinless chicken breast. The replica food items were placed on a small table in aluminium serving dishes. The energy contents of the fake foods were estimated by comparison with corresponding real food items. For methodological details, see [2, 3].

Participants

Children aged 7 to 10 years and their parents were invited by mail to participate in a study about children’s food preferences. Children following a medically prescribed diet were excluded from participation. Written informed consent was obtained from all parents. The study was approved by the ethics committee of the ETH Zurich (EK 2012-N-37).
5.2. METHODS

Experimental procedure

Hunger and preference for the foods were assessed before the experiment. Each child was randomly assigned to one of three different replica food selections. The buffet under condition carrots ($n = 32$) consisted of cooked carrots, pasta and chicken. Under condition beans, ($n = 34$) children could serve themselves green beans, pasta, and chicken, and under condition carrots & beans ($n = 34$), children were offered both vegetables in addition to pasta and chicken. In the experiment each child was asked to serve him- or herself a meal, from the presented selection, such as they would like to eat for lunch from the presented selection on a normal school day. The experiment took place in the absence of the parent. The child’s height and weight were measured by the experimenter.

Measures

The theoretical energy of the fake foods was determined by weighing the replica foods and multiplying the weight with a conversion factor to correct for weight differences between fake and real foods [2]. The outcome variable *percentage energy from vegetables* was determined by computing the relative energy from vegetables compared with the total energy.

Measured weight and height were used to calculate the children’s BMI (weight in kilograms divided by the square of height in meters ($\text{kg/m}^2$)). Hunger was measured with the question ‘How hungry do you feel right now?’ on a three-point scale ($1 = \text{not hungry}$, $2 = \text{medium}$; $3 = \text{hungry}$). Preferences were assessed with the question ‘How much do you like this food?’ on a five-point smiley scale ($1 = \text{I like it very much}$ to $5 = \text{I don’t like it at all}$). Picky eating was assessed with a six-Item scale (Cronbach’s $\alpha = .88$), which was included in the parent’s questionnaire. The items were derived from Wardle et al. [13].
Statistical analysis

Data were analysed using IBM SPSS Statistics, Version 19 (SPSS. Inc., Chicago, IL, USA). Univariate ANOVAs were conducted to determine whether the buffet conditions were associated with the three outcome variables. Effect sizes ($\eta^2$) are reported. In case of a significant omnibus $F$–test, planned group comparisons were made using the Bonferroni correction ($P$ values of the least significant difference test are multiplied by the number of comparisons). Means ($M$) and standard deviations ($SD$) are reported. All tests are based on a .05 significance level.

5.3 Results

One hundred children participated in this study, ($n = 52$ boys). One-way ANOVAs did not detect any significant differences between the experimental groups in terms of age ($M = 8.8$ ($SD = 1.1$) years), BMI percentiles ($M = 52.2$ ($SD = 24.6$)), preference for the offered food items (carrots: $M = 2.2$, $SD = 1.1$; beans: $M = 2.6$, $SD = 1.3$; pasta: $M = 1.4$, $SD = 0.7$; chicken: $M = 2.0$, $SD = 1.1$, hunger ($M = 1.6$, $SD = 0.6$) or picky eating ($M = 19.6$, $SD = 7.3$).

To test whether vegetable variety affects the total energy from vegetables (kJ), the means of the energy derived from vegetables were compared between experimental groups (Table 5.1). ANOVA revealed a significant main effect ($F(2, 97) = 5.10$, $P = .008$, $\eta^2 = .10$). The energy derived from vegetables increased significantly when two vegetables were offered instead of only one. Planned contrasts showed statistically significant differences between condition carrots & beans ($M = 64$ ($SD = 51$) kJ) and conditions carrots ($M = 37$ ($SD = 25$) kJ, $P = .018$) and beans ($M = 38$ ($SD = 34$) kJ, $P = .025$).
Table 5.1: Differences in meal composition depending on the experimental conditions (one-way ANOVA).

