Towards reduced meat consumption: A systematic literature review of intervention effectiveness, 2001–2019

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ABSTRACT

A reduction of meat consumption and shift to plant-based diets, especially in industrialized countries, is acknowledged as crucial for reaching climate targets, addressing public health problems, and protecting animal welfare. While scholarly research distilled drivers of meat consumption and barriers to its reduction, insights into the effectiveness of measures to initiate such a profound change in consumer behaviour are relatively scarce. This paper presents a systematic literature review on consumption-side interventions in the context of meat consumption across scholarly disciplines. Our analysis confirms that existing research predominantly assessed interventions addressing personal factors of behavioural change such as knowledge and emotions. Whether these interventions are effective depends on whether information (i) is provided on health, animal welfare or environmental effects, (ii) is emotionally or cognitively framed, and (iii) is aligned with consumers' information needs. Moreover, linking meat to living animals or to the humanness of animals activates negative emotions and, thus, reduces meat consumption. Further, increasing the visibility and variety of vegetarian dishes in food environments decreases meat-eating. Also, educational courses on how to shop and cook vegetarian food are effective in reducing meat consumption. There is less evidence on the effectiveness of interventions addressing socio-cultural factors such as social norms. Regarding future research directions, existing research mainly investigated the influence of interventions on attitudes and behavioural intentions. Hence, there is still a need for studies to assess more long-term effects of intervention measures on actual meat consumption and their potential to initiate fundamental changes in dietary habits.

1. Introduction

A substantial transformation of current food consumption and production systems, especially in industrialized countries, is paramount for reaching climate targets (IPCC, 2019) and delivering on the Sustainable Development Goals (SDGs) (United Nations, 2017). The livestock sector is responsible for approximately 14.5% of global GHG emissions and is the single most important source of methane, a particularly problematic greenhouse gas (Gerber et al., 2013). Consequently, reduced meat consumption and a shift to more plant-based diets appears crucial to mitigate anthropogenic climate change (Hedenus, Wirsenius, & Johansson, 2014; Marinova & Bogueva, 2019; L.; Reisch, Eberle, & Lorek, 2013). From a public health perspective, consumers in industrialized countries exceed the recommended nutritional amount of red and

processed meat intake, i.e. a maximum of 500 g per week, which may have negative health effects (World Cancer Research Fund, 2018). Moreover, the industrialization of meat production also leads to increasing concerns around animal welfare (Bonnet, Bouamra-Mechemache, Réquillart, & Treich, 2020).

However, fostering a more climate-friendly and healthier diet among consumers is challenging because meat consumption is rooted in cultural practices, societal norms, and daily habits (Stoll-Kleemann & Schmidt, 2017). Indeed, scholarly research documents a range of barriers to reducing meat consumption ranging from personal over socio-cultural to political and socio-economic factors (Bogueva, Marinova, & Raphaely, 2017; de Bakker & Dagevos, 2012; Hoek, Pearson, James, Lawrence, & Friel, 2017). In addition, consumers fail to link meat consumption with environmental issues or to consider its reduction a

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climate change mitigation option (Campbell-Arvai, 2015; de Boer, de Witt, & Aiking, 2016).

This situation calls for effective consumption-side intervention measures to reduce meat consumption and foster plant-based diets among consumers. Scholars from different disciplines including social psychology, sociology, food science, health studies, ecological economics, political science as well as marketing and communication science have tested various interventions in reducing individuals' consumption of meat. However, while a systematic literature review of 22 experimental articles on strategies to reduce meat consumption was published in the health literature (Harguess, Crespo, & Hong, 2020), a comprehensive overview across disciplines on which consumption-side interventions are effective in which circumstances is still lacking.

Against this background, the present paper provides a systematic literature review of interventions in individuals' meat consumption across all scholarly disciplines. In particular, we systematically reviewed experimental studies that assessed the effects of various consumption-side measures. Furthermore, we categorized the reviewed interventions according to the factors of behavioural change they addressed. These factors are outlined in the conceptual framework on meat-eating behaviour by Stoll-Kleemann and Schmidt (2017). Their framework distinguishes between (i) *personal factors* (i.e. knowledge and skills, emotions and cognitive dissonance, values and attitudes as well as habits), (ii) *socio-cultural factors* (such as social norms, culture and religion), and (iii) *external factors* (in particular, the food environment). The framework expands other established models such as the theory of planned behaviour (Ajzen, 1991) or the norm activation theory (Schwartz, 1977) by including further personal and social factors.

In our systematic review, we synthesized existing findings on main effects, moderating variables, mediating processes, and boundary conditions for different types of interventions. Furthermore, we developed the *Meat Reduction Intervention Framework* (see Fig. 1) to link intervention effectiveness with moderating and mediating variables. Based on the analysis, we provide recommendations for policy design and make suggestions for further research. Therefore, the contributions of the paper are three-fold: First, it integrates empirical findings across disciplines and identifies gaps in the scholarly literature. Second, the *Meat Reduction Intervention Framework* contributes to our understanding for whom certain interventions may be effective and how interventions reduce meat consumption. Third, the paper provides a knowledge base for evidence-based policy-making and management which could potentially enhance the effectiveness of policy measures and other interventions implemented to reduce meat consumption.

2. The Meat Reduction Intervention Framework

High meat consumption levels, a low consideration of plant-based alternatives, and consumer resistance to reduce meat consumption are still dominant patterns in most western societies (e.g. Latvala et al., 2012; E. J. Lea, Crawford, & Worsley, 2006; Schösler, Boer, & Boersema, 2012, 2015). Consumers' reluctance to reduce meat consumption can be explained by various factors: Beliefs about the positive health effects of eating meat (de Bakker & Dagevos, 2012; E.; Lea & Worsley, 2008) and a lack of knowledge about negative environmental effects of meat consumption (de Boer et al., 2016; Pohjolainen, Tapio, Vinnari, Jokinen, & Räsänen, 2016) prevent consumers from reducing their meat intake. Some consumers feel pleasure from eating meat and enjoy the taste of it. At the same time they avoid information about the negative impacts of meat consumption that contradicts their moral values not to feel emotionally distressed (Festinger, 1957; Loughnan, Haslam, & Bastian, 2010). Also consumers' social environment and the cultural importance meat holds together with established social norms positioning meat as the central part of a dish (de Bakker & Dagevos, 2012) can complicate a change in diet. Furthermore, external factors in the food environment such as a lack of vegetarian offers in a restaurant hinder consumers from choosing a meatless dish (Kurz, 2018). These barriers are at the same time focal factors of behavioural change which could be addressed by policy interventions to foster plant-based diets and further, to reduce meat-eating (Stoll-Kleemann & Schmidt, 2017).

To provide a systemized overview on types of interventions targeting meat consumption reduction at an individual level, we developed the *Meat Reduction Intervention Framework* (see Fig. 1). The framework borrows insights from Stoll-Kleemann and Schmidt's (2017) conceptual framework on factors that influence meat-eating behaviour. In addition to focal factors addressed by interventions, the framework further comprises (i) the underlying processes of change that lead to meat reduction behaviour and, (ii) variables that may strengthen or attenuate the intervention effects. This helps to better understand differences in
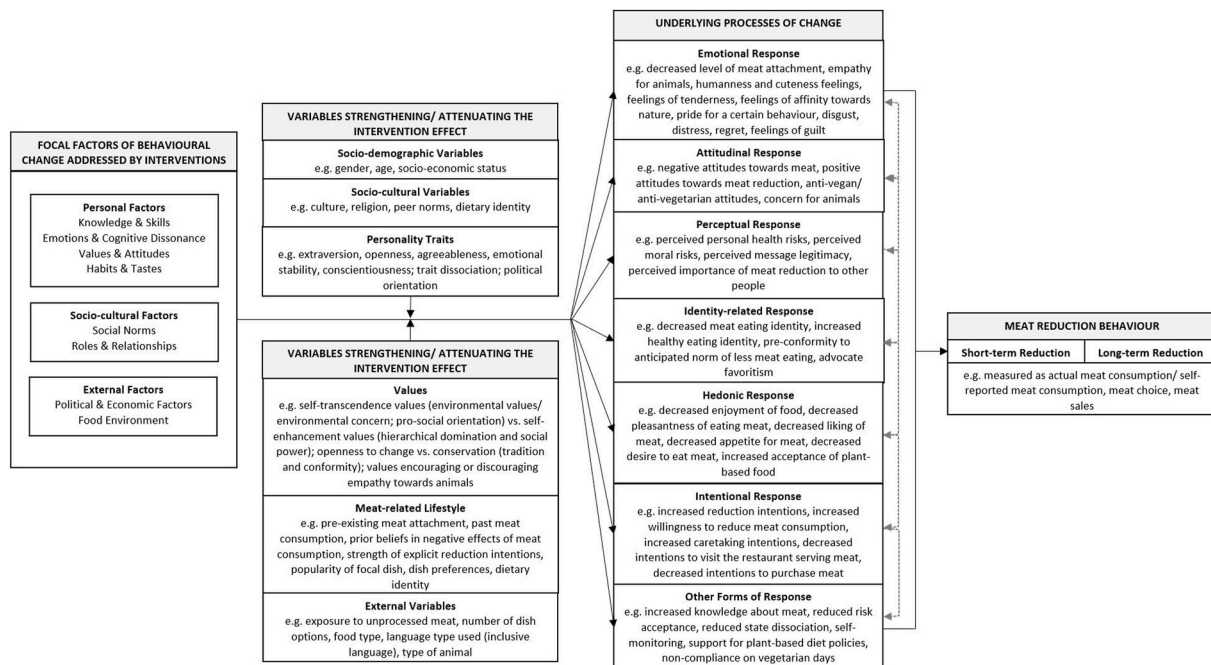

Fig. 1. The meat reduction Intervention framework.

consumers' responses to certain interventions. Our framework includes moderators and mediators that have already been measured in extant research as well as variables that might potentially be assessed in the future.

