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Healthy diet: Health impact, prevalence, correlates, and interventions

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Objective: To discuss healthy diet from a psychological perspective by considering definitions of healthy diet in terms of consumer understanding; the health effects of specific dietary elements in terms of overweight and (chronic) illness; the prevalence of healthy diet; the psychological and environmental determinants of healthy diet; and the psychological interventions that have been designed to promote healthy diet.
Design: A systematic review of the psychological literature on healthy diet.
Results: Our findings suggest that consumers have a relatively poor understanding of a healthy diet. The literature also demonstrates that there is poor evidence on the health protective effects of single foods or nutrients. We further show that low SES is the single consistent risk factor for not adhering to a healthy diet. Our review of the literature on determinants demonstrates that intentions, habits, self-regulatory skills, and the social and physical environment are the most important determinants of a healthy diet, which are in turn amenable to change by intervention strategies with varying levels of effectiveness. Educational interventions generally show a limited effect on practising a healthy diet whereas interventions targeting habitual behaviour and/or the physical environment seem more promising.
Conclusions: In view of the large number of people who are concerned about their diets and make attempts to change their dietary patterns, we conclude that it is crucial to gain a better understanding of both the automatic and environmental influences that are responsible for people not acting upon their good intentions for diet change.

Keywords: healthy diet; consumer perception; healthy diet communication; dieting; interventions

Introduction

Eating and food are important to people. Even when we are not actually consuming food, thinking about food and longing for food play a key role in our lives with people making more than 200 food decisions daily (Wansink & Sobal, 2007) and food desires making up about one-third of our desires during the day (Hofmann, Baumeister, Förster, & Vohs, 2012). Evolutionarily, people have evolved to like eating because it is significant for survival (Pinel, Assanand, & Lehman, 2000). In addition to its biological

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function, eating is also a principal social and cultural activity that people tend to enjoy for aesthetic or communal reasons (Cornil & Chandon, 2016; Rozin, 1999). However, food is no longer a sole source of pleasure and enjoyment nowadays, but has increasingly become a cause of concern because of its potential consequences for ill health. The prime reason for such concern has been the growing epidemic of overweight resulting from our obesogenic environment with plenty of cheap and high caloric foods available at any place any time (Swinburn, Egger, & Raza, 1999). A substantial proportion of the population worldwide, including children and adolescents, is now overweight, with far-reaching consequences in terms of increased risk of chronic illness (World Obesity Federation, 2014). The overweight epidemic has spurred research into the health consequences of overeating and overweight, and information about this has found its way to the general public that now tends to associate eating with health, especially in the US (Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999).

In the present review, we will discuss eating from a health psychology perspective. In particular, we will discuss why and how people regulate their food intake while taking into consideration the health consequences of this behaviour, either as interpreted by health professionals or by themselves. Considering that people may eat for many other reasons than for improving their health (Verhoeven, Adriaanse, De Vet, Fennis, & De Ridder, 2015), we will from this point onwards use the term 'diet' when people eat for health reasons. By diet we mean a pattern of food intake that meets certain demands that are relevant to weight or health. Diet is different from eating behaviour which we consider as a more unconstrained behaviour that may be guided by individual habits or ingrained social and cultural standards but not so much by distinct requirements. In view of such requirements, people cannot afford to simply eat what is on their plate or what they like, but have to base their food choices in consideration of the health consequences, including weight status. In other words, they have to regulate their food in view of a short-term or long-term health goal. The psychological literature on self-regulation has documented that this is not an easy task, especially because health goals may be forgotten in the heat of the moment, as when one is standing face to face with a delicious chocolate cake (Mann, De Ridder, & Fujita, 2013).

This review is organised in six sections. We will first discuss which kind of eating patterns are defined as a healthy diet, how these insights are communicated to the public, and the public's understanding of professional recommendations for healthy diet. Second, we discuss what is known about the effect of certain nutrients and foods on weight status and health. Third, we will discuss how many people and the type of people who are able and willing to regulate their food intake from a health perspective and adhere to recommendations for healthy diet. Fourth, we continue with an overview of psychological and environmental determinants of healthy diet. Fifth, we consider psychological interventions that have been designed to improve healthy diet. The sixth and final section identifies issues that stand out for future research on the psychology of healthy diet.

Definitions of healthy diet

A healthy diet can be defined as a pattern of food intake that has beneficial effects on health or at least no harmful effects (Stevenson, in press). Although it has proven difficult to specify the exact nutritional elements that contribute to health, as we will discuss in the next section, there is consensus about the essential features of nutritionally poor

quality diets. These are characterised by higher intakes of processed foods, sugar-sweetened beverages, trans and saturated fats, and added salt and sugar, and lower intakes of fresh fruits, vegetables, nuts and whole grains (Willett, 1994; Wirt & Collins, 2009). However, as it has proven difficult to establish a firm body of empirical evidence about the *specific* elements of a healthy diet, governmental expert panels who are responsible for communication of nutritional guidelines to the general public tend to derive recommendations from observational studies (Ioannidis, 2013; Truswell, 2005).

What then does advice for a healthy diet generally entail? Although the specific foods or nutrients that are part of advice to the public may vary, recommendations are very similar over countries (European Food Information Council [EUFIC], 2009; Food & Agricultural Organization of the UN, 2016; https://health.gov/dietaryguidelines/2015/guidelines/). Eighty-three countries have installed official dietary guidelines (Food & Agricultural Organization of the UN, 2016), which generally call for a varied and balanced diet (named in 80% of the guidelines) that is high in vegetables and fruits (94%), and low in fat (93%), sugar (86%) and salt (96%). Healthy diets are also rich in polyunsaturated fatty acid, whole grains and fibre, low-fat or non-fat dairy, fish, legumes, and nuts and low in refined grains, and saturated fatty acids. Guidelines may differ in their advice regarding the consumption of (red or processed) meat (24%), alcohol (54%) and dairy (specifically recommended in the Netherlands), probably relating to the national food culture, as do recommendations regarding food safety (51%) and sustainable food choices (3%). A review of European guidelines concluded that dietary recommendations are still insufficient given disagreement on how to group foods (Montagnese et al., 2015). The way in which these guidelines are communicated also varies greatly (Food & Agricultural Organization of the UN, 2016). Some countries provide very short, simple and broad messages, while others give detailed advice, including information on specific quantities or the frequency with which food should be eaten, sometimes even tailored to specific groups (e.g. pregnant women, adolescents, the elderly). Some countries only present a visual food guide (in the form of a pyramid [most popular], a wheel, a house, a cooking pot, a plate, stairs or, in China, a pagoda), either or not accompanied by top level messages, whereas others use simple messaging supported by a report describing the evidence on which the recommendation are based upon. Overall, developers of healthy nutrition advice seem to struggle with striking a good balance between providing reliable and detailed information about which foods in what quantities are (un)healthy (which is a complex task given the discrepancies in the scientific evidence for the health effects of foods) and reducing the complexity of how this information is communicated to the general public (sometimes resulting in vague recommendations, such as 'eat a balanced diet'). Nevertheless, there is much attention given to providing information in an easy-to-comprehend way (e.g. the widespread use of visual attributes in all kinds of forms) that may increase the understanding of a healthy diet, but not so much attention to the way consumers can adhere to advice on healthy diets, such as where, when and how they should implement advice in their daily lives (De Ridder, De Vet, Stok, Adriaanse, & De Wit, 2013). Communication of advice for healthy diets is also hampered by information released by diet gurus on the internet as well as personal communication of opinions about foods on social media, which some people tend to trust better than professional advice (according to a survey in a sample of 1063 participants representative of the Dutch population; Netherlands Institute for Public Health & the Environment [NIPHE], 2016).

