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Monitoring a meat-free pledge with smartphones: An experimental study

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ABSTRACT

Pledges are a popular strategy to encourage meat reduction, though experimental studies of their efficacy are lacking. Three-hundred and twenty-five participants from three different countries (UK, Germany, Australia) were randomly assigned to pledge 28 days meat-free or not, and their behavior was tracked via smartphones. Participants answered daily surveys regarding their eating behavior, meat cravings, and shared photos of their meals. Baseline data was collected prior to the pledge, after the 28 days, and one-month post-intervention. Participants assigned to the pledge condition ate less meat across the 28 days, compared to control participants. Meat reductions, observed at outtake, did not endure one-month post-intervention. Overall, German participants ate the least amount of meat, and showed the sharpest decrease in consumption when pledging. Meat cravings tended to increase among pledgers, relative to control participants. Pledgers who reported high starting intentions and conflict about meat tended to eat less meat and reported fewer cravings. All participants reported reduced meat-eating justifications one-month post-intervention. These findings provide experimental evidence that pledges can encourage meat consumers to reduce their intake, though additional mechanisms are needed to sustain commitments.

1. Introduction

For several decades, non-government and government organizations have been calling for global reductions in the consumption of animal products and a greater shift towards plant-based eating to address issues around health, climate change, food waste, animal welfare, and the transmission of zoonotic disease (e.g., de Boer et al., 2013; Gerber et al., 2013; Mepham, 2004; Pan et al., 2011; Smil, 2002; Tilman & Clark 2014; Wellesley et al., 2015; Willett et al., 2019). Understanding how such a transition can be implemented is of increasing interest to policy makers, market researchers, and social scientists. In the present study, smartphone-based experience sampling was used to investigate the efficacy of pledging as a vehicle for promoting meat reduction. The intervention was tested in relation to individual differences in meat-eating conflict and cultural context.

1.1. Meat-reduction interventions

With the aim of promoting lasting meat reduction, organizations and veg*n strategists have employed a number of strategies, including but not limited to humane education, veg*n-eating apps and meat-free pledges (Animal Charity Evaluators, 2019; Graça et al., 2019; Harguess et al., 2020). How effective these strategies are, remains unclear. According to the COM-B model of behavior change, effective strategies are those that provide the individual with the *opportunity* to act and support them in their *motivations* and *capacity* to do so (Atkins & Michie, 2013, 2015; Michie et al., 2011). Here we consider whether pledging—that is, making a commitment to behave in a certain manner—may be one method to give individuals an opportunity to make efforts towards meat reduction and build capacities for sustained change.

Pledging has been studied as a mechanism for supporting behavioral change in a number of domains, including recycling (DeLeon & Fuqua, 1995; Wang & Katzev, 1990), energy conservation (Pallack &

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Cummings, 1976; Shippee & Gregory, 1982), voting (Burgess, Haney, Snyder, Sullivan, & Transue, 2000), using public transport (Bachman & Katzev, 1982), seatbelt use (Geller & Bigelow, 1984; Gamble & Kalsher, 1990), and smoking cessation (Cahill & Perera, 2011). These studies converge on the general finding that pledging can promote attitudinal and behavioral changes, at least in the short-term. However, there are important facilitating factors that moderate these effects.

One key moderator is the attitudinal state of the pledger. Individuals who engage with pledges are often those individuals who express conflict about the target behavior. For example, Bass et al. (2019) found that the majority of university students who succeeded in avoiding a popular binge-drinking event were those individuals who expressed prior concern with binge drinking (see also Hallaq, 1976, regarding smokers). This highlights an important consideration when generalizing pledge-based interventions to the larger population: not everyone will be interested in engaging with such an intervention or benefit from it, thus, it may be more resource-effective in identifying individuals who have intentions to change or express some degree of conflict about the to-be-changed behavior.

Meat consumption tends to be a behavior that generates substantial levels of attitudinal conflict for many people (Berndsen & Van der Pligt, 2004; Povey et al., 2001; Rothgerber, 2014). Cognitive dissonance theory has been applied as a framework for understanding the “meat paradox,” or the attitudinal inconsistency that many consumers experience regarding their meat consumption (Bastian & Loughnan, 2017; Loughnan et al., 2010, 2014; Rothgerber, 2014, 2020). Dissonance might occur because a person holds conflicting views about meat (e.g., enjoying it, while being aware of the suffering caused to animals or the environmental impact of meat production) or they feel responsible for negative aspects of meat. Research has shown that when consumers experience conflict about their meat consumption, they engage in a number of “dissonance-reducing strategies,” including efforts towards meat reduction, to resolve the apparent conflict (e.g., Bastian et al., 2012; Buttlar & Walther, 2018; Loughnan et al., 2010; Rothgerber, 2014).