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Carrots</th>
<th>Beans</th>
<th>Carrots &amp; beans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Total energy from vegetables (kJ)</td>
<td>46</td>
<td>40</td>
<td>37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25</td>
</tr>
<tr>
<td>Total energy from meal (kJ)</td>
<td>759</td>
<td>297</td>
<td>725</td>
<td>282</td>
</tr>
<tr>
<td>Percentage energy from vegetables</td>
<td>7.5</td>
<td>7.9</td>
<td>5.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.5</td>
</tr>
</tbody>
</table>

<sup>a,b</sup>: Means with different superscripts in each row are significantly different (<i>p</i> < .05). Bonferroni post hoc tests were conducted.
CHAPTER 5. EFFECT OF VEGETABLE VARIETY

The same results were observed, when the percentage energy from vegetables was analysed, which indicates that children offered two vegetables served themselves healthier meal.

The variety of vegetables presented did not influence the total energy of the meal \( F(2, 97) = 0.81, P = .448, \eta^2 = .016 \) (Table 1). A visualisation of the proportions of foods served on the plate is found in Figure 5.1.

![Figure 5.1: Visualisation of the plate. Children who were offered two vegetables instead of one chose a more balanced meal, containing a higher proportion of vegetables. (Grams of food were calculated based on the energy per 100 g values derived from the Swissfir nutrient database [15])](image)

The preference ratings for the individual food items were significantly related to the amount of the item that was served (chicken: \( r = .52, P < .001 \), pasta: \( r = .31, P = .002 \), carrots: \( r = .33, P = .001 \), beans: \( r = .57, P < .001 \)). Picky-eating was inversely related to the amount of vegetables scooped (\( r = -.35, P < .001 \)). These results are a measure of face validity for children’s natural behaviour in the experimental setting.
5.4 Discussion

While most children like fruits, they are pickier when it comes to vegetables. Increasing children’s vegetable intake is therefore more difficult. In this study, we show that vegetable variety has the potential to increase the amount of vegetables selected and thereby improve children’s meal composition.

The percentage of energy from vegetable almost doubled from 6% to 11% when two vegetables were served instead of only one. At the same time, the energy of the total meal was not changed, suggesting that children chose a healthier meal containing a higher proportion of energy from vegetables. The result is consistent with our previous findings in adults. In contrast to previous findings with younger children [14], we found a positive effect of offering a choice of vegetables to children aged 7 to 10 years. It might be that younger children are less responsive to food-related cues compared to older children.

The foods chosen for the study were relatively low in energy. If non-vegetable items, which would have been higher in energy density had been chosen, the energy of a meal could have been reduced by increasing the variety of vegetables.

The findings are limited to food choice to a certain extent, as the replica foods were not consumed. Nevertheless, the result that choice can be improved is relevant, because once healthy foods are on the plate, the likelihood that they will also be consumed is higher. The children were asked to choose only foods that they would like to eat, and the amounts of food chosen were related to their preferences. Further, children that were classified as picky eaters based on their mothers’ assessment, chose fewer vegetables. The findings indicate that, overall, the children behaved naturally during the experiment.

Vegetable variety can increase the proportion of vegetables selected in
both adults and children. Serving a bigger variety of vegetables at lunch in school cafeterias or after-school nurseries seems to be a simple and effective strategy to improve children’s food choices. Further research should investigate this within a natural eating environment.
Bibliography


CHAPTER 5. EFFECT OF VEGETABLE VARIETY


Chapter 6

General Discussion
Knowing is not enough; we must apply.
Willing is not enough; we must do.

Johann Wolfgang von Goethe in 'Wilhelm Meister’s Journeyman Years' (1892)

During the last few decades, our food and eating environments have changed. It is widely believed that certain alterations, such as bigger portion sizes or easier access to food, have contributed to the obesity epidemic of today’s society. Various studies have demonstrated that even small environmental cues can have a major impact on food choices and amounts consumed. For example, a pleasant ambience, a bigger plate size or a reduced effort to eat a food, can increase amounts consumed without the consumer being aware of these influences [29, 30, 5].

Although findings about unconscious influences that increase food intake are alarming, recent research has shown that environmental cues can also be used to nudge consumers toward healthier eating. However, investigating environmental influences on food choices is challenging. To assess the effect of a single environmental cue, all other factors need to be kept constant and consumers need to be tested individually to avoid group effects. As a consequence, experiments with real food in natural eating environments take great effort. Studies in this research field are therefore often limited to single food products.

