Appetite 187 (2023) 106595

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Mental models of the protein shift: Exploring consumers' perceptions of the transition

Lieke A.T.P. van den Boom [a,*], Karlijn L. van den Broek [b,c], Floor M. Kroese [a], Ellen H.M. Moors [b], Denise T.D. de Ridder [a]

[a] Department of Social, Health & Organizational Psychology, Utrecht University, Heidelberglaan 1, 3584 CS, Utrecht, the Netherlands
[b] Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB, Utrecht, the Netherlands
[c] Research Centre for Environmental Economics, Heidelberg University, Bergheimerstr. 20, 69115, Heidelberg, Germany

ARTICLE INFO

Keywords:
Protein transition
Sustainability
Reducing meat intake
Consumer perceptions
Mental models

ABSTRACT

The protein transition is one of today's major societal challenges to mitigate climate change. To support lasting consumer engagement, it has been suggested to look into consumers' understanding of the protein transition to identify barriers that go beyond the practical issues of changing one's diet. The current study explored consumers' *mental models* of how the transition unfolds to examine which factors consumers perceive as important drivers of the transition. With a fixed set of factors and actors identified with a questionnaire, Dutch consumers ($N = 214$) mapped their mental models. The content and structure of the mental models were analyzed with a focus on how consumers perceive their own role. Animal well-being and environmental concerns were most often included as important drivers. The findings showed a lack of consensus about which actor(s) drive the transition (i.e., none of the actors were included by a majority of the participants). This diffusion of responsibility may be a barrier for consumers to act. Moreover, the relative simplicity of the observed mental models suggests that consumers do not yet employ systems thinking. A systems thinking mindset may help consumers understand how the system behind the transition works and how their individual contributions matter. Two avenues to encourage consumer engagement were identified: 1) emphasizing the responsibility of different actors and what consumers can contribute, and 2) encouraging a systems thinking mindset.

1. Introduction

Climate change has become irreversible and a drastic decrease of greenhouse gas emissions is needed to prevent the earth from warming up even more (IPCC, 2022). Because the food system is responsible for a large part of these emissions, designing more sustainable diets is crucial (Clark et al., 2020). In Western diets, proteins are mainly obtained from meat or dairy consumption while these animal-based proteins have a much higher environmental impact than plant-based proteins (Poore & Nemecek, 2018). Therefore, the *protein transition,* the societal transition from a diet with mainly animal-based proteins to a "plant-rich diet" with a moderate amount of animal-based proteins or a "plant-based diet" with no animal-based proteins is important to mitigate climate change (Aiking & de Boer, 2020; Clark et al., 2020; Wynes & Nicholas, 2017).

This transition requires the lasting engagement of consumers, meaning a lasting motivation to be involved in the transition resulting in a persistent reduction of meat and dairy intake (Goldberg, Gustafson, & Linden, 2020). Although many consumers appear to be open to the idea of reducing their meat consumption for environmental reasons, only a minority have actually changed their diets because of these concerns (Sanchez-Sabate & Sabaté, 2019). Various interventions, such as increasing knowledge or nudging, to promote pro-environmental choices and the reduction of meat consumption have been explored (Harguess, Crespo, & Hong, 2020). However, whether these interventions are able to promote lasting engagement is unclear (Nisa, Bélanger, Schumpe, & Faller, 2019).

To facilitate consumers' engagement with the protein transition in the long run, it is important to consider the type of interventions which would be able to produce enduring changes in consumer behavior. Interventions targeting people's understanding of the protein transition (e.g., the drivers and processes that instigate the protein transition) have been identified as a promising avenue (Goldberg et al., 2020). To help design such interventions, the current study explored consumers' *mental models* of how the transition comes about.

* Corresponding author. Utrecht University, Department of Social, Health and Organizational Psychology, Heidelberglaan 1, 3584 CS, Utrecht, the Netherlands.
E-mail address: l.a.t.p.vandenboom@uu.nl (L.A.T.P. van den Boom).

https://doi.org/10.1016/j.appet.2023.106595
Received 9 December 2022; Received in revised form 4 May 2023; Accepted 6 May 2023
Available online 8 May 2023

1.1. Identifying barriers to consumer engagement in the protein transition

To design interventions for lasting consumer engagement in the protein transition, it is important to identify barriers preventing the reduction of meat and dairy intake (c.f., Van Valkengoed, Abrahamse, & Steg, 2022). Previous research has shown important individual barriers to shift towards more plant-based diets, such as the need to learn how to cook new (plant-based) dishes, social norms and the (un)availability of alternatives (Graça, Godinho, & Truninger, 2019; Stoll-Kleemann & Schmidt, 2017). However, how consumers perceive the transition has received less attention, while this may be an important predictor of consumer engagement in the protein transition (Goldberg et al., 2020). For example, whether climate change is perceived as distal and abstract or rather proximal and concrete predicts consumers' response and willingness to act (Maiella et al., 2020). Moreover, what is considered the most important cause of climate change, determines which solution is perceived suitable and, thus, which policy is supported (Bostrom et al., 2012).

Previous research observed various consumer perceptions likely affecting the willingness to engage in the protein transition. Some consumer perceptions may hinder consumer engagement in the protein transition. For example, consumers often underestimate the impact of meat consumption on climate change (Hartmann & Siegrist, 2017; Sanchez-Sabate & Sabaté, 2019; Truelove & Parks, 2012). Moreover, reducing meat intake is often perceived as ineffective compared to other climate change mitigation strategies, such as saving energy and driving less (De Boer, de Witt, & Aiking, 2016). In contrast, the surge of the flexitarian diet (i.e., an identity which allows one to reduce one's meat intake without fully committing to a vegetarian or vegan diet) illustrates how a different perception of diets may facilitate the protein transition (Stoll-Kleemann & Schmidt, 2017). Contributing to previous research, examining consumer perceptions of the drivers of the transition may help identify important facilitating or hindering perceptions.

Moreover, little research has explored how consumers view their role in the protein transition. Recent research among European consumers showed that in North-Western Europe, a large part of the population (58%) believed consumers should contribute to improving the sustainability of food systems, next to other actors such as producers (74%) and national governments (52%) (De Boer & Aiking, 2022). However, the feeling that individual behavior change cannot significantly contribute to mitigating climate change can demotivate sustainable behavior (Gifford, 2011). Although, consumers play an important role in the protein transition by creating demand and questioning established norms around meat consumption (Tziva, Negro, Kalfagianni, & Hekkert, 2020), it is yet unclear how consumers themselves view their role. The current study aims to shed light on these knowledge gaps by mapping consumers' mental models to enable the identification of barriers for consumers' engagement in the protein transition.

1.2. Mapping mental models

While interacting with the world around them, people use their experiences to create simplified representations of reality, so-called mental models (Craik, 1943; Jones, Ross, Lynam, Perez, & Leitch, 2011). Mental models allow people to understand what happens around them, anticipate what will happen next, and determine how to act. In this manner, mental models serve as frameworks for reasoning and decision-making (Biggs et al., 2011; Güss & Robinson, 2014) and are essential to understand how people respond to events or developments in the world. Mental models can vary across individuals as they are personal understandings of a particular issue or event and are not necessarily accurate. Mental models affect what solutions are considered suitable and who is seen as responsible for resolving the issue (Nisbet, 2009).

Various methods have been developed to map mental models (Jones et al., 2011). These methods aim to create a schematic visualization of the mental models called *cognitive maps*. These maps consist of the most relevant concepts in relation to a particular issue and the causal relationships people perceive between the concepts (Kaplan & Kearney, 1997; Özesmi & Özesmi, 2004). The maps can be distilled from questionnaires or interviews (i.e., indirect elicitation), or created directly by respondents themselves (i.e., direct elicitation; Jones et al., 2011). Direct elicitation has the advantage that it bypasses the researcher's interpretation of the interview resulting in a more direct measurement of the respondent's mental model.