Whether interventions are successful in changing consumers' diets depends on socio-demographic and socio-cultural variables, personality traits, values, meat-related lifestyles and external variables, such as available food options. Consumers' pre-existing meat attachment refers to people's affective connection to meat-eating and exemplifies one of the key variables influencing individual responses to a respective intervention. Consumers attached to meat show patterns of high positive affect and commitment towards meat-eating and have strong feelings against the idea of reducing their meat intake (Berndsen & Van Der Pligt, 2004; Graça, Oliveira, & Calheiros, 2015). Consumers with lower levels of meat attachment seem to be more open to information about negative consequences of meat-eating and advantages of altering eating habits (Graça, Calheiros, & Oliveira, 2015). For instance, reminding consumers that meat is derived from animals and providing information about animal suffering can activate emotional responses such as empathy for animals which could weaken consumers' attachment to meat-eating and further, foster meat reduction behaviour (Kunst & Hohle, 2016; Rothgerber, 2020b). While interventions of this kind might be successful for women who generally show lower levels of meat attachment and tend to hold values that encourage empathy towards animals, exposure to such information might be insufficient for men, for consumers holding values discouraging empathy towards animals and for those with high pre-existing meat attachment. For such consumer groups certain interventions might backfire and trigger defensive mechanisms such as meat-eating justifications resulting in even greater meat consumption (Graça, Oliveira, & Calheiros, 2015; Rothgerber, 2020b). Hence, other variables could be considered and addressed by interventions such as conservative values of purity held by political conservatives (e.g. by relating meat to contamination with antibiotics or hormones) (Rothgerber, 2020b) or environmental values and environmental concern (e. g. by informing consumers about negative environmental effects related to meat consumption) (Vainio, Irz, & Hartikainen, 2018; Verain, Sijtsema, Dagevos, & Antonides, 2017).

Consequently, interventions might have varying success among different individuals. Hence, it is important to design tailored interventions that take into account how committed individuals are to eating meat and what their values are (Graça, Oliveira, & Calheiros, 2015). When studying the effectiveness of interventions to reduce meat consumption one needs to carefully take moderating and mediating variables into account. Moreover, interrelations and causalities between mediating variables should be considered as, for example, intentional responses might be influenced by preceding processes of change such as attitudinal responses to an intervention. This relates to the theory of planned behaviour suggesting that attitudes, subjective norms as well as perceived behavioural control predict intentions to a respective behaviour and furthermore, actual behaviour (Ajzen, 1991; Ajzen & Fishbein, 1980).

3. Method

In this paper, we followed the systematic literature review methodology which involved (i) specifying review objectives, (ii) defining a search strategy as well as inclusion and exclusion criteria to build a sample of relevant journal articles, and (iii) analysing and synthesizing the data (Briner & Denyer, 2012). The core objective of this review was to locate studies that tested interventions in consumer behaviour to reduce the intake of meat or to increase the consumption of plant-based foods resulting in a reduction of meat consumption. Studies exploring diet changes focusing on foods other than meat were excluded. Also, studies focusing upon the measurement of health effects of reduced meat consumption only, as opposed to studies assessing effects on consumption, were not included in the review. Moreover, we only included

peer-reviewed journal articles in English published between 2001 and 2019 and consciously omitted grey literature such as books, reports, or unpublished work. Given our focus on experimental studies across scholarly disciplines, as only experimental settings allow for testing causality and a quantification of effectiveness, we trusted only peer-reviewed articles to ensure a robust evidence-base for our analysis and recommendations. The databases Web of Science, Science Direct and SCOPUS were used for the initial literature search. The keyword search included the search strings "meat reduction" OR "reducing meat" OR "less meat" OR "low meat" OR "reduced meat" OR "decrease meat", "plant-based" OR "vegetarian" OR "meat" AND "behav* change" OR "intervention" as well as "meat consumption" AND "reduction" OR "reducing" OR "decrease".

The articles retrieved from the initial search were screened for inclusion by reading through the abstracts which resulted in a pool of 67 articles that were further analysed at the full-paper level. Here, 12 articles were excluded because they did not fulfil all inclusion criteria. 14 additional articles were identified via snowballing by scanning the bibliography of retrieved articles. Therefore, the literature search resulted in a final sample of 67 peer-reviewed journal articles which built the basis for the systematic literature review (see Fig. 2).

Two authors coded the data independently with the MAXQDA software for qualitative data analysis. The codes were established around interventions addressing the before mentioned factors of behavioural change, namely personal, socio-cultural, external, and multi-factors. In addition, categories were formed according to bibliographic information, methodology and research design, variables of measurement as well as main study findings and intervention effectiveness. Sub-codes were developed and adapted throughout the analysis process resulting in a detailed overview of existing interventions specifically relevant for reducing meat consumption. Finally, the gathered data was synthesized making use of the narrative synthesis approach which comprised (i) an initial thematic analysis of study results, (ii) a summary table of differences in effects between studies, and (iii) an overall assessment of the degree of evidence on intervention effectiveness (Popay et al., 2006). We chose this approach because it allows for flexibility in organising narratives and describing the direction of intervention effects (Briner & Denyer, 2012).

4. Findings

In this section we first provide an overview on study characteristics and designs followed by a detailed section on interventions structured according to the main factors of behavioural change related to meat-eating. Hence, we discuss interventions addressing personal, socio-cultural, external as well as multi-factors of behavioural change.

4.1. Study characteristics and designs

The 67 identified journal articles included a total of 99 empirical studies, as some papers comprised more than one study (see supplementary material). Fig. 3 shows the number of peer-reviewed articles that discussed intervention measures to reduce meat consumption over the last 19 years. Apparently, the scholarly interest in the topic intensified, especially in the last four years. Most articles (n = 16) were published in the journal *Appetite*. The remaining 51 articles were published in 42 different journals with a strong thematic focus on food and/ or health.

The study characteristics and designs are summarized in Table 1. Most articles framed meat consumption as a public health issue or positioned meat consumption in the context of the environment, specifically climate change. A set of articles addressed the issue of animal welfare, in particular the cognitive dissonance associated with the killing and eating of animals.

Geographically, most studies were conducted in industrialized countries located across North America and Europe, while few studies
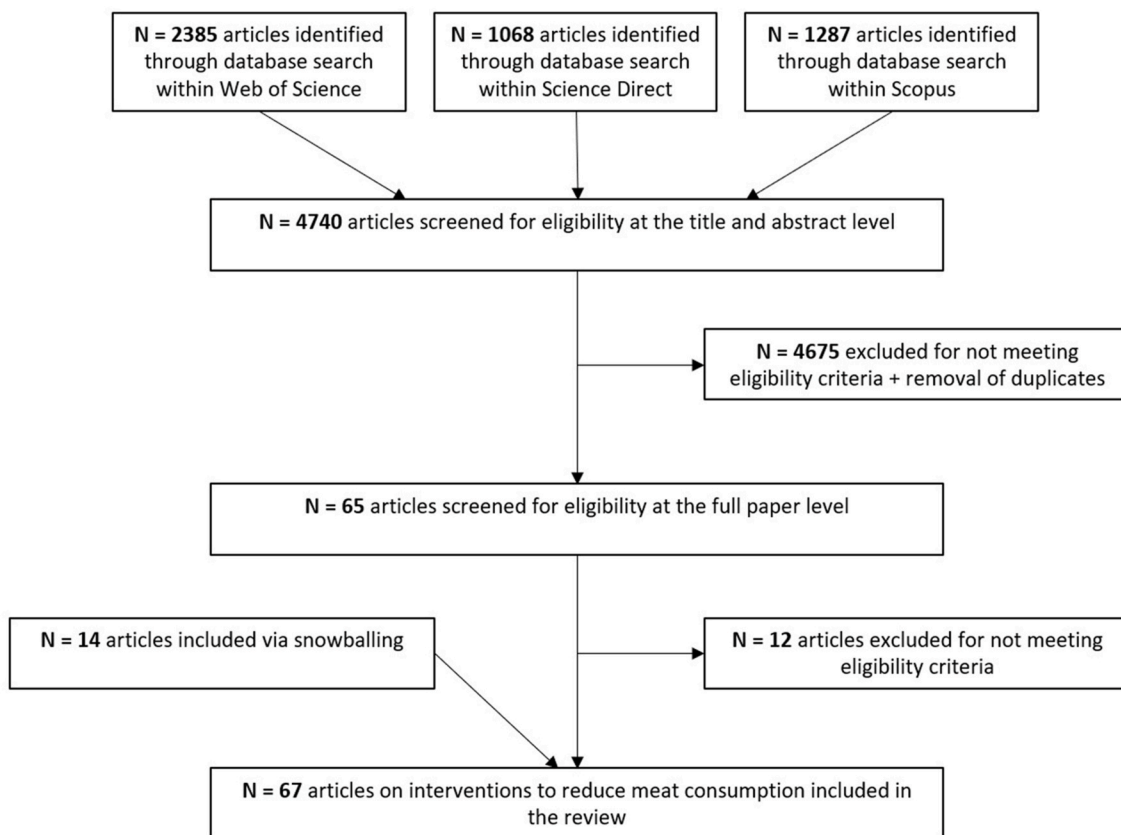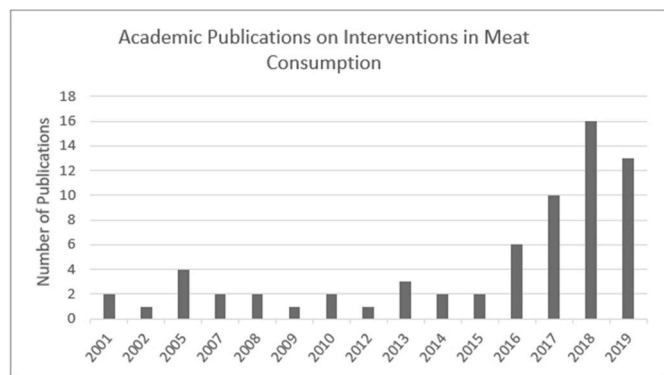
Fig. 2. Systematic literature review process.

Fig. 3. Academic Publications on interventions to reduce meat consumption.

Table 1
Overview of study characteristics and designs.