The present work introduced the fake food buffet (FFB) as a new method that allows studying environmental influences on food choices in controlled laboratory settings. In the first study, the FFB method was validated for behavioural nutrition research, and in subsequent studies, it was applied to examine how nutrition information affects consumers’ meal composition and whether vegetable variety can be used strategically to improve children’s and adults’ meal composition.
6.1 Summary and Discussion of the Central Findings

I The Fake Food Buffet Is a Valuable Method for Food Choice Research

Although sometimes used as portion size measures for dietary assessment, fake foods have not been used for experimental nutrition research before. Using fake foods for experimental nutrition behaviour research has many advantages over using real foods; most importantly, study subjects can be tested individually in a controlled eating environment where they can compose meals from a range of replica items that are constant in colour, shape and size.

In the first study of this thesis, the usefulness of replica foods for experimental nutrition research was examined. Two experiments were conducted to assess the reliability and the validity of the method.

In the reliability experiment, participants were invited to scoop themselves a lunch they would like to eat from a FFB containing a small selection of food items commonly eaten at lunch. The same participants were invited again two weeks later to perform the same task. The meals chosen by the participants each time were compared and weights of the individual food items were correlated.

The results of the experiment show that the amounts served are highly correlated, which indicates a good reliability of the method. Also, it was found that served amounts of food were related to an individual’s energy need. This indicates that people behave naturally when they are scooping fake food.

In the second experiment, validity of the FFB was assessed. For this purpose, meals served from a FFB were compared with meals from a buffet containing the corresponding real food items. Participants were invited to scoop themselves a meal they would normally eat for lunch from a buffet.
containing either fake chicken, pasta or beans or corresponding real food items. Two weeks later, the same participants were invited to again select a meal, but this time each person selected from the buffet they had not used last time, real or fake. Subsequently, meals served from the fake and the real food buffets were compared and weights calculated for correlation. Again, very high weight correlations were found between fake and real foods.

Over all, study subjects perceived the replica foods as very realistic and behaved normally during the experiments. It was found that the amount of food people served themselves from the FFB was related to their personal energy requirement, and amounts of individual items served were highly correlated with the preference scores for the corresponding real food products.

The results of these experiments show that the FFB is reliable and valid to be applied in experimental behavioural nutrition research. Further implications and limitations of the method are discussed below. This work formed the basis for the subsequent studies.

II Current Dietary Guidelines Are Not Sufficient to Help Consumers Compose Healthier Meals

Consumers’ motivation, their nutritional abilities and the environment have been suggested as the main determinants of healthy eating [4]. To eat healthily, people should be able to compose a meal that consists of starch-containing products, relatively large amounts of vegetables and fruits and reasonable amounts of meat or protein-containing foods. A certain level of nutrition knowledge is prerequisite to choosing a healthy diet. However, studies have shown that nutrition information is relatively abundant and nutrition knowledge correlates only weakly with healthy eating [12].

The purpose of the second study was to investigate how people compose meals and how they change the composition to make meals healthier. To answer this research question, an experiment was carried out using an FFB
containing 55 replica food items. Participants, who were invited to select a lunch, were given one of the following three instructions: Participants in the control group were asked to select a meal from the buffet that they would like to eat. Participants in the second group were asked to select a meal that they thought would be healthy for them and people in the third group were instructed to select a healthy meal, but they also received nutritional information in the format of a brochure of current dietary advice. The brochure contained recommendations about reasonable portion sizes and an illustration of the Swiss food guide pyramid.

The study revealed that people were able to improve their meals only to a certain extent. Consumers who were asked to choose a healthy meal substituted fruit for the dessert. This strategy to replace unhealthy sweets with fruits appears to have been quite smart, because this way, participants managed to select meals they perceived as healthier but equally tasty. This means they did not compromise on taste.

Participants who were asked to select a healthy meal and received nutritional information in advance did not select different meals than people who were only asked to select a healthy meal. This finding suggests that the information did not help people compose healthier meals. The reason for this might be that the nutritional information in the brochure was too difficult to translate into practice.

Interestingly, the chosen proportions of meat, starchy foods and vegetables, which constitute the main course, did not differ among the experimental groups. The question remains whether a more applied type of dietary guideline such as the plate model\textsuperscript{1}, would be effective to nudge people composing meals toward a higher proportion of vegetable.

