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Social network research and meat reduction – An overview of research directions and results from a study in Denmark

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A R T I C L E   I N F O

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A B S T R A C T

Reducing the current level of meat consumption would reap significant environmental benefits. However, a consumer transition towards more plant-rich eating is lagging, and the social sciences have had limited success in understanding behavioural change in this area. Here, we advocate a research agenda focussing on the role social networks could play in encouraging consumers to eat less meat. We present main research directions in social network theory and highlight the distinction between simple and complex behavioural domains of which food and eating practices are an example of the latter. To illustrate one way in which social network insights can contribute to meat reduction research, we then present results from a questionnaire-based study of Danish consumers. We examine the association between an individual’s personal network and reduced meat consumption. In line with assumptions, we show that, for a complex domain such as food and eating practices, exposure from multiple network sources is central to behavioural adoption. However, multiple network exposure is predominantly important for the initial decision to eat less meat. A narrower network of personal contacts become more central during the implementation stage. We end by outlining future research directions for social network research regarding meat reduction.

1. Introduction

A plant-based transition is urgently needed to reduce the environmental and climatic impact of livestock production and to improve public health (Chiavaroli et al., 2018; Gerber et al., 2013; Poore and Nemecek, 2018). As the dietary patterns of many consumers in the Global North are still dominated by excessive consumption of animal products (Willett et al., 2019), much research has been dedicated to studying what might encourage people to consume less meat. One research direction focusses on the cognitive precursors of meat reduction, including the role of awareness, beliefs, motivations, meat attachment, and dietary identity (Cheah et al., 2020; Graça et al., 2015; Randers and Thogersen, 2023). Another research direction looks at how interventions aimed at changing social norms, attitudes or the choice architecture can influence meat consumption (Alblas et al., 2022; Boerman et al., 2022; Mathur et al., 2021; Taufik et al., 2022). Another research direction focusses on the practical dimensions of meat reduction, including socio-cultural food understandings, habitual/routinised behaviour and everyday life dynamics in food practices (Fuentes and Fuentes, 2022; Halkier and Lund, 2023; White et al., 2022).

In contrast, the role social interactions could play in reducing meat consumption has received less attention. This was already noted some years ago (Sanchez-Sabate and Sabaté, 2019), and research about this has not evolved much since then (see Section 2.4). Social networks are central to the diffusion of behaviours (Centola, 2018; Christakis and Fowler, 2013; Rogers, 2003), including eating behaviour (Higgs and Thomas, 2016; Pachucki et al., 2011; Paisley et al., 2008; Rydén and Sydner, 2011; Salmivaara et al., 2021). In the sustainable transition literature, social tipping points (Global Systems InstituteUniversity of Exeter, 2022; Stadelmann-Steffen et al., 2021) are increasingly considered a central element for societal wide change to occur, also in the food consumption domain (Aschemann-Witzel and Schulze, 2023; Schulze et al., 2024). Here, the diffusion of sustainable behaviour is assumed to involve a process of “social contagion” whereby the initial adopters of a sustainable behaviour inspire others to adopt the behaviour. At a certain point a critical mass is reached after which the adoption rate accelerates and grows and becomes self-sustaining. Eventually, population-wide change occurs (Global Systems Institute, University of Global Systems InstituteUniversity of Exeter, 2022). This must be supported by policy interventions that facilitate and trigger social tipping (Global Systems...
Three are multiple ways that consumers can reduce their meat intake (Hargreaves et al., 2023). A distinction can be drawn between complete meat avoidance, often referred to as a vegan or vegetarian diet, and a diet where meat is reduced, often referred to as a flexitarian diet (Dag-Bakke, 2021). Analyses of diet transformations have been modelled according to a vegetarian diet (Eker et al., 2019). Since a shift to a vegetarian diet is not currently favoured by many, with only a modest population share considering such a change (Hielkema and Lund, 2021), opting for a reduction in meat consumption might be a more pragmatic approach for the majority. Previous research has investigated the social dynamics of vegetarians/vegans, focusing on aspects such as identity formation and group dynamics (Bagci et al., 2022; Rosenfeld et al., 2020). Additionally, studies have explored the challenges encountered in intimate relationships, for instance, among family members (Beardsworth and Keil, 1992; Jabs et al., 2000; Roth, 2005; Salmivaara et al., 2022), as well as the complexities that can emerge in more casual associations (Buttny and Kinefuchi, 2020; Salmivaara et al., 2022). However, the social reinforcement and coordination involved when consumers adopt and maintain a vegetarian/vegan diet are likely to be different to those involved in initiating and maintaining a flexitarian diet. Thus, flexitarians exhibit limited ingroup identification with other flexitarians, while high ingroup identification is a central feature for vegetarians/vegans (Bagci et al., 2022). Furthermore, having vegetarians in one’s social network does not correlate with the degree to which flexitarians identify as vegetarians (Rosenfeld et al., 2020). For these reasons, we cannot model and understand the role that social networks may play in meat reduction based on vegetarians/vegans. Therefore, a distinct understanding of interpersonal relations and influences that could tip the population towards eating less meat is called for.

In the following, we present a brief overview of the main research directions in social network theory and highlight the concepts that are central to meat reduction. Having these research directions and concepts in mind, we then provide an overview of the ways that studies about meat reduction/flexitarianism so far examined social influences and networks. Subsequently, we use data from a recent questionnaire study (target population: Danish consumers) to illustrate how insights from social network theory can be used in practical research to understand population-wide personal network relations around meat consumption and meat reduction behaviour. In general, the paper advocates a sociologically oriented research agenda focussing on the role social networks could play in encouraging people to eat less meat. Therefore, in the discussion, we highlight promising directions for future research.