1.2. Meat-free pledging

Pledge programs are an increasingly common campaign strategy to promote meat reduction. Veganuary, for example, is a hugely popular campaign that has grown from just 3300 official sign-ups in 2014 to over a half million in 2021. Data published by the Veganuary campaign suggests that 59% of those who pledged a month of vegan eating in January 2020 said that they had been successful (Veganuary, 2020). Other popular pledge programs include Meat-Free Mondays, Animal Aid’s “Great Vegan Challenge”, and Viva’s “30 Day Vegan”. Despite the growth of these campaigns, experimental research investigating their efficacy is limited. Furthermore, the voluntary nature of these campaigns, and the lack of suitable control groups, limits the causal inferences that can be drawn about their success. Individuals who pledge to eat meat-free are usually already motivated to reduce their consumption (Grassian, 2020), which raises the question of whether commitments to eat meat-free have the potential to galvanize individuals without preexisting reduction goals.

In one of the most extensive evaluations of real-world pledging, Grassian (2020) tracked 1539 people who were taking part in one of seven UK meat reduction and vegan campaigns over a twelve-month period. At six different time points, pledgers reported on their adherence to their reduction/abstention goals. Just over half reported meeting their goal at each time point, and the greatest successes were reported by pledgers who had already eliminated most animal products from their diet (e.g., vegetarians attempting a vegan diet). With few exceptions, the vast majority of pledgers (82.1% across all campaigns) self-described as pre-existing meat reducers, or, for many vegan campaigns, as vegetarians.

In studying the outcomes of those already reducing or abstaining, we

fail to learn whether invitations to eat meat-free can successfully engage people without a prior history of reducing. Likewise, as Grassian (2020) warns, by relying on self-reports of goal adherence, existing studies of pledge campaigns may be inflating our sense of pledging as an effective meat-reduction intervention.

1.3. Experience sampling and the present study

The present study sought to address some of these limitations by using an experimental method to randomly assign participants to attempt a meat-free month or not. Experience sampling was used to track participants’ daily eating practices and minimize misreporting. A secondary aim of the study was to investigate whether conflict over one’s meat consumption, or “omnivore conflict” (Ruby et al., *in prep*), might facilitate pledge adherence. In addition to assessing omnivore conflict, and in accordance with the COM-B model, we assessed pledgers’ starting intentions and their self-appraised capacity to fulfill the meat-free pledge.

The study employed a 28-day period of smartphone-based experience sampling (Hofman & Patel, 2014; van Berkel et al., 2017) to gather a rich assessment of pledge adherence that moves beyond retrospective self-reports of pledge fulfilment. Experience sampling is well-known method that helps address issues around optimism bias (e.g., underestimating the amount of food eaten), recall bias (e.g., forgetting or misremembering what one has eaten), and social desirability (e.g., deliberately misreporting what one has eaten) (Csikszentmihalyi & Larson, 1987). It has been used in several domains of life, including consumer appraisals and emotion (Liu et al., 2016; Macht et al., 2004), dieting and self-control (Hofman et al., 2014), and psychological well-being (Hunter & Csikszentmihalyi, 2003). It has the advantage of reducing cognitive errors, relative to traditional self-reports, by having participants report on their behavior temporally closer to the moment of enactment, which makes it an ideal technique to apply in the context of daily consumption behaviors.

1.4. Preregistered hypotheses

The study had several preregistered hypotheses. The first hypothesis (Hypothesis 1) was that the pledge intervention would interact with omnivore conflict, such that highly conflicted participants would adhere to the pledge and reduce their meat consumption to a greater extent than less conflicted pledgers, during the 28 days. This hypothesis was based on the perspective that conflicted omnivores are motivated reduce their conflict (Loughnan et al., 2014; Rothgerber, 2020). In line with Hypothesis 1, we also explored whether pledgers’ self-reported intentions and their perceived capacity to fulfill the pledge might relate to their meat-reduction efforts during the 28 days.

The second set of preregistered hypotheses (Hypotheses 2a-d) focused on the main effects of pledging. It was hypothesized that, compared to the control group, pledgers would consume less meat across the 28-day period (Hypothesis 2a). We also predicted that pledgers would crave meat less, relative to control participants, as a result of replacing meat in their diet, and satiating themselves on meat alternatives, during the 28 days (Hypothesis 2b). In hindsight, this hypothesis may have underestimated the strength of participants’ meat attachments (e.g., see Graça et al., 2015), a point we return to in the Discussion.