Problem Framing	Geographical Spread
Health Focus (n = 33)	North America (n = 50)
Environmental Focus (n = 16)	Europe (n = 41)
Health and Environmental Focus (n = 9)	Australasia (n = 5)
Animal Focus (n = 9)	South America (n = 2)
	Asia (n = 2)
Factors of Behavioural Change	**Experimental Method**
Single-Factor (n = 78)	Online Studies (n = 44)
Multi-Factors (n = 15)	Field Studies (n = 43)
Comparison of Factors (n = 6)	Lab Studies (n = 12)
Samples & Sampling Strategy	**Dependent Variables**
Consumer Samples (n = 68)	Consumption-related Variables (n = 49)
Student Samples (n = 30)	Actual Meat Consumption (n = 35)
Consumer and Student Samples (n = 1)	Food Choice or Food Sales (n = 15)

were conducted in Australasia, South America and Asia. Only three articles investigated cross-national or cross-cultural dimensions of interventions. They identified cultural differences as influencing variables of the willingness to eat meat or of actual food choice of participants.

Interventions predominantly addressed a single factor of behavioural change, whereas fewer studies addressed multiple factors simultaneously. Only a few compared the relative effectiveness of interventions that addressed different factors of behavioural change. With regards to the temporal design of interventions, mainly single-time interventions were tested, while fewer studies assessed the effects of long-term intervention programmes which included, for instance, educational sessions over a period of several weeks or months.

Most studies were conducted online or in the field, and collected data from consumer samples. Participants were mainly recruited via convenience sampling. Sample sizes ranged from 24 study participants to approximately 100,000 supermarket customers, whereas most studies

worked with moderate sample sizes between 100 and 500 participants.

In terms of focal effects, studies mainly assessed the main effects of interventions on consumption-related dependent variables such as consumption intentions, attitudes towards meat, consumer acceptance, empathy towards animals or policy support. Less than half of extant studies measured the effect of interventions on actual meat consumption. Table 2 provides an overview of all dependent variables measured in the reviewed studies.

Furthermore, extant research tested a range of mediating variables that helped to understand consumers' responses to an intervention as well as moderating variables that strengthened or attenuated the intervention effect. Table 3 and Table 4 give an overview of the moderating and mediating variables that were assessed in existing

Table 2
Dependent outcome variables assessed in the reviewed studies.

DEPENDENT VARIABLES ASSESSED IN REVIEWED STUDIES		n	EXAMPLES
Empathy towards the animal	Emotional Response	2	Kunst and Hohle (2016)
Meat attachment	Emotional Response	1	Dowsett et al. (2018)
Affect towards meat	Emotional Response	1	Dowsett et al. (2018)
Attitudes towards meat	Attitudinal Response	13	Berndsen and Van Der Pligt (2005); Byrd-Bredbenner et al. (2010); Graham and Abrahamse (2017); Palomo-Vélez et al. (2018)
Consumer acceptance	Attitudinal Response	4	Spencer and Guinard (2018); Spencer, Cienfuegos, and Guinard (2018)
Antivegan/vegetarian attitudes	Attitudinal Response	2	Earle et al. (2019)
Concern for animals	Attitudinal Response	1	Dowsett et al. (2018)
Appetite for meat	Hedonic Response	3	Piazza et al. (2018)
Pleasantntess/experience of eating meat	Hedonic Response	3	Anderson and Barrett (2016)
Desire to eat meat	Hedonic Response	3	Tybur et al. (2016)
Liking of meat	Hedonic Response	1	Bertolotti et al. (2016)
Willingness to eat meat/to reduce meat consumption	Intentional Response	16	Earle et al. (2019); De Groeve et al. (2019); Tian et al. (2016); Zickfeld et al. (2018)
Intention to eat meat/to reduce meat consumption	Intentional Response	13	Byrd-Bredbenner et al. (2010); Cordts et al. (2014); Stea and Pickering (2019); Vainio et al. (2018)
Intention to purchase meat	Intentional Response	4	Wang and Basso (2019)
Likelihood of ordering meat/vegetarian	Intentional Response	2	Kunst and Hohle (2016); Sparkman and Walton (2017)
Intention to visit the restaurant	Intentional Response	2	Wang and Basso (2019)
Support for plant-based diet policies	Other Forms of Response	1	Whitley, Gunderson, and Charters (2017)
Non-compliance on vegetarian days	Other Forms of Response	1	Lombardini and Lankoski (2013)
Knowledge about meat	Other Forms of Response	1	Byrd-Bredbenner et al. (2010)
Self-reported meat consumption	Meat Reduction Behaviour	28	Allen and Baines (2002); Amiot et al. (2018); Carfora et al. (2017)
Food/meat sales	Meat Reduction Behaviour	8	Brunner et al. (2018); Flynn et al. (2013); Coucke et al. (2019)
Food choice	Meat Reduction Behaviour	7	Zhou et al. (2019); Campbell-Arvai et al. (2014); Saulais et al. (2019)
Actual food consumption (g)	Meat Reduction Behaviour	8	Anderson and Barrett (2016); Friis et al. (2017); Reinders et al. (2017); Rolls et al. (2010)

intervention research. The mediating processes and moderating effects are outlined in more detail in the scope of section 4.2.

4.2. Effectiveness of interventions in reducing meat consumption

In this section, we discuss key empirical findings of the 99 reviewed studies that tested various types of interventions to reduce meat consumption. For this discussion, we structure the studies based upon our *Meat Reduction Intervention Framework*. Overall, almost 60% of all studies assessed interventions addressing personal factors, followed by 22% of studies testing external factors and 15% investigated interventions addressing more than one factor of behavioural change. Finally, not more than five studies tested the effectiveness of interventions addressing socio-cultural factors.

4.2.1. Interventions addressing personal factors

Most intervention studies addressed personal factors to influence meat-eating behaviour. Personal factors include knowledge, skills, values, and attitudes together with emotional involvement and are further influenced by variables such as sociodemographic factors and personality traits. Understanding the role of personal factors in influencing meat-eating behaviour seems helpful to unravel individual reluctance to reduce meat consumption and to develop interventions addressing these personal barriers (Stoll-Kleemann & Schmidt, 2017). We highlight findings relating to these personal factors in the following.

4.2.1.1. Knowledge. Interventions addressing knowledge (gaps) build on the information-deficit model of consumer behaviour and on the logic that more information and knowledge on a specific issue will change attitudes and consequently behaviour of individual consumers (Bak, 2001; Sturgis & Allum, 2004). Hence, consumers' lack of information about environmental, health or animal welfare issues linked to meat consumption might act as a barrier to reduce meat intake

(Campbell-Arvai, 2015; de Boer et al., 2016; E.; Lea & Worsley, 2001). Increasing consumers' awareness of issues around meat consumption should help them to form understanding of and commitment to meat reduction (Dagevos & Voordouw, 2013).

Extant research tested two types of interventions addressing knowledge: (i) information provision and (ii) message framing. With regard to the former, interventions aimed at educating consumers about environmental issues caused by meat consumption, nutritional effects of meat-eating or effects on animals showed to be effective in reducing meat consumption (e.g. Byrd-Bredbenner, Grenci, & Quick, 2010; Jay et al., 2019).

For example, displaying living animals and information on the effects of meat-eating in a television programme was effective in increasing consumers' knowledge and negative attitudes towards meat-eating, which further led to lower intentions to consume meat (Byrd-Bredbenner et al., 2010). Moreover, providing information on the life cycle and environmental footprints of meat and other foods in the course of university lectures reduced students' red meat consumption (Jay et al., 2019). The effect might be explained by participants' higher perceptions of environmental costs of eating meat and by their knowledge on how to replace meat with less impactful food (Jay et al., 2019). In contrast, providing environmental information in the form of a colour-based labelling scheme at the point of sale (representing the total CO_2 emissions of each dish as either green-low impact, yellow-medium impact, or red-high impact) failed to be effective in decreasing the sale of meat dishes in a university restaurant context (Brunner, Kurz, Bryngelsson, & Hedenus, 2018). One explanation of the limited impact of carbon labels could be that consumers usually tend to weigh their taste preferences higher than environmental concerns when eating at a restaurant (Brunner et al., 2018). Irrespective whether information was provided via television, university lectures, or carbon labels; information should be aligned with the decision-stage that consumers are in (e.g. consumers in the pre-decision stage receiving information on reasons to

Table 3
Moderating variables assessed in the reviewed studies.

MODERATORS - VARIABLES STRENGTHENING/ ATTENUATING THE INTERVENTION EFFECT		n	EVIDENCE ON EFFECTS	EXAMPLES
Gender	Socio-demographic Factors	9	moderation of the effect on appetite for meat by gender; no moderation of the effect on intentions to eat meat by gender; moderation of the effect on feelings towards meat by gender; moderation of the effect on self-reported meat consumption by gender;	Dowsett et al. (2018); Kunst and Hohle (2016); Piazza et al. (2018); Sorensen et al. (2005)
Education	Socio-demographic Factors	1	moderation of the effect on self-reported meat consumption by participants' level of education;	Sorensen et al. (2005)
Culture	Socio-cultural Factors	1	moderation of the effect on willingness to eat meat by culture;	Zickfeld et al. (2018)
Trait dissociation	Personality Traits	3	moderation of the effect on empathy towards the animal by trait dissociation;	Kunst and Hohle (2016)
Conservatism	Personality Traits	2	no moderation of the effect on emotions by individual's degree of conservatism;	Earle et al. (2019)
Environmental consciousness/concern	Values	2	moderation of the effect on intentions by environmental consciousness;	Verain et al. (2017); Graham and Abrahamse (2017)
Self-transcendence values	Values	1	moderation of the effect on concern about climate impacts of meat consumption by self-transcendence values;	Graham and Abrahamse (2017)
Pro-social orientation	Values	1	moderation of the effect of empathy towards the animal on willingness to eat meat by pro-social orientation;	Zickfeld et al. (2018)
Past eating behavior/past meat consumption	Meat-related Lifestyle	2	moderation of the effect on food choice by past vegetarian dish consumption; moderation of the effect on self-reported meat consumption by past meat consumption;	Bacon and Krpan (2018); Rees et al. (2018)
Dish preference	Meat-related Lifestyle	2	no moderation effect was found;	Palomo-Vélez et al. (2018)
Strength of explicit reduction intentions	Meat-related Lifestyle	1	moderation of the effect on self-reported meat consumption by the strength of explicit intentions to reduce meat consumption;	Loy et al. (2016)
Popularity of focal dish	Meat-related Lifestyle	1	moderation of the effect on food choice by the initial popularity of the dish;	Saulais et al. (2019)
Dietary identity	Meat-related Lifestyle	1	moderation of the effect on willingness to eat less meat by participants' dietary identity	De Groeve et al. (2019)
Prior beliefs in negative health/environmental effects	Meat-related Lifestyle	1	moderation of the effect on intentions by believes in negative heath and/or climate effects of meat consumption;	Vainio et al. (2018)
Exposure to unprocessed meat	External Variables	1	moderation of the effect of dissociation on willingness to eat meat by the level of exposure to unprocessed meat;	Kunst and Palacios Haugestad (2018)
Number of dish options	External Variables	1	moderation of the effect on food choice by the number of alternative dish options offered;	Saulais et al. (2019)
Language type	External Variables	1	moderation of the effect on tolerance of perceived inconsistency by language type	De Groeve et al. (2019)
Animal type	External Variables	1	moderation of the effect on attitudes towards food by type of animal shown	Wang and Basso (2019)

reduce meat consumption; consumers in the decision stage receiving support on how to reduce meat-eating). Information that was aligned with the decision stage of consumers and at the same time matched their current goal orientation (i.e. health vs. environment vs. global justice) significantly reduced their meat consumption compared to accessing full information on a website (Klöckner & Ofstad, 2017).