Consumer perception of healthy diet

In view of the (oftentimes) complex information about healthy diet that is released by professional and governmental bodies, the public understanding of healthy nutrition is remarkably accurate and reflects the headlines of dietary guidelines. In a survey amongst 14.331 European consumers, balance and variety, low fat, more fruit and vegetables, and variety and fresh foods were the most mentioned aspects of a healthy diet (Lappalainen, Kearney, & Gibney, 1998). Similar findings were reported in a review of 38 international studies, naming vegetables and fruit, less meat, low levels of fat, salt and sugar, and balance, variety and moderation as essential elements of a healthy diet by many consumers (Paquette, 2005; see Lake et al., 2007; and Povey, Conner, Sparks, James, & Shepherd, 1998 for similar findings). Notwithstanding their accurate replication of the essentials of healthy diet in terms of recommended foods, many consumers think of nutritional recommendations as confusing and complex (Boylan, Louie, & Gill, 2012). This may be one of the reasons why Michael Pollan's #1 New York Times best-seller on food rules (2009) is so popular: it gives concrete and do-able advice such as 'Eat your colors', or 'Sweeten and salt your food yourself'. Perhaps in response to what consumers consider confusing and complex information, they do not only rely on professional guidelines, but find their information on the internet as well. The previously mentioned Dutch survey reported that 28% of consumers turn to friends and relatives for information about healthy diet and another 45% navigates the internet for information (NIPHE, 2016). Because of the large amount of information coming from a variety of media, it becomes more difficult to distinguish scientifically proven food facts (if any) from misinformation about healthy food choices (Evers & Carol, 2007). This may lead to consumers getting puzzled about healthy diet and at least for part of them to indifference to healthy eating. It is also problematic that whereas at least a significant proportion of the population has sufficient knowledge about the elements of a healthy diet, this does not necessarily mean that they actually eat a healthy diet. In the aforementioned survey amongst European consumers it was found that a majority of participants believe they do not need to alter their diets, because they perceive them to be already healthy enough. Furthermore, a lack of knowledge about nutrition was not a commonly cited barrier to healthy eating. The problem facing consumers may not, therefore, be a lack of knowledge, but rather how nutritional guidelines pertain to themselves (Lappalainen et al., 1998). Findings from the Netherlands illustrate the gap between knowledge and practice, with about 85% of the Dutch people reporting to be familiar with the Wheel of Five (Healthy Foods) but only 38% saying they adhere to it whereas estimates of actual adherence are even lower (about 10%) (NIPHE, 2016). Thus, whereas information about healthy diet is available to consumers, it is often regarded as complicated and not-so-easy to implement, even if consumers have digested this knowledge. In sum, the research evidence suggests that knowledge about healthy diet is insufficient for actually practicing a healthy diet.

Summary and conclusions

Although there is consensus about the features of an unhealthy diet, there is less agreement on the exact elements of a healthy diet. As a result of inconsistent findings on the health effects of specific foods, communication of healthy diet to the general public is

complex although a substantial amount of healthy diet education manages to focus on the headlines of a healthy diet, which many people are able to replicate but nevertheless fail to implement in their daily lives.

Health impact of healthy diet

Many people tend to associate eating with health these days and information about the health consequences of certain foods is ubiquitous both in lay blogs and professional guidelines. In view of this widespread information of the health consequences of food, the actual scientific evidence for protective or harmful effects of specific nutrients or foods is surprisingly weak or mixed, and in many cases subject of heavy debate amongst researchers. When reading syntheses of the existing literature, such as those made by the Cochrane group that has produced more than hundred reviews on nutrition and health, it becomes obvious that there are very few robust effects of single nutrients or single foods on health (either positive or negative) with cautious conclusions in terms of 'modest benefits/harmful effects are observed although more evidence is required to confirm this' in most cases. This even holds for the classic major culprits of an unhealthy diet such as sugar, fat and salt, and for the classic recipe for a healthy diet in terms of fruits and vegetables.

Sugar, fat, salt

The suggestion that *sugar* might have adverse health effects has been a recurring theme for decades, with claims that high intake may be associated with an increased risk of conditions as diverse as obesity, cardiovascular disease, diabetes and some cancers. A recent meta-analysis (Te Morenga, Mallard, & Mann, 2013) commissioned by the WHO and following Cochrane guidelines, concluded that in trials of adults with ad libitum diets (i.e. with no strict control of food intake), reduced intake of so-called free sugars (particularly from sugar sweetened beverages) was associated with a slight decrease in body weight (.80 kg) while increased sugar intake was associated with a comparably modest weight increase (.75 kg) over the course of 10 weeks. The data from this meta-analysis further show that the change in body fatness results from an alteration in energy balance rather than from metabolic consequences of sugar consumption, suggesting that the health risks of overconsumption of sugar primarily lie in increasing the risk of overweight rather than having a direct impact on risk of chronic illness. A recent Cochrane review on the health impact of *fat* suggested a small but potentially significant reduction in cardiovascular risk (by slightly lower weight) when people (both low risk and high risk population groups) replace saturated fat by unsaturated fat (although the ideal type of unsaturated fat remained unclear) and concludes that reduction of total fat intake does not lower cardiovascular risk (Hooper et al., 2012). A Cochrane review of the health benefits of *salt* reduction was even more cautious and concluded that cutting down on the amount of salt had no clear benefits in terms of reducing the risk of cardiovascular disease, although the authors suggest that reformulating processed foods with less salt by the food industry might have beneficial effects as compared to encouraging the population to use less salt at the table and in home cooking (Adler et al., 2014).

Fruits and vegetables

Modest effects have also been reported on the health protective effect of one of the cornerstones of healthy diet, the consumption of *fruit and vegetables*. In a meta-analysis of 10 randomized controlled trials (six examining the provision of fruit and four trials examining dietary advice to increase fruit and vegetable intake), a Cochrane review failed to find evidence of reduced risk of cardiovascular events or beneficial effects on blood pressure and lipid levels within one year, suggesting an absence of direct health benefits when people eat more fruits and vegetables (Hartley et al., 2013).

Problems with assessing health effects of nutrition

These weak health effects may come as a surprise. However, Cochrane type of reviews on nutrition and health have been criticised and two major reviews on fat and salt were not adopted by expert committees because the conclusions were not accepted (Truswell, 2005). It has been argued that Cochrane type of synthesising the knowledge on health effects of nutrition is inadequate because randomised controlled trials of diet change usually focus on the addition or removal of one single component, with modest overall effects on health as a result. Indeed, it seems that every single nutrient imaginable has peer-reviewed publications associating it with almost any possible health outcome, often suggesting that just a couple of servings a day of the specific nutrient would be able to significantly decrease the risk of ill health – which are subsequently refuted in an attempt at replication (Schoenfeld & Ioannidis, 2013). Trials with whole diets are rare for obvious reasons. It is hard to imagine a trial in which half of a large group of people would agree to avoid vegetables for five years to see who will develop cancer (Truswell, 2005). Observational cohort studies which have a more ecologically valid design are not the answer, however, as they suffer from limitations as well, including the absence of control groups and flawed registration of food intake (Archer, Hand, & Blair, 2013) – even in the case of more sophisticated assessments such as camera, mobile or biochemical records (Illner et al., 2012). In fact, with both types of designs – observational studies and randomised controlled trials – it has proven very difficult to find robust effects of modest changes in nutrient intake on health outcomes beyond major nutritional deficiencies. Common problems are small samples, lack of long-term follow-up, and neglect of psychological or social and environmental factors that may influence diet and lifestyle in general. Moreover, many studies have been conducted in high risk populations (e.g. metabolic syndrome) or people suffering from chronic illness, making it difficult to generalise preventative implications of diet to the general population. Altogether, it has proven extremely difficult to draw any definite conclusions about the specific components of a healthy diet on risk factors for chronic illness (Casazza et al., 2013; Ioannidis, 2013). In contrast, results on comprehensive dietary patterns are more encouraging, with the so-called Mediterranean diet as a prime example of a promising candidate.

Mediterranean diet

In recent years, research on nutrition and health has shifted towards a greater emphasis on dietary patterns instead of single nutrients or foods, acknowledging that individuals

eat foods in a variety of combinations that may have interactive and potentially cumulative effects on health status. After all, why would the prototypical 'apple a day' protect your health if you consume lots of fried foods in the evening? In particular, beneficial effects of the Mediterranean diet have been reported (Estruch et al., 2013; De Lorgeril et al., 1999). The Mediterranean diet refers to a collection of eating habits traditionally followed by people in the countries bordering the Mediterranean Sea and typically consists of high consumption of fruits and vegetables, legumes and complex carbohydrates (whole grains), a moderate consumption of fish and low consumption of red meat, olive oil as the main source of fat, low-to-moderate consumption of red wine, and low-to-moderate consumption of milk and dairy products. A recent meta-analysis including >2 million people has suggested a significant protection against chronic illness for people who report a greater degree of adherence to this diet with 6–13% reduction of death and/or incidence of neurodegenerative disease, cardiovascular illness and cancer (Sofi, Abbate, Gensini, & Casini, 2010). These findings were replicated in a Cochrane review, albeit the conclusions were somewhat more modest and call for replication with studies that address the heterogeneity of participants and the number of Mediterranean components included (Rees et al., 2013).