In this study, an extended FFB was used. It must be noted that the

\textsuperscript{1}The plate model is a schematic representation of how a balanced main meal should be composed. In Switzerland, the optimal plate is filled with 1/5 meat or protein containing products, 2/5 starchy foods such as pasta and 2/5 vegetables. [13].
method was validated only for four specific fake food items. Therefore, absolute energy values derived from single products should be interpreted with care. Also, the study population consisted mainly of staff and students from the university. Higher baseline knowledge might bias results to a certain extent. It is possible that the information would have had a beneficial influence on a study population with very low nutrition knowledge. However, it was found that participants in the group that received it did not choose different meals, although their nutrition knowledge increased significantly compared to the groups that did not read the information.

This study demonstrates that the effect of certain types of nutrition information might be limited when it comes to translating it into practice. When people aim to choose a healthy meal, they replace dessert with fruit rather than changing the amount of vegetables, starchy food or meat that constitutes the main course. To help people compose healthy meals, nutritional information should increase consumers’ procedural nutrition knowledge, which refers to the practical information that helps people make nutritious choices in everyday life. Factual knowledge about ingredients or nutrients might be helpful, but to eat healthy in a food environment where most of the meals are consumed away from home, consumers need to be able to identify healthy options in cafeterias, create balanced meals from buffets and identify healthy convenience and snack products. Which types of information help the consumer achieve these goals remains to be examined by further research.

III Variety is an Environmental Factor That Can Improve Adults’ and Children’s Food Choices

The environment has a major impact on what and how much we eat. Food variety was shown to increase consumed amounts in several experimental studies. So far, however, no study had looked at the influence of variety
on the composition of a meal. As variety seemed to be effective to increase the intake of unhealthy foods such as candies, we hypothesised that variety within the healthy choices might be strategically used to improve a meal. As evidence for the health benefits of high fruit and vegetable intake is substantial [28, 2, 11, 21], increasing the intake of these foods is a key goal of various public health campaigns. Children are often the target population of these campaigns, as studies have shown that eating habits established at a young age are often maintained throughout life span [25, 17]. Therefore, many public-health interventions aim to increase fruit and vegetable intake in children. A higher variety of vegetables was proposed as a promising strategy to increase the intake of these foods in children [18].

To examine the effect of vegetable variety on the composition of a meal, two experimental studies using the FFB method were conducted. In the first study, participants were invited to select lunch from a buffet with either one vegetable (carrots or beans), or two vegetables (carrots and beans). Meals composed by participants were then compared by the experimental condition. Results showed that, indeed, variety was effective in increasing vegetable selection in adults. But more interestingly, the overall energy content of the meal was not altered, which means that participants chose a higher percentage of energy from vegetables, and served themselves a healthier meal [7].

The results of this study show that variety is very promising as a way to improve consumers’ lunch choices in public settings such as work cafeterias. Meanwhile, findings of this study were confirmed by a very similar experiment conducted with real carrots, peas and broccoli in a laboratory setting [20].

For preventive reasons, an increase in vegetable consumption would be even more desirable in a younger population. However, it was not clear whether children are responsive to food-related cues to the same extent
that adults are. Previous research has shown that appetitive traits related to higher satiety tend to decrease with maturation, while those associated with food responsiveness increase [1].

To examine whether variety is effective at increasing vegetable choice in a population of school-aged children, a second experimental study with a similar setting was conducted. Children aged 7 to 10 were invited to scoop a lunch they would like to eat from one of three possible fake food selections. As had the adults in the first experiment, the children received a selection of foods with either one vegetable (carrots or beans) or two vegetables (carrots and beans). When the meals were compared by the experimental conditions, it was found that vegetable variety had a similar effect on the children’s meal composition as it had on the adults’ choices. Children chose more vegetables when they were offered two instead of only one. At the same time, they did not increase the amount of calories served, which indicates that they chose a healthier meal with a higher proportion of energy from vegetables. In terms of volume, the amount of vegetables served almost doubled from 6 to 11 percent. Even children who were classified as picky eaters based on their mothers’ assessments chose more vegetables.

These findings are important, because serving an increased variety of vegetables as side dishes might be a very simple strategy to increase a child’s vegetable intake without pushing the intake of disliked foods [6]. In contrast to previous findings with younger children 4–6 [33], the data showed a positive effect from offering a variety of vegetables to children aged 7–10. It might be that children younger than this are less responsive to food-related cues compared to older children [1].

Variety influences consumers’ choices unconsciously. The two studies showed that vegetable variety is a very promising environmental cue that can improve meal composition. The applicability of intervention remains to be tested in real-world settings such as school and office cafeterias or homes.
How Does Variety Affect the Consumer?