Furthermore, we predicted that pledgers would report reduced commitment to eating meat by the end of the study (Hypothesis 2c), and reduced endorsement of meat-eating justifications (Hypothesis 2d).¹ We

¹ The preregistration also contains one hypothesis about the effect of pledging on attitudes towards the treatment of farmed animals. However, due to experimenter error, items intended to measure this outcome were not included in the study.

did not expect non-pledgers to exhibit reductions in meat commitment or meat-eating justifications. Because we measured meat consumption, meat-commitment, and meat-eating justifications at three different time points: intake, outtake, and one-month post-intervention, we were able to test Hypotheses 2a and 2c-d, in terms of changes from intake (i.e., baseline) to outtake and one-month later.

Finally, as exploration of the generalizability of our intervention to different cultural settings, participants from three different countries were sampled: the United Kingdom (UK), Germany, and Australia (we made no hypothesis regarding the interaction of Pledge and Country). These locations were mainly a product of the research teams involved. Yet, all three countries have seen rises in plant-based eating in recent years (e.g., Collins, 2019; Mensink et al., 2016; Oberst, 2018). Germany was deemed a site of particular interest, as a global leader in the production and consumption of veg*n foods (Bielinska et al., 2020; Saari et al., 2021).

The preregistered hypotheses, measures, recruitment and analysis plan can be found here: <https://aspredicted.org/tj6a3.pdf>. For an anonymized version of the data, R script, and all study materials: <https://doi.org/10.17605/OSF.IO/U4J58>.

2. Method

2.1. Recruitment plan and participants

In line with our preregistered power analysis, we aimed to recruit between 120 and 150 participants from three different university campuses: Lancaster University (UK), Johannes Gutenberg-University Mainz (Germany), and La Trobe (Australia). UK recruitment spanned December 2018 to June 2019; in Germany, it spanned April 2019 to August 2019; in Australia it was from September 2019 to March 2020. Recruitment at the Australian site proved challenging. To encourage participation, we adapted the recruitment strategy from in-person lab sessions to remote (online) video sessions and recruitment was extended to non-students living in Melbourne via targeted Facebook advertisements. Due to the extensive time commitment of this study and concerns about attrition, participants were substantially compensated (£30 GBP in the UK; 30€ Euro in Germany; \$50 AUD in Australia).²

In the end, we were able to recruit a total of 420 participants, across three sites. However, 95 participants (31 UK, 50 Germany, 14 Australia) were excluded from analysis because they either (a) failed to complete the outtake survey ($n = 10$ UK, 3 Germany, 1 Australia), (b) completed less than 50% of the daily surveys (i.e., reported their eating behavior on fewer than 14 days; $n = 9$ UK, 2 Germany, 7 Australia), or (c) reported in the intake survey that they did not eat meat of any kind ($n = 12$ UK, 45 Germany, 6 Australia); specifically, participants classifying as “lacto- or ovo-vegetarian”, “strict vegetarian”, “dietary vegan” or “lifestyle vegan” were excluded, while “meat lovers”, “omnivores”, “semi-vegetarians/meat reducers”, and “pescatarians” were retained. We preregistered exclusion criterion (c); criteria (a) and (b) were deemed necessary to address issues of high levels of missing data reflecting a failure on the part of some participants to engage conscientiously with the experience-sampling procedure. The final sample consisted of 325 participants: 127 from the UK, 142 from Germany and 56 from Australia. This was slightly below the preregistered target of 360. The breakdown by condition at each site was: UK (pledge = 69, control = 58); Germany (pledge = 62, control = 80); Australia (pledge = 28, control = 28). Among the final sample, 266 participants (82%) completed the 1-month follow-up survey (96 from the UK, 125 Germany, 45 Australia).

Table 1 presents the demographic profile of each sample. As can be seen, the profile of the samples tended to be skewed in the direction of more female to male participants; there was some diversity in the age,

² Participants who completed fewer than one-third of the daily surveys were paid per survey rather than the flat fee.

ethnicity, and political orientation of the samples; Germany had the largest proportion of semi-vegetarians.

2.2. Procedures

2.2.1. Overview of procedures

Participants first completed a briefing session and intake survey, followed by 28 days³ of experience sampling. After the 28 days, participants were contacted by the experimenter to schedule an in-lab (UK, Germany) or online (Australia) outtake session, where they completed the outtake survey, received a partial debriefing, and their payment. Participants who were unable to attend the outtake session in person were emailed this information. Participants were reminded at this time that they would receive a follow-up survey, by email, one month later. Additional debriefing information was provided upon completion of the follow-up survey, which revealed the conditions of the experiment and full aims.