Health risks of overweight

In contrast with the mixed and inconclusive findings on the effect of specific dietary elements on health (with the exception of the Mediterranean diet), the health effects of overweight and obesity – and thus of eating *too much* rather than eating a specific diet – are relatively straightforward and robust. This corresponds with the results from a systematic review of the association between healthy dietary patterns and weight status, suggesting that quantity of intake plays an important role in weight gain (Nutrition Evidence Library of the US Department of Agriculture, 2014). Overweight results from eating too much in combination with low levels of physical activity: when energy intake exceeds energy expenditure, the excess energy is stored in the body as fat mass and when fat accumulation is excessive a person has overweight or obesity, as measured by Body Mass Index (BMI: weight in kilograms divided by height in metres squared), waist circumference, or body fat. In almost all European countries the prevalence of overweight and obesity has increased in the past decades, just like in the US, Canada and Australia (Seidell, 2002; World Obesity Federation, 2014). According to global estimates of the World Health Organization (WHO, 2016), almost two billion adults are overweight (40% of the population), of whom over 600 million are obese, and an estimated 41 million children under the age of five years are overweight or obese. In Europe, the percentage of adults being overweight (excluding obesity) ranges from 36% in the Netherlands and Belgium up to 40% in Spain, and for obesity the percentages range from 10% in the Netherlands and Belgium up to 25% in Italy (World Obesity Federation, 2016). While malnutrition has been the leading cause of global mortality for centuries, nowadays more people die from eating too much rather than too little (Ng et al., 2014). Obesity harms virtually every aspect of health, from shortening life and contributing to chronic conditions such as diabetes and cardiovascular disease to interfering with breathing and mood. It does this through a variety of pathways, some as straightforward as the mechanical stress of carrying extra pounds and some involving complex changes in hormones and metabolism. The condition most strongly

influenced by body weight is type 2 diabetes. A meta-analysis of 89 studies on weight-related diseases revealed that diabetes was at the top of the risk list. Compared with people in the normal weight range (BMI < 25), men with BMIs >30 had a 7-fold higher risk of developing type 2 diabetes, and women with BMIs >30 had a 12-fold higher risk. (Guh et al., 2009). Body weight is also directly associated with various cardiovascular risk factors. As BMI increases, so do blood pressure, low-density lipoprotein (LDL or 'bad') cholesterol, triglycerides, blood sugar and inflammation, increasing the risk for coronary heart disease (Bogers et al., 2007). The association between obesity and cancer is not as clear as that for diabetes and cardiovascular disease and depends on the type of cancer. A meta-analysis suggests direct associations between obesity and cancers of the breast, colon and rectum, endometrium, oesophagus, kidney, ovary and pancreas (Guh et al., 2009). Excess weight has also been linked with asthma and obstructive sleep apnea (McClean, Kee, Young, & Elborn, 2008) and osteoarthritis of the knee and hip, as are back pain and disability due to musculoskeletal conditions (Anandacoomarasamy, Caterson, Sambrook, Fransen, & March, 2008). Finally, overweight and obesity are also related to mental health. A meta-analysis of 15 studies that followed 58,000 participants up to 28 years found that people who were obese at the start of the study had a 55 per cent higher risk of developing depression, while depressed people had a 58 per cent higher risk of becoming obese (Luppino et al., 2010).

Summary and conclusions

There is poor evidence for health protective effects of *single* foods or nutrients. Only comprehensive dietary patterns such as the Mediterranean diet have been suggested to have quantifiable beneficial effects on health. Moreover, direct health effects of specific nutrients and foods may be negligible when compared with the pervasive health effects of overweight which is the result of overeating on all kinds of (primarily high caloric) foods. It should also be noted that many results found in observational studies on nutrition and health have not been replicated in randomised controlled trials with more rigorous designs. Nevertheless, most of American and European government nutritional recommendations are derived from observational studies.

Prevalence of healthy diet

Dietary recommendations are often complex and poorly understood by the general population. In this section, we will discuss how many people actually manage to follow dietary recommendations (quality of diet) and/or restrict their food intake, and who these people are.

Adhering to dietary recommendations

There is compelling evidence that the majority of people from industrialised countries do not meet professional recommendations for eating a healthy diet (EFSA, 2016; Harika, Eilander, Alssema, Osendarp, & Zock, 2013; Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). A telling example is an Australian study in middle-aged women that revealed that only two women in a sample of 10,561 participants met the

13 dietary guidelines that were examined (Ball, Mishra, Thane, & Hodge, 2004). When taking a more lenient approach, about one-third of the participants complied with more than half of the guidelines (Ball et al., 2004). Specifically, many people do not manage to eat sufficient healthy foods, fruit and vegetables in particular. WHO guidelines recommend eating >400 g of fruits and vegetables per day. Dietary surveys assessing food intake in Europe report that the mean fruit and vegetable intake in Europe is 386 g per day (220 g of fruits and 166 g of vegetable); and in about one-third of European countries less than 300 g per day (EUFIC, 2016). Many people also consume too many calories on a daily basis. The mean daily total energy intake amongst US adults increased from 1,803 kcal in the 1970s to 2374 kcal in 2003–2006 (Duffey & Popkin, 2011), which is higher than the recommended 2000 kcal for adult women but not for adult men (2500 kcal). For European samples, the daily intake is estimated to be lower; in UK, for example, 1727 kcal per day in the adult population (National Centre for Social Research, 2012). High caloric intake comes especially from eating snacks in between meals. A representative survey in the US revealed that daily caloric intake from snacks increased from 357 kcal in the 1970s to 579 kcal in 2003–2006 (i.e. about 25% of the recommended daily intake; Piernas & Popkin, 2010). The situation is even worse in US children (2–19 years) for whom the percentage of kcal consumed from snacks per day increased from 24% in the 1970s to 36% in 2003–2006 (Piernas & Popkin, 2011). Another source of high caloric intake comes from beverages. In the US the percentage of intake from beverages significantly increased from 12% in 1965 to 21% in 2002 (Duffey & Popkin, 2007). This represents an overall increase of 222 kcalories per person per day from beverages, largely resulting from sugar sweetened soft drinks (108 kcalories) and alcohol (73 kcalories). It is important to note that there was not only an increase in the percentage of people consuming these beverages, but also in the amount of consumption per person.

Who eats an unhealthy diet?

The low numbers of adherence to dietary guidelines illustrate that it is almost impossible to determine which people eat an unhealthy diet, as almost all people seem to do so. When considering demographic characteristics such as age, gender or ethnic background, no clear pattern emerges from the empirical literature. This even holds for gender, which is generally regarded a distinctive factor in eating a healthy diet. To illustrate, a large European study revealed that men eat different types of food than women (e.g. more red meat and less fruits and vegetables), but the proportion of total energy from macronutrients was found to be similar for men and women (Beer-Borst et al., 2000). Regarding gender differences in overweight and obesity, no clear pattern emerges as well with large differences within and between countries, generally showing that in developing countries (particularly in the Middle East and North Africa) women are more often found to be overweight whereas in industrialised countries men are (Kanter & Caballero, 2012).

SES gradient in unhealthy eating

Only one factor so far has witnessed consistent evidence for eating an unhealthy diet and risk of overweight and obesity: low Socio-Economic Status (SES) in terms of

education level, work status and income. A large body of epidemiologic data illustrates that low SES is associated with unhealthier diet, higher levels of obesity and more diet-related diseases (e.g. Darmon & Drewnowski, 2008; De Irala-Estévez et al., 2000; Hulshof, Brussaard, Kruizinga, Telman, & Löwik, 2003; Mazzocchi, Brasili, & Sandri, 2008; Pechey et al., 2013). SES differences in diet are particularly manifested in food groups rather than in nutrients (Pechey et al., 2013). Large systematic reviews of eating patterns in a number of industrialised countries have demonstrated that lower education and income are associated with the consumption of fewer healthy foods, such as fruits and vegetables (De Irala-Estévez et al., 2000; Giskes, Avendaňo, Brug, & Kunst, 2010; Van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocké, 2011), and lower adherence to dietary guidelines (Hulshof et al., 2003). Lower SES groups also spend more money on unhealthy foods and beverages as was shown in a detailed account of purchasing by SES in 25,000 British households (Pechey et al., 2013). SES family status also affects the food consumption of children. Children (4–13 years) from low SES families consume lower amounts of fruit and vegetables compared to children from high SES families (De Jong, Visscher, HiraSing, Seidell, & Renders, 2015).