Turning to the latter, message framing in general relates to cognitive biases in that the presentation of a choice option changes consumers' choice behaviour, although the option itself remains unchanged (Levin, Schneider, & Gaeth, 1998). In the context of meat consumption, a set of studies tested whether the identical core message (i.e. meat consumption should be reduced) resulted in different consumer responses contingent upon the problem appeals used (i.e. health, environmental, or animal welfare issues linked to meat consumption) (e.g. Cordts, Nitzko, & Spiller, 2014; Verain et al., 2017).

Indeed, both environmental and health appeals changed attitudes and behaviours towards reduced meat consumption (Bertolotti, Chirchiglia, & Catellani, 2016; A.; Cordts et al., 2014). Moreover, a combination of environmental and health appeals seemed to be more effective than single-framed messages in increasing intentions to reduce meat intake (Verain et al., 2017). When comparing appeals, health appeals appeared to have a stronger effect on intentions to reduce meat consumption than environmental appeals (A. Cordts et al., 2014). Health messages seemed to be especially effective when framed in factual (i.e. describing the actual effects of certain behaviours such as an

unbalanced diet) rather than prefactual terms (i.e. describing hypothetical future effects as a consequence of hypothetical present behaviour) (Bertolotti et al., 2016). One possible explanation for the stronger effect of health appeals could be that egoistic motivations such as health consciousness generally tend to influence food consumption more strongly than altruistic motivations (Birch, Memery, & De Silva Kanakaratne, 2018). This finding is in line with results from organic food consumption (Yadav, 2016) and local food consumption (Birch et al., 2018) where egoistic values influence the intention to choose organic or local food more than altruistic values. Besides health and environmental appeals, presenting aspects of animal welfare (i.e. linking to animal slaughtering and suffering) was also reported to be effective in increasing intentions to reduce meat consumption (A. Cordts et al., 2014). However, as Whitley, Gunderson, and Charters (2017) failed to show any effects of environmental, health and animal welfare appeals on support for plant-based diet policies, evidence on the effectiveness of messages with differently framed problem appeals seems to be mixed.

Further, it should be noted that the effect of health and environmental appeals on consumption intentions was moderated by prior beliefs in the negative health effects or existing consciousness about climate change implications of meat consumption. More specifically, health and environmental appeals only changed intentions of participants who believed in negative health and climate impacts beforehand (Vainio et al., 2018; Verain et al., 2017).

Table 4

Mediating variables assessed in the reviewed studies.

MEDIATORS - EXPLAINING UNDERLYING PROCESSES OF CHANGE		n	EVIDENCE ON EFFECTS	EXAMPLES
Empathy towards the animal	Emotional Response	12	full mediation of the effect on willingness to eat meat by empathy via cuteness; partial mediation of the effect on willingness to eat meat and likelihood to choose vegetarian by empathy, fully explained by decreasing state dissociation from the animal; no mediation of the effect on attitudes by empathy;	Earle et al. (2019); Kunst and Hohle (2016); Palomo-Vélez et al. (2018); Zickfeld et al. (2018)
Disgust	Emotional Response	6	partial mediation of the effect on willingness to eat meat and likelihood to choose vegetarian by disgust, partially explained by decreasing state dissociation from the animal; no mediation of the effect on attitudes by disgust;	Earle et al. (2019); Kunst and Hohle (2016); Kunst and Palacios Haugestad (2018); Palomo-Vélez et al. (2018)
Feelings of anticipatory guilt	Emotional Response	3	partial mediation of purchase intentions by anticipatory guilt feelings;	Wang and Basso (2019)
Distress about meat consumption	Emotional Response	2	partial mediation of the effect on willingness to eat meat by meat distress;	Earle et al. (2019)
Anticipated regret	Emotional Response	2	partial serial mediation of the effect on reduction intention and further on self-reported meat consumption by anticipated regret;	Carfora et al. (2017); Carfora et al. (2019)
Humanness and cuteness feelings	Emotional Response	2	full mediation of the effect on willingness to eat by humanness and cuteness; no mediation effect of babyness via cuteness on appetite for meat;	Piazza et al. (2018); Zickfeld et al. (2018)
Feelings of tenderness	Emotional Response	1	mediation of the effect of babyness on appetite for meat by feelings of tenderness (evidence is inconclusive i.e. more evidence is needed to determine whether it is full mediation or partial mediation);	Piazza et al. (2018)
Emotions towards meat- eating	Emotional Response	1	partial mediation of the effect on self-reported meat consumption by a reduction in positive emotions towards meat-eating;	Amiot et al. (2018)
Negative attitudes towards meat	Attitudinal Response	5	partial mediation of purchase intentions by less favorable attitudes towards meat;	Wang and Basso (2019)
Positive attitudes towards meat reduction	Attitudinal Response	1	full mediation of the effect on self-reported meat consumption by positive attitudes towards meat reduction;	Carfora, Catellani, et al. (2019)
Perceived personal health risks	Perceptual Response	2	partial mediation of the effect on risk acceptance by perceived personal health risks;	Berndsen and Van Der Pligt (2005)
Perceived moral risks	Perceptual Response	2	partial mediation of the effect on risk acceptance by perceived moral risks;	Berndsen and Van Der Pligt (2005)
Perceived message legitimacy	Perceptual Response	1	partial serial mediation of the effect of perceived inconsistency on willingness to eat meat by message legitimacy;	De Groeve et al. (2019)
Perceived message inconsistency	Perceptual Response	1	partial mediation of the effect on message legitimacy by perceived inconsistency;	De Groeve et al. (2019)
Advocate favoritism	Identity-related Response	1	partial serial mediation of the effect of perceived inconsistency on willingness to eat meat by advocate favoritism;	De Groeve et al. (2019)
Pre-conformity to a future norm	Identity-related Response	1	partial mediation of the effect on intention to eat meat by future norm (pre-conformity);	Sparkman and Walton (2017)
Perceived importance to other people	Identity-related Response	1	partial mediation of the effect on the intention to eat meat by perceived importance to other people;	Sparkman and Walton (2017)
Healthy-eating identity	Identity-related Response	1	partial serial mediation of the effect on reduction intentions by healthy eating identity;	Carfora et al. (2017)
Meat-eating identity	Identity-related Response	1	partial serial mediation of the effect on reduction intentions by meat-eating identity; partial mediation of the effect on willingness to eat meat by self-identity i.e. identification as a meat eater; partial mediation of the effect on advocate favoritism by identification as a meat eater;	Carfora et al. (2017); De Groeve et al. (2019)
Inferred enjoyment of food	Hedonic Response	1	full mediation of the negative effect of anthromorphism on intentions to visit the restaurant by inferred enjoyment of food;	Wang and Basso (2019)
Reduction intention	Intentional Response	5	partial mediation of self-reported meat consumption by reduction intention;	Berndsen and Van Der Pligt (2005); Carfora et al. (2017); Carfora et al. (2017)
Caretaking intentions	Intentional Response	1	partial mediation of the path between cuteness and willingness to eat meat by caretaking intentions; partial mediation of the path between empathy and willingness to eat meat by caretaking intentions;	Zickfeld et al. (2018)
State dissociation	Other Forms of Response	8	full mediation of the effect on empathy by state dissociation; partial mediation of the effect on disgust by state dissociation; full mediation of the effect on willingness to eat meat by state dissociation via empathy and disgust; full mediation of the effect on willingness to eat meat by state dissociation via empathy and cuteness;	Kunst and Hohle (2016); Kunst and Palacios Haugestad (2018); Zickfeld et al. (2018)
Risk acceptance	Other Forms of Response	2	full mediation of the effect on reduction intention by risk acceptance;	Berndsen and Van Der Pligt (2005)
Self-monitoring	Other Forms of Response	1	partial mediation of the effect on self-reported meat consumption by self-monitoring;	Rees et al. (2018)

4.2.1.2. Skills. Another personal factor that was frequently addressed by intervention studies relates to fostering skills and procedural knowledge (e.g. on how to prepare plant-based dishes or on how to shop plant-based foods). A lack of skills about how to shop, prepare and cook meatless dishes might act as a barrier to reduce meat consumption (Stoll-Kleemann & Schmidt, 2017).

Interventions fostering skill development were mainly implemented long-term and lasted several weeks or months. A set of studies employed cooking courses on how to shop and prepare plant-based foods accompanied by information provision, which seemed to be effective in increasing the intake of plant-based foods and decreasing meat consumption (Carmody, Olendzki, Reed, Andersen, & Rosenzweig, 2008; Flynn, Reinert, & Schiff, 2013; Zazpe et al., 2008). Notably, two of those effective studies targeted participants with pre-existing illnesses and employed interventions to reduce meat consumption aiming to prevent diseases (Carmody et al., 2008; Zazpe et al., 2008). However, research

on interventions addressing skill development among participants other than those with pre-existing illnesses seems to be scarce. Only two studies assessed the effect of interventions fostering skill development among participants with different socio-economic backgrounds at worksites (Hunt, Stoddard, Kaphingst, & Sorensen, 2007; Sorensen et al., 2005). These interventions included various elements such as health fairs, support with nutrition and physcial activity, group discussions as well as educational material. However, from two studies only one study showed significant effects on participants' meat consumption (Sorensen et al., 2005), with stronger intervention effects among women than men and among participants with less education than among those with higher education. In contrast, Hunt et al. (2007) did not report signficant effects on participants' meat consumption. Possibly the intervention was not effective because the measures were not tailored to participants' multi-ethnic backgrounds (i.e. Non-Hispanic, Hispanic, Mixed/other).