2.2.2. Briefing session and pledge manipulation

At all sites, the briefing sessions, which lasted approximately 30–40 min, were run with 2–8 participants to reduce the number of total sessions required. In the UK and Germany, sessions were run in the lab, whereas in Australia most groups were run remotely via video chat, rather than in person. To avoid diffusion of information between the pledging and non-pledging conditions, all participants within a session were assigned to the same condition, thus, random assignment was applied to sessions. However, participants performed the 28-day task on their own, not in groups. Before participants gave their consent to participate, they were first provided verbal instructions from the experimenter about the aims and procedures of the study. All participants were informed that the researchers were interested in the use of smartphones to study food habits over time.

In the pledge condition, participants were additionally invited to engage in 28 days of meat-free eating. Effective pledges generally involve mechanisms that bind an individual to the intended act, for example, through signed pledges or public declarations (Cioffi & Garner, 1996; Lokhorst, Werner, Staats, van Dijk, & Gale, 2013). However, pledges that place rigid or inflexible demands on people can cause reactance or a sense of coercion (Spelt et al., 2019). To establish a declaration of intent, while minimizing the potential for reactance, participants in the experimental condition were invited by the experimenter to take part in a 28-day commitment to eat meat-free and they were given the opportunity to freely opt out of the pledge, by withdrawing from the study,⁴ or continue with it, by offering their written consent. This served as their declaration of intent. To minimize reactance, rather than presenting the pledge as a directive, participants were encouraged to “do their best” to try to eat meat-free for the duration of the study. Participants were advised that they were not required to adopt a vegan or animal product-free diet (e.g., avoid eggs or dairy); they were only being asked to eat meat-free meals, and there would be no penalty, payment or otherwise, for failing to maintain the pledge. The full briefing script used by the experimenters at each site can be found at <https://doi.org/10.17605/OSF.IO/U4J58>.

Once written consent was obtained, participants completed the intake survey on one of the lab computers in a private cubicle or, if

³ We originally planned 30 days, but logistically we found it easier to coordinate a four-week schedule, as opposed to a period of four weeks plus two days.

⁴ At Lancaster, no participants declined to take up the pledge or withdrew from the study. At La Trobe/Melbourne, two participants declined to take part and withdrew after being briefed about the pledge; three further participants withdrew after spending some time in the pledge condition. At Johannes Gutenberg, one person declined to pledge, but expressed a desire to continue with the study. Their data was omitted from the analysis to avoid exposure bias.

Table 1
Demographic profile of each sample by country.

	UK (N = 127)	Germany (N = 142)	Australia (N = 56)
Gender	92 female, 34 male, 1 other/unspecified	113 female, 16 male, 13 other/unspecified	44 female, 11 male, 1 other/unspecified
Age	M = 21.04 years, SD = 4.26, range = 18-62	M = 25.17 years, SD = 5.38, range = 18-52	M = 32.71 years, SD = 13.44, range = 18-69
Nationality	59.1% British, 40.9% other	90.8% German, 9.2% other	76.8% Australian, 23.2% other
Ethnicity	65.4% White, 26.8% Asian, 3.1 Black/African, 3.9% multiple, 0.8% Latino	90.1% White, 4.2% multiple, 3.5% Latino, 1.4% Asian, 0.7% Black	58.9% White, 33.9% Asian, 1.8% Latino, 5.4% multiple
Political orientation	55.0% liberal, 33.1% neutral, 11.9% conservative	58.5% liberal, 33.8% neutral, 7.7% conservative	37.4% liberal, 48.2% neutral, 14.3% conservative
Diet	10.2% meat lover, 66.9% omnivore, 19.7% semi-vegetarian, 3.1% pescatarian	2.1% meat lover, 48.6% omnivore, 43.0% semi-vegetarian, 6.3% pescatarian	16.1% meat lover, 57.1% omnivore, 25.0% semi-vegetarian, 1.8% pescatarian
Omnivore Conflict	M = 25.56, SD = 6.97	M = 26.73, SD = 4.06	M = 24.63, SD = 6.28

online, on their personal computer. Participants in the pledge condition first completed an additional questionnaire concerning their motivations to fulfill the pledge. Once participants completed the questionnaire, the experimenter proceeded to assist them in installing the MetricWire experience-sampling application on their smartphone. All participants received training on how to use the application, including how to locate and complete the daily survey, before the session adjourned. On the evening of the briefing session, the experimenter emailed all participants a document that included a list of resources (e.g., links to websites, books, and documentaries) discussing reasons for eating meat-free, and information on local and chain restaurants serving vegetarian food (tailored to each recruitment site), tips on how to substitute meat products, recipes, and other useful resources – see <https://doi.org/10.17605/OSF.IO/U4J58>. Although this information had the potential, if utilized, to encourage both pledgers and non-pledgers to eat meat-free, all participants received this material to avoid establishing a confound between conditions (i.e., possession vs. lack of knowledge about meat-free eating).