To create the cognitive maps, respondents first need to identify the most relevant concepts and, subsequently, arrange those to show the perceived causal relationships between the concepts. The identification of the relevant concepts can be done by each respondent individually (e.g. Kaplan & Kearney, 1997; Özesmi & Özesmi, 2004) or a fixed set can be created based on interviews, a survey or a literature review (Van den Broek, Luomba, van den Broek, & Fischer, 2021). Standardizing the set of concepts enables not only the aggregation of cognitive maps over multiple respondents, but also allows for the comparison of cognitive maps in different consumer groups. Examining differences between consumer groups can show whether consumer characteristics and/or behavior can be related to certain perceptions.

Both the *content* and the *structure* of the cognitive maps provide insight into consumers' mental models of the protein transition (Langfield-smith & Wirth, 1992; Moon et al., 2019; Van den Broek, Luomba, van den Broek, & Fischer, 2023). The content, i.e., the concepts and connections present in the cognitive map, shows which concepts and processes are deemed relevant. The structure of a cognitive map, i.e., the number of concepts and connections present in the cognitive map, reveals the level of complexity of consumers' conceptualization of the issue and the processes involved. The structure therefore indicates the degree to which consumers engage in systems thinking. Systems thinking is a way of thinking which focuses on the bigger picture and acknowledges how all elements within a system are constantly changing and interacting (Randle & Stroink, 2018). It may help to understand that cause and effect are not always straightforward and how an event can have indirect consequences in the system (Goldberg et al., 2020; Lezak & Thibodeau, 2016).

1.3. The current research

What consumers consider important drivers of the transition (e.g., environmental concerns or a new marketing opportunity) and what role consumers see for themselves (e.g., an important role or negligible) may determine whether consumers think it is a transition worth engaging in. To contribute to research on consumer perceptions and inform interventions facilitating consumer engagement in the protein transition, the current study explored consumers' mental models of the societal movement towards more plant-based diets (the protein transition) and identified avenues to encourage consumer engagement with the protein transition. We created a fixed set of relevant concepts consisting of factors and actors driving the protein transition, which participants used to create a cognitive map of their mental model using the M-Tool app (Van den Broek, Klein, Luomba, & Fischer, 2021; Van den Broek, Luomba, et al., 2021).

Moreover, we explored between-person differences in the mental models by comparing mental models between participants in different stages of behavior change (DiClemente & Prochaska, 1998). Stages of behavior change reflect individuals' positions in a behavior change process, ranging from not considering changing one's behavior to already having automated the new behavior (Norcross, Krebs, & Prochaska, 2011). Individuals who are further in their own behavior change process (i.e., have already made an individual-level change from an animal-based to a plant-based diet) may have a different perspective on the societal transition than those who do not consider changing at all. However, to what extent or in what way their perspectives (i.e., mental models) differ, has not yet been explored. Most research on behavior change stages has focused on their relation with (perceptions of)

individual behavior and not with the higher order level of societal transitions. Hence, we conducted exploratory analyses to test whether individuals' stage of behavior change is associated with their understanding of the protein transition.

2. Materials and methods

2.1. Ethical statement

The study was approved by the Ethics Committee of the Faculty of Social and Behavioral Sciences of Utrecht University (reference number: 20-567).

2.2. Participants

Participants were recruited by a research agency (Flycatcher.eu) that invited a representative sample ($N = 1117$) from their Dutch consumer panel (>18 years old) to participate in an online study. The link to the study was clicked on by 712 potential participants, with 223 individuals completing the task. The demographic characteristics of the group who completed the study did not differ from the demographic characteristics of the invited group. The non-response and the drop-out appeared to be random in terms of demographic characteristics and may be due to the unconventional method of the study which needed the participants to use a tablet or computer and listen to audio instructions. The data of nine participants were excluded from the analysis due to missing data. The final sample consisted of 214 participants (53.7% men, 45.8% women and 0.5% non-binary) between 18 and 84 years old ($M = 45.97$, $SD = 17.31$) with various educational backgrounds (10% low education level, 40% secondary education level and 50% higher education level; categorization according to standards of Statistics Netherlands).

2.3. Procedure and materials

Participants created a cognitive map in M-Tool, a validated online tool in which participants can select and arrange icons of relevant concepts to map their mental model (Van den Broek, Klein, Luomba, & Fischer, 2021; Van den Broek, Luomba, et al., 2021).

2.2.1. Set of concepts

In M-Tool, a fixed set of concepts of relevant factors and actors was provided with which the participants could create their own mental model. To create this fixed set of concepts, a pilot study was conducted to elicit the most important factors and actors in the protein transition. In two subsequent convenience samples of Dutch consumers (Samples 1a and 1b), relevant concepts to the protein transition were elicited by means of an online survey. After an introduction referring to the growing interest in reducing meat consumption in the Netherlands, participants answered two open-ended questions: 1) What drivers prompt the growing interest in consuming less meat? (*factors*), and 2) Who do you think is responsible for this trend? (*actors*). In Sample 1a ($N = 111$), participants' responses were coded to establish a set of common concepts (i.e., a bottom-up approach). With Sample 1b ($N = 115$), we verified the lists of concepts and examined whether data saturation had been reached or additional concepts needed to be added to the set. A more detailed description of the development of the set of concepts can be found in the supplementary materials.

The most frequently mentioned factors and actors were selected for the fixed set of concepts to create the cognitive maps in the second phase of the study. The set consisted of 17 concepts: that is, six factors (*Environmental concerns, Animal well-being concerns, Health concerns, Availability of alternatives, Current trend* and *Available information)* and 11 actors (*Political parties, Food producers, Societal organizations, Media, Supermarkets, Social groups, Consumers, Influencers, Government, Protest groups,* and *Social environment)*. For each of the 17 concepts an icon and a definition were developed based on participants' descriptions of the concepts (see Table 1). The icons and definitions were pretested with a convenience sample of six participants to ensure the comprehensibility of the materials.

2.3.2. Creating the cognitive maps

To get familiar with M-Tool and creating a cognitive map, participants replicated an example map of the processes leading to happiness. Subsequently, participants were asked to create a cognitive map of the protein transition. Because the 'protein transition' is a rather abstract concept, a more concrete and familiar operationalization was used: the interest in reducing meat intake or meat replacement in the Netherlands. To create the cognitive map, participants could select concepts from the fixed set of concepts. Before starting the mapping task, all concepts were presented to the participants with their icon, label and audio definition.

Next, participants were shown the mapping screen in M-Tool (see Fig. 1). They were instructed to select the concepts they considered relevant and connect them with arrows to indicate how the concepts influence each other and the target variable. With three types of arrows participants could indicate whether a concept has a weak, moderate or strong influence on another concept. The M-Tool registered for each participant the connections drawn and the weight assigned to them, 1 = weak influence, 2 = moderate influence, 3 = strong influence. This data was used to determine whether a concept was selected (1 = yes, 0 = no). The task in M-Tool was pretested with a convenience sample of five participants to assess the usability of the tool. Based on this test, instructions were revised to better guide participants through the task. Participants took on average about 5 minutes to create their cognitive map ($M = 4.76$, $SD = 3.89$).

2.3.3. Additional measures

After completing the mapping task, a short survey assessed participants' *attitude* towards the protein transition, as well as their *expectations* for the future. To assess attitudes, participants indicated whether they considered the interest in reducing meat consumption to be good or bad (1 = *very bad*, 6 = *very good*) and reported their expectations of this trend by answering two questions: "To what extent do you think reducing meat intake will become more common in the Netherlands in the next five years?" and "To what extent do you think the interest in reducing less meat will grow in the Netherlands in the next five years?" (1 = *not likely*, 6 = *very likely*; Sparkman & Walton, 2017).