4.2.1.3. Emotions. Emotions are another personal factor that were frequently addressed by intervention studies. Consumers' emotional reactions are a crucial aspect of behavioural change in general, and of dietary changes in particular (Kollmuss & Agyeman, 2002). An emotion *"is a mental state of readiness that arises from cognitive appraisals of events or thoughts; has a phenomenological tone; is accompanied by physiological processes; is often expressed physically (…); and may result in specific actions to affirm or cope with the emotion (…)"* (Bagozzi, Gopinath, & Nyer, 1999). Emotional involvement is the ability to have an emotional response when confronted with certain issues such as environmental harm or animal suffering. Generally, consumers are more likely to engage in a new behaviour when they show a stronger emotional response to a certain issue (Kollmuss & Agyeman, 2002). Emotional responses such as empathy can be activated by observing emotional conditions of others (e.g. suffering humans or animals). This triggers certain brain responses involved in processing the same state in oneself (e.g. pain or disgust) and enables consumers to share another person's feelings (Filippi et al., 2010). Some intervention studies aimed at activating negative emotions such as fear, guilt, sadness or disgust or positive emotions such as pleasure. For example, Tybur, Laakasuo, Ruff, and Klauke (2016) activated negative emotions of disgust by pairing pictures of either meats or plants with disgust-eliciting pictures of pathogens (i.e. visuals of an infected boil, an infected toe, a toilet covered with bodily wastes, or a pile of vomit) and showed that participants reduced their desire to eat the portrayed meats.

A number of intervention studies further compared the effectiveness of informational messages addressing knowledge and emotional messages and found emotionally framed messages to have stronger effects in reducing intentions to eat meat than informational messages (Berndsen & Van Der Pligt, 2005; Carfora, Bertolotti, & Catellani, 2019). In this vein, messages reading as *"If you eat an excessive amount of red and processed meat, you will not protect your health […]"* increased reduction intentions less than messages reading as *"If you eat an excessive amount of red/processed meat, you could feel regret for not protecting your health […]"* (Carfora et al., 2019)). Participants receiving the emotional message also significantly reduced their actual meat consumption, which was not the case for the informational condition. This could potentially be explained by increased feelings of anticipated regret in the emotional condition for exceeding the recommended amount of meat intake (Carfora et al., 2019). In line with the above finding, emotional messages triggering feelings of disgust or empathy towards the animal both had a stronger negative effect on attitudes towards meat than informational messages about health and environmental issues (Palomo-Vélez, Tybur, & van Vugt, 2018). Similarly, describing animal suffering in the context of factory farmed meat (i.e. animals confined to indoor pens in relatively inhumane conditions) showed to activate negative feelings and resulted in meat-eating being less pleasurable due to perceiving meat as less appealing, less tasteful, and less enjoyable than humanely raised meat (i.

e. animals graze outdoors) (Anderson & Barrett, 2016). Consequently, across studies, activating negative emotions towards meat-eating, especially feelings of disgust or regret, seemed to be effective in reducing meat consumption.

4.2.1.4. Cognitive dissonance. Consumers tend to avoid meat-related information that contradicts their existing values or beliefs, such as information on animal suffering (Festinger, 1957; Loughnan et al., 2010). This so called meat-related cognitive dissonance occurs when a meat-eater's behaviour is inconsistent with their values, beliefs or attitudes (e.g. love of animals) and this inconsistency generates an arousal that subsequently leads to a desire to reduce the dissonant state (Rothgerber, 2020b). Consumers aim to avoid meat-related cognitive dissonance, for instance, by ignoring information that increases this dissonance and tend to dissociate meat from the living animal. When cognitive dissonance does appear, consumers try to reduce the dissonant state by denying responsibility, denying the animal mind by dehumanizing animals, or by justifying meat-eating (Rothgerber, 2014, 2020b; Rothgerber & Rosenfeld, 2021). These strategies decrease emotional involvement and thus, the intention to reduce meat consumption (Stoll-Kleemann & Schmidt, 2017). Closely related to cognitive dissonance is the so-called "meat paradox", a phenomenon that describes meat eaters' psychological conflict between their liking of meat and their moral responsibility to avoid animal harm (Loughnan et al., 2010; Rothgerber, 2020a; Rothgerber & Rosenfeld, 2021).

Existing intervention studies either addressed the prevention mechanism of dissociation (Earle, Hodson, Dhont, & MacInnis, 2019; Kunst & Hohle, 2016; Kunst & Palacios Haugestad, 2018; Piazza, McLatchie, & Olesen, 2018; Tian, Hilton, & Becker, 2016; Zickfeld, Kunst, & Hohle, 2018) or reduction mechanisms such as denying the animal mind (Dowsett, Semmler, Bray, Ankeny, & Chur-Hansen, 2018; Wang & Basso, 2019). Findings showed that providing messages or pictures relating meat to living animals reduced dissociation from the animal and, further, consumers' willingness to eat meat (Earle et al., 2019; Kunst & Hohle, 2016; Kunst & Palacios Haugestad, 2018; Piazza et al., 2018; Tian et al., 2016; Zickfeld et al., 2018). These effects were mediated by empathy towards the animal. More specifically, associating the meat product with the animal itself increased empathy and disgust and subsequently decreased intentions to eat meat (Kunst & Hohle, 2016; Kunst & Palacios Haugestad, 2018). This effect varied across cultures, seemingly because the level of consumers' exposure to unprocessed meat differed between countries. For instance, Ecuadorian consumers who were frequently exposed to unprocessed meat showed higher degrees of dissociation, less disgust and empathy for the killed animal and lower reduction intentions than US participants with little exposure (Kunst & Palacios Haugestad, 2018). Moreover, participants exposed to pictures of cute animals were less likely to eat meat compared to participants exposed to pictures of neutral animals. Again, the effect was mediated by empathy and caretaking intentions (Zickfeld et al., 2018). In a different context, showing pictures of baby animals reduced consumers' appetite for meat, but only for women and not for men. However, findings showed no mediation effect of babyness via cuteness on appetite for meat (Piazza et al., 2018).

Two intervention studies addressed the cognitive dissonance reducing mechanism of denying animal mind (Dowsett et al., 2018; Wang & Basso, 2019). Humanizing animals (for instance, by referring to either a human-animal friendship or an animal-animal friendship) increased consumers' feelings of anticipatory guilt. Those feelings partially explained less favorable attitudes towards meat leading to lower intentions to purchase meat. However, this effect seemed contingent upon the target animal as this effect was only found for pigs and not for cows (Wang & Basso, 2019). Furthermore, humanizing animals by reminding consumers about the animal's intelligence and personality increased negative feelings towards meat with stronger effects on women than men (Dowsett et al., 2018).

4.2.1.5. Values and attitudes. Values are guiding principles of behaviour and build the basis of many everyday decisions. They help individuals to evaluate situations in terms of what is right or wrong. While values transcend specific situations, attitudes are subject-specific evaluations of another person, an object, an idea or action (Darnton & Evans, 2013; Schwartz & Bilsky, 1987). Values and attitudes are influencing factors of food choices, and thus, meat consumption (Graham & Abrahamse, 2017). Meat consumption in particular is linked to ethical questions and moral values around the killing and suffering of animals. Hence, moral values with regards to animal welfare, but also consumers' value orientations towards self and others seem to be important factors determining meat consumption (Graham & Abrahamse, 2017; Rothgerber, 2017).

Two studies assessed the influence of values on meat consumption by either testing messages appealing to consumers' self-transcendence or self-enhancement values (Graham & Abrahamse, 2017) or by appealing to the values symbolized by meat i.e. hierarchy and dominance values (Allen & Baines, 2002). Informational messages appealing to either self-transcendence values (i.e. *"If as a country, we reduce our meat intake to the World Health Organisation (WHO) recommended 90 g per day this will reduce New Zealand's carbon emissions […] Together we can make a difference."*) or self-enhancement values (i.e. *"If as an individual, you reduce your meat intake to the WHO recommended 90 g per day this will reduce your carbon emissions […] Individually, you can make a difference."*) were found to be effective in creating negative attitudes towards meat consumption with a stronger effect of messages relating to self-transcendence values. However, other than hypothesized, the effect was stronger when consumers received a message not aligned with their values, but their opposite value orientation. More specifically, consumers with high self-transcendence values showed more negative attitudes towards eating meat when they received the self-enhancement message (Graham & Abrahamse, 2017). One explanation could be that consumers with high self-transcendence values are generally more personally involved in environmental issues and thus, respond more strongly to the individual message. Differently, one might argue that framing effects are usually lower for participants with specific predispositions to an issue, such as strong values (Graham & Abrahamse, 2017). Consequently, messages on environmental impacts of meat consumption were not more effective when they were aligned with consumers' value orientations.

In a different study setting, presenting information on the values symbolized by meat (i.e. *"Previous research has found that people who consume more meat endorse hierarchy and dominance values, whereas people who consume more fruit and vegetables reject hierarchy and dominance values."*) lowered preferences for meat among consumers who rejected social dominance. More so, they showed lower meat identification and higher intentions to eat more fruit and vegetables and reported higher actual consumption of fruit and vegetables. However, these expressed preferences did not translate to reductions in actual meat consumption (Allen & Baines, 2002).