2.3. Measures and materials

All materials for UK and Australian samples were in English, and in German for German participants. Two authors fluent in English and German handled the German translation. One of the authors translated the English materials into German, and another translated them back into English to validate them.

2.3.1. Pledgers' starting intentions

In the intake survey, six items assessed pledgers' starting intentions to fulfill the meat-free pledge. Intentions were measured both in terms of *motivations* and *perceived capacity* to act consistent with the pledge. Pledgers' motivations to eat meat-free were assessed with 3 items: "How motivated are you to eat meat-free over the next 28-days?", "How important is it for you to eat meat-free for the next 28-days?", "How much do you think you will enjoy eating meat-free?". Another three items assessed their perceived capacity to eat meat-free: "How well do you think you will perform eating meat-free for the next 28-days?", "How experienced are you in preparing meat-free meals?", "How difficult do you think it is to eat meat-free?". The items were developed by the authors to relate to the motivation and capability components of the COM-B model (Atkins & Michie, 2015), respectively. The items were assessed on 7-point scales (1 = "Not at all" to 7 = "Very," e.g., "Very difficult"). The initial internal reliability of the six items was below satisfactory levels (Cronbach's $\alpha = 0.65$). Further analysis indicated that, by excluding the item "How difficult do you think it is ...", reliability increased to 0.87. Therefore, this item was dropped from the final index, with higher scores representing greater intention to fulfill the pledge.

2.3.2. Intake, outtake, and follow-up surveys

The intake survey gathered baseline data from participants at the

beginning of the study, including basic demographics (e.g., age, gender, nationality). The outtake and 1-month follow-up surveys contained the same measures as the intake survey.

Classification of Diet. This measure, taken from Piazza et al. (2018), was used primarily to identify participants, at intake, who were already omitting meat from their diet. Participants selected from eight categories: (1) meat lover, (2) omnivore, (3) semi-vegetarian, (4) pescatarian, (5) lacto- or ovo-vegetarian, (6) strict vegetarian, (7) dietary vegan, and (8) lifestyle vegan. See Supplements for full definitions.

Food Frequency. We used a food frequency questionnaire (Animal Charity Evaluators, 2016) as the baseline measure of meat consumption behavior to compare at outtake and one-month post-intervention. We measured food frequency two ways: (a) global estimated frequency, and (b) 24-h recall of the past day's meals. For the present purposes, we were interested in the 24-h recall measure, as it corresponded more closely to the format of the daily survey, and it is arguably less susceptible to social-cognitive distortions (e.g., desirable responding) than using frequency estimates (Castell, Serra-Majem, & Barba, 2015). For the 24-h recall version, participants were presented a list of 17 food elements (see Supplements for items) and reported "how many meals or snacks contained elements the food category" within the past day, with "past day" defined as "what you ate yesterday from the moment you woke up until the moment you went to sleep". The 6-point scale ranged from "0" to "5 or more". We were mainly interested in meat products, which included *beef*, *pork*, *chicken*, *turkey*, and *other meats*. Scores obtained for these five products were summed.

Conflicted Omnivore Scale. To measure conflict about meat, we used the 6-item Conflicted Omnivore Scale (Ruby et al., in prep). The scale is intended to be used with meat consumers, to assess common concerns about eating meat. Participants were presented with the following six statements about meat production or consumption: (1) "I feel bad about eating meat", (2) "I think that eating meat is ethically acceptable", (3) "I am okay with how animals raised for food are killed", (4) "I am okay with how animals raised for food are treated", (5) "I am concerned about the effects of meat production on the environment" and (6) "I am concerned about the effects of meat consumption on my health". These items were assessed on a 7-point scale of agreement-disagreement (1 = "strongly disagree" to 7 = "strongly agree"). Items 2–4 were reverse-scored, and the six items were summed with higher scores indicating greater conflict about eating meat. The scale had acceptable reliability at each site and timepoint (Cronbach's α at intake = 0.74 [UK], 0.70 [Germany], 0.74 [Australia]; outtake = 0.78 [UK], 0.78 [Germany], 0.75 [Australia], follow-up = .81 [UK], 0.74 [Germany], 0.83 [Australia]; see Table 1 for sample means at intake).