2. Social network theory: main research directions and concepts relevant to reduction in meat consumption

2.1. Social network research traditions

According to Scott (2012), multiple research traditions contributed to the formation of social network theory. For this article, three overlapping branches of social network research are highlighted. In the sociometric line of research, the connections between all people in a group (e.g. pupils at a school, individuals in an organization or a city, members of a social media channel, etc.) are studied so that the relational characteristics of the group, subgroups and individuals, can be characterised according to e.g. distance, periphery, centrality and cliques (Crossley et al., 2015; Scott, 2012). Also, value homophily (i.e., whether people are tied to others with whom they share values and beliefs) and status homophily (ties to others who have the same characteristics, e.g., gender, social status, and age) can be studied (Crossley et al., 2015). Another line of research, which initially was inspired by findings in mass media research (Katz, 1957), focuses on how interpersonal relations help spread novel technologies, ideas, and behaviour, and recognises the importance of interpersonal communication and word-of-mouth in local networks. Rogers (2003) expanded on this and formulated a formal model for the diffusion of innovations in which individuals in a target population are divided according to the pace at which they adopt the innovation (from innovators/early adopters to laggards). There is a theoretical and analytical overlap between sociometric research and diffusion research, and they have converged into one framework (Valente, 1995) with multiple research directions (Valente, 2009). However, in practical research, there is a distinction between studies that collect complete network data of all people in a particular group and conduct sociometric analyses, and diffusion studies of larger communities or entire populations where it is not possible to survey everyone (Crossley et al., 2015; Perry et al., 2018). In the latter case, a population sample can be used to study interpersonal relations and exposure (e.g., Valente and Saba, 1998). Also, ego-net data can be collected and used to construct some core measures from sociometric research (Crossley et al., 2015; Perry et al., 2018). The third line of research is a qualitative and ethnographic tradition where natural inquiries of social networks are studied to obtain an insider’s perspective on the connections and bonds between people. Here, the focus is on stories, meaning-making and cultural scripts (Dobbie et al., 2018; Bernhard, 2018; Manzo, 2020). This tradition has been particularly strong within the sociology and anthropology of food in which the material and symbolic meanings of food and meals, and the coupling of these to the division of family roles and labour in the family, and the exchange of gifts in connection with celebratory meals, have been studied (Dreyer and Dreyer, 1973; Douglas, 1975; Theopanos and Curtis, 1991).

2.2. Weak and strong ties and complex behavioural diffusion

Social network and diffusion theories suggest that the adoption of a new behaviour runs through several phases: knowledge/awareness, persuasion, trial, confirmation, and adoption (Rogers, 2003; Valente and Fosados, 2006). Interpersonal communication becomes particularly important during the persuasion phase, when favourable attitudes are activated and the decision to adopt the innovation is made (Rogers, 2003). Interpersonal communication is most influential for those who adopt an innovation at a relatively late stage (the ‘late majority’ or ‘laggards’), as they tend to adopt when they have observed the innovation working successfully for others in their social circle (Rogers, 2003; Valente et al., 2003; Valente and Saba, 1998).

In this perspective, the character of a person’s social connections (or ties) must be considered. A main distinction can be drawn between weak and strong ties (Granovetter, 1973). Weak ties denote people who individuals know but not very well, such as colleagues and acquaintances, while strong ties indicate those with whom individuals are close and often emotionally connected, typically family, friends, and spouses. Granovetter suggested that weak ties are central to the societal-wide diffusion of new ideas and behaviour because communication with weak ties establishes a connection to information, ideas and novel behaviour performed by people and social cliques that are otherwise unknown to the person (Granovetter, 1973).

However, later research highlighted that weak ties are not always central to behavioural diffusion. A distinction can be drawn between simple and complex behavioural diffusion (Centola and Macy, 2007), where the former consists of behaviours that require relatively little effort to act upon and that can be adopted easily by newcomers after exposure to the behaviour from just one person. Weak ties are important for—and accelerate—the diffusion of such simple ideas and behaviours. In contrast, complex behaviour is characterised by domains of practices that are more demanding and difficult to change. For this reason,
exposure to the idea or behaviour from only one source is unlikely to initiate behavioural adoption. Instead, multiple sources of activation are required (Centola and Macy, 2007), provided that these social contacts promote favourable attitudes towards the behaviour (Guilbeault et al., 2017).

2.3. The food domain and meat reduction

Recalling the distinction between simple and complex contagion, food consumption is a clear case of a complex behavioural area. It is a repeated action (White et al., 2019) that is highly intertwined with social coordination, timing and physical location in everyday life (Phan, 2024; Southerton, 2020; Warde, 2016; White et al., 2022). Close family members and significant others often play a key role in food planning, coordination around meals, social norms and preferences (Bove and Sobal, 2006; Dreyer and Dreyer, 1973; Halkier, 2022; Theopano and Curtis, 1991; Thompson et al., 2016; Wingard, 2015). Meat plays a central part in these everyday practices, as meat has compelling sensory characteristics and strong cultural and symbolic meaning (Beardsworth and Keil, 1997; Fuentes and Fuentes, 2022; Piazza et al., 2015).

Having in mind these characteristics of the food domain and meat consumption, it suggests that the reduction of a meat-eater’s intake of meat requires complex behavioural reconfiguration which can be difficult to implement in practice. This complexity must be taken into consideration when examining the role of a person’s network relations. We elaborate more on this and connect to the idea of interpersonal communication and weak and strong ties in Section 2.5.