The overwhelming evidence for a strong SES gradient in diet quality has been explained by a variety of different underlying mechanisms. First, it is often argued that low SES people have less money to spend and accordingly purchase more unhealthy foods because they are cheaper. It is indeed well established in the literature that foods of lower nutritional value and lower quality diets generally cost less per calorie (Darmon & Drewnowski, 2008) and that people who have less money to spend make food choices based on price whereas people who have more money choose foods based on taste and health considerations (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998). A compelling illustration of the role of price in food choice is that during the economic recession of 2008 when more British consumers turned to foods with lower cost per calorie (i.e. energy-dense foods that are higher in sugar and fats and lower in nutritional value; Darmon & Drewnowski, 2015). A second explanation states that lack of food knowledge and low ability for adhering to nutritional guidelines are important for understanding why low SES is so strongly associated with unhealthy diet. The ability to obtain, read, understand, and use health-related information and to make appropriate health decisions has been referred to as health literacy (Nutbeam, 2000). Low health literacy, including a lack of nutrition knowledge (Spronk, Kullen, Burdon, & O'Connor, 2014), apathy towards nutrition prevention messages (Patterson, Satia, Kristal, Neuhouser, & Drewnowski, 2001), and an erroneous perception of body weight (Jeffery, French, Forster, & Spry, 1991), has indeed shown to be associated with unhealthy diet and overweight in low SES groups. A third and final explanation states that diet and weight status inequalities can be explained by environmental factors, such as neighbourhood differences in the availability of healthy foods (Larson & Story, 2009). Some low-SES neighbourhoods in the US have been characterised as 'food deserts' with low access to fruits and vegetables and high access to fast food outlets (Lang & Caraher, 1998; Powell, Slater, Mirtcheva, Bao, & Chaloupka, 2007). Indeed, the quality of food choices has been shown to be directly influenced by the presence of healthy foods in the close neighbourhood (Darmon & Drewnowski, 2008).

Dieting

Although hard evidence is lacking, it seems that more people are trying to change their diet for the purpose of weight loss rather than for better adherence to dietary recommendations in terms of diet quality (Kumanyika et al., 2000). As a result many people are watching their weight or dieting for weight loss. Dieting, or dietary restraint, has been defined as the intentional and sustained restriction of caloric intake for the purpose of weight loss or maintenance (Herman & Mack, 1975). It is important to note that such a weight loss or weight maintenance goal is not necessarily health related, as people may diet for appearance or other reasons as well (Steptoe, Pollard, & Wardle, 1995). Although dieting is a popular means to regulate one's weight, most people find it difficult to maintain a successful weight loss diet over time (Kumanyika et al., 2000). The majority of dieters manage to lose some weight initially but regain the weight within two years, whereas only a small minority is able to maintain weight loss in the long term (Jeffery et al., 2000; Mann et al., 2007). Notwithstanding the low chances of long-term success, many people engage in dieting. In a representative Dutch community sample it was found that about 60% of the >1000 participants qualified as a dieter according to the norms of the Dutch Eating Behaviour Questionnaire, regardless of gender, age and weight status (De Ridder, Adriaanse, Evers, & Verhoeven, 2014). Another study revealed that about 45% of American adolescent girls call themselves a dieter (Stice, Cooper, Schoeller, Tappe, & Lowe, 2007). In several large-scale studies in American community samples, it was estimated that about 13–44% of men and about 25–65% of women diet (Andreyeva, Long, Henderson, & Grode, 2010). These widely varying prevalence rates may result from time of study as there is an increasing trend in dieting over the past decade (Andreyeva et al., 2010), but also from the one item questions that are typically used to assess dieting in these epidemiological studies (e.g. 'During the past 12 months, have you tried to lose weight?'; Weiss et al., 2006), making it difficult to assess what people actually mean when they call themselves a dieter. It seems that dieting may be more an expression of a desire to lose weight rather than an accurate description of actual restricted food intake as witnessed by epidemiological, observational, and lab studies showing that dieting status is unrelated to consumption (see Stice et al., 2007 for an overview), which may also be the main reason for low chances of dieting success.

Several explanations have been proposed for the poor association between restraint status and actual caloric intake. One explanation suggests that restrained eaters may cognitively *want* to restrict their overeating tendencies, yet they may not be successful in doing so (De Witt Huberts, Evers, & De Ridder, 2013). This aligns with the more general finding that people's good intentions often do not translate into actual behaviour (the so-called 'intention – behaviour gap'; see next section). Another explanation states that dieters are more responsive to external food cues, like the sight and smell of foods, because they try to regulate their food intake by adhering to self-set dieting rules rather than responding to internal hunger signals, which makes them easily abandon their diet goals (Harvey, Kemps, & Tiggemann, 2005). Living in a food replete obesogenic environment confronts dieters with the temptation of high caloric foods on a daily basis, which may contribute to increased risk of diet failure. Thus far, it is unknown under which circumstances dieting – as in intentionally trying to restrain caloric intake – is successful with some studies suggesting that for people with a strong dieting goal

exposure to food temptations may even activate (rather than inhibit) attempts to restrain one's food intake (Fishbach, Friedman, & Kruglanski, 2003) and other studies suggesting that diet attempts are doomed to fail because they rely on effortful inhibition of the desire to eat.

Summary and conclusions

Many people fail to adhere to healthy diet recommendations and eat too much in general and too many unhealthy foods in particular with large numbers of people being overweight or obese as a result. The prevalence of unhealthy diet is widespread and not particular present in specific groups with the exception of low SES being a risk factor for unhealthy diet, overweight and diet-related diseases. Many people hold the intention to change their diets, especially for the purpose of weight loss, but nevertheless fail to maintain changes in their habitual consumption patterns with weight regain within a few years as a result. Insight into the factors that contribute to a maintained successful change of diet is lacking.

Correlates and determinants of healthy diet

In this section, we will provide an overview of key modifiable psychological and environmental factors that affect to what extent people manage to adhere to a healthy diet. By focusing on psychological and environmental determinants, we unavoidably ignore many other relevant factors affecting food intake, such as neurobiological (e.g. Morton, Meek, & Schwartz, 2014) or cultural factors. Although reviewing these factors is beyond the scope of this paper, it is important to realise they do also affect healthy diet, and that they may interact with the determinants discussed below. In addition, we need to emphasise that the determinants we discuss are mostly based on research conducted in adult populations. Lastly, by focusing on modifiable factors, we disregard more stable factors such as personality traits or environmental factors that are not amenable to change (e.g. different types of food may be more easily accessible at different places), nor do we pay attention to economic factors such as the pricing of foods. Although these may certainly also be of importance, an emphasis on modifiable factors is deemed most useful as these are – by definition – the factors that psychologists can target in interventions to promote a healthy diet. Several overall classifications of determinants of healthy diet have been proposed (e.g. Brug, 2008; Stok et al., 2016). Here we focus on the most relevant candidates in terms of reflective influences (e.g. social-cognitive predictors), affective and automatic influences (e.g. habits), self-regulatory skills, and environmental influences.

Reflective influences

One relevant set of determinants is related to people's general preparedness to adhere to a healthy diet. The ultimate factor in this domain is behavioural intention: the extent to which people actually plan to eat a healthy diet. Behavioural intention is the major predictor of (health) behaviour in social-cognitive models (e.g. the Theory of Planned Behavior, Social-Cognitive Theory, and the Protection Motivation Theory). Below we

discuss the empirical knowledge on intentions, while first highlighting three precursors that have been found most relevant: for a person to have the intention to adhere to a healthy diet, he or she should (a) know what constitutes a healthy diet; (b) feel motivated to adhere to a healthy diet; and (c) feel capable of adhering to a healthy diet.

Knowledge

Possessing correct and useful knowledge of what constitutes a healthy diet seems important as it is necessary for allowing people to make the 'right' choices. A systematic review by Guillaumie, Godin, and Vezina-Im (2010) indeed suggests that nutrition knowledge is one of the factors that are most consistently related to healthy diet (in this case, fruit and vegetable intake). Moreover, the review by Shaikh, Yaroch, Nebeling, Yeh, and Resnicow (2008) even reported strong evidence for the effect of knowledge on healthy eating. Less convincing evidence, however, exists for any (negative) relationships between nutrition knowledge and unhealthy food intake, suggesting that knowing what constitutes a healthy diet does not necessarily prevent people from consuming unhealthy products (Spronk et al., 2014). As touched upon in the first two sections of this paper, the nutritional guidelines communicated by official institutions are often complex and do not necessarily provide straightforward directions on *how* to incorporate these recommendations into one's daily diet. In addition, evidence-based nutritional guidelines may get lost amongst the overload of nonscientific, but frequently more appealing advice communicated by popular sources (e.g. diet hypes on social media).

Motivation

Next to knowing what a healthy diet should look like, it is important to consider factors that may affect the extent to which someone appraises nutritional recommendations as personally relevant and feels committed to healthy eating ('this is something I want to do'). Motivation or commitment is for example related to beliefs about the consequences of a behaviour: perceived benefits when someone would adjust one's eating behaviour and/or perceived personal risk of negative consequences if the guidelines would *not* be followed (e.g. Guillaumie et al., 2010). Commitment to healthy eating is further associated with an individual's social identity as a 'healthy eater' (e.g. Strachan & Brawley, 2009) or the internalisation of this behaviour and the values related to it (i.e. intrinsic motivation; Deci & Ryan, 2011). Finally, based on a review of reviews it has been concluded that motivation to eat a healthy diet is associated with attitudes or preferences related to healthy foods, particularly those that are based on expected short-term effects: people tend to eat foods they expect will taste good, and avoid foods they have negative expectations about (e.g. because it tastes bad or made them sick in the past; Brug, 2008).