Meat Commitment. Commitment to eating meat was measured with Piazza et al.'s (2015) Meat Commitment Scale, which assesses commitment to eating meat with seven items (e.g., "I don't want to eat meals without meat", "I cannot imagine substituting meat from a meal"). The items were measured on a 7-point scale of agreement-disagreement, ranging from 1 = "strongly disagree" to 7 = "strongly agree", with higher scores indicating greater levels of meat commitment. At each

timepoint, the scale had high levels of reliability (α s at intake = 0.93 [UK], 0.90 [Australia]; uptake = 0.94 [UK], 0.93 [Australia], follow-up = .94 [UK], 0.92 [Australia]; data missing for German sample).

4N-Meat Justifications. Piazza et al.'s (2015) 4N Scale was used to assess the extent to which people endorse certain claims about the necessity, normalness, naturalness, and niceness of eating meat. The scale is comprised of sixteen items (see Supplements) rated on a 7-point scale of agreement-disagreement, ranging from 1 = "strongly disagree" to 7 = "strongly agree", with higher scores indicating greater meat-eating justification. Scale reliabilities were high at all sites and timepoints (α s at intake = 0.91 [UK], 0.88 [Germany], 0.90 [Australia]; uptake = 0.90 [UK], 0.90 [Germany], 0.93 [Australia], follow-up = .91 [UK], 0.91 [Germany], 0.93 [Australia]).

Additional Measures. To help obfuscate from control participants that the main interest was on meat consumption, we included two additional measures, not focused on meat consumption: the Eating Motivation Survey (Renner et al., 2012), which identifies 15 different motivations for general food choices, and the 10-item version of the Big Five Personality Inventory (Rammstedt et al., 2014). Because these scales were unrelated to the research aims, they were not analyzed.

2.3.3. Daily experience-sampling survey

We used the MetricWire research tool to design and deliver the daily survey (<https://metricwire.com/>). We programed the application to deliver one daily survey to the mobile devices of enrolled participants, one day after enrollment, and then every day at 4 p.m. for a period of 28 days. A series of hourly push notifications alerted the participant to the opening of the survey and reminded them to complete it. The daily survey contained three elements: a request to upload a photo of the participant's main meal, a food consumption questionnaire, and a measure of their craving for meat.

Photo. Participants were asked to upload a picture of their main meal (i.e., "most substantial meal of the day"), as it had been plated that day. Participants had the flexibility of taking an image of their main meal at any point in the day, storing this in their camera roll and uploading it to the application when the survey became live. Participants were given the rationale that these images would be used to help develop computer-learning programs. The main purpose for collecting these images was an added deterrence to the temptation of misreporting what they ate.

Daily Meat Consumption. Participants were asked to indicate, using a binary response (Y/N), whether they had eaten breakfast (morning meal), lunch (midday meal), and dinner (evening meal or tea). For each meal that participants confirmed, they were asked to indicate from a list of 17 food elements, all those that the respective meal contained. See the Supplements for the full list of items. As with the food frequency questionnaire, we were mainly interested in *beef*, *pork*, *chicken*, *turkey*, and *other meats*. An index of *daily meat consumption* was obtained by summing these items for each day (range = 0–5 [*3 meals]). Since we retained pescatarians in the sample, we also conducted the analyses with an index of meat consumption that included *fish* and *shellfish* (range = 0–7 [*3 meals]). The results were very similar when including these items; the only difference involves the interaction of pledge and omnivore conflict (for details, see Supplementary Materials).

Meat Craving. Participants were asked to state the extent to which they had craved meat that day. Meat craving was assessed on a 3-point scale, ranging from 0 – "no cravings", 1 – "some cravings" and 2 – "a lot of cravings". Once participants completed this final question, they submitted their responses to the server and the survey closed.

Completion Rate. On average, participants completed 23.97 ($SD = 3.01$) of the daily surveys.

3. Results

3.1. Analysis plan

The preregistered plan was to use multilevel modeling for the daily survey data, given its repeated-measures nature. In keeping with this plan, we used mixed-effect modeling, either for normal or non-normal variables, depending on the distribution patterns of each measure. Mixed-effect modeling allows for the inclusion of random effects, which is needed when handling repeated measures (Baayen et al., 2008; Krefl & De Leeuw, 1998). The potential for within-participant variability was accommodated with a random intercept over Subjects within the model. To examine whether more parsimonious models better fit the data than more complex models, we followed a stepwise procedure of eliminating parameters (Tenenbaum & Filho, 2016). We used the lme4 package (Bates et al., 2014) in R Core Team (2014). To compare different models, we used likelihood ratio tests, which tests the improvement of model fit (log-likelihood) of a more complex model with a simpler one (Jaeger, 2008). In all cases, the hypothesized model was first tested against an Intercept-only model. A comparison of models with and without random effects was also performed to examine whether the inclusion of the random effect was justified. The Intraclass Correlation Coefficient (ICC) was used as an index of the amount of variation explained by the random effect of Subjects (Rabe-Hesketh & Skrondal, 2012).