2.4. Research on interpersonal relations and social networks in meat reduction

The three social network directions laid out in Section 2.1 have been used to varying extents in existing research on reduction of meat consumption. First, to date, sociometric examinations of whole networks have not been conducted regarding meat reduction. Turning to qualitative and ethnographic lines of research, some studies have focused on how people who follow a meat reduced diet communicate this to others (Kondrup et al., 2023; Weihe et al., 2022), how they socially coordinate and negotiate meals (Wendler, 2023; Sundet et al., 2023), and how young people who live together and follow different meat-reduced diets maintain commensality (Veen et al., 2023). Finally, some authors have used approaches akin to the diffusion research tradition in that they examine whether the practice of eating less meat is influenced by other people in the consumer’s personal network (Aschemann-Witzel et al., 2023; Hielkema and Lund, 2021; Lea and Worsley, 2001; Vandermoire et al., 2019). These studies use questionnaire data, so the results allow us to discuss population-level patterns. It is clear from these studies that consumers with personal contacts who have reduced or phased out meat are more likely to embark on the process of reducing meat consumption themselves (Hielkema and Lund, 2021), consume meat less frequently (Lea and Worsley, 2001) or be a less convinced meat-eater (Vandermoire et al., 2019). Furthermore, Aschemann-Witzel and colleagues used cluster analysis to divide consumers into segments and found that segments in which consumers are less likely to identify themselves as meat-eaters know more people who have reduced their meat consumption and consider these persons to be important (Aschemann-Witzel et al., 2023).

2.5. Empirical study aims and operationalisation

From the above overview, we conclude that, so far, authors in the meat reduction literature have only focussed on social dynamics to a limited extent. Further, the available social network approaches presented in Section 2.1 have not been frequently used. Specifically, to date, there are no sociometric analyses of reduction of meat consumption. There are quite many qualitative and ethnographic investigations in the field, which show that reducing meat consumption involves complex behavioural change with ensuing challenges in terms of social acceptance and coordination. However, qualitative inquiries are based on small sample sizes, and the results are not easily translated to the population level. The results of diffusion inspired quantitative studies are better suited for generalisation to larger target populations, but such studies have not considered the complexity of food practices or the distinction between weak and strong ties (Granovetter, 1973).

The empirical contribution of this article is that it illustrates that the main concepts from the social network and diffusion literature, such as complex contagion and weak and strong ties, can be employed in questionnaire-based research to examine how personal network factors influence meat consumption behaviour at the population level.

We deal with the complexity that is assumed to exist around reducing meat consumption by differentiating between two separate stages of change in meat reduction (Kristal et al., 1999; Frohaksa and Diclemente, 1983). We draw a distinction between the initial decision to reduce meat (Stage 1), and then eating meat-free meals in everyday situations for those who have made such a decision (Stage 2). We focus on this distinction because this is likely to be the threshold at which complex behavioural reconfiguration is initiated. The initial decision to eat less meat (Stage 1) requires limited practical effort. Therefore, following the assumption about complex behavioural domains, the decision is more likely also to be influenced by a host of personal network factors. This is because increased exposure to meat reduction through a person’s network will tend to reinforce the individual’s perception that meat reduction is the norm and thus promote behavioural change (Centola and Macy, 2007; Guilbeault et al., 2017). On the other hand, when it comes to maintaining or adopting meat reduction practices in everyday life and situations (Stage 2), everyday challenges to reconfigure eating practices may ensue and intentions may not be translated into behaviour (cf. also the intention-behaviour gap (Adriaanse et al., 2011; Iaffan et al., 2023; Loy et al., 2016)). Here, it is less clear whether any kind of network exposure is instrumental. We posit that having more personal connections who have reduced their meat intake or are vegetarian/vegan (henceforth referred to as personal network exposure, cf. below) is central.

We will consider several personal network factors. This follows the assumption in recent network theory suggesting that multiple sources of activation increase the likelihood of behavioural adoption for complex behavioural domains (Centola and Macy, 2007). We will employ the following four personal network measures: 1) Personal network exposure (Valente and Saba, 1998) is the extent to which a consumer’s personal network engages in the behaviour. Variations of this construct have been used in previous studies of associations between social networks and meat reduction (Aschemann-Witzel et al., 2023; Hielkema and Lund, 2021; Lea and Worsley, 2001; Vandermoire et al., 2019). The next two measures are operationalisations of weak and strong ties, and they centre around the extent to which the individual has spoken to others about eating less meat. In conversational exchange theory (Thomas et al., 1982), conversations with people in one’s social network can include non-binding discussions about a topic where there is not necessarily any pressure to act or express values and opinions. Despite their non-binding nature, such conversations can influence the decision to change behaviour by modifying perceptions of dominant norms so that the behaviour appears normal and acceptable (Gialdini et al., 1991; Valente and Saba, 1998). In this connection, we will distinguish between 2) Range of weak ties and 3) Range of strong ties, whereas range is operationalised as the number of different social ties with whom the individual had conversed. These two constructs are theoretically akin to the interpersonal communication measure employed in Valente and Saba’s study about reproductive health (Valente and Saba, 1998). However, we operationalise the construct differently here, as Valente and Saba did not differentiate between weak and strong ties, and only included a binary distinction (in their case: whether the individual had spoken to anyone about reproductive health). Finally, we include a measure of 4)
persuasion attempts, as conversations about meat reduction can take the form of persuasion (Thomas et al., 1982), where an agent tries to convince other conversation partners to change a behaviour (Humá et al., 2020; Petty and Cacioppo, 1986).

2.6. Research questions and analytical approach

Two research questions have been formulated to study the influence of personal network factors at the two separate stages of change pointed out in Section 2.5. First, (Research question 1) we investigate which personal network factors promote the initial decision to reduce one’s meat intake (i.e., become a flexitarian; Stage 1). Then (Research question 2), we investigate which personal network factors increase the propensity for flexitarians to eat meat-free meals in everyday situations (Stage 2).

Even though we are mainly interested in personal network factors, we will also study whether attitudes towards meat reduction make a difference, since it is a central assumption in social network and diffusion theory that, before behavioural change is adopted, people must have favourable attitudes towards the novel behaviour, or develop such attitudes during the network-persuasion process (Guilbeault et al., 2017; Rogers, 2003).

Furthermore, we will examine possible interactions between all personal network measures and between favourable attitudes and the personal network measures. This is because we believe that it is important to investigate whether and, if so, how personal network factors interact in order to consider and explore the assertion that multiple sources of activation are required to trigger adoption in a complex behavioural area (Centola and Macy, 2007).