4.2.1.6. Habits. Food consumption behaviour and, therefore, meat consumption, is a strongly habitualized behaviour. Habits are cognitive processes in certain situations (e.g. having lunch at a restaurant) that trigger a particular behaviour (e.g. ordering the meat dish) (Rees et al., 2018) and tend to be automatic and routinized. Meat consumption is largely driven by unreflective and automatic processes that are influenced by situational contexts, rather than the result of solely conscious cognitive processes (Rees et al., 2018; Zur & Klöckner, 2014). Changing meat consumption habits is challenging, because shopping and preparing meals requires extra time as well as physical and mental effort. Therefore, habits and routines belong to the main barriers of reducing meat consumption (Hoek et al., 2017). Still, not more than two studies focused on interventions solely addressing habit change to reduce meat consumption (Camp & Lawrence, 2019; Rees et al., 2018).

Setting goals[1] and forming intentions of where, when and how to achieve the predefined goal seems to be a successful way of changing eating habits (Van't Riet, Sijtsema, Dagevos, & Bruijn, 2011). Goals are linked to desired outcomes and derive from a dissatisfaction with the current situation (Locke & Latham, 2006). The role of goals in changing eating habits can be described through four dimensions: (i) goals help to focus on activities that are goal-relevant and direct attention away from those that are not; (ii) goals motivate behaviour in that harder goals lead to more effort than easier ones; (iii) goals influence determination, because higher set goals require more effort; and (iv) goal setting impacts behaviour indirectly because individuals develop knowledge and task-related competences that help them to adapt their plans and actions to improve goal attainment (Locke & Latham, 2006). Accordingly, goal setting helps to achieve an expected behaviour (e.g. eating only two meat dishes per week). Results showed that goal setting and forming implementation intentions helped consumers to eat less meat. This effect could partially be explained by increased self-monitoring and thus, more concern with goal achievement among those consumers (Rees et al., 2018).

Also, response inhibition trainings seemed to be useful to foster habit change. Such training involved learning in the automatic system by (i) presenting pictures of meat together with no-go cues and inhibiting consumers' motoric responses of pressing a button and (ii) presenting pictures of healthy foods (fruit and vegetables) together with go cues allowing consumers' motoric response of pressing a button. Providing meat pictures paired with no-go cues and response inhibition effectively reduced meat consumption (Camp & Lawrence, 2019). Consumers generally seem to be able to inhibit their performance of habitual behaviours after it has been mentally triggered by a cue, depending on their level of self-control (Van't Riet et al., 2011).

4.2.2. Interventions addressing socio-cultural factors

Socio-cultural factors influence and shape meat consumption behaviour including culture and religion as well as social norms. Certain cultural rituals and religious traditions forbid to eat specific types of meat or provide rules of when and how to eat meat (Bonne & Verbeke, 2008). While extant research on interventions to reduce meat consumption did not address cultural and religious factors, a few studies explored the role of social norms in meat consumption behaviour. Social norms, defined as general standards for behaviours and attitudes within a relevant social group (Sunstein, 1995), affect a wide range of individual attitudes, choices and behaviours. The basic premise is that, if consumers have information on what other consumers are thinking, feeling, or doing with regards to a specific behaviour (i.e. consuming meat), they will adapt their own attitudes and behaviours to adhere to the presented social norm if certain conditions, such as observability and normative expectations, are met (Bicchieri & Xiao, 2009; Cialdini, Reno, & Kallgren, 1990).

Rendering attitudes or behaviours of other consumers in a message can activate social norms and motivate participants to adhere to this social norm (e.g. eating more plant-based foods). However, scholarly research on this effect in the context of meat consumption is scarce. Sparkman and Walton (2017) found that integrating dynamic social norms into messages (e.g. *"in the last 5 years, 30% of Americans have made an effort to reduce their meat consumption"*) increased the choice of a meatless lunch in a restaurant context. Moreover, portraying a meat reduction advocate as either a member of the in-group (i.e. being a meat-eater) or the out-group (i.e. being a vegetarian) had an impact on whether information was perceived as legitimate and consequently on willingness to reduce meat consumption. Consumers who identified less

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[1] A similar measure in the food literature refers to the use of pledges defined as a promise to eat certain foods such as vegetables and to avoid others such as meat. Similarly, pledges strengthen the level of commitment to adhere to certain behaviours (Raju, Rajagopal, & Gilbride, 2010).

as meat eaters and showed higher advocate favoritism perceived the message as more legitimate and were more willing to reduce meat consumption (De Groeve, Bleys, & Hudders, 2019).

4.2.3. Interventions addressing external factors

Interventions addressing external factors of behavioural change go beyond personal factors and the sociocultural level. The environment of food consumption (e.g. types of food offered, availability and access to food) can be designed to promote vegetarian food choices (Bianchi, Garnett, Dorsel, Aveyard, & Jebb, 2018; Stoll-Kleemann & Schmidt, 2017). Interventions in the food environment are often referred to as "nudges" (Sunstein, 2014) which include any aspect of the decision environment that purposeful changes consumers' food choices without forbidding any options or limiting choices. Implementing nudges assumes that individuals do not behave rationally in the respective decision context but rely on their automatic thinking. Hence, making changes in the food environment should guide consumers and facilitate their automatic decision making (Sunstein, 2014; Thaler & Sunstein, 2008).

In our analysis, we distilled three main types of nudging interventions in the food environment: (i) making vegetarian food more visible, (ii) changing the portion sizes of meals and, (iii) setting vegetarian meals as the default. Furthermore, we identified an alternative way of changing the food environment by restricting choices in the form of mandatory vegetarian days.

4.2.3.1. Making vegetarian food more visible.
Research showed that increasing the visibility and variety of vegetarian foods led to higher sales and consumption of these foods. The basic premise of enhancing the visibility and increasing perceived variety of food options is that certain foods become more prominent in the consideration set of consumers without restricting choice (Kurz, 2018; Wansink & Love, 2014).

In a restaurant setting, changing the order of menu items and thereby making vegetarian dishes more visible to consumers increased the share of vegetarian dishes sold (Kurz, 2018). Similarly, simply offering more vegetarian menu options was found to increase the choice of vegetarian meals versus meat-based meals (Garnett, Balmford, Sandbrook, Pilling, & Marteau, 2019). Another successful way of fostering the choice of vegetarian food was by increasing the perceived variety of vegetables (e. g. by splitting up various salads into individual bowls) (Friis et al., 2017; Kongsbak et al., 2016). In a different study, the visibility of meat substitutes was enhanced by placing it next to meat products in a supermarket. Consequently, sales of meat substitutes showed to increase while meat sales stayed stable (Vandenbroele, Slabbinck, Kerckhove, & Vermeir, 2019). More so, increasing the visibility of certain meat products (i.e. poultry) in a supermarket setting significantly increased the sale of these products (Coucke, Vermeir, Slabbinck, & Van Kerckhove, 2019).

Other interventions that increased the visibility of vegetarian food included labelling vegetarian dishes as "chef's recommendation" (Bacon & Krpan, 2018), using descriptive names of dishes in menus (Bacon & Krpan, 2018) or using visual stimuli or odours of food (Friis et al., 2017). We found mixed evidence that labelling a vegetarian menu option as "dish of the day" or as "chef's recommendation" reduced the consumption of meat. Two studies found no effects of the "dish of the day" label on menu choice (dos Santos et al., 2018; Zhou et al., 2019); however, in another context this labelling increased the selection of the vegetarian meal (Saulais et al., 2019). The effect was moderated by the size of the choice set – if the number of meal options was higher, participants were more likely to choose the vegetarian "dish of the day". This might be explained by research on choice overload, i.e. a high number of food choices can be confusing making people to prefer the easiest option (Iyengar & Lepper, 2000; Johnson et al., 2012). Moreover, the "dish of the day" effect was larger for meals with lower initial popularity (Saulais et al., 2019). One study found that the label "chef's

recommendation" and descriptive menu items seemed to increase the choice of vegetarian foods but only for infrequent eaters of vegetarian foods (Bacon & Krpan, 2018).

A different approach of increasing the visibility of plant-based foods involved placing plants and herbs in a buffet setting to create a green ambience so consumers were visually exposed to the plants while interacting with the entire buffet area. Thereby, total food consumption was found to be reduced, mainly by a reduction in the consumption of meat dishes (Friis et al., 2017).

4.2.3.2. Changing the portion sizes of meals.
Increasing the portion sizes of vegetable dishes in restaurants or canteens (and reducing meat portions) led to an increase in vegetable consumption and a decrease in meat consumption (Reinders, Huitink, Dijkstra, Maaskant, & Heijnen, 2017; Rolls, Roe, & Meengs, 2010). Results showed that the idea of changing portion sizes and replacing meat with vegetables was widely accepted among consumers (Spencer, Kurzer, Cienfuegos, & Guinard, 2018) although the degree of this acceptability seemed to depend on consumers' taste preferences (Spencer, Cienfuegos, & Guinard, 2018; Spencer & Guinard, 2018). Reducing the portion size of meat was also found to be effective in a supermarket setting, where offering a smaller portion of meat products decreased overall meat sales, because consumers tended to buy the smaller portion (Vandenbroele, Slabbinck, Van Kerckhove, & Vermeir, 2018).

4.2.3.3. Setting vegetarian meals as the default.
One type of nudge prominently discussed in the scholarly literature are *defaults*. Extant studies showed that setting an option as the default, seemed to increase the likelihood that this option is chosen (e.g. Campbell-Arvai, Arvai, & Kalof, 2014; Friis et al., 2017). From the perspective of rational choice theory, consumers choose the default option because the cognitive effort and/or the switching costs of choosing an alternative option are too high. Also, defaults cater to decision-making biases like loss aversion and the endowment effect, which denote decision-makers tendencies to attribute greater value to options set as the status-quo (Jachimowicz, Duncan, Weber, & Johnson, 2019).

Surprisingly, only two studies investigated default effects in the context of meat consumption (Campbell-Arvai et al., 2014; Friis et al., 2017), both of which found a positive effect on choosing meat-free meals. Vegetarian options were presented, for instance, as the default on a menu (Campbell-Arvai et al., 2014) or by providing a prepared, fixed portion of salad as the default in a canteen setting (Friis et al., 2017). The default effects were amplified if the vegetarian food presented was appealing to the respective consumers (i.e. for vegetarian dishes that were evaluated as more attractive, pleasing, exciting and more desirable). Neither information on the benefits of eating vegetarian nor the value orientation and worldview of consumers made any significant difference to this effect (Campbell-Arvai et al., 2014). However, what did enhance the default effect was if the (cognitive) effort needed to choose the non-default meat-option was higher i.e. walking a few meters to look at the non-vegetarian menu (Campbell-Arvai et al., 2014) or self-serving on plates (Friis et al., 2017).