Participants also indicated what stage of change best represented their current position towards reducing meat intake (1 = *not considering reducing meat intake*, 2 = *considering reducing meat intake,* 3 = *having the intention to reduce meat intake,* 4 = *consciously reducing meat intake,* 5 = *reducing meat intake is a habit*; based on Weibel, Ohnmacht, Schaffner, & Kossmann, 2019). They further reported the frequency of their meat intake at lunch and dinner in the past week and whether they would identify themselves as a meat-eater, flexitarian, vegetarian or vegan. To avoid the strict categories and commit participants to one identity, we provided a continuous scale from 0 (meat-eater) to 100 (vegan) with the labels flexitarian and vegetarian in between presented at 25% and 75% of the slider. Participants could indicate what position on the slider best represented themselves. Lastly, demographic information was collected including age, gender, educational level and living situation (i.e., living alone, living together with a partner and/or children).

2.4. Data analysis

2.4.1. Analyzing the cognitive maps

To analyze the cognitive maps, a network analysis approach was used (e.g., Newman, 2010). We used the nodes (the concepts) and edges (the connections) in the cognitive map to calculate the outcome variables. Our main variables of interest were the concepts included in the cognitive maps and their centrality (i.e., the content), and the complexity of the cognitive maps (i.e., the structure).

Table 1
The 17 concepts participants could use to create the map of their mental model. Factors are indicated by a blue border, actors by a yellow border (this distinction between factors and actors was not presented to participants).

Icon	Concept label	Definition
	Environmental concerns	*Concerns about the impact of meat production on the environment, such as CO2 emissions or land use.*
	Animal well-being concerns	*Concerns about the well-being of animals, such as animals' living situation or how they are treated.*
	Health concerns	*Concerns about personal health, such as how healthy meat is or what nutrition you need.*
	Availability of alternatives	*The range of alternatives to meat, such as meat substitutes or meatless recipes.*
	Current trend	*A new way of eating that receives a lot of attention, such as a vegetarian cooking trend or a health trend.*
	Available information	*Information that is available, for example about how meat is produced or the consequences of meat consumption.*
	Political parties	*Political parties and their ideas about the food industry, such as the Party for the Animals or the VVD.*
	Food producers	*Companies that produce meat or meat substitutes, such as Kips or the Vegetarian Butcher.*
	Societal organizations	*Organizations that are committed to the environment, health or animal well-being, such as the nutrition center or ProVeg.*
	Media	*Programs, documentaries and social media that discuss reducing meat intake, such as Zondag met Lubach or Facebook where information is shared.*
	Supermarkets	*Stores where meat and meat substitutes are sold, such as the Albert Heijn or the Lidl.*
	Social groups	*Groups in society with a great interest in eating less meat, such as vegans or the younger generation.*
	Consumers	*The people who buy the products in the supermarkets, such as meat or meat substitutes.*
	Influencers	*Famous people who influence others through television or social media, such as TV chefs or food bloggers.*
	Government	*The Dutch Government who determines policy, such as which measures are taken against climate change or what subsidies are available in the food industry.*
	Protest groups	*Groups that campaign and try to influence the government, such as Animal Rights or Wakker Dier.*
	Social environment	*The opinion about meat or meat substitutes in the social environment, such as among family or friends.*
	Target variable: Protein transition	*The interest in reducing meat intake and/or meat replacement in the Netherlands.*

Fig. 1. Mental model mapping in M-Tool: (A) presentation of concepts, (B) mapping screen, and (C) example of a cognitive map.

2.4.2. Content

To examine which concepts and connections are considered relevant in the protein transition, the percentages with which each concept and connection was mentioned in the sample were calculated and an aggregated cognitive map was computed. The centrality of the concepts was reflected in the number of connections a concept has with other concepts (in-/out degrees) and the weight assigned to those connections (weighted in-/out degrees), indicating to what extent the concept was connected to other concepts in the model and able to receive or exert influence (see Opsahl, Agneessens, & Skvoretz, 2010). Centrality based on degrees was determined by the sum of the number of connections going in and out. Centrality based on strength was determined by the sum of weights assigned to connections going in and out.

2.4.3. Structure

Complexity of the cognitive maps was indicated by the number of concepts and connections included and the proportion of direct versus indirect connections to the outcome (i.e., protein transition). A high proportion of direct connections would indicate a more simple model of the protein transition, whereas a high proportion of indirect connections indicates that participants hold more complex models.

2.4.4. Examining differences between behavior change stages

To assess whether mental models of the protein transition differed between consumers who were in different stages of behavior change, three regressions examined the differences in three outcome variables: 1) the selection of concepts, 2) the centrality of concepts based on degrees, and 3) the centrality of concepts based on strength. All three regressions included stage of behavior change, concept number and their interaction as predictors. Because each outcome variable was calculated for each concept and participants included multiple concepts in their cognitive map, there were multiple observations per participant and a random subject effect was included in the regressions.

First, the logistic regression with the selection of the concepts (yes/no for each concept) as outcome variable was run. A main effect of concept number would indicate that concepts differ in the frequency with which they were included in the cognitive maps. A main effect of stage of behavior change would indicate that stage of behavior change affects the number of concepts included. An interaction would indicate that the stage of behavior change affects which concepts are included. The second and third Poisson regression with the outcome variables concepts' centrality based on degrees and centrality based on strength, examined whether consumers in different stages of behavior change evaluate the importance of concepts differently, which would be indicated by the interaction between stage of behavior change and concept number.

3. Results

3.1. Descriptives

3.1.1. Attitude and expectations

Participants were rather positive about the general interest in reducing meat consumption and replacing meat ($M = 4.80$, $SD = 1.20$). Moreover, they considered it likely that reducing one's meat intake would become more common in the Netherlands in the next five years ($M = 4.72$, $SD = 1.03$) and that the interest in reducing meat consumption would grow ($M = 4.77$, $SD = 0.93$).

3.1.2. Stages of behavior change

A total of 29% of the participants did not actively reduce their meat intake and had no intention of doing so in the near future, 8% indicated considering reducing their meat consumption, 6% had the intention to do so, 30% was already engaging in reducing their meat consumption, and for 27% it was already a habit. Because only a few respondents reported considering reducing their meat intake ($n = 18$) or the intention to reduce their meat intake ($n = 12$), those groups were combined to allow for group comparisons (see Table 2 for the descriptives per stage of behavior change).

3.1.3. Diet identification

Identification as a meat-eater, flexitarian, vegetarian or vegan was assessed on a continuous scale. However, the distribution of this variable peaked at the different labels, which indicated participants often placed themselves on or near a specific label rather than in between specific diet identities. Dividing the continuous scale into categories showed that 55% identified as meat-eater, 32% as flexitarian, 9% as vegetarian and 4% as vegans. This distribution of the diets is comparable to previous observations in a large Dutch sample with a small underrepresentation of flexitarians and a small overrepresentation of vegetarians and vegans (Statistics Netherlands, 2021).

3.1.4. Meat intake

On average, participants reported eating meat for dinner four times in the past week ($M = 3.98$, $SD = 2.24$) and two times for lunch ($M = 2.35$, $SD = 2.52$).

4. Results mental models

4.1. Content

An aggregated cognitive map of the sample was created by calculating the sum of weights for all the connections drawn (see Fig. 2). This cognitive map shows the concepts included and the most important connections between the concepts perceived by participants (i.e., connections frequently mentioned or assigned a high weight).