Finally, we control for socio-demographic confounding to ensure that our results do not just reflect that some population segments (such as women or younger age groups) are more likely to become flexitarians (Hielkema and Lund, 2021).

3. Methods

3.1. Participants and materials

We employ cross-sectional data consisting of responses to a questionnaire (n = 3000), collected through computer-assisted telephone interviewing. Data were collected by a commercial survey company in the summer of 2020. The target population was Danes above 17 years of age. To ensure data that are representative of the Danish population, probability-based sampling was employed, where participants were recruited via telephone using random-digit dialling (response rate ~14%). Socio-demographic details about the data are provided in Table 1 and compared with the Danish population census. Further details about data collection is provided in Halkier and Lund (2023).

3.2. Measures

Dietary group: we asked participants to self-declare which of the following statements best described their food habits: I eat meat (including fish and poultry); I eat small amounts of meat; I am a vegetarian; I am a vegan. If participants selected the first statement, a follow-up question was provided to operationalise participants who were recent flexitarians: ‘Have you started to eat less meat within the past year?’ If participants selected the second statement, we prompted about how long had they had eaten small amounts of meat (response options were: 0–6 months, 6–12 months, 1–2 years, 2–5 years, 5–10 years, >10 years, My whole life). Using these three questions, a dietary group variable was constructed with the following categories: 1) meat-eater without restrictions, 2) recent flexitarian (0–12 months), 3) longer-term flexitarian (>12 months), 4) vegetarian, 5) vegan.

We developed two separate measures of meat-free eating behaviour. Meat-free dinner: We asked whether meat was consumed at the dinner

| Table 1 Socio-demographic details of the study sample. |
|----------------|----------------|----------------|
| Gender         | Frequency | Percent | Population census % |
| Male           | 1400     | 46.7    | 49.0               |
| Female         | 1600     | 53.3    | 51.0               |
| Age            |           |         |                    |
| 18–29          | 405      | 13.5    | 19.0               |
| 30–39          | 310      | 10.3    | 15.0               |
| 40–49          | 442      | 14.7    | 18.0               |
| 50–59          | 494      | 16.5    | 17.0               |
| 60–69          | 569      | 19.0    | 15.0               |
| 70+            | 780      | 26.0    | 16.0               |
| Education      |           |         |                    |
| (highest completed) |       |         |                    |
| Secondary school | 353     | 11.8    | 26.2               |
| Vocational education | 777      | 25.9    | 33.3               |
| Higher general education | 521    | 10.7    | 9.2                |
| Short-cycle higher education | 273 | 9.1    | 7.7               |
| Medium-cycle higher education | 850      | 28.3    | 17.0               |
| Long-cycle higher education/.PhD | 426     | 14.2    | 9.6                |
| Geographical region |       |         |                    |
| Capital         | 856      | 28.5    | 31.0               |
| Zealand         | 454      | 15.1    | 15.0               |
| South Denmark   | 685      | 22.8    | 22.0               |
| Mid Jutland     | 707      | 23.6    | 22.0               |
| North Jutland   | 298      | 9.9     | 10.0               |
| Total           | 3000     | 100.0   | 100.0              |

The total in the study sample column do not necessarily sum to 100 because of rounding error.

the day before the interview took place (1 = meat-free meal; 0 = inclusion of meat (i.e., poultry, pork, beef, veal, lamb).

Frequent vegetable consumption: This was based on a food frequency question with five categories that we collapsed into a binary variable (1 = more than once per day; 0 = once per day or less).

Favourable attitudes. This measure was based on three statements focussing on positive characteristics of a plant-based diet: ‘Plant-based food is healthier’; ‘Plant-based food is more climate-friendly’; ‘Eating meat is unethical towards the animals’. Participants had five response options ranging from ‘completely disagree’ to ‘completely agree’. Fit indices from confirmatory factor analysis (RMSEA = 0.00 (95% CI: 0.00–0.00); CFI = 1.0) and assessment of internal consistency (Cronbach’s alpha = 0.60; average interitem correlations = 0.37) indicate that the three questions form an acceptable one-dimensional measure. We constructed the measure as a composite index and rescaled it to range from 0 (very low favourable attitudes) to 1 (very high favourable attitudes). The mean score was 0.54.

Personal network exposure. Participants were prompted about the number of people they knew personally who had reduced their meat intake or were vegetarians/vegans.

Range of weak ties. This was based on a multiple-choice question where participants were asked to specify which people they had talked to about reducing meat consumption over the past 6 months. A count variable with five levels was constructed by summing together the types of weak ties with whom the participant had spoken. We treated the following connections as weak ties: roommate, acquaintance, colleague, peer (students), extended family, others.

Range of strong ties. This was based on the same multiple-choice question as above (range of weak ties). We treated the following connections as strong ties: spouse, partner, child, parent, friend.

Persuasion attempts. Participants were asked about the number of people who had tried to convince them to change their eating habits over the past year.

Details of question formulations and response options for all personal network measures are outlined in Table 2 in the results section.
interaction effects that were not statistically significant at the 0.05 level. A. We used the stepwise backward elimination method to remove descriptive statistics of these control variables are reported in Appendix (determined using the likelihood ratio (LR) chi

As controls: age (inserted as continuous predictor), gender, household total). In addition, the following sociodemographic variables were used network variables and favourable attitudes (i.e., ten interactions in more, we included all two-way interaction effects between the four

The four personal network factor measures and the

test). All main effects of the four personal network variables and the interaction effects

were detected and reported by comparing the likelihood ratio chi2 value of the full model with a model where the effect in question was omitted.

To study the effect of the network variables on flexitarians’ propensity to eat meat-free meals (Stage 2), we singled out a sub-sample consisting of flexitarians (i.e., recent flexitarians or longer-term flexitarians). We then ran two separate multivariable logistic regressions for both measures of meat-free eating behaviour in this sub-sample. We included the same main and interaction effects as in the Stage 1 analysis. In addition, we included a binary variable indicating whether the participant was a recent or longer-term flexitarian. We employed the same backwards stepwise elimination of interaction effects, and the overall regression model was evaluated in the same way as for Stage 1. To present statistically significant interaction effects, Stata’s margins command was used to calculate predicted probabilities that were then converted to percentages and displayed in figures.