Self-efficacy

A key social cognitive predictor of eating healthily is a belief about one's own *capability* of adhering to a healthy diet ('this is something I can do'). This is generally referred to as perceived behavioural control, or *self-efficacy.* People may perceive barriers that

reduce their feelings of being able to maintain a healthy diet. Such barriers include lacking the necessary skills to prepare healthy meals, low availability and/or high price of healthy products, or the time and effort needed to cook healthy dishes (Glasson, Chapman, & James, 2011). Indeed, several studies have shown that higher self-efficacy has been associated with higher healthy food intake in various samples (e.g. Fitzgerald, Heary, Kelly, Nixon, & Shevlin, 2013; Strachan & Brawley, 2009), and self-efficacy has been found to be consistently related to fruit and vegetable consumption in two reviews (Guillaumie et al., 2010; Shaikh et al., 2008).

Intention

Beliefs that eating healthily is important, together with possessing the necessary knowledge of how to accomplish this behaviour, may or may not accumulate into actual intentions to eat a healthy diet. By 'intentions' we refer to explicit plans to do so (Gollwitzer, 1999). Typically, out of the rational determinants discussed in this section, intentions are most strongly related to eating behaviour with a meta-analysis report in a medium to large correlation ($\rho = .44$) between intentions and prospective dietary behaviour (McEachan, Conner, Taylor, & Lawton, 2011). One prospective study even showed that (stable) intentions predicted healthy eating over a period of six years, accounting for 9% of the variance (Conner, Norman, & Bell, 2002). Importantly, the more specific one's intention (e.g. 'I plan to eat an apple with lunch' vs. 'I plan to eat more healthily'), the more likely it is to be associated with behaviour. Nonetheless, the relationship between intention and behaviour is not as strong as one may assume. This is most convincingly demonstrated in meta-analytical evidence for the 'intention-behavior gap' (Webb & Sheeran, 2006), which refers to the fact that across behaviours a medium-to-large change in intention only resulted in a small-to-medium change in behaviour (Webb & Sheeran, 2006). The observation that having the intention to eat healthily is not sufficient to impact eating behaviour becomes evident in a review of predictors of fruit and vegetable consumption which reported overall relatively weak ('suggestive') support for the impact of intentions on fruit and vegetable intake (Shaikh et al., 2008). One reason for the discrepancy between intentions and behaviour is that intentions are not necessarily stable: they may be waxing and waning and sometimes even deliberately put aside, for example when someone feels he deserves a nice treat (De Witt Huberts, Evers, & De Ridder, 2012). Another important explanation for the intention-behaviour gap is that rational considerations can be overruled by automatic influences that direct people's choices to unhealthy alternatives. For example, looking at unhealthy food intake, the role of intentions appears overruled by the strength of habits (Verhoeven, Adriaanse, Evers, & De Ridder, 2012). These influences are discussed below.

Automatic and affective influences

In contrast to reflective determinants that require mental effort to be processed (cf., System 2, Kahneman, 2011), automatic influences by definition do not involve effortful processing but are based instead on affect-driven, fast and automatic processes (cf., System 1). While effortful processing is not always available, for example when people are cognitively occupied with other things, the automatic processing system is always

active (Kahneman, 2011). This becomes problematic when automatic influences and reflective considerations do not align towards the same behaviour, i.e. in the context of healthy eating when automatic influences favour unhealthy choices while someone rationally prefers healthier options. At the same time, when healthy eating is supported by automatic processes (such as healthy habits), the 'right' behaviour is all the more likely to occur. We focus on three such important automatic influences on behaviour: habits, implicit preferences and emotions.

Habit

One factor that is most consistently linked to eating behaviour, in particular as a moderator of the intention-behaviour link, is habit. Habits are defined as behaviours that occur frequently and automatically (Verplanken, 2006). This means that people can execute a behaviour (e.g. fill their grocery basket, pick a dessert) without having to deliberate about it. Habits are very adaptive as they allow people to rely on routines instead of having to think about every single decision, which would be undoable if only just considering the estimated number of 200 food-related decisions we have to make each day (Wansink & Sobal, 2007). However, habits become problematic when they do not align with people's rational considerations. For example, someone may have sincere intentions to have a salad instead of his usual burger for lunch, but once he sits at the office cafeteria chatting with his coworkers, he might have already taken his first burger bite before realising he forgot to go for the salad. Research has shown indeed that habits are strong predictors of eating behaviour (Gardner, De Bruijn, & Lally, 2011; Van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011; Verhoeven et al., 2012). In fact, Gardner et al. (2011) concluded that 'habit alone can explain about 20% of variation in nutrition-related behaviors' (i.e. $r = .43$).

Implicit preferences

Although research on implicit preferences is relatively more scarce and less synthesised compared to the work on rational factors, it suggests that people tend to be automatically drawn towards hedonically appealing, unhealthy foods. Such automatic attraction, translating into greater approach motivation, is found especially amongst people who indeed report having trouble adhering to a healthy diet (Stice, Yokum, Bohon, Marti, & Smolen, 2010) while successful dieters do not show such implicit preferences (Gillebaart, Schneider, & De Ridder, 2015; Van Koningsbruggen, Stroebe, & Aarts, 2012). Certain varying states *within* individuals can also have impact on their implicit preferences. For example, it has been shown that after previous exertion of cognitive control (i.e. ego-depletion) people become more strongly oriented towards rewarding, unhealthy foods (Cheung, Gillebaart, Kroese, & De Ridder, 2016). Similarly, so-called visceral states are known to make people more focused on hedonically appealing choice options: hungry people demonstrate stronger approach responses to unhealthy (energy-dense) food as compared to satiated people (Seibt, Häfner, & Deutsch, 2007; Siep et al., 2009). While these findings have not been subject to a meta-analysis, and strong conclusions about the magnitude of their effects cannot be drawn, it is relevant to consider these implicit preferences as 'the other side of the coin', which may (not) align with their explicit preferences or intentions to consume a healthy diet.

Emotions

Emotions are generally considered to be important triggers for both decreased and increased eating (Cardi, Leppanen, & Treasure, 2015). Overeating in response to emotions rather than hunger is also known as 'emotional eating'. Many studies on emotional eating show that emotions indeed lead to overeating in samples with eating disorders. In non-clinical samples, an inconsistent pattern emerges, with some studies showing that emotions lead to overeating, while other studies suggest that emotions are related to decreased eating or do not affect intake at all. A recent meta-analysis of lab studies suggests that induced negative mood (e.g. sadness) caused greater food intake in restrained and binge eaters specifically, whereas induced positive mood (e.g. happiness) triggered greater caloric intake across both non-clinical and problematic eating samples (Cardi et al., 2015).

Regulatory influences

Given the potential dilemma between rational considerations and automatic influences, for people to adhere to a healthy diet it seems important to be able to limit the impact of automatic forces that steer towards unhealthy but attractive choices either by using their executive control resources (Hall, 2012) or by using smart self-regulatory strategies that do not require effortful control such as planning, monitoring or stimulus control. Meta-analytic evidence has shown that the role of trait self-control in eating behaviour is modest (i.e. a small overall effect of $r = .17$) as compared with its role in other types of behaviours (De Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). In contrast, the scarce evidence from syntheses on self-regulatory skills points to a promising role of using such strategies in implementing a healthy diet. For example, a review showed consistent positive associations of self-monitoring dietary intake with reduced consumption and weight loss (Burke, Wang, & Sevick, 2011), and various studies have shown that the extent to which people engage in action planning (i.e. planning specific actions or preparatory behaviours to reach the target behaviour) is associated with both healthy and (inversely) unhealthy food intake (e.g. van Osch et al., 2009). Moreover, teaching such self-regulatory strategies to people who do not spontaneously use them can lead to beneficial effects on food intake, as we will discuss in the section on interventions.

So far, this section has highlighted how the interplay between rational and automatic influences, which is moderated by regulatory factors, affects dietary choices. However, all three factors discussed above can in turn be influenced by external sources (i.e. social or environmental influences) that may either downplay or contribute to long-term rational considerations regarding healthy eating, drive an individual towards either healthy or unhealthy choices through automatic processes, and scaffold or hinder regulatory strategies.