4.2.3.4. Mandatory vegetarian days.
Lombardini and Lankoski (2013) investigated the effect of a weekly mandatory vegetarian day at a school cafeteria on students' acceptance of vegetarian meals. During the phase of choice restriction, less students visited the cafeteria and plate waste increased which indicated a lack of acceptance. However, in the medium-term, the share of vegetarian dishes consumed increased when meat and fish dishes were available.

4.2.4. Interventions addressing multi-factors

Some interventions combined habit change techniques with other factors such as knowledge and skill development, changes in the food environment, social influence, or emotions (e.g. Amiot, El Hajj Boutros,

Sukhanova, & Karelis, 2018; Valentina; Carfora et al., 2019; Stea & Pickering, 2019). These studies, however, assessed combined effects of various factors rather than testing effects of single factors in isolation. Hence, these studies did not allow to draw conclusions about the effectiveness of specific intervention components.

Often, these interventions were employed long-term and lasted several weeks or months. They were predominantly targeted towards former health care patients with pre-existing illnesses who had stronger motivations to change their dietary habits (Delichatsios, Hunt, Lobb, Emmons, & Gillman, 2001). Counselling and goal setting to foster habit change combined with educational materials on healthy lifestyles (i.e. on sports exercises, healthy meals, and recipes) appeared to be an effective approach to reduce meat consumption (V. Carfora, Caso, & Conner, 2017; V. Carfora, Caso, & Conner, 2017; V. Carfora et al., 2019; Emmons, McBride, et al., 2005; Emmons, Stoddard, et al., 2005; Grimmett, Simon, Lawson, & Wardle, 2015; Hawkes, Gollschewski, Lynch, & Chambers, 2009; Hawkes, Patrao, Green, & Aitken, 2012). Furthermore, the effects of providing information (e.g. about the consequences of meat consumption or dietary recommendations) were enhanced when consumers additionally set personal goals related to meat consumption (e.g. V. Carfora, Caso, & Conner, 2017; Loy, Wieber, Gollwitzer, & Oettingen, 2016). In contrast to effective study findings of goal setting in combination with information and education, goal setting showed to be ineffective when the education was provided via an automated computer system (Delichatsios, Friedman, et al., 2001). In another study setting, providing education and personal counselling including goal setting showed positive effects on fruit and vegetable consumption, but not on reduced meat consumption. One explanation might be that the broad majority of participants chose their motivational counselling sessions to focus on fruit and vegetables only rather than on the other three food groups (i.e. red/processed meat, whole-fat dairy foods, low-fat dairy products) (Delichatsios, Friedman, et al., 2001).

In a different study four factors were addressed by combining a social norm, an informational and a goal setting and self-monitoring component with an appeal to fear (Amiot et al., 2018). More specifically, consumers received a description about emerging social norms showing a significant reduction in meat-eating and information about the negative effects of meat consumption. More so, a fear appeal relating to animal harm was presented and consumers received tips on how to plan meat free meals accompanied by setting dietary goals for the following month. Consumers significantly reduced their actual meat consumption, and the intervention appeared to even result in a greater decrease over time. The effect was partially mediated by emotions in that the intervention decreased positive emotions towards meat (Amiot et al., 2018). In another study, Stea and Pickering (2019) tested the effect of a social norm message combined with information on the environmental impact of meat-eating by referring to a location consumers had a place identity connection with (place identity refers to the extent to which consumers' identity is tied to a particular place or location). However, the combined message did not result in reduced intentions to eat meat. One possible explanation could be that referring to consumers' personal location might decrease the perceived need for action, since consumers tend to hold optimistic views about their personal location or towards their fellow residents (Stea & Pickering, 2019).

5. Discussion

Scholarly research on interventions to reduce meat consumption addressed one or more focal factors of behavioural change, namely, personal, socio-cultural and/or external factors. There is strong evidence that especially certain interventions addressing personal and external factors are effective in reducing meat consumption. More specifically, factual or emotional messages, information relating meat to living animals, educational measures including cooking courses as well as increasing the visibility of vegetarian food appear to be effective. There is less evidence that interventions addressing socio-cultural factors such

as social norms foster reduced meat intake. Intervention effectiveness varies across consumer groups with different socio-demographic and socio-cultural characteristics, personality traits, values and meat-related lifestyle (see also Fig. 1: *The Meat Reduction Intervention Framework*). The following section provides (i) recommendations for policy-makers, (ii) directions for substantive research and, (iii) methodological advances for future intervention studies.

5.1. Recommendations for policy-makers

Consumption-side interventions have great potential for reducing meat consumption in industrialized countries and thereby tackling public health problems and reducing greenhouse gas emissions. The evidence of intervention effectiveness put together in this review can inform public policymakers on the design of policy measures that support a diet with less meat and more plant-based foods. In this section, we recommend a set of actions for policy design to reduce meat consumption levels based on the evidence gathered in the course of our systematic review (see Table 5).

5.1.1. Inform about negative side-effects with a focus on health

As outlined in our findings, it is worthwhile for public policymakers to inform consumers about the negative side effects of consuming meat. Thereby, combining information about negative effects on health and the environment might be more effective than using single-framed messages to reduce intentions to eat meat. If single-framed messages are communicated, the focus should be on the potentially detrimental health consequences of meat-eating such as a higher risk for strokes, heart attacks or cancer rather than environmental issues such as greenhouse gas emissions. Moreover, to ensure cost-effectiveness of policies, these information measures should be mainly aimed at consumers who already believe in negative health effects of meat consumption and who show environmental concern (Vainio et al., 2018; Verain et al., 2017). Information should ideally be tailored to the decision-stage that consumers are in: consumers who consider reducing their meat intake should primarily receive information about reasons to do so (e.g. about negative side effects). Consumers who already have intentions to reduce their meat intake require information on how to do so. Additionally the information should match consumers' goal orientation (i.e. focusing either on environmental, health or global justice reasons) (Zur & Klöckner, 2014).

5.1.2. Trigger emotions

Even more effective than providing facts about meat consumption and its consequences, is activating emotions such as empathy, guilt or even disgust. For instance, messages about slaughtering or animal suffering as well as pictures of unprocessed meat increase disgust among consumers. While messages that talk about the personality of animals or about human-animal and animal-animal friendships increase feelings of guilt, pictures of cute and baby animals foster empathy and caretaking-intentions. Triggering these emotions is especially effective in reducing meat consumption among women and consumers with low exposures to unprocessed meat (Kunst & Hohle, 2016; Kunst & Palacios Haugestad, 2018). When designing such interventions, one needs to consider that the type of animal can play a role in intervention effectiveness, for instance, interventions referring to human-animal or animal-animal friendships are more effective when showing pigs than cows (e.g. Wang & Basso, 2019).

5.1.3. Provide competence training and support habit change

It is worthwhile to invest in more long-term intervention measures that combine, for instance, counselling by personal health coaches with educational materials on healthy lifestyles (e.g. Emmons, McBride, et al., 2005; Grimmett et al., 2015; Hawkes et al., 2012). Here, the focus should be specifically on changing meat consumption habits (i.e providing support on how to reduce and substitute meat consumption),

Table 5
Recommendations for designing interventions.

	Type of Intervention	Recommendations	References
Targeting Policies to Specific Consumer Groups	Inform about Negative Side-effects with a Focus on Health	• combine health and environmental appeals • highlight health appeals rather than environmental appeals • provide personalized information aligned with consumers' decision stage and goal orientation	e.g. Cordts et al., 2014; Klöckner & Ofstad, 2017; Vainio et al., 2018
	Trigger Emotions	• communicate emotionally framed messages • relate to animal suffering or show pictures of unprocessed meat • show pictures of living animals or cute animals in restaurant contexts	e.g. Carfora et al., 2019; Kunst & Hohle, 2016; Palomo-Vélez et al., 2018
	Provide Competence Training and Support Habit Change	• combine goal setting and counselling with educational materials on healthy lifestyles • provide cooking courses to assist in the preparation of vegetarian food	e.g. Carmody et al., 2008; Emmons, McBride, et al., 2005; Grimmett et al., 2015;
	Increase the Visibility of Vegetarian Food	• make vegetarian food more visible in the food environment (e.g. restaurant; supermarket) • increase the visibility of vegetarian food by labelling a vegetarian meal as "dish of the day"	e.g. Garnett et al., 2019; Kurz, 2018; Reinders et al., 2017

not (only) on how to eat more vegetables and fruit (Delichatios, Friedman, et al., 2001; Delichatsios, Hunt, et al., 2001). To further support habit change towards eating less meat, cooking courses can educate consumers on shopping and preparing for vegetarian meals (Carmody et al., 2008; Zazpe et al., 2008).

5.1.4. Increase the visibility of vegetarian food

An effective type of "nudge" that is relatively easy to implement is making vegetarian food more visible, for example, by placing it differently in a restaurant or supermarket (e.g. Reinders et al., 2017). Another tactic to increase the visibility of vegetarian meals is to frame them as "dish of the day". Here, one needs to consider that the effect of such an intervention depends on consumers' liking of the respective dish as well as on the size of the choice set (Saulais et al., 2019).

To summarize, a multi-faceted approach and combination of intervention measures will be critical as there is no silver bullet solution for reducing meat consumption levels. Targeting policy measures to specific consumer groups according to socio-demographic characteristics such as gender, health conditions, or prior beliefs will make them more powerful. While we have not assessed the cost-effectiveness of the different intervention types in this paper, we are confident that our policy recommendations are easier to implement and more acceptable for consumers than more comprehensive measures such as bans or meat taxes (L. A. Reisch et al., 2021).

5.2. Directions for substantive research

Our review shows strong evidence that activating negative emotions is effective in reducing meat consumption, while less is known about the influence of triggering positive emotions.

Moreover, previous research mainly focused on two cognitive dissonance-reducing mechanisms of consumers, namely dissociation and dehumanizing animals. Other mechanisms to overcome cognitive dissonance, such as denial of animal suffering, dichotomizing animals into those we love and those we eat or pro-meat justifications (Rothgerber, 2014, 2020b), were not addressed in experimental settings. Also, no experimental study focused on dissonance factors outside animal welfare contexts, although cognitive dissonance can also be experienced over environmental or health concerns of meat consumption (Rothgerber, 2020b).