We considered p-values below 0.05 as statistically significant in all analyses.

An earlier publication exploiting these data showed that the sample deviates slightly from the Danish adult population in terms of gender, geographical location and age, and overrepresents Danes with higher educational level (Halkier and Lund, 2023). To account for these socio-demographic discrepancies, we used weights in all descriptive analyses (with the following weight adjustments: gender, age, region and highest completed education) to ensure that the reported shares

We first provide a descriptive overview of the dietary groups and then characterise differences between the groups in terms of the four personal network factors (personal network exposure, range of weak ties, range of strong ties and persuasion attempts).

To examine whether personal network factors are associated with the initial decision to reduce meat consumption (Stage 1), we isolated the relevant sub-sample (namely meat-eaters without restriction and recent flexitarians) and conducted a multivariable logistic regression (dependent variable: \(1 = \text{recent flexitarian} \); \(0 = \text{meat-eater without restrictions}\)). The four personal network factor measures and the favourable attitude measures were used as main effects in the regression model. These variables were treated as continuous predictors. Furthermore, we included all two-way interaction effects between the four network variables and favourable attitudes (i.e., ten interactions in total). In addition, the following sociodemographic variables were used as controls: age (inserted as continuous predictor), gender, household composition, education, population density and region of Denmark. The descriptive statistics of these control variables are reported in Appendix A. We used the stepwise backward elimination method to remove interaction effects that were not statistically significant at the 0.05 level (determined using the likelihood ratio (LR) chi2 test). All main effects variables were included in the model regardless of their significance levels. After eliminating the non-significant interaction effects, we evaluated the overall regression model fit of the final model using the LR chi2 test and Nagelkerke’s pseudo-R2. Statistically significant main effects of the four personal network variables and the interaction effects

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Overview of personal network variables according to diet groups (column percentages).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meat-eater. no restrictions (1514)</td>
</tr>
<tr>
<td>Range of strong ties (a)(b)</td>
<td>No conversation 63%</td>
</tr>
<tr>
<td></td>
<td>Conversation with one type of strong tie 15%</td>
</tr>
<tr>
<td></td>
<td>Conversation with two types of strong ties 10%</td>
</tr>
<tr>
<td></td>
<td>Conversation with three types of strong ties 7%</td>
</tr>
<tr>
<td></td>
<td>Conversation with &gt;3 types of strong ties 4%</td>
</tr>
<tr>
<td>Mean (s.d.)</td>
<td>0.7 (1.2)</td>
</tr>
<tr>
<td>Range of weak ties (c)(d)</td>
<td>No conversation 69%</td>
</tr>
<tr>
<td></td>
<td>Conversation with one type of weak tie 16%</td>
</tr>
<tr>
<td></td>
<td>Conversation with two types of weak ties 7%</td>
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<tr>
<td></td>
<td>Conversation with &gt;3 types of weak ties 4%</td>
</tr>
<tr>
<td>Mean (s.d.)</td>
<td>0.6 (1.1)</td>
</tr>
<tr>
<td>Personal network exposure (e)</td>
<td>None 37%</td>
</tr>
<tr>
<td></td>
<td>One or two people 33%</td>
</tr>
<tr>
<td></td>
<td>Three to five people 18%</td>
</tr>
<tr>
<td></td>
<td>More than five people 12%</td>
</tr>
<tr>
<td>Persuasion attempts (f)</td>
<td>None 85%</td>
</tr>
<tr>
<td></td>
<td>Once 4%</td>
</tr>
<tr>
<td></td>
<td>A few times 8%</td>
</tr>
<tr>
<td></td>
<td>Many times 3%</td>
</tr>
</tbody>
</table>

Weighted shares and means are reported in the table.

Unweighted sample sizes are reported.

\(a\) The question was: “Did you speak with any of the following people about eating less meat or a plant-based diet over the past year?”

\(b\) Strong ties were operationalised as: spouse. partner. child. parent. friend.

\(c\) Weak ties were operationalised as: roommate. Acquintance. colleague. student peer. extended family. others.

\(d\) The question was: “How many of your personal contacts eat small amounts of meat or are vegetarian or vegan?”

\(e\) The full question was: “Over the past year. did someone in your life who eats less or no meat try to convince you to change your eating habits?”

\(f\) Chi2-tests of associations.

3.3. Data analysis

We first provide a descriptive overview of the dietary groups and then characterise differences between the groups in terms of the four personal network factors (personal network exposure, range of weak ties, range of strong ties and persuasion attempts).

To examine whether personal network factors are associated with the initial decision to reduce meat consumption (Stage 1), we isolated the relevant sub-sample (namely meat-eaters without restriction and recent flexitarians) and conducted a multivariable logistic regression (dependent variable: \(1 = \text{recent flexitarian} \); \(0 = \text{meat-eater without restrictions}\)). The four personal network factor measures and the favourable attitude measures were used as main effects in the regression model. These variables were treated as continuous predictors. Furthermore, we included all two-way interaction effects between the four network variables and favourable attitudes (i.e., ten interactions in total). In addition, the following sociodemographic variables were used as controls: age (inserted as continuous predictor), gender, household composition, education, population density and region of Denmark. The descriptive statistics of these control variables are reported in Appendix A. We used the stepwise backward elimination method to remove interaction effects that were not statistically significant at the 0.05 level (determined using the likelihood ratio (LR) chi2 test). All main effects variables were included in the model regardless of their significance levels. After eliminating the non-significant interaction effects, we evaluated the overall regression model fit of the final model using the LR chi2 test and Nagelkerke’s pseudo-R2. Statistically significant main effects of the four personal network variables and the interaction effects

were detected and reported by comparing the likelihood ratio chi2 value of the full model with a model where the effect in question was omitted.