Environmental influences

Social environment

One way in which the social environment affects eating behaviour is by providing *norms* for what is appropriate behaviour. This includes certain family traditions that can affect

diets from early on (e.g. to what extent does a family have breakfast together, eat home-cooked meals, have TV dinners, etc.), whereas later in life someone's peers become important too. For example, a systematic review concluded that adolescents' fast food consumption was associated with that of their friends (Fletcher, Bonell, & Sorhaindo, 2011). Furthermore, perceived descriptive norms (i.e. what people *believe* their peers do) are typically associated with eating behaviour (e.g. Prinsen, De Ridder, & De Vet, 2013; Robinson, Thomas, Aveyard, & Higgs, 2014) and are estimated to have an overall moderate effect on unhealthy as well as healthy eating behaviour (Robinson et al., 2014). This can have ironic effects when these perceived norms are in fact not accurate, for example when adolescents overestimate their peers' consumption of unhealthy foods and in turn behave accordingly (Lally, Bartle, & Wardle, 2011). The presence of others can also more directly affect eating behaviour through processes related to *modelling* or *impression management*. To illustrate, a meta-analysis by Vartanian, Spanos, Herman, and Polivy (2015) showed a large modelling effect ($r = .39$) whereby participants ate more or less based on the consumption of their companion.

While in the examples above other people in one's environment did not purposely attempt to exert influence on someone's eating behaviour, their role can also be more explicit. For example, others can provide *social support* when someone is contemplating about whether or not to start a dieting programme, and family members can help someone who already decided he wants to eat more healthily by cooking appropriate meals and not leaving too many chocolates and ice cream available in the house. A review of reviews concluded that weight loss programmes that engaged social support were indeed more successful (Greaves et al., 2011). Of course, the social environment can also have more negative effects: if one's peers think it is ridiculous to quit eating meat someone may be less likely to do so, and if family members keep offering pieces of cake on a birthday party it may become difficult to successfully regulate one's behaviour. Thus, other people can play a role in the formation of intentions (either promoting or discarding the importance of healthy eating) or in the effectiveness of regulatory efforts (by being supportive of or interfering with one's good intentions).

Physical environment

A final set of factors that is relevant to consider in the context of eating behaviour are influences from the physical environment (Faith, Fontaine, Baskin, & Allison, 2007). Not without reason, the so-labelled 'obesogenic environment' is often blamed for the steep rises in numbers of people who are overweight or obese (Cohen & Babey, 2012; Swinburn et al., 1999). Like any other factor, the environment can either support or hinder healthy eating. In this section, we focus on three important influences that have been connected to eating: availability of foods, accessibility of foods and portion sizes. The extent to which (un)healthy foods are *available* naturally has relevant implications for what people eat. Availability of foods can be determined by their actual presence (e.g. does a school cafeteria only serve fried food or are salads also available) but something like the price of certain foods can also render them (un)available (Chandon & Wansink, 2012). To some extent, the availability of healthy food is beyond an individual's control, in particular when it concerns locations other than one's own home. However, within households, the person who is responsible for grocery shopping has a large say in deciding whether the fridge is filled with fruits or cream pies. The fridge

content then determines the availability of healthy choices for the more dependent family members (e.g. children). Overall, availability of healthy food has been consistently associated with healthy diet (Caspi, Sorensen, Subramanian, & Kawachi, 2012).

Where food availability refers to (objective) external constraints that determine whether or not someone is able to get (un)healthy food, *accessibility* concerns the relative *ease* with which certain foods can be obtained. One relevant aspect in this regard is people's mere *distance* towards food. This includes the distance people would have to travel to the nearest grocery store or fast food restaurant, although findings on this factor in relation to healthy eating are mixed according to a systematic review (Caspi et al., 2012). Another important aspect, that is partly related to distance, is the *effort* that is required to obtain certain foods. Next to effort that is related to distance (i.e. having to walk farther toward the fruit stand than toward the bowl of donuts), effort can have effects on food intake in even more subtle ways. For example, it has been shown that people consume less unhealthy food when they have to use small utensils, or when they have to use tongs instead of large spoons to dish up a portion of fries. Conversely, *convenience* is one factor that is associated with higher consumption of foods (Chandon & Wansink, 2012), which (like all factors) can have beneficial or adverse consequences depending on which type of foods (healthy or unhealthy) are most convenient. Foods can also be more or less accessible in a more figurative sense, depending on their *salience*. For example, foods that are placed in opaque containers are consumed less than foods from transparent containers (Wansink, Painter, & Lee, 2006). Next to mere visibility, foods' attractiveness or other attention-grabbing properties can also play a role. For example, an attractively lit salad bar in the middle of a restaurant may seduce more customers than a single bowl of green leaves positioned at a less prominent location. Thus, food accessibility – in terms of the ease with which they can be obtained as well as the ease to which a certain food choice may come to mind – can affect consumption of both healthy and unhealthy foods.

A final important environmental factor that affects food intake is *portion size*. Simply put, the more people get, the more they eat. A famous illustration of this effect is provided by Wansink, Painter, and North (2005) who showed that people consumed up to 73% more soup from a bowl that was secretly refilled through a cleverly installed, invisible tube under the table (and thus never emptied) compared to from a regular bowl, while they were explicitly instructed to eat until they were satisfied. A meta-analysis demonstrated that, on average, a doubling of portion sizes results in 35% greater intake of food (Zlatevska, Dubelaar, & Holden, 2014). It is particularly relevant in this regard to consider the role of *defaults*: the standard portion sizes in which products are offered. It has been shown that typical portion sizes of a single hamburger or muffin, for example, have largely increased over the past decades (Wansink & van Ittersum, 2007), which is likely to have contributed to the increased number of calories people consume.

Summary and conclusions

This section outlined a large number of determinants of dietary intake, which illustrates the complexity of eating behaviour. Although reflective determinants as described in social-cognitive models are amongst the most frequently studied in the context of eating behaviour, the evidence on their importance in the context of eating behaviour is

moderate, at best, according to an umbrella review by Sleddens et al. (2015). To illustrate, a meta-analysis on the predictive value of the Theory of Planned Behaviour variables concluded that they explained approximately 20% of variance in eating behaviour (McEachan et al., 2011). Yet, we still consider them relevant as intending to eat healthily is generally a necessary precondition in the early stages of behaviour change. That is, self-regulation strategies aimed at changing eating patterns, such as implementation intentions, are effective only when people are intending to change their eating behaviour (Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011). Overall, it seems that there are only a few determinants for which robust and consistent evidence is available. The most important factors appear to be intentions, habits, self-regulatory skills, and the social and physical environment, which all tend to have their effects on eating in a 'mindless' fashion. When considering potential interventions to improve people's food intake, these could be directed to each of these categories of determinants.

Interventions to change healthy diet

Determinants of healthy diet as discussed in the previous section constitute the foundation of many interventions aimed at increasing healthy eating or decreasing unhealthy eating. In the following section, we will present an overview of studies and interventions that have been done in order to improve eating behaviour. As in the previous section, the focus will be on modifiable psychological factors that influence people's eating behaviour, or their ability to adhere to a healthy diet. We will start by discussing interventions targeting reflective influences, then move on to interventions that have aimed at modifying automatic influences and enhancing regulatory skills, and finally, interventions will be discussed that make use of social and environmental factors.

Reflective influences

Several reviews and meta-analyses have analysed effectiveness of interventions for healthy eating behaviour that rely on improving knowledge about diet and aim to persuade people about the benefits of a healthy diet. Many of these analyses do not discriminate between different components of the interventions per se, but rather focus on for instance the delivery format (e.g. McArthur, 1998). In an analysis of school-based interventions, Van Cauwenberghe et al. (2010) concluded that there was limited evidence for effectiveness of education-only school interventions on dietary behaviour, but that multi-component interventions proved more effective in children. However, limited evidence was found for effectiveness of these interventions in adolescents. Effect sizes were not reported, but the findings are in line with other review studies (e.g. Jaime & Lock, 2009). Jeffery et al. (2000) likewise reported that education-based interventions show limited results, and that interventions show greater effectiveness in children than in adults, emphasising that long-term effects are often not supported by the findings. Stice, Shaw, and Marti (2006) drew similar conclusions from a meta-analytic review of obesity prevention programmes, concluding that only 21% of these programmes affected the prevention of weight gain, with a modest average effect size of $r = .04$. From another large meta-analysis on the effectiveness of health campaigns it was concluded that in general, in the USA and Europe, campaigns are moderately effective, with an average effect size of $r = .05$, meaning that the mean change in outcome

measures after an intervention is 5 percentage points. Isolating health campaigns focused on improving healthy eating, the effect sizes seem a bit stronger, ranging from $r = .08$ to $r = .12$, although the number of intervention studies included was relatively small (Snyder, 2007). It should be noted that although these effect sizes may be statistically significant, the actual change in behaviour may be too small to have health effects (e.g. an 8% intake in fruit consumption).