The question of how the variety effect works remains open to a certain extent. Early studies conducted by Rolls et al. hypothesised that variety would increase consumption by a reduction of sensory-specific satiety. The phenomenon of so-called sensory-specific satiety refers to a declining satisfaction generated by consumption of a certain type of food and subsequent renewal of appetite upon exposure to another, still-palatable food [24, 23]. Later studies in which M&M candies were offered in 10 instead of 7 colours demonstrated that even perceived variety can increase consumed amounts [16]. This suggests that if the variety effect acts through a specific sense, visual perception of variety seems to be sufficient. Visual variety might be effective at the moment when consumers select food and must decide among alternatives. The wish to try a little bit of each of the foods available probably seduces people to scoop more food at a buffet.

Therefore, it is possible that variety first increases amounts served and subsequently elevates amounts consumed because of the tendency to finish food already on the plate [29]. Whether this hypothesis holds true remains to be tested in future research. A study conducted by Zeinstra et al., in which 4–6-year-olds were given two instead of only one vegetable [33], did not find an effect of vegetable variety on intake. It is possible that in that study consumption was not increased because the children did not serve the vegetables themselves. However, the subjects in that study were younger than the ones in the current study. It might be that children younger than 7–10 are less responsive to food-related cues. Also, younger children might be less likely to continue eating once they are satiated [1].
6.2 Limitations and Methodological Issues

The results and conclusions of the presented studies should be interpreted respecting certain limitations.

Experimental Study Design and Study Population

People who participated in these experimental studies were not randomly recruited from the general population. Participants (except the children in study 4) were mainly university students and staff. It can be assumed that the education level and baseline nutrition knowledge was higher in this group compared to the general population. However, random assignment of participants to experimental conditions should have controlled for potential differences among study groups. There is no indication that environmental influences should have a different effect on populations with a higher education level. In study 2, which investigated the effect of nutrition information on choices, a significant gain of nutrition knowledge was found in the intervention group.

Fake Food Buffet Method

There are certain constraints to the FFB method that should be acknowledged. Replica foods are not consumed, which limits findings derived by the FFB method to choices. Although there is a tendency by the consumer to ’empty the plate’, amounts consumed might differ from amounts served. The habit of emptying the plate might also depend on age, parenting style, education and culture.

It should be mentioned that the FFB method was validated for four food items only. Validity of food items probably depends on similarity of the fake foods to their corresponding real food items. In study 2, a buffet containing 55 items was used for the experiment. Although replica products looked very
authentic and were recognised by the study subjects, only limited statements about food groups were made. No conclusions about calories from single food items were derived.

The weight of the fake food products is not equal to the weight of real food items and conversion factors were calculated to estimate the energy content of fake food items. The replica foods are cast from polyvinylchloride, which has a density similar to that of water. Most of the fake foods have a weight comparable to their corresponding real foods, but some do not. It is possible that certain individuals take the weights of the foods as an intuitive reference during the serving process. It has been shown, however, that visual cues are major determinants when people choose food [31].

The validity of the FFB was not assessed for experiments with children. However, children did not seem to have any difficulties with pretending the fake food was real. In fact, many children did not believe that the food items were fake in the first place. Also, our finding that preference and picky eating were related to the amount of the foods served (e.g. children that did not like vegetables did not take vegetables) indicates that the children behaved naturally during the experiment.

The FFB is useful for experimental research in which group comparisons are of interest, but its use for application in general dietary assessment, for which a full range of food products would be desirable, might be limited because the buffet represents a small selection of food items, which is not representative of all the foods available in real life.

Finally, it must be noted that the selection of replica foods for a buffet is biased by the experimenter. The items for FFB experiments must be chosen very carefully. The range of convenience products and unhealthy snack items available as replica foods is limited. However, healthy and unhealthy food items and different food categories within an FFB should be balanced. Therefore, the FFB might also be complemented with certain
common convenience and snack items, such as packets of ketchup, salad dressings or crisps.

6.3 Integration of the Findings and Future Research

The food and eating environments, consumers' motivation and abilities have been suggested as the main determinants of healthy eating. [4]. To date, most effort in the public-health sector still targets the consumer. For decades now, public-health campaigns have tried to motivate people to make healthier food choices mainly through education. Information about healthy nutrition is abundant, and most people in Western countries have a basic knowledge about healthy eating and are confronted with different kinds of nutrition information. However, as the results in these studies showed, certain types of information might not help people choose healthier meals.