To study the effect of the network variables on flexitarians’ propensity to eat meat-free meals (Stage 2), we singled out a sub-sample consisting of flexitarians (i.e., recent flexitarians or longer-term flexitarians). We then ran two separate multivariable logistic regressions for both measures of meat-free eating behaviour in this sub-sample. We included the same main and interaction effects as in the Stage 1 analysis. In addition, we included a binary variable indicating whether the participant was a recent or longer-term flexitarian. We employed the same backwards stepwise elimination of interaction effects, and the overall regression model was evaluated in the same way as for Stage 1.

To present statistically significant interaction effects, Stata’s margins command was used to calculate predicted probabilities that were then converted to percentages and displayed in figures.

We considered p-values below 0.05 as statistically significant in all analyses.

An earlier publication exploiting these data showed that the sample deviates slightly from the Danish adult population in terms of gender, geographical location and age, and overrepresents Danes with higher educational level (Halkier and Lund, 2023). To account for these socio-demographic discrepancies, we used weights in all descriptive analyses (with the following weight adjustments: gender, age, region and highest completed education) to ensure that the reported shares
were representative of the Danish population. We did not apply weights in multivariable analyses and in tests of association.

4. Results

4.1. Dietary groups and personal network factors relevant to meat reduction

The study sample consisted of 2% vegetarians, 1% vegans, 21% longer-term flexitarians (meaning that they had eaten less meat for 1 year or more), 22% recent flexitarians (meaning they had made the initial decision to eat less meat within the past year) and 54% meat-eaters without any restrictions.

There were clear differences between the dietary groups in terms of personal network factors. On average, participants had a conversation about meat reduction with approximately one type of strong tie (Mean (entire sample) = 1.2) and one type of weak tie (Mean (entire sample) = 0.9) over the past 6 months (details in Table 2). However, meat-eaters without restrictions had considerably fewer conversations, while the mean number of conversations was substantially higher for recent flexitarians, longer-term flexitarians, vegetarians and vegans. In relation to personal network exposure, most respondents knew at least one person who ate small amounts of meat or was a vegetarian/vegan. There were again marked differences, and vegetarians and vegans clearly had the highest level of personal network exposure. Approximately one third (37%) of meat-eaters without restrictions did not have any personal contacts who had reduced their meat consumption or were vegetarian/vegan. Finally, 18% had a person in their network who had attempted to persuade them to change their eating habits at least once. This rate was highest in the recent flexitarian group, where 24% had experienced such an attempt (either once or more than once).

4.2. How are personal network relations associated with the decision to eat less meat (stage 1)?

We focussed on identifying the personal network variables that could predict that meat-eaters without restrictions would become a recent flexitarian. The multivariable logistic regression (dependent variable: 1 = Recent flexitarian; 0 = Meat-eater without restrictions) was statistically significant (LR Chi2 = 451.7 (19); p < 0.001; Nagelkerke’s R² = 0.26; model results are presented in Appendix B.1). We identified a statistically significant main effect from personal network exposure (p < 0.05). The pattern of this association is presented in Table 3, where we report the share of meat-eaters without restrictions who had recently decided to eat less meat (i.e. become recent flexitarian) according to personal network exposure. The share increases with the number of personal contacts who eat small amounts of meat or are vegetarian/vegan.

Among the ten interaction effects that were tested, two statistically significant effects were identified. Firstly, there was a significant interaction effect between the range of strong ties and weak ties (p < 0.001). The character of this interaction is depicted in Fig. 1, where the likelihood of becoming a recent flexitarian is indicated by colour brackets in a two-dimensional space according to the range of strong ties (x-axis) and weak ties (y-axis). Generally, the propensity to decide to eat less meat increases with the range of weak ties and strong ties. Furthermore, personal network exposure from either strong or weak ties appears to be a sufficient condition to decide to eat less meat. Thus, even if the respondent did not speak to any strong ties about meat reduction, the propensity to reduce meat intake still increases if they spoke with one or several types of weak ties. A similar pattern is seen for strong ties. Still, when considering the two types conjointly, there is not a monotonous increase in the likelihood to decide to eat less meat the more weak and strong ties a person spoke with. In particular, the likelihood to decide to eat less meat is lower if people had conversations with many weak and many strong ties (upper-right hand of Fig. 1) compared to those that had conversations with few weak and many strong ties (lower-right hand of Fig. 1).

There was also an interaction effect between persuasion attempts and favourable attitudes (p < 0.05). We present this pattern in Fig. 2 and report favourable attitudes at the mean and one and two standard deviations (SD) below and above the mean. In general, it appears that the share who become recent flexitarians increases with favourable attitudes (x-axis). However, the number of persuasion attempts reinforces whether the consumer reacts to such favourable attitudes. For instance, focussing on the right-hand part of the figure, where favourable attitudes are above the mean score, the proportion who decide to eat less meat is clearly lower among consumers when “no attempts” were made to persuade, compared with those where “a couple” or “many” attempts were made to persuade the consumer to eat less meat.

![Fig. 1. The percentage of meat eaters who recently decided to eat less meat (i.e., recent flexitarian) according to range of strong ties (x-axis) and weak ties (y-axis) with whom they had talked about reducing meat consumption.](image1)

![Fig. 2. The percentage of meat eaters who recently decided to eat less meat (i.e., recent flexitarian) (y-axis) according to number of persuasion attempts and favourable attitudes (x-axis).](image2)

Table 3

<table>
<thead>
<tr>
<th>(Personal network exposure): How many of your personal contacts eat small amounts of meat or are vegetarians or vegans?</th>
<th>Recent flexitarian</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>19%</td>
</tr>
<tr>
<td>One or two people</td>
<td>29%</td>
</tr>
<tr>
<td>Three to five people</td>
<td>36%</td>
</tr>
<tr>
<td>More than five people</td>
<td>39%</td>
</tr>
<tr>
<td>Total</td>
<td>28%</td>
</tr>
</tbody>
</table>

Weighted shares are reported in the table.
4.3. How are personal network factors associated with meat-free eating among flexitarians (stage 2)?