Other meta-analyses and reviews have used a theoretical framework to categorise *active ingredients* of interventions, like factors from the Theory of Planned Behavior (Ajzen, 1991). This framework includes attitudes, subjective norms and perceived behavioural control as determinants of behaviour. Riebl et al. (2015) conducted a review and meta-analysis on the application of this theory on eating behaviour in children. Although 34 studies were included, only three reported on actual interventions. These intervention studies produced large effect sizes (d's ranging from .79 to .91) on dietary intentions as well as behaviour, but considering this variation as well as the small number of studies, conclusions are limited in terms of generalisability. A meta-analysis of (quasi)experimental intervention studies on healthy eating and physical activity by Michie, Abraham, Whittington, McAteer, and Gupta (2009) encompassed 122 studies, and indicated that in general, the effect size of the interventions could be estimated at $d = .31$, which suggests a small to medium effect on behaviour. Looking more closely at the different intervention characteristics, results indicate effectiveness of interventions that focused on providing education and information was limited (with an effect size of $d = .26$) as compared with interventions that focused on improving self-regulatory skills (with an effect size of $d = .42$). A follow-up analysis (Dusseldorp, van Genugten, van Buuren, Verheijden, & van Empelen, 2014) examined whether specific combinations of intervention ingredients proved more effective than single strategies and found evidence that providing information about the health consequences of behaviour could in fact influence healthy eating and physical activity when combined with intention formation prompting. Interventions aimed at the 'rational' determinants of eating behaviour thus seem to be effective to some extent, but effect sizes are mostly within the small to medium range. Interventions that are solely focused on education, instructions and information do not seem to affect eating behaviour.

Automatic and affective influences

A significant portion of behaviour, including eating behaviour, is governed by automatic processes (Marteau, Ogilvie, Roland, Suhrcke, & Kelly, 2011). In order to be effective, attempts to influence eating behaviour should take these automatic processes into account. As discussed earlier, implicit preferences and habitual behaviour are both important determinants of eating behaviour, residing in automatic processes rather than rational decision-making. Habits are strong predictors of eating behaviour (Van't Riet et al., 2011). Therefore, interventions that target these habits can be an effective way of improving eating behaviour. Over the last 20 years, *implementation intentions* have gained popularity as an effective intervention strategy targeting habits. Implementation intentions are specified action plans on how one will act in certain situations (e.g. 'If I am watching TV and craving a snack, I will eat an apple') that aim to install habitual behaviour (automatised associations between a contextual cue and a specific behaviour; Gollwitzer, 1999). A meta-analysis on implementation intentions and healthy eating

demonstrated that these intentions can indeed affect eating behaviour (Adriaanse et al., 2011), although the effect on increasing healthy eating was stronger ($d = .51$) than on decreasing unhealthy eating ($d = .29$).

Apart from having habits that guide eating behaviour, people tend to be, to a certain extent, reward oriented, preferring immediate rewards over delayed ones (Metcalfe & Mischel, 1999). In general, unhealthy foods are often regarded as more hedonically pleasing than healthy alternatives (Raghunathan, Naylor, & Hoyer, 2007), therefore having greater reward value in the moment itself, causing implicit preferences towards these foods. However, it must be noted that this intuitively appealing notion seems to be culturally dependent: French people, for instance, have opposite associations (Werle, Trendel, & Ardito, 2013). Moreover, successful dieters seem to be able to overcome these implicit preferences. Nevertheless, the all-familiar chocolate cravings have even been compared to cravings for drugs (Bruinsma & Taren, 1999). Potentially, interventions could focus on changing these perceptions to create a better balance between healthy and unhealthy foods. However, emphasising healthiness may in fact lead to increased consumption of unrelated foods (Finkelstein & Fishbach, 2010). Of course, one could fall back on Pavlovian conditioning to change liking and disliking of specific foods (Rozin & Zellner, 1985). Recent research has indicated that evaluative conditioning (e.g. pairing images of unhealthy snacks with aversive images) may also form a basis for targeting this determinant (Hollands, Prestwich, & Marteau, 2011; Shaw et al., 2016), although meta-analyses on sets of studies are lacking at this point.

A slightly less elegant intervention strategy that can be effective in people with high levels of reward sensitivity (especially children) is to simply reward healthy choices (Vandeweghe, Verbeken, Moens, Vervoort, & Braet, 2016), although the association between rewards and consumption is complex. Rewards, as an extrinsic motivator, may undermine intrinsic motivation to eat healthily, therefore only accomplishing short-lived or even opposite effects (Birch, Marlin, & Rotter, 1984; Deci et al., 1999; Newman & Taylor, 1992). Affective or emotional processes have been the focus of health interventions in other areas of behaviour (e.g. fear appeals on cigarette packaging), but emotion interventions aimed at healthy eating are not as common.

Self-regulatory training

The consequences of implicit preferences in which immediate gratification from unhealthy food is preferred to delayed gratification from healthy food overlap with those of another important eating behaviour determinant, namely self-regulatory skills. In fact, some studies show that implicit preferences only lead to unhealthy eating when self-regulatory capacity is low (Appelhans et al., 2012; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Although little is known specifically about training or improving self-control in terms of eating behaviour interventions, self-regulation in a broader sense has been the focus in many recent interventions. In fact, interventions aimed at improving self-regulatory skills are amongst the most successful in affecting healthy eating, according to the aforementioned meta-analysis by Michie et al. (2009). These types of interventions typically involve self-monitoring of behaviour, goal-setting and review, intention formation, and providing behavioural feedback, with monitoring being the most important active intervention ingredient. Self-regulatory components in

interventions may be especially important for long-term maintenance of healthy eating behaviour. A two-year study by Stadler, Oettingen, and Gollwitzer (2010) demonstrated that both an information-only and an information-plus-self-regulation intervention were able to increase fruit and vegetable intake with .47 to 1.00 servings per day in the first four months following the intervention, but that this increase was only sustained at follow-up two years later in the group that received the self-regulation intervention on top of the information. Similarly, a study including a six-month follow-up demonstrated improved fruit and vegetable intake following both a self-efficacy intervention, as well as a self-efficacy combined with action planning intervention (Luszczynska, Tryburcy, & Schwarzer, 2007). Another longitudinal study spanning 2 years indicated that in an adolescent sample, small to medium sized effects of self-efficacy ($d = .46$) and planning ($d = .39$) interventions on fruit and vegetable intake were still present at a 14-month follow-up, demonstrating long-term effects of self-regulatory-based interventions, although there were no effects on body weight (Luszczynska et al., 2016). These effect sizes translated into an increase of 1/4 to 1/3 portion per day, which again may be too small to have significant health benefits.

Eating behaviour interventions focusing on self-regulatory factors seem to be somewhat effective based on the reported effect sizes, although translating these small to medium effects to real-life eating behaviours indicates that the clinical relevance of these effects may be less impressive. As with interventions focusing on rational considerations, self-regulation interventions tend to focus on the (intra-)individual processes that take place in the isolation of the individuals' mind, without considering the direct social and physical environment. Since the environment does play an important role in directing behaviour (Story, Neumark-Sztainer, & French, 2002), there have been several efforts in designing interventions that take this into account, as a main focus or in addition to more individual-focused components.

Interventions aimed at changing the environment

Social environment

Eating is considered a social behaviour, often done in the presence of others like friends, family or colleagues. General principles of intervention design therefore, not surprisingly, include the guideline to take the participant's social environment into account when developing interventions (Bartholomew et al., 2016). Although the association between social norms and eating behaviour has been the topic of meta-analysis (Robinson et al., 2014), less information is available on the effectiveness of interventions utilising social norms to change eating behaviour. However, separate studies have looked into these types of interventions. For instance, an experimental study compared the effects of manipulating descriptive (i.e. what others do) vs. injunctive (i.e. what others think I should do) norms on fruit intake in high school students. While injunctive norms did not result in changes in fruit intake, presenting a descriptive norm had a positive effect on fruit intake over a two-day timespan, with a one-sentence message having a significant ($d = .59$) impact. However, other studies report no such effects: providing participants with information on previous participants' choices did not change food choices between palatable and non-palatable foods in a study by Pliner and Mann (2004). Thus, although there is consensus about the importance of social norms in

eating behaviour, more systematic research is needed in which the effects of changing these social norms as an intervention are assessed.