When modeling, our hypothesized moderator, conflicted omnivore (CO), was treated as a continuous measure with scores centered due to its involvement in interactions (Aiken & West, 1991). Finally, for our exploratory analysis of starting intentions, we correlated the starting intention index with (a) the meat consumption scores (sum of the 28 days), and (b) average meat-craving scores across the 28 days.

3.2. Modeling procedures and hypothesis testing

3.2.1. Daily meat consumption

Participants reported a total of 3955 instances of meat consumption across a total of 7809 daily surveys submitted. On average, participants reported eating meat on 12.70 days, across the 28 days ($SD = 7.16$). Daily meat consumption was highly positively skewed (Skewness = 1.24, $SE = 0.01$). To test the distribution that best fit daily meat consumption scores (i.e., how many times meat was consumed in the 28-day interval), we compared the fit of a Poisson, Negative Binomial and Normal distribution using the Akaike Information Criterion (AIC). A Negative Binomial distribution best fit the pattern of daily meat consumption (AIC of Neg. Binomial = 18619.79 < Poisson = 18692.89 < Normal = 21278.50). For the analysis, we used a generalized linear mixed-effect model (GLMM), which allows for both a negative binomial distribution and the inclusion of random effects. (See Supplemental Materials and Fig. S1, for daily meat consumption counts and analysis with *fish* and *seafood* included).

Hypothesis 1 was that meat conflict would moderate success with pledging, and Hypothesis 2a was that pledging would lead to significant reductions in daily meat consumption. To test these hypotheses, we started with a complex model that could test these hypotheses and then used a stepwise procedure as described above. The first model included fixed effects of Pledge (pledge vs. control), Country (UK, Germany, Australia), Conflicted Omnivore (CO), and the interaction of Pledge x CO (to test Hypothesis 1), and Pledge x Country (to test the generalizability of Pledging). We added Subject as a random effect in the model to account for unexplained variation between subjects. This model performed significantly better than a model without this random effect, $\chi^2(1) = 1548.90$, $p < .001$, justifying its inclusion. Including Time (28 days) as a random effect did not show improvement on the Intercept-only model, $\chi^2(27) = 13.94$, $p = .98$, thus, it was excluded from the procedure. Our first model showed improvement on the Intercept-only model, $\chi^2(7) = 192.12$, $p < .001$. However, the interaction of Pledge x CO did not contribute significantly to the model. When it was removed,

the simpler model retained comparable levels of fit, $\chi^2(1) = 0.74, p = .39$. Removing the interaction of Pledge x Country led to worse performance than a model that retained the interaction, $\chi^2(2) = 29.48, p < .001$. Thus, the final model retained Pledge x Country, along with the main effects of Pledge, Country, and CO, and Subjects as a random effect.⁵

Table 2 presents the estimates for the Intercept-only model and the best-fit model. Because the interaction of Pledge x CO did not improve model fit, and was eliminated, we can conclude that Hypothesis 1, regarding the moderating influence of CO on the effect of pledging for daily meat consumption, was not supported.⁶ However, CO did have a main effect on daily meat consumption, with highly conflicted participants consuming less meat than less conflicted participants. As depicted in Table 2, there was a main effect of Pledge in the predicted direction (Hypothesis 2a). Participants assigned to the Pledge condition consumed less meat across the 28 days than control participants. Thus, Hypothesis 2a was supported.

The Pledge x Country interaction is depicted in Fig. 1. Simple slope tests revealed that participants in the Pledge condition consumed less meat than control participants for all three samples: Germany, $\beta = -1.53, SE = 0.16, t = -9.37$, Australia, $\beta = -0.64, SE = 0.24, t = -2.66$, UK, $\beta = -0.31, SE = 0.15, t = -2.18$. Note that the "reg-helper" R package that we used does not generate *p*-values for simple slopes that result for a fitted GLMM negative binomial. However, it does provide test statistics (Hughes, 2021). More extreme test statistics ($t > 2$) return lower *p*-values giving greater indication that the null hypothesis is false. Pledging produced the greatest meat reductions in the German sample, followed by Australia and the UK. Between country comparisons showed that pledgers in the UK consumed more meat than pledgers in Germany, $\beta = 1.86, SE = 0.17, t = 10.69$, and pledgers in Australia, $\beta = 0.50, SE = 0.22, t = 2.30$. Pledgers in Australia also consumed more meat compared to Germany, $\beta = 1.36, SE = 0.21, t = 6.68$.