The most frequently included concepts were *Animal well-being concerns*, *Environmental concerns*, and the *Availability of alternatives* for meat (included by respectively 86%, 83%, and 69% of the sample). Notably, the most frequently included concepts were factors rather than actors involved in the protein transition (see Table 3). The most frequently included actors were the *Supermarket*, *Media* and *Social environment* (included by respectively 49%, 48%, 44%). Participants less often included the *Government*, *Societal organizations*, and *Political parties* as relevant concepts in their mental models (respectively 30%, 27%, 22%).

The most central concepts based on their in-/out degrees (i.e., the number of connections with other concepts) and in-/out strength (i.e., the sum of weights of the connections) were the *Consumers*, *Government*, and *Available information* (see Table 3 and Table 4). This means those concepts are perceived as important concepts in the system as they are

Table 2
Descriptives for each of the behavior change stages.

Behavior Change Stage	*n*	Age Mean (SD)	Gender	Education	Diet	Meat intake at dinner Mean (SD)	Attitude Mean (SD)
Not considering reducing meat intake	63	45.19 (14.93)	27% Female 73% Male	14% low 38% secondary 48% high	97% meat eater 3% flexitarian	6.06 (1.18)	3.64 (1.17)
Considering/Intention to reduce meat intake	30	48.87 (20.96)	33% Female 67% Male	7% low 63% secondary 30% high	87% meat eater 13% flexitarian	5.40 (1.07)	4.80 (0.76)
Consciously reducing meat intake	64	45.97 (16.97)	59% Female 40% Male	9% low 39% secondary 52% high	39% meat eater 59% flexitarian 2% vegetarian	3.47 (1.23)	5.30 (0.79)
Reducing meat intake is a habit	57	45.30 (18.33)	58% Female 40% Male	7% low 32% secondary 61% high	10% meat eater 44% flexitarian 32% vegetarian 14% vegan	1.51 (1.64)	5.53 (0.78)

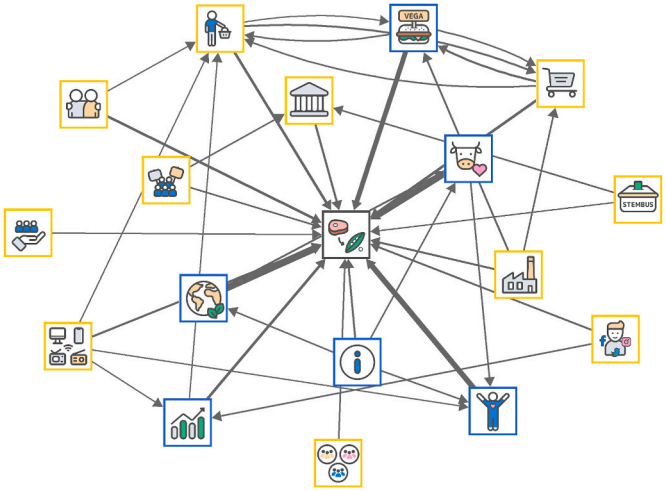

Fig. 2. Aggregated mental model of the sample ($N = 214$). The arrows show the connections made (with a sum of weight >20). The width of the arrow indicates the sum of the weight assigned to the connections. Factors are indicated by a blue border, actors by a yellow border.

able to influence other concepts through many and impactful connections.

The most frequently included connections were the direct connections between the most frequently included concepts (*Animal well-being concerns*, *Environmental concerns* and the *Availability of alternatives*) and the protein transition.

4.2. Structure

In creating the cognitive maps, participants included on average eight concepts ($M = 7.89$, $SD = 4.15$) and about nine connections ($M = 8.80$, $SD = 5.39$). On average, each concept had one connection with another concept ($M = 1.09$, $SD = 0.21$). The average proportion of direct connections in the cognitive map was 59% ($M = 0.59$, $SD = 0.33$). This means that from all the connections participants made, more than half indicated a direct influence of a concept on the protein transition. Over a third of participants (37%) included only direct influences in their cognitive map. These results indicate that there was a rather strong focus

Table 3
Per concept the percentage of participants ($N = 214$) who included each concept in their cognitive map, its mean centrality based on the number of connections (degrees) and its mean centrality based on the sum of weights of those connections (strength).

Concepts – factors and actors	% of participants	Centrality – Degrees	Centrality – Strength
Animal well-being concerns	86	1.70	3.78
Environmental concerns	83	1.75	3.97
Availability of alternatives	69	1.90	3.80
Health concerns	63	1.74	3.84
Current trend	50	2.13	4.20
Supermarket	49	1.98	4.06
Media	48	1.74	3.18
Social environment	44	1.73	3.41
Influencers	41	1.55	2.85
Food producers	39	1.87	3.71
Consumers	38	3.01	5.73
Available information	37	2.42	4.37
Protest groups	36	1.54	2.89
Government	30	2.52	4.52
Social groups	29	1.60	2.86
Societal organizations	27	1.53	2.75
Political parties	22	1.84	3.25

Table 4
Most frequently included connections (top 10) with the percentage of participants ($N = 214$) who included the connection in the cognitive map and their mean weight.

Connection	% of participants	Mean weight
Animal well-being concerns – Protein transition	56	2.48
Environmental concerns – Protein transition	52	2.73
Availability of alternatives – Protein transition	46	1.93
Health concerns – Protein transition	44	2.43
Social environment – Protein transition	25	2.00
Current trend – Protein transition	24	1.94
Supermarket – Protein transition	20	1.95
Media – Protein transition	19	1.78
Consumers – Protein transition	17	2.11
Government – Protein transition	15	1.85

on the direct influences of various concepts on the protein transition and less so on how the concepts in the system influence each other.

4.3. Differences between stages of behavior change

The logistic regression testing the effect of stage of behavior change on the selection of concepts, showed a significant interaction effect between concept number and stage of behavior change ($\chi 2$ (48, 214) = 877.09, $p < .001$), indicating that participants' stage of behavior change affected which concepts they included in their cognitive maps (regression estimates can be found in the supplementary materials). The differences were mainly visible in the frequency with which the concepts *Current trend, Available information, Influencers, Social groups* and *Protest groups* were selected (see Fig. 3). For example, participants who did not consider reducing their meat intake appeared to include actors such as *Protest groups, Social groups* and *Influencers* more often, suggesting they assign more importance to these actors in the transition compared to participants in the other stages of behavior change. Participants who were considering reducing their meat intake or had the intention to do so, tended to include social drivers, such as *Current trend*, *Supermarket*, *Influencers* and *Protest groups,* relatively less often. Participants who consciously reduced their meat intake and participants for whom it was already a habit included *Available information* relatively often. These results suggest the perceived drivers of the protein transition differ per stage of behavior change.

Because we observed a significant interaction effect between concept number and stage of behavior change, we were unable to interpret the main effect of stage of behavior change on the number of concepts selected. To examine whether the number of concepts included in the maps differed between the stages of behavior change, an additional logistic regression was performed with the selection of concepts as outcome variable, stage of behavior change and concept as predictors, excluding the significant interaction term. This analysis showed a main effect of stage of behavior change on concept selection ($\chi 2$ (3, 214) = 8.10, $p = .044$). Participants who indicated that reducing their meat consumption was already a habit, included more concepts in their cognitive maps than participants who were not considering reducing their meat intake (Log OR = 1.00, $p = .005$), suggesting that this first group created more complex cognitive maps than the latter group. The mean odds for selecting a concept was 2.71 (profile log-likelihood CI OR = 1.36, 5.41) times higher for participants for whom it was a habit compared to participants who did not consider reducing their meat intake.