Even though the strength of the environments’ influence on food choices was recognised some time ago, little effort has been invested in how it could be changed to promote healthy eating, most likely because investigation of environmental cues on food choices requires so much effort.

In this work, a new method was presented that facilitates the examination of environmental influences. The FFB was applied to demonstrate that the effect of nutrition information might be limited in a population with basic knowledge about healthy eating and to demonstrate that variety is a promising environmental cue that can be used strategically to improve adults’ as well as children’s food choices.

Consequences for the Research Field

The FFB method can overcome several limitations and issues that emerge in studies using real food items. Experiments conducted with fake foods
are inexpensive, subjects can be tested individually and the composition of meals containing multiple components may be assessed with relatively little effort.

Besides its applications in these studies, the FFB can be used to answer further research questions. Other environmental influences, such as ambience (lighting, temperature, music), food colouring and shape, positional arrangement, the effect of serving utensils, plate or portion sizes, can be examined for their effects on meal composition and their potential to improve choices.

In the second study (Chapter 3), it was found that current dietary guidelines, including the food-guide pyramid, did not help the consumer choose a healthy meal. To assist the consumer in choosing a healthy meal, nutrition information must be reduced to actionable knowledge. The FFB method is useful to assess practical nutrition abilities (procedural knowledge [32, 10]) of different consumer groups, such as children, adolescents, obese people, elderly people or restrained eaters. The method can be applied to investigate how distinct nutrition information formats (e.g. graphic representations of healthy portions or labels) affect choices and meal composition. Simple formats, such as the plate model, in which healthy proportions of the main food groups are represented, could be tested for their effects in a similar experimental setting as used in Study 2.

Further, the FFB facilitates experimental studies with more challenging population groups, such as younger children, who cannot fill out questionnaires and often have difficulties recalling food products. As fake foods are not meant to be consumed, certain ethical considerations (like giving children unhealthy food products) can be overcome.

Potential applications of the FFB are numerous. However, future research should also combine fake food experiments with field studies. Cues that are found to affect consumers’ choices need to be examined further.
in natural eating environments. Natural test settings such as cafeterias or restaurants are very volatile: Factors such as temperature, weather, season or type of customers might not be constant. However, if an effect previously found in the laboratory can be confirmed in a natural environment, it is likely to be robust and promising for intervention.

**Nudging Consumers Toward Healthier Choice**

Finally, a statement about nudging, which is also referred to as *libertarian paternalism*\(^2\) In the broadest sense, nudging means to design the environment in a manner that alters people’s behaviour in a predictable way without forbidding options [26]. The term ‘nudging’ was coined by a book of the same title by Thaler and Sunstein [26].

As did previous studies, the presented work showed that people’s choices are influenced by environmental factors. Environmental alterations, such as changing defaults, have been recognised as powerful tools to guide decisions. For the sake of public health, the concept of nudging people has recently been taken up by governments in the U.S., the U.K. and France [27]. How paternalistic approaches might be applied to change health behaviour it’s a controversial discussion \(^3\). Such discussion is beyond the scope of this work. However, nudging requires the existence of an expert or an authority with superior knowledge. To date, though, few nudging interventions have been evaluated for their effectiveness in changing behaviour in the general population and it is simply not known whether a behavioural change is sustained [19].

Some studies suggest that misapplying environmental alterations might even be harmful. It has been shown that labelling foods as healthy can lead to a ‘halo’ effect, resulting in underestimation of the energy content and

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\(^2\)The term ‘libertarian paternalism’ is an oxymoron to a certain degree. For a debate on the topic see S. Vallgarda [27].

\(^3\)For further discussions on this topic, see [27, 14, 15, 3, 22].
resulting in unintended overconsumption [8]. Also, adding a healthy side dish could have an unintentional effect. In one study, consumers estimated that an unhealthy food, for example, a cheesesteak was lower in energy when a healthy side dish was added. Alarmingly, this effect was strongest among people concerned about managing their weight [9].

Environmental interventions are promising, but it is not evident under what circumstances and for whom nudges are effective. Clearly, in this area more research is necessary.

6.4 Conclusion

Knowledge and motivation alone are not sufficient to change health behaviour. The food and eating environments have major impact on what and how much is consumed. How the environment affects choices and how distinct alterations can be made to increase healthy food choices needs to be examined in laboratory settings as well as in natural eating environments.