Another social influence that is important in eating behaviour is social support. Intuitively, one would predict that support from someone's direct social environment could be helpful, or may even be a necessary condition, for long-lasting eating behaviour change. However, research supporting this notion is limited. One systematic review on interventions including family involvement demonstrated inconclusive results, suggesting that not only were there very few attempts to systematically assess the effects of social support on weight loss interventions, but that the effectiveness of family involvement remained to be properly tested (McLean, Griffin, Toney, & Hardeman, 2003). A more recent systematic review on facilitators and barriers of healthy eating behaviour in children did conclude that social support was an important facilitator in healthy eating, specifically support from parents and other family members, whereas friends and teachers were not considered to be effective sources of social support (Shepherd et al., 2006). Although these results do not necessarily lead to similar conclusions, there does seem to be consensus on the notion that more systematic intervention research is needed before these types of influences can be accurately assessed.

Physical environment

General frameworks for intervention development take the physical environment into account in several ways, ranging from environmental barriers to policy-making (Bartholomew et al., 2016). The 'obesogenic environment' has been identified as an important factor in (unhealthy) eating behaviour. In line with this, a relatively recent development in eating behaviour interventions is focused on adjusting the direct physical environment. These interventions can be categorised as *nudges*: strategies involving changes in the choice architecture, making the desirable choice (e.g. the healthy choice) easier to make (Thaler & Sunstein, 2008). Examples of healthy eating nudges include placing fruit at the cash registry instead of candy bars, which increased fruit intake (Kroese, Marchiori, & De Ridder, 2016), implicitly signalling a social norm by displaying packaging of healthy snacks, influencing food choice between healthy and unhealthy food choices (Prinsen et al., 2013), traffic light labelling of foods, leading to increased nutrient knowledge as well as identification of health as an important factor in purchasing decisions (Roberto et al., 2012; Sonnenberg et al., 2013), and changing default portion sizes or choices, although results are mixed: one paper reports similar energy intake with smaller versus bigger plates, with bigger plates having the advantage of more vegetable sidedishes (Libotte, Siegrist, & Bucher, 2014) whereas another warns against the danger of overeating with big plates (Wansink & Van Ittersum, 2013).

Despite the relative novelty of nudging as a behavioural intervention, a number of reviews demonstrate the potential of these kinds of interventions. A systematic review of nudging interventions involving changing the availability of food options in terms of proximity or order showed that healthy food choices increased as a result of the intervention, although effect sizes could not be analysed due to the variety in outcome measures used in different studies (Bucher et al., 2016). Another narrative review on nudging in self-service restaurants likewise concluded that availability of healthy options increased healthy choices (Skov, Lourenço, Hansen, Mikkelsen, & Schofield, 2013), as did health labelling. The same review showed inconclusive results on

interventions involving changing the size of plates and cutlery. A review of 16 studies in school settings indicated that increasing accessibility to healthy foods, or decreasing accessibility to unhealthy foods, increased dietary behaviours, as measured by plate waste analysis, self-reports, and sales numbers (Frerichs et al., 2015). A fourth narrative review demonstrated that although nudging interventions focusing on one specific aspect (e.g. availability, accessibility, visibility) were moderately effective, combined strategies including multiple factors at once were the most effective in achieving healthier food choices (Wilson, Buckley, Buckley, & Bogomolova, 2016). All reviews stress that the quality of studies included was suboptimal, and in some cases even weak, and that more systematic, experimental studies are needed into the effectiveness of nudging strategies. In summary, although nudging shows promise when considering health behaviour interventions, as a low-cost, effective way of increasing healthy choices, caution is needed due to the lack of population-based long-term effectiveness.

Summary and conclusions

Interventions in eating behaviour are abundant, and the literature provides us with a vast amount of studies investigating single or multiple intervention strategies, targeting rational, cognitive factors like knowledge, beliefs and attitudes, but also automatic influences like habits and reward orientation have been the focus of intervention research. Meta-analyses and reviews on these interventions show limited and inconclusive support for education-based intervention programmes, and small to medium sized effects of interventions focusing on attitudes, subjective norms, and perceived behaviour control (factors from the Theory of Planned Behavior), although the long-term and clinical relevance remains to be investigated further. Interventions targeting habitual behaviour like implementation intentions seem promising based on the available meta-analyses. Evidence on social support as an active intervention ingredient remains inconclusive due to a lack of systematic studies, but separate studies on social norms seem promising in terms of affecting eating behaviour. Finally, intervening in the physical environment in the form of implementing *nudges* has gained a lot of research and policy attention over the last years. This intervention strategy has the potential to be very effective, and has additional benefits of being easy to implement and low-cost, but more empirical research is needed to form a proper evidence-based foundation as well.

Conclusions and directions for future research

In this review we aimed to provide a state-of-the-art overview of what is known about healthy diet from a psychological perspective: what actually constitutes a healthy diet and how is this information communicated to the public; who is able to eat a healthy diet and adhere to professional recommendations for eating the 'good' food; which behavioural and environmental factors are important for understanding which people manage to eat a healthy diet; and which interventions have been shown to be effective in promoting healthy diet in the general public, were the main questions we tried to answer. Answers to these questions are important in view of the current absence of healthy diet in large parts of the population, which is a cause of major concern for global public health bodies, national governments and health professionals alike. Concern is also warranted by the growing numbers of people with overweight and obesity which

are the direct result of an unhealthy diet, either in terms of diet quality or, and perhaps even more important, the number of kcalories that people tend to consume.

In the past decades, numerous research efforts have been made to understand and eventually curb the overweight epidemic by investigating the parameters of a healthy diet. To illustrate, a google search with the term 'healthy diet scientific publications' resulted in about 20 billion hits in less than a second. In view of this massive attempt to gain more insight into the underpinnings of healthy diet, surprisingly little robust evidence is available on the major aspects of the association between diet and health. As a result, it is not well understood which kind of diets have health effects (either for good or for bad), although it is increasingly acknowledged that eating patterns rather than single foods or nutrients may have important health implications, as is demonstrated by the negative health effects of overweight on the one hand and the positive health effects of specific dietary patterns (e.g. the Mediterranean diet) on the other hand. Yet, it has proven difficult to communicate information about healthy diet – insofar hard evidence is available – to the public in an easy-to-understand way and even harder to ensure that people will act upon these guidelines. Professional communication of healthy diet recommendations has witnessed relatively weak results insofar that many people are aware of the negative consequences of eating too much or eating an unhealthy diet but rarely manage to implement advice in their dietary routines over prolonged periods of time. As with regard to the question which people manage to adhere to a healthy diet, it seems that especially poor living circumstances in terms of education, income and job status have a pervasive negative effect on healthy diet. Unfortunately, it may be not so easy to target SES-related factors in health promotion interventions. Research on the determinants of a healthy diet has also proven to be challenging and has so far not resulted in clear and corroborated patterns of factors that matter. 'Classic' social-cognitive determinants have been investigated for decades, but the impact of these determinants on actual dietary behaviour has been shown to be small to medium. Many studies on determinants focus on one or two factors in isolation, while – similar to examining specific patterns or combinations of diet components – insight in particular combinations of determinants may be required to improve a comprehensive understanding of the drivers of healthy diet. The only exception in this regard is the role of habits as automatic, undeliberate patterns of food intake that are strong drivers of consumption but are unfortunately not easy to change. In line with the relatively strong effect of food habits, suggesting that people most of the time do not think a lot about what they put in their mouths, effects of the physical environment in terms of the availability and accessibility of food seem to be an important determinant of diet, although more meta-analytic evidence is required. Finally, with regard to interventions for promoting healthy diet the traditional focus on individual behavioural determinants in terms of knowledge, intention and motivation research has demonstrated disappointing effects. More promising intervention strategies relate to taking advantage of the automatic and undeliberate nature of many food decisions and making it easier to act upon their intention to eat a more healthy diet by changing the social and physical environment, although there is more systematic research required before comprehensive intervention strategies can be implemented.

In summary, for psychologists it is important to realise that the traditional focus on individual social-cognitive determinants of healthy diet is limited in scope and that taking advantage of the mindless decisions people make about food needs more

consideration. In view of the large number of people who are concerned about their diets and make attempts to change their dietary patterns (but unfortunately often fail), it is crucial to gain a better understanding of both the automatic and environmental influences that are in part responsible for people not acting upon their good intentions for diet change. While good health is important to people, more attention should be paid to how health considerations may actually backfire and make it more difficult for people to change their diet. It is also important to invest in more systematic research that investigates the combined impact of several determinants rather than studying determinants in isolation. Finally, it is important to realise that the core components of healthy diet are still unclear which makes communicating recommendations for healthy diet to the general public quite complex. It is obvious that insight into the health benefits or health risks of specific nutrients, foods or dietary patterns is beyond the task of health psychologists. Nevertheless, a better insight into valid, reliable and robust nutritional recommendations is mandatory for improving the understanding of the role of behaviour in healthy diet.

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