The regression analysis examining group differences in the centrality of the concepts based on the degrees, showed a significant interaction between concept number and stage of behavior change ($\chi 2$ (48, 214) = 304.84, $p < .001$), even as the regression examining group differences in centrality of the concepts based on strength ($\chi 2$ (48, 214) = 606.76, $p < .001$) These results indicate that stage of behavior change affected the perceived importance of concepts in the cognitive maps, indicated by their centrality based on degrees (i.e., the number of connections with other concepts) and centrality based on strength (i.e., the sum of weights of the connections). The differences between the stages of behavior change were mainly visible in variation in the centrality based on degrees of *Government* and *Available information* (see Fig. 4). In addition, variation was observed in the centrality based on the strength of the concepts *Current Trend, Food producers, Government, Available information, Health concerns* and *Animal well-being concerns* (see Fig. 5).

For participants who did not consider reducing their meat intake *Current trend, Food producers,* and *Government* were central in their cognitive maps, as indicated by the centrality based on degrees and strength, suggesting this group perceived those concepts as drivers and actors with much influence on other concepts in the system. For participants who considered reducing their meat intake or had the intention to do so, central concepts were *Health concerns* and *Animal well-being concerns* as indicated by their centrality based on strength. Noticeable in the cognitive maps of participants for whom it was already a habit, was the relative high centrality based on degrees and strength of *Available information.*

5. Discussion

The protein transition can significantly contribute to mitigating climate change. To facilitate this transition, consumer engagement is crucial. In line with previous research, we observed a positive attitude towards the trend of reducing meat intake in the Netherlands (Dagevos & Verbeke, 2022; ProVeg, 2022). Despite of this positive attitude, however, there is still little change in behavior. To know how consumer engagement with the protein transition and associated behavior change can be promoted, the current study explored consumers' perceptions of the transition.

The current research yields three main insights based on an examination of consumers' mental models. First, concerns about animal well-being, concerns about the environment, and the availability of alternatives were most often present in the mental models as important factors driving the protein transition. In contrast, there appears to be less agreement on the important actors driving the transition, as a large variety of actors were present in the mental models. Second, the average

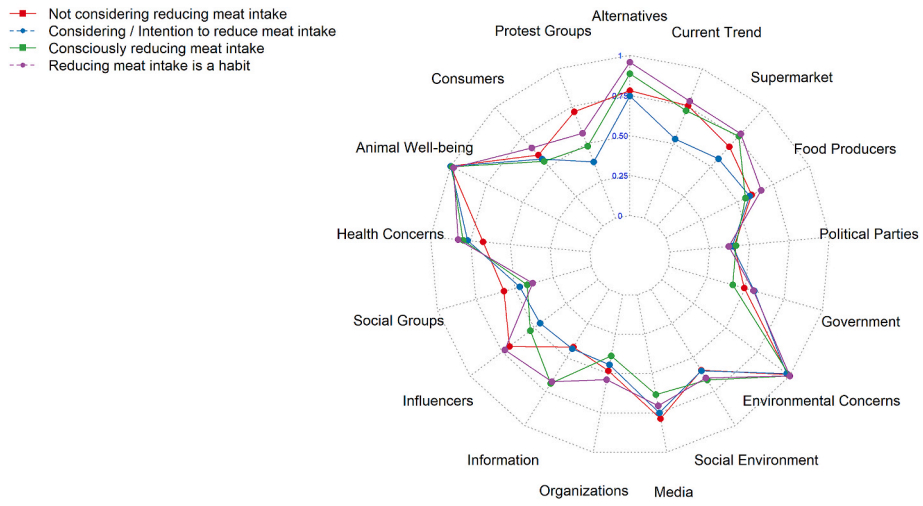

Fig. 3. The mean frequency with which the concepts were included in the cognitive map for each stage of behavior change. The radar plot shows standardized values.

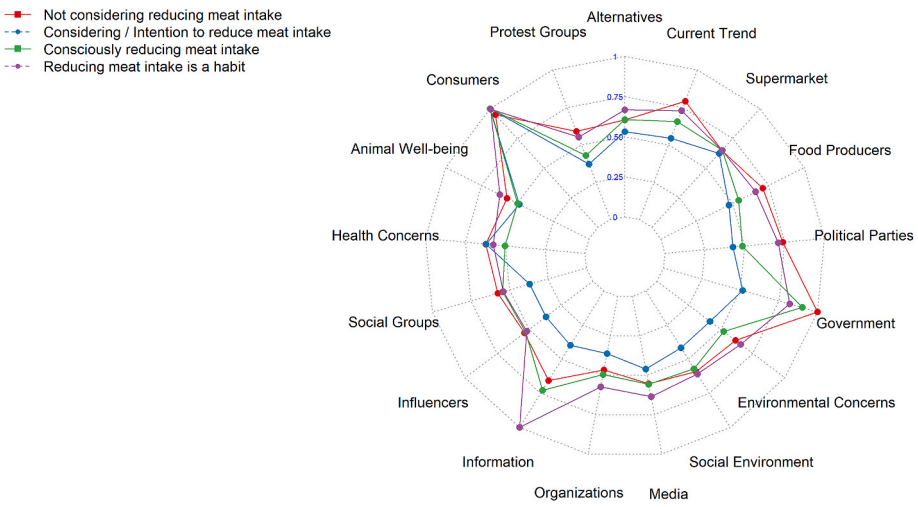

Fig. 4. The mean centrality of each concept based on degrees for each stage of behavior change. The radar plot shows standardized values.

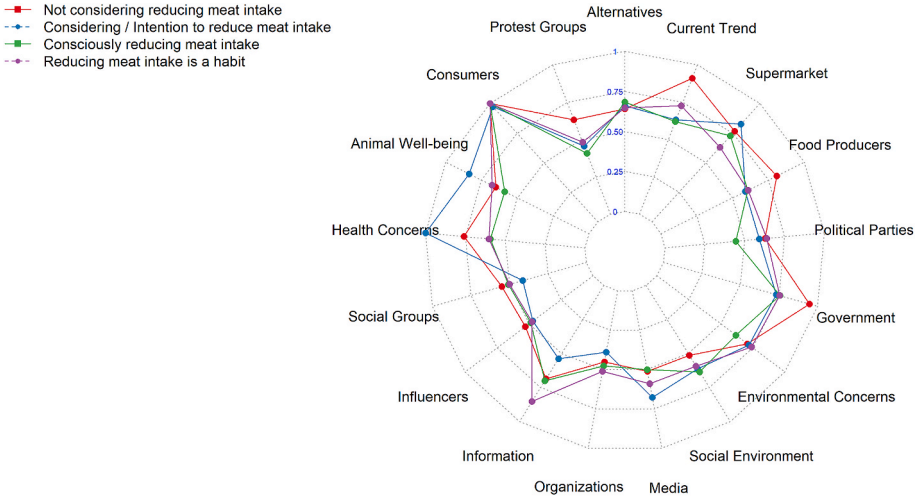

Fig. 5. The mean centrality based on strength for each stage of behavior change. The radar plot shows standardized values.

mental model of the protein transition showed relatively few connections between included concepts, suggesting that the interaction between the various factors and actors in the food system may not be evident to consumers. Lastly, consumer groups in different stages of behavior change differed somewhat in the concepts deemed relevant. For example, people not considering reducing their meat intake more often perceived influencers, social groups, and protest groups as important actors. For people who were already familiar with reducing meat intake the availability of information was more central in their mental models.

The current findings reveal a prominent link between concerns about the environment and animal well-being and the protein transition in the consumers' mental models. Those concerns were considered important drivers by over 80% of the participants. Environmental and animal well-being concerns have previously been identified as predictors of a vegetarian diet (De Backer & Hudders, 2014). However, nowadays environmental concerns may also motivate larger groups of consumers to engage with the protein transition (Sanchez-Sabate & Sabaté, 2019). Also the perceived importance of availability of alternatives for the protein transition observed in the current research is in line with previous research stressing the importance of availability of alternatives to stimulate meat intake reduction (Kemper, 2020).