The FFB is a reliable and valid method to assess environmental influences under controlled conditions. Vegetable variety is an environmental cue that has the potential to improve meal composition in adults and children. Further studies need to be conducted in natural settings to examine the robustness of the effect in real life and the sustainability of interventions aimed at improving consumers’ diets.
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Summary

Motivation, consumers’ abilities and the food and eating environments have been suggested as the main determinants of healthy eating. To date, most effort in the public-health sector targets the consumer. Public-health campaigns try to motivate people to make healthier food choices, mainly through education. Information about healthy nutrition is abundant and most people in Western countries have a basic knowledge about healthy eating; yet, obesity rates continue to increase.

During the last few decades our food and eating environments have changed. It is widely believed that unfavourable alterations in our food and eating environments, such as bigger portion sizes or easier access to food, have contributed to the obesity epidemic in today’s society. Studies have shown that small environmental cues can have major effects on food choices and amounts consumed without the consumer being aware of these influences.

Comparatively little is known about how environmental cues might be altered to promote healthy choices. Most likely, this is because investigating environmental influences on food choices is challenging. To assess the effect of a single environmental cue, all other factors need to be kept constant and consumers need to be tested individually.

The current work introduced a new method that allows study of environmental influences on food choices under controlled laboratory settings. In the Fake Food Buffet method, consumers are invited to select meals from
a buffet of very authentic replica foods.

In the first study, applicability of the FFB method for nutrition behaviour research was assessed. The validity was confirmed by comparison of meals served from the FFB with meals served from a buffet with corresponding real food items.

In the second study, the FFB method was applied to demonstrate that current dietary guidelines are insufficient to help consumers compose better meals.

The third and fourth studies investigated whether an increase in vegetable variety can improve the meal composition of children and adults. It was shown that meals selected from an FFB contained a higher proportion of vegetables when two instead of only one vegetable was offered.

The FFB is a reliable and valid method with a broad range of possible applications. Besides the study of environmental influences on food choices, it can be used to examine nutrition knowledge and nutrition-related abilities in different populations. Findings gained by using the FFB can be directly applied to promote healthy eating and to improve current dietary guidelines.
Zusammenfassung


In den letzten Jahrzehnten hat sich unsere Essumgebung verändert. Experten sind sich einig, dass gewisse dieser Änderungen wie zum Beispiel die Zunahme der Packungsgrössen oder der einfachere Zugang zu Nahrung, mit zur Übergewichtsepidemie der heutigen Gesellschaft beigetragen haben. Experimentelle Studien haben gezeigt, dass bereits relativ kleine Veränderungen in der Essumgebung einen grossen Einfluss auf die konsumierte Menge haben können, ohne dass der Konsument sich dieser Einflüsse bewusst ist.

Darüber, wie Änderungen in der Umgebung eingesetzt werden können, um ein gesundes Essverhalten zu fördern, ist vergleichsweise wenig bekannt. Wahrscheinlich auch deshalb, weil die Erforschung von Umgebungs einflüssen auf die Ernährung sehr aufwändig ist. Um den Einfluss eines Faktors auf die Lebensmittelwahl experimentell untersuchen zu können, müssen alle anderen Einflüsse konstant gehalten werden und Versuchspersonen müssen separat getestet werden können. In der vorliegenden Arbeit wird eine neue
ZUSAMMENFASSUNG


In der ersten Studie wurde die Anwendbarkeit der FFB Methode in der Ernährungsverhaltensforschung geprüft. Durch einen Vergleich von Mahlzeiten, welche vom FFB gewählt wurden, mit Mahlzeiten, die von den entsprechenden echten Lebensmitteln gewählt wurden, konnte die Validität belegt werden.

In der zweiten Studie wurde die FFB Methode angewendet, um zu zeigen, dass gängige Ernährungsempfehlungen den Konsumenten nicht dabei helfen, gesündere Mahlzeiten zu wählen.

In Studie drei und vier wurde untersucht, ob eine höhere Gemüsevielfalt die Zusammensetzung der Mahlzeiten von Kindern und Erwachsenen verbessern kann. Es konnte belegt werden, dass Mahlzeiten, die von einem FFB gewählt wurden einen höheren Anteil an Gemüse enthalten, wenn zwei Sorten Gemüse anstelle von nur einer angeboten wurden.

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