Also, measures aiming towards skill development were barely addressed in existing research. In this respect, research only revealed positive effects of specific measures such as cooking courses for people with pre-existing illnesses on meat consumption. Future research should assess the effects of education fostering food competences in different contexts (e.g. nutrition courses held in companies) and with different samples.

Moreover, little is known about interventions addressing socio-cultural factors such as culture and religion, social influence, and identities in the context of meat consumption. However, research indicated that relating to the dietary preferences of other consumers could be effective, especially when communicated by advocates belonging to the consumers' reference group (i.e. a vegetarian advocate approaching vegetarians or a meat-eating advocate addressing meat-eaters). Hence, future research could further test the impact of differently framed social norm messages personalized to consumers' eating identities communicated by role models.

Given that nudges are so prominently discussed as promising tools to influence consumers' food consumption habits without restricting choice (Kurz, 2018; Lehner, Mont, & Heiskanen, 2016), scholarly evidence on the effectiveness of measures employed in the food environment is surprisingly rare. While increasing the visibility of vegetarian food appears to be effective, research on other interventions such as setting vegetarian dishes on default is rather scarce. To verify effectiveness, there is a need for more experimental studies in this area as well as for insights into consumers' acceptance of these nudging interventions (Lehner et al., 2016).

Furthermore, we know little about the effectiveness of choice restricting measures employed in food environments such as mandatory vegetarian days or other restricting economic policy instruments such as "meat taxes" (i.e. a higher value-added tax for emission-intensive food such as meat). While currently employing a meat tax is discussed in several countries, it has not yet been implemented anywhere. While it is expected that higher meat prices would indeed influence consumer's food choices (L. Reisch et al., 2013; Tukker et al., 2009), there is no experimental research investigating these causal links.

5.3. Methodological advances for future intervention studies

5.3.1. Sample characteristics

More than one third of all studies included in our systematic literature review relied on student samples. One might argue that the difference between student and non-student samples biases results and decreases external validity (Ashraf & Merunka, 2017). However, student samples exhibit homogenous profiles, and thus, inter-group differences in empirical results cannot be attributed to sample characteristics, but to the manipulation (i.e. the intervention) itself. This justifies the use of student samples with high internal validity (Ashraf & Merunka, 2017). However, responses from students and other well-educated populations to an intervention may differ from those of other population groups, especially in the case of meat consumption since education strongly

influences consumption patterns of meat (E. Lea & Worsley, 2001). More specifically, a higher level of education positively correlates with meat reduction and following a vegetarian diet (V. A. Cordts, Nitzko, Grethe, & Duman, 2013). Therefore, future research should aim towards more non-student samples with high external validity and replicate findings in consumer samples with varied socio-demographic profiles.

Health motivated papers (i.e. papers with a problem framing emphasizing the health consequences of meat consumption) provided insights that might be useful for designing future interventions to reduce meat intake. However, the majority of these studies used samples of participants with pre-existing illnesses having stronger motivations for behavioural change. Therefore, it remains unclear in how far findings from this research can be generalized to other consumer samples and study contexts.

5.3.2. Geographical spread

As the vast majority of studies was conducted in industrialized countries, one should be cautious to transfer the reviewed results to other countries or cultural contexts because culture influences food preferences (Tiu Wright, Nancarrow, & Kwok, 2001). While reducing meat consumption levels is currently mainly discussed in industrialized countries (Chemnitz, 2014; Jensen, 2014), projections show a growing trend of meat consumption levels in emerging countries, especially among the growing middle class with higher incomes (Zastiral, 2014). Only three studies addressed cross-cultural differences in meat consumption and intervention effectiveness (Kunst & Palacios Haugestad, 2018; Tian et al., 2016; Zhou et al., 2019) with two studies assessing effects on consumers from Ecuador and China (Kunst & Palacios Haugestad, 2018; Tian et al., 2016). This points to a future need for additional research on interventions in other cultural settings, especially addressing the growing middle class in urban regions of emerging countries.

5.3.3. Dependent variables

Our systematic review clearly shows that most studies, especially those testing interventions providing information and framing of issues of meat consumption, measured the effects of interventions on attitudes or intentions rather than actual consumption. Informing consumers about the negative consequences of meat consumption might increase consumers' awareness or even intention to eat less meat; however, they might still fail to act accordingly referring to the so-called intention-behaviour gap (Loy et al., 2016). Although interventions providing information alone are often not effective in changing actual eating behaviour long-term, knowledge about issues seems to be the basis for consumers' actions (White, Habib, & Hardisty, 2019). Future research might address the intention-behaviour gap by (i) employing more experimental studies testing the effects on actual meat consumption rather than on intentions, and (ii) combining information with other tactics such as changes in the food environment.

The few studies that assessed the effects of interventions on actual consumption collected mainly self-reported consumption data. Self-reported measures may be subject to bias in that consumers tend to assess themselves as better than they truly are and provide answers that they perceive as socially desirable (Kruger & Dunning, 2000). Future research should therefore investigate behaviour based upon objective measures, which certainly is more challenging with respect to the study design. Moreover, extant studies primarily assessed immediate effects on food choice rather than fundamental changes in dietary habits which calls for research on long-term impacts of specific interventions.

Generally, only few studies compared the effects of different factors (e.g. comparing emotional and informational messages addressing knowledge). Also, long-term interventions that integrated different factors such as information and changes in the food environment assessed all measures combined, but not of each component in isolation. Future research should further test multi-factor interventions and allow for comparisons of their effectiveness by measuring both, the total effect of all intervention components combined and the effects of each component in isolation.

In addition, statistical power and thus, detecting effect sizes is of high importance so as not to miss potentially impactful interventions. However, 41 studies did not report effect sizes explicitly. Future experimental studies should explicitly refer to study power by reporting effect sizes.

5.3.4. Mediating and moderating variables

The Meat Reduction Intervention Framework presented in chapter two illustrates the varying effectiveness of interventions to reduce meat consumption and provides an overview of moderating and mediating variables (see Fig. 1). Our review identifies several mediating variables that add to our understanding of how interventions affect meat consumption behaviour including consumption intention, self-identity, empathy towards animals, disgust, and state dissociation from the animal, among others. Meat consumption behaviour is complex with many potentially influencing factors which need to be considered when intervention studies are designed. Tables 3 and 4 provide a more detailed list of mediators and moderators that have already been assessed in existing research. Most likely, those lists are not fully complete yet and more studies are needed to identify further variables that influence and explain intervention effectiveness.

In contrast to moderating variables, mediating variables were more frequently assessed in previous experimental research. Still, an interesting path for future research could be to focus on the mediating role of creating positive emotions such as pleasure, feelings of tenderness linked to cuteness of animals, feelings of affinity towards nature or pride in determining certain behaviours (White et al., 2019). Previously most studies tested the mediating role of negative emotions linked to meat consumption such as disgust or regret.

When designing future intervention studies, moderators relating to sociodemographic variables should be further assessed in different contexts. Sociodemographic variables such as gender, age and social class strongly influence meat consumption (V. A. Cordts et al., 2013). However, only few studies assessed the moderating role of gender in the context of meat consumption and no studies assessed the moderating role of age and social class. Also, cultural factors were barely addressed in existing research, although culture and religion seem to strongly shape meat consumption (Bonne and Verbeke, 2008). Future research could explore the moderating effects of consumers' cultural background by employing cross-cultural studies. Moreover, consumers' pre-existing levels of meat attachment seems to play a role in intervention effectiveness (Graça, Calheiros, & Oliveira, 2015; Rothgerber, 2020b). However, meat attachment and consumers' commitment towards eating meat were barely considered in previous research. Future research could test interventions tailored to consumers with varying levels of meat attachment. In the context of the food environment, individual dish preferences seem to influence meat consumption (Sunstein, 2017) and could thus be further explored as a moderating variable.

6. Conclusion

A transformation of food consumption patterns is essential, particularly a reduction of meat consumption to meet climate targets and address the Sustainable Development Goals (SDGs), counteract public health problems and solve issues around animal welfare and meat production. This situation calls for a combination of effective policy measures and interventions addressed at individual consumers and households. However, although the scholarly discourse on consumption-based interventions intensified in the last years, there is still a relative paucity of experimental research testing the effectiveness of different intervention options.

There is a pressing need for a robust evidence base on the effectiveness of various interventions to foster meat consumption reduction. Our systematic literature review is the first that provides the existing

evidence across disciplines and thus, presents relevant insights for policy-makers and other designers of consumption-based interventions. Our findings refer to experimental research studies between 2001 and 2019 only, since they allowed for a quantitative testing of intervention effects. However, potentially complementary findings discussed in empirical studies with other research designs are not covered in this review.

Throughout the review we identified existing gaps in the scholarly literature across all types of interventions addressing personal, external, and especially socio-cultural factors. This calls for more experimental studies that test long-term effects of various interventions on actual consumption, ideally applying objective rather than self-reported assessment measures.

In terms of future intervention design, our review highlights the importance of investigating combinations of interventions addressing different factors of behavioural change and linking intervention effectiveness to the respective intervention component. Hence, there is a need for future research covering a broader scope of complementary factors of behavioural change that go beyond knowledge and include further factors such as habits or external factors in the food environment. Moreover, our review shows that various disciplines study the effectiveness of interventions, thus we suggest leveraging experience and conceptual frameworks from different disciplines by intensified cooperation and involvement of different stakeholders (consumers, retailers, restaurants, producers, nutritionists etc.) to effectively design interventions to reduce meat consumption.

Declaration of competing interest

The authors have no conflicts of interest to declare.

Author contributions

T.K. had the research idea, developed the search strings and selection criteria, conducted the database search and article selection, the analysis of the articles and drafted the manuscript. K.D. contributed to the research design by assisting in the construction of the search strategy, analysed articles and contributed to the writing of the manuscript. P.R. provided critical input to the methods and overall guidance through the review and provided critical inputs on the manuscript draft. All authors read and approved the final manuscript.

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Appendix A. Supplementary data

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