It is noteworthy that the link between actors and the protein transition was less pronounced in the mental models. The observation that no single actor was selected by a majority of the participants may suggest a lack of agreement on who plays an important role in the transition. Moreover, various actors were present in the mental models and not one actor stood out as the prominent actor, implying a possible *diffusion of responsibility* to act in the protein transition (Bandura, 2007). This is in line with other research showing that multiple actors are recognized in the transition towards a more sustainable food system (De Boer & Aiking, 2022). Because responsibility is shared, it may be unclear who is supposed to act at this moment.

Interestingly, consumers themselves were not often present as relevant actors in the mental models. For only 38% of the participants, consumers were part of their mental model of the protein transition. Notably, participants who did perceive consumers as a relevant actor, constructed their role to be quite influential, meaning the actor was connected to many other concepts in the mental model and was receiving and exerting influence. This suggests that few consumers recognize their important role in the transition. However, when recognized as an important actor (i.e., included in the mental model), the consumer is seen as quite influential in the system. Viewing oneself or the group one belongs to as an important actor in the protein transition and being able to meaningfully contribute may be important conditions to engage with the transition (De Boer & Aiking, 2022). Previous research shows that low response efficacy (i.e., the idea that individual contributions are insignificant) and low perceived responsibility are

important barriers to engagement in sustainability transitions (Graça et al., 2019; Kothe et al., 2019). The current results suggest that these factors may need to be addressed to increase consumer engagement in the protein transition.

The current study thus indicates that consumers' mental models mainly consist of factors and, to a lesser extent, of actors directly influencing the protein transition. How the factors and actors interact and which processes lead to the protein transition, was not a prominent part of the mental models. When considering the protein transition, consumers appear to only slightly employ systems thinking, i.e., they are focusing on the separate relevant concepts rather than on the interactions and adopting a more holistic systemic view (Randle & Stroink, 2018). Understanding how elements in a system are related and influence each other may be important to understand how consumer behavior can have consequences at a larger scale (Davis & Stroink, 2015; Goldberg et al., 2020; Lezak & Thibodeau, 2016).

The examination of the different consumer groups revealed that mental models are affected by the extent to which one engages with the protein transition (as indicated by their stage of behavior change). Some issues are noteworthy in this regard. First, the groups appeared to consider different concepts relevant to the protein transition. For example, people who did not consider reducing their meat intake were more likely to perceive social groups and protest groups as relevant actors, indicating they may consider the transition to be driven by groups who oppose to the status quo. Second, the importance of the concepts was evaluated differently across the different stages of behavior change. For example, available information related to meat consumption (e.g., how meat is produced or the consequences of consumption for health or the environment) was not considered equally important in the different groups (as indicated by the centrality measures). Finally, the complexity of the mental models differed between groups. Consumers for whom it was a habit to reduce their meat intake included more concepts in their cognitive maps resulting in more complex mental models. This may suggest that they engage in more cognitive elaboration on the protein transition or reasons to reduce meat consumption. Further research is needed to understand the reasons for the observed differences and investigate whether the different mental models may be a cause or a consequence of behavior change.

5.1. Promising avenues to facilitate consumer engagement

The mapped mental models are not set in stone; they can change through new experiences and learning (Jones et al., 2011; Nersessian, 2002). Promoting mental models facilitative for the protein transition and addressing hindering models can have long-term effects influencing various behaviors, making this a promising approach for accelerating the protein transition (Goldberg et al., 2020). Based on the current findings, two promising avenues to facilitate consumer engagement with the protein transition can be identified.

First, addressing the diffusion of responsibility and emphasizing what role consumers can play, may motivate consumers to engage with this transition. To facilitate the protein transition and mitigate climate change, changes are needed on the consumer side, as well as elsewhere in the system (Rust et al., 2020). Consumer behavior is part of a larger system (e.g., Poore & Nemecek, 2018) and consumers expect other actors in the system, such as the government, to act as well (Dubois et al., 2019). Highlighting a shared responsibility, how various actors in the protein transition, such as organizations, producers and government, are working towards the common goal of reducing the environmental impact of the food system, and the meaningful contribution consumers can make, may motivate consumer engagement (Camilleri & Larrick, 2019; Obradovich & Guenther, 2016; Van Zomeren, Saguy, & Schellhaas, 2013).

The second avenue to facilitate consumer engagement with the protein transition is addressing the relatively simple representation of the protein transition by stimulating a systems thinking mindset. A systems thinking mindset is recognized as a potential means to promote pro-environmental behaviors both in the short-term (e.g., Thibodeau, Winneg, Frantz, & Flusberg, 2016) and in the long-term as it may help consumers to see how their behavior relate to the bigger picture and can have a ripple effect in the system (Goldberg et al., 2020; Lezak & Thibodeau, 2016). Understanding how individual sustainable behavior can be amplified and have consequences beyond the immediate gain for the environment may be difficult (Hornsey, Chapman, & Oelrichs, 2021). Systemic metaphors or games that emphasize interconnectedness within a system may help grasp the idea that opting for plant-based can have an impact on food producers or inspire others so the positive impact on the environment can be increased (Sweeney, Meadows, & Mehers, 2010; Thibodeau et al., 2016).

5.2. Strengths and limitations

Mapping mental models of the protein transition enabled us to capture a comprehensive map of consumers' understanding of the transition, which provides many leads for further investigation. Future research may explore specific relationships observed to gain more insight into consumer engagement in the protein transition (e.g., Can the perception of a trend as an important driver be motivating or rather alienating?) or the differences between the stages of behavior change (e.g., Why are different drivers considered important and do the differences predict or follow behavior?). Moreover, future researchers can test the effectiveness of interventions based on the avenues suggested here.

A limitation of the current research is that participants created cognitive maps of the interest in reducing meat intake, while the protein transition would involve the reduction of dairy intake as well. The mental models of the interest in reducing dairy intake may be different from the mental models observed in the current research, as people may think differently about meat and dairy. Research shows that consumption of plant-based dairy alternatives can be motivated by similar concerns as plant-based meat alternatives, including concerns about health, the environment and animal well-being (Haas, Schnepps, Pichler, & Meixner, 2019). However, research also suggests that perceptions of meat and dairy are not necessarily related. For example, people who limit their meat intake to two times a week, appreciate meat products less, but cheese, as a dairy product, more (Dagevos & Voordouw, 2013). Future research may look at potential differences between meat reduction and dairy reduction mental models.

Another limitation pertains to the representativeness of the sample. Although there was considerable variety in education levels in the preliminary phase identifying the relevant concepts as well as among the participants who created the mental models, there was an overrepresentation of highly educated consumers. Previous research indicates that mental models regarding the protein transition may differ between various education levels. Research suggests that education level is associated with the degree to which reducing meat intake is perceived as valuable in addressing environmental concerns (Siegrist, Visschers, & Hartmann, 2015). Therefore, environmental concerns may be more prominent among this sample which may have affected the mental models. Moreover, research eliciting mental models suggests that a higher education level is associated with higher complexity of the mental models (Van den Broek, Luomba, et al., 2021). Future research is needed to examine whether or how mental models exactly vary over different education levels.

Lastly, as only a few studies have used similar regression analyses to explore between-person differences in mental models, limited information was available on effect sizes to conduct power calculations. Mental model studies typically employ small sample sizes (Özesmi & Özesmi, 2004). M-Tool allowed us to collect a relatively large sample and enabled the comparison of mental models between groups of participants. Yet few studies have used this method and similar analyses to explore between-person differences in mental models (De Ridder, van den Boom, Kroese, Moors, & van den Broek, 2022; Van den Broek et al.,

2023). As the method and analyses will become more frequently used, a better estimation of expected differences in mental models and proper power calculation may be possible.