Here the analysis is limited to the flexitarian subgroup (i.e., recent and longer-term flexitarians (unweighted n = 1395)).

4.3.1. A meat-free dinner

In total, 31% of the flexitarians enjoyed a meat-free dinner the day before the interview took place. The multivariable logistic regression examining predictors of eating a meat-free dinner returned a statistically significant model (LR Chi2 = 56.90 (17); p < 0.001; Nagelkerke’s R² = 0.06; further model details in Appendix B.2). The main effect of personal network exposure was statistically significant (p < 0.05). Table 4 shows that eating a meat-free dinner increases with the number of personal connections who eat small amounts of meat or are vegetarian/vegan.

4.3.2. Frequent consumption of vegetables

In total, 43% of the flexitarians reported that they ate vegetables more than once per day. The multivariable logistic regression returned a statistically significant model (LR Chi2 = 196.4 (18); p < 0.001; Nagelkerke’s R² = 0.18; further model details in Appendix B.3). None of the four main effects of the personal network variables predicted frequent consumption at a statistically significant level. However, there was a statistically significant interaction effect between personal network exposure and favourable attitudes (p < 0.05). The character of this interaction (see Fig. 3) is that consumers who know 3–5 or >5 people who eat small amounts of meat or are vegetarians/vegans tend to consume vegetables more frequently if they also have more favourable attitudes. In contrast, for those who know 0–2 people, this frequency does not change considerably across different levels of favourable attitudes.

5. Concluding discussion

This paper advocated a research agenda focussing on the role that social networks may play in the transition towards plant-based eating. It was further illustrated empirically that this approach is likely to produce relevant insights. We stress that the presented results is just one of many possible research avenues that can be pursued based on social network theory. Thus, after discussing our main results we go on to consider possible directions for future research.

5.1. Study findings

Overall, the findings show that a person’s network can influence meat-consumption behaviour. This is in line with prior findings (Aschemann-Witzel et al., 2023; Hielkema and Lund, 2021; Lea and Worsley, 2001; Vandermoere et al., 2019). It was further shown that the way a person’s network influences meat-consumption is stage-dependent. We divide our discussion of the results into the two stages of meat-reduction that were examined.

Starting with Stage 1 we found that a higher level of personal network exposure increases the likelihood that a meat-eater will decide to eat less meat. Persuasion attempts also increase the likelihood, although the success of attempts to persuade in interpersonal interactions ultimately depends on the consumers’ favourable attitudes towards plant-based eating (in line with Rogers’ assumption (2003)). Without favourable attitudes, attempts have little effect, while on the other hand, more persuasion attempts increase the likelihood if people have favourable attitudes. We also found that conversations about meat reduction with social ties increase the likelihood of deciding to eat less meat. Both weak and strong ties can have an effect independently. Here, we observed a surprising pattern in that the likelihood to decide to eat less meat is lower if people had conversations with many weak and many strong ties than if people had conversations with few weak ties and many strong ties. We cannot examine this pattern further using the present data. A possible explanation is that conversations with weak ties may be more negatively laden, i.e., reducing meat consumption is framed as negative, and thus a transition is less frequently promoted. Either way, the surprising pattern deserves attention in future research as it suggests that the extent of behavioural adoption that occurs depends on the types of persons (weak or strong ties) that people speak with.

At a general note, since the decision to eat less meat increased with all types of personal network factors investigated, our findings regarding Stage 1 corroborate the assumptions from the literature that, for complex ideas and practices, consumers require exposure from multiple network sources before action to adopt the behaviour is taken (Centola and Macy, 2007).

Turning to Stage 2, i.e., flexitarians adopting or maintaining meat-reduction behaviour in everyday eating situations, we identified fewer associations between personal network factors and meat-free eating behaviour. Persuasion attempts did not predict increased propensities to avoid meat in the dinner and frequently consume vegetables. Similarly, conversations with more weak and strong ties did not increase these propensities. The most consistent personal network factor involved in a higher propensity to eat plant-based dishes was the flexitarian’s personal network exposure: having more personal contacts who eat small amounts of meat or are vegetarian or vegan. The result suggests that, in the practical stage of behavioural adoption, multiple network sources become less impactful. This likely reflect the complexity of practices surrounding food and eating mentioned earlier, namely that it is a repeated and ordinary behaviour (Gronow and Warde, 2001; White et al., 2019) strongly imbued in everyday life and socio-material practices where changes in eating practices require a complex reconfiguration of daily routines. Here, conversations with, and learning from, connections that have adopted a meat reduced or meat-free diet are more likely to make a difference. Additionally, even though we cannot

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Table 4

<table>
<thead>
<tr>
<th>Personal network exposure</th>
<th>A meat-free dinner³ (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>25%</td>
</tr>
<tr>
<td>One or two people</td>
<td>29%</td>
</tr>
<tr>
<td>Three to five people</td>
<td>30%</td>
</tr>
<tr>
<td>More than five people</td>
<td>38%</td>
</tr>
<tr>
<td>Total</td>
<td>31%</td>
</tr>
</tbody>
</table>

Weighted shares are reported in the table.

³ The question was: “What did you eat for your main meal yesterday?” Respondents were registered as avoiding meat if they did not select any of the following food items: poultry, pork, beef, veal, lamb.
back this up with the present data, it is likely that this influence also is based on observing and trying novel foods and dishes that are prepared by personal connections (Wendler and Halkier, 2023). In general, practical, and material learning and behavioural change depend on both “sayings and “doings” (Schulz et al., 2019).

### 5.2. Reflection on the study’s findings

It is an assumption in the social tipping point literature that the bulk of consumers will transition to pro-environmental practices in general, and plant-based eating specifically (Aschemann-Witzel and Schulze, 2023) when a critical mass is reached (Global Systems Institute University of Exeter, 2022; Stadelmann-Steffen et al., 2021). Our findings demonstrate that personal network factors encourage people to eat less meat. Therefore, interpersonal relations and influences could be instrumental in terms of reaching such a critical level.