5.3. Conclusion

In consumers' mental models, the protein transition is clearly linked to concerns about animal well-being and the environment. However, which actor is driving the protein transition appears to be less evident and consumers are not often assigned a role. Moreover, our examination suggested that consumers may not employ systems thinking (yet) regarding to the protein transition. Therefore, we identified two promising ways to encourage consumer engagement with the protein transition: 1) emphasizing the responsibility of actors and what consumers can contribute, and 2) encouraging a systems thinking mindset. The examination of mental models generated insights into consumers' perspectives of the protein transition that can inspire future research and help find ways to facilitate the protein transition.

Ethical statement

The study was approved by the Ethics Committee of the Faculty of Social and Behavioral Sciences of Utrecht University (reference number: 20-567).

Author contributions

All authors contributed to the conceptualization and study design. Investigation and data curation: L.B. Formal analysis: L.B. & K.B. Writing - original draft: L.B. Writing – Review and editing: K.B., F.K., E. M., D.R.

Funding

This work was supported by the Netherlands Organization for Scientific Research (NWO) [grant number 403.19.202].

Declaration of competing interest

None.

Data availability

Research data is made available at https://doi.org/10.34894/H1QRP6.

Acknowledgements

We thank all consortium members of the project 'Accelerating the transition to plant-based proteins' for their valuable input on the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2023.106595.

References

Aiking, H., & de Boer, J. (2020). The next protein transition. *Trends in Food Science and Technology, 105*, 515–522. https://doi.org/10.1016/j.tifs.2018.07.008

Bandura, A. (2007). Impeding ecological sustainability through selective moral disengagement. *International Journal of Innovation and Sustainable Development, 2*(1), 8–35.

Biggs, D., Abel, N., Knight, A. T., Leitch, A., Langston, A., & Ban, N. C. (2011). The implementation crisis in conservation planning: Could "mental models" help? *Conservation Letters, 4*(3), 169–183. https://doi.org/10.1111/j.1755-263X.2011.00170.x

Bostrom, A., O'Connor, R. E., Böhm, G., Hanss, D., Bodi, O., Ekström, F., et al. (2012). Causal thinking and support for climate change policies: International survey findings. *Global Environmental Change, 22*(1), 210–222. https://doi.org/10.1016/j.gloenvcha.2011.09.012

Camilleri, A. R., & Larrick, R. P. (2019). The collective aggregation effect: Aggregating potential collective action increases prosocial behavior. *Journal of Experimental Psychology: General, 148*(3), 550–569. https://doi.org/10.1037/xge0000563

Clark, M. A., Domingo, N. G. G., Colgan, K., Thakrar, S. K., Tilman, D., Lynch, J., et al. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science, 370*(6517), 705–708. https://doi.org/10.1126/science.aba7357

Craik, K. J. W. (1943). *The nature of explanation*. Cambridge, UK: Cambridge University Press.

Dagevos, H., & Verbeke, W. (2022). Meat consumption and flexitarianism in the low countries. *Meat Science, 192*, Article 108894. https://doi.org/10.1016/j.meatsci.2022.108894

Dagevos, H., & Voordouw, J. (2013). Sustainability and meat consumption: Is reduction realistic? *Sustainability: Science, Practice and Policy, 9*(2), 60–69. https://doi.org/10.1080/15487733.2013.11908115

Davis, A. C., & Stroink, M. L. (2015). The relationship between systems thinking and the new ecological paradigm. *Systems Research and Behavioral Science, 33*(4), 575–586. https://doi.org/10.1002/sres.2371

De Backer, C. J. S., & Hudders, L. (2014). From meatless mondays to meatless sundays: Motivations for meat reduction among vegetarians and semi-vegetarians who mildly or significantly reduce their meat intake. *Ecology of Food and Nutrition, 53*(6), 639–657. https://doi.org/10.1080/03670244.2014.896797

De Boer, J., & Aiking, H. (2022). Do EU consumers think about meat reduction when considering to eat a healthy, sustainable diet and to have a role in food system change? *Appetite, 170*, Article 105880. https://doi.org/10.1016/j.appet.2021.105880

De Boer, J., de Witt, A., & Aiking, H. (2016). Help the climate, change your diet: A cross-sectional study on how to involve consumers in a transition to a low-carbon society. *Appetite, 98*, 19–27. https://doi.org/10.1016/j.appet.2015.12.001

De Ridder, D. T., van den Boom, L. A., Kroese, F. M., Moors, E. H., & van den Broek, K. L. (2022). How do people understand the spread of COVID-19 infections? Mapping mental models of factors contributing to the pandemic. *Psychology and Health*, 1–20. https://doi.org/10.1080/08870446.2022.2129054

DiClemente, C. C., & Prochaska, J. O. (1998). Toward a comprehensive, transtheoretical model of change: Stages of change and addictive behaviors. In W. R. Miller, & N. Heather (Eds.), *Treating addictive behaviors* (pp. 3–24). Plenum Press. https://doi.org/10.1007/978-1-4899-1934-2_1.

Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., et al. (2019). It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. *Energy Research & Social Science, 52*, 144–158. https://doi.org/10.1016/j.erss.2019.02.001

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist, 66*(4), 290–302. https://doi.org/10.1037/a0023566

Goldberg, M. H., Gustafson, A., & Linden, S. Van Der (2020). Perspective leveraging social science to generate lasting engagement with climate change solutions. *One Earth, 3*(3), 314–324. https://doi.org/10.1016/j.oneear.2020.08.011

Graça, J., Godinho, C. A., & Truninger, M. (2019). Reducing meat consumption and following plant-based diets: Current evidence and future directions to inform integrated transitions. *Trends in Food Science & Technology, 91*, 380–390. https://doi.org/10.1016/j.tifs.2019.07.046

Güss, C. D., & Robinson, B. (2014). Predicted causality in decision making: The role of culture. *Frontiers in Psychology, 5*, 479. https://doi.org/10.3389/fpsyg.2014.00479

Haas, R., Schnepps, A., Pichler, A., & Meixner, O. (2019). Cow milk versus plant-based milk substitutes: A comparison of product image and motivational structure of consumption. *Sustainability, 11*(18). https://doi.org/10.3390/su11185046

Harguess, J. M., Crespo, N. C., & Hong, M. Y. (2020). Strategies to reduce meat consumption: A systematic literature review of experimental studies. *Appetite, 144*, Article 104478. https://doi.org/10.1016/j.appet.2019.104478

Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science and Technology, 61*, 11–25. https://doi.org/10.1016/j.tifs.2016.12.006

Hornsey, M. J., Chapman, C. M., & Oelrichs, D. M. (2021). Ripple effects: Can information about the collective impact of individual actions boost perceived efficacy about climate change? *Journal of Experimental Social Psychology, 97*, Article 104217. https://doi.org/10.1016/j.jesp.2021.104217

IPCC. (2022). Climate change 2022 impacts, adaptation, and vulnerability: Summary for policymakers. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf?ref=refind.

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental models: An interdisciplinary synthesis of theory and methods. *Ecology and Society, 16*(1). https://doi.org/10.5751/ES-03802-160146

Kaplan, S., & Kearney, A. R. (1997). Toward a methodology for the measurement of knowledge structures of ordinary people: The Conceptual Content Cognitive Map (3CM). *Environment and Behavior, 29*(5), 579–617.