On the other hand, the concept of social tipping point has been criticized on several theoretical and methodological grounds. It is by no means clear that the assumptions underlying social tipping are operational in all domains relevant to the sustainability transition (Milkoreit, 2023). We will not attempt to resolve whether a social tipping point could emerge for plant-based food consumption; but see the discussion in Aschemann-Witzel and Schulze (2023). What we can say, is that there is still a long way to go, as the majority of Danes in 2021 were still eating meat without any restrictions in the present study. This is in accordance with findings from other countries (Dagevos, 2021). Added to this, many (i.e., >60%) meat-eaters without restrictions did not talk with weak or strong ties about meat reduction, and one in three within this group did not know anyone who had reduced or removed meat from their diet. Having these figures in mind, a negative interpretation of our findings is that a rather large segment of the population does not, and is not likely in the foreseeable future to, engage with people in their social network who will influence them to reduce their meat consumption through, e.g., persuasion and/or practical demonstrations of meat reduced dishes.

In a more positive reading of our results, we emphasise that conversations with a larger range of weak ties increased the likelihood that meat-eaters would decide to eat less meat, and that weak ties could prompt this decision, even if the consumers did not speak with strong ties about meat reduction. However, more research is needed to understand the way in which the influence of weak ties, and indeed other interpersonal connections, affects this decision.

### 5.3. Directions for future research on the influence of social networks on meat consumption

The empirical results and findings presented in this paper are by no means exhaustive of the avenues that social network theory offers to researchers with interest in the plant-based food transition. Here, we provide suggestions as to how, and for what purpose, social network research can be used. We divide them according to the three research directions that were presented in Section 2.1.

It is relevant to focus on complete network data, which comprises information about the social relations and interactions of all persons in a network, so that a sociometric analysis can be carried out (Scott, 2012). Extremely little is known about social dynamics and network characteristics when it comes to reducing/avoiding meat consumption in common institutional settings such as school classes, schools, work organizations, and leisure or interest associations. Network structure information such as degree centrality, value homophily, status homophily, and structural equivalence (Crossley et al., 2015) would be valuable to map within and across institutions. Also, studying how intention to eat plant-based food develops over time on account of people’s position and connections in a network may help us understand temporal dynamics, conversion rates and characteristics.

Qualitative and ethnographic studies of the social dynamics of reducing meat consumption have already surfaced (see Section 2.4). We think that more research could be useful to expand the study range regarding populations (countries or communities studied) and institutional context (e.g., in the home, at work, with friends, etc). Over time, findings from qualitative data about conflicts, roles, interpersonal communication, and meaning-making could be transferred to questionnaire-based studies so population-wide inferences can be made. One promising perspective that has not yet been addressed by qualitative researchers in the field is qualitative social network analysis where social networks are at the core of the inquiry, and where the intersection of network relations, stories and meaning-making are studied in greater detail (Bellotti, 2015; Ryan et al., 2014). This approach offers tools that are relevant to researchers working with food consumption and the reduction of meat consumption, including exploration of network boundaries (Heath et al., 2009), and taking socio-material practices and “doings” and “sayings” into consideration (Decuyper, 2020; Schulz et al., 2019). In a mixed method perspective (Crossley et al., 2015), this line of research could also provide in-depth, qualitative insights into results from sociometric network analysis about reducing meat consumption.

In the questionnaire-based diffusion research tradition, where a larger community or culture is studied using a random sample of the population, more attention could be given to the development of fine-grained social network measures. The bulk of studies so far have employed just one measure, typically personal network exposure (Hiellkema and Lund, 2021; Lea and Worsley, 2001; Vandermoeore et al., 2019). Along with Aschemann-Witzel et al. (2023), who considered both personal network exposure and the importance attached to the persons that eats less meat in an individuals’ network, the present paper is the first to explore multiple dimensions of personal networks with a starting point in previous social network research (Granovetter, 1973; Valente and Saba, 1998). More refined and different measures can surely be developed. It is recommended for questionnaire-based research to collect ego-net data using the methods of resource generators and name generators (Crossley et al., 2015; Perry et al., 2018). This type of data allows a person’s social network characteristics to be captured and the attributes of the person’s ties to be recorded. Attributes of interest could be, for instance, whether the tie is a flexitarian or vegetarian, whether the respondent finds the tie trustworthy and important, and whether the respondent was encouraged to try a plant-based dish by the tie.

### 5.4. Limitations

The data and analyses presented in this paper have some limitations. The cross-sectional nature of the data means that we cannot make the causal inference that it is the social network variables that affect the examined meat-reduction outcomes. It is also possible that there could be a reverse causal effect. The risk of this is highest for the two measures of range of weak and strong ties, as such conversations could, in principle, be initiated by the study respondents if they, e.g., were interested in disclosing their altered diet behaviour.

Another limitation is that we did not measure actual meat-consumption behaviour. It is methodologically challenging to assess meat-reduction behaviour accurately (Dagevos and Verbeke, 2022). Our study is no exception to this, and external validity is therefore unclear on this point, although we believe that our measurement based on a question about the dinner meal consumed the previous day is likely to be quite reliable, as there is limited risk of memory recall bias. Finally, we only examined the influence from social networks on consumption of a meat-free dinner and vegetables in the flexitarian subgroup where an intention to eat less meat has emerged (Stage 2). Meat eaters without restrictions were not considered. However, even though this sub-group has not formulated an intention they could also consume less meat and more vegetables on account of interactions with persons in their network. This consumer group certainly merits attention in future research.
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CRediT authorship contribution statement
Thomas Boker Lund: Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Bente Halkier: Writing – review & editing, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The Velux Foundation supported the research financially (project number 27826).

Data availability
Data will be made available on request.

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Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.crc.2024.100203.

References