Kemper, J. A. (2020). Motivations, barriers, and strategies for meat reduction at different family lifecycle stages. *Appetite, 150*, Article 104644. https://doi.org/10.1016/j.appet.2020.10464

Kothe, E. J., Ling, M., North, M., Klas, A., Mullan, B. A., & Novoradovskaya, L. (2019). Protection motivation theory and pro-environmental behaviour: A systematic mapping review. *Australian Journal of Psychology, 71*(4), 411–432. https://doi.org/10.1111/ajpy.12271

Langfield-smith, K. I. M., & Wirth, A. (1992). Measuring differences between cognitive maps. *Journal of the Operational Research Society, 43*(12), 1135–1150.
Lezak, S. B., & Thibodeau, P. H. (2016). Systems thinking and environmental concern. *Journal of Environmental Psychology, 46*, 143–153. https://doi.org/10.1016/j.jenvp.2016.04.005
Maiella, R., La Malva, P., Marchetti, D., Pomarico, E., Di Crosta, A., Palumbo, R., & Verrocchio, M. C. (2020). The psychological distance and climate change: A systematic review on the mitigation and adaptation behaviors. *Frontiers in Psychology, 11*, Article 568899. https://doi.org/10.3389/fpsyg.2020.568899
Moon, K., Guerrero, A. M., Adams, V. M., Biggs, D., Blackman, D. A., Craven, L., et al. (2019). Mental models for conservation research and practice. *Conservation Letters, 12*(3), Article e12642. https://doi.org/10.1111/conl.12642
Nersessian, N. J. (2002). The cognitive basis of model-based reasoning in science. In P. Carruthers, S. Stich, & M. Siegal (Eds.), *The cognitive basis of science* (pp. 133–153). Cambridge University Press. https://doi.org/10.1017/CBO9780511613517.008.
Newman, M. E. J. (2010). *Networks: An introduction*. Oxford University Press.
Nisa, C. F., Bélanger, J. J., Schumpe, B. M., & Faller, D. G. (2019). Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change. *Nature Communications, 10*(1). https://doi.org/10.1038/s41467-019-12457-2
Nisbet, M. (2009). Communicating climate change: Why frames matter for public engagement. *Environment: Science and Policy for Sustainable Development, 51*(2), 12–23. https://doi.org/10.3200/ENVT.51.2.12-23
Norcross, J. C., Krebs, P. M., & Prochaska, J. O. (2011). Stages of change. *Journal of Clinical Psychology, 67*(2), 143–154. https://doi.org/10.1002/jclp.20758
Obradovich, N., & Guenther, S. M. (2016). Collective responsibility amplifies mitigation behaviors. *Climatic Change, 137*(1–2), 307–319. https://doi.org/10.1007/s10584-016-1670-9
Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks, 32*(3), 245–251.
Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: A multi-step fuzzy cognitive mapping approach. *Ecological Modelling, 176*(1–2), 43–64. https://doi.org/10.1016/j.ecolmodel.2003.10.027
Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science, 360*(6392), 987–992. https://doi.org/10.1126/science.aaq0216
ProVeg. (2022). Wat vindt nederland van de eiwittransitie? De toekomst van de veehouderij. https://proveg.com/nl/wat-vindt-nederland-van-de-eiwittransitie/.
Randle, J. M., & Stroink, M. L. (2018). The development and initial validation of the paradigm of systems thinking. *Systems Research and Behavioral Science, 35*(6), 645–657. https://doi.org/10.1002/sres.2508
Rust, N. A., Ridding, L., Ward, C., Clark, B., Kehoe, L., Dora, M., et al. (2020). Science of the total environment how to transition to reduced-meat diets that benefit people and the planet. *Science of the Total Environment, 718*, Article 137208. https://doi.org/10.1016/j.scitotenv.2020.137208
Sanchez-Sabate, R., & Sabaté, J. (2019). Consumer attitudes towards environmental concerns of meat consumption: A systematic review. *International Journal of Environmental Research and Public Health, 16*(7). https://doi.org/10.3390/ijerph16071220
Siegrist, M., Visschers, V. H., & Hartmann, C. (2015). Factors influencing changes in sustainability perception of various food behaviors: Results of a longitudinal study. *Food Quality and Preference, 46*, 33–39. https://doi.org/10.1016/j.foodqual.2015.07.006
Sparkman, G., & Walton, G. M. (2017). Dynamic norms promote sustainable behavior, even if it is counternormative. *Psychological Science, 28*(11), 1663–1774. https://doi.org/10.1177/095679761771995
Statistics Netherlands. (2021). Klimaatverandering en energietransitie: Opvattingen en gedrag van Nederlanders in 2020. https://www.cbs.nl/nl-nl/longread/rapportages/2021/klimaatverandering-en-energietransitie-opvattingen-en-gedrag-van-nederlanders-in-2020.
Stoll-Kleemann, S., & Schmidt, U. J. (2017). Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: A review of influence factors. *Regional Environmental Change, 17*, 1261–1277. https://doi.org/10.1007/s10113-016-1057-5
Sweeney, L. B., Meadows, D., & Mehers, G. M. (2010). In R. Füglein, B. Klöckener, & A. Lutz (Eds.), *The systems thinking playbook for climate change: A toolkit for interactive learning*. Deutsche Gesellschaft für Internationale Zusammenarbeit.
Thibodeau, P., Winneg, A., Frantz, C., & Flusberg, S. (2016). The mind is an ecosystem. *Metaphor and the Social World, 6*(2), 225–242. https://doi.org/10.1075/msw.6.2.03thi
Truelove, H. B., & Parks, C. (2012). Perceptions of behaviors that cause and mitigate global warming and intentions to perform these behaviors. *Journal of Environmental Psychology, 32*(3), 246–259. https://doi.org/10.1016/j.jenvp.2012.04.002
Tziva, M., Negro, S. O., Kalfagianni, A., & Hekkert, M. P. (2020). Understanding the protein transition: The rise of plant-based meat substitutes. *Environmental Innovation and Societal Transitions, 35*, 217–231. https://doi.org/10.1016/j.eist.2019.09.004
Van Valkengoed, A. M., Abrahamse, W., & Steg, L. (2022). To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour. *Nature Human Behaviour*, 1–11. https://doi.org/10.1038/s41562-022-01473-w
Van Zomeren, M., Saguy, T., & Schellhaas, F. M. H. (2013). Believing in "making a difference" to collective efforts: Participative efficacy beliefs as a unique predictor of collective action. *Group Processes & Intergroup Relations, 16*(5), 618–634. https://doi.org/10.1177/1368430212467476
Van den Broek, K. L., Klein, S. A., Luomba, J., & Fischer, H. (2021). Introducing M-tool : A standardised and inclusive mental model mapping tool. *System Dynamics Review, 37*(4), 353–362. https://doi.org/10.1002/sdr.1698
Van den Broek, K. L., Luomba, J., van den Broek, J., & Fischer, H. (2021). Evaluating the application of the mental model mapping tool (M-Tool). *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.761882
Van den Broek, K. L., Luomba, J., van den Broek, J., & Fischer, H. (2023). Content and complexity of stakeholders' mental models of socio-ecological systems. *Journal of Environmental Psychology, 85*, Article 101906. https://doi.org/10.1016/j.jenvp.2022.101906
Weibel, C., Ohnmacht, T., Schaffner, D., & Kossmann, K. (2019). Reducing individual meat consumption: An integrated phase model approach. *Food Quality and Preference, 73*, 8–18. https://doi.org/10.1016/j.foodqual.2018.11.011
Wynes, S., & Nicholas, K. A. (2017). The climate mitigation gap: Education and government recommendations miss the most effective individual actions. *Environmental Research Letters, 12*(7), Article 074024. https://doi.org/10.1088/1748-9326/aa7541