In sum, the pledge intervention produced significant reductions in meat consumption in all three samples, compared to control, though the German site showed the greatest levels of reduction.

3.2.2. Changes in meat consumption

Hypothesis 2a was also tested in terms of changes in meat consumption, comparing 24-h meat consumption levels at intake, outtake and 1-month follow-up. Because 24-h meat consumption was positively skewed (Skewness = 4.57, $SE = 0.06$), we conducted a comparison of distribution fit, which showed that a log-normal distribution best fit the data, compared to other distributions (AICs: Log-Normal = 3135.46; Normal = 3762.80; Gamma = 3306.91; Poisson = 3759.61; Neg Binomial = 3761.61). Therefore, we conducted a mixed-effect log-linear regression where meat consumption had been log transformed. Since Hypothesis 2a relates to the main effect of Pledge, and the interaction of Pledge x Timepoint, we tested a model of Pledge, Timepoint (intake, outtake, follow-up), and their interaction, as fixed effects, and Subjects as a random effect.

This model showed significant improvement over the Intercept-only model, $\chi^2(5) = 15.59, p = .01$. Adding Subjects as a random effect was justified; compared to the model without, the model with Subjects had a better fit, $\chi^2(1) = 46.12, p < .001$. When fitting this model, using intake (our baseline) as the reference level for Timepoint, we found a

⁵ We performed additional diagnostic tests on the best fit model, which showed no existence of outliers in the output and no multicollinearity issues related to the Pledge x Country interaction. Additionally, although we had an excess of zeros (days with no meat consumption) for daily meat consumption, a zero-inflation test suggested zero-inflated models were not needed (see Supplementary Materials for details).

⁶ The interaction of Pledge x CO did improve model fit and was significant when including fish and seafood in the measure of daily meat consumption (see Supplementary Materials Table S1).

significant interaction of Pledge x Timepoint, such that participants in the pledge condition reported lower meat consumption at outtake compared to intake, $\beta = -0.02, SE = 0.01, t = -2.36, p = .02, 95\%CI [-0.04, -0.004]$, but no difference in meat consumption between follow-up and intake, $\beta = 0.01, SE = 0.01, t = 0.74, p = .46, 95\%CI [-0.01, 0.03]$. The variance for the random effect was very low = 0.004 ($SD = 0.06$) and ICC was 0.26 [pseudo- R^2 (total) = 0.27].

Next, for exploratory purposes, we added variables to the model unrelated to Hypothesis 2a. Adding Country and CO to the model as fixed effects further improved model fit, $\chi^2(3) = 66.89, p < .001$. But adding the interaction between Pledge x CO, $\chi^2(1) = 0.76, p = .39$, and Pledge x Country, $\chi^2(2) = 0.28, p = .87$, did not. Since the previous model indicated significant changes in meat consumption between the intake and outtake, but not between intake and follow-up, the final model was fitted using outtake as the reference level. Table 3 depicts the estimates of the final model.

As with daily meat consumption, there were significant main effects of Pledge and Country: participants in the Pledge condition reported less meat consumption than control participants; and German participants reported less meat consumption than UK and Australian participants. The interaction of Pledge x Timepoint was significant and showed that pledgers at outtake reported less meat consumption compared to intake and follow-up (see Supplemental Fig. S2). Meat consumption at intake and follow-up did not differ for pledgers, $\beta = -0.01, SE = 0.01, t = -0.87, p = .39$. By contrast, control participants showed no differences in meat consumption at intake and outtake, $\beta = -0.01, SE = 0.01, t = -0.71, p = .48$, or intake and follow-up, $\beta = -0.01, SE = 0.01, t = -1.92, p = .06$, though meat consumption was lower at follow-up than outtake, $\beta = -0.02, SE = 0.01, t = -2.57, p = .01$.

Thus, consistent with Hypothesis 2a, pledging participants reported significant reductions in meat consumption at outtake, relative to the intake baseline, whereas this was not the case for control participants. However, pledgers did not report significant reductions, relative to baseline, one-month post-intervention.

3.2.3. Daily meat cravings

To test Hypothesis 2b, we conducted a linear mixed-effect procedure, similar to the one used for daily meat consumption, using stepwise comparisons of model fit. Simplified models were tested against more complex ones. Because the outcome variable (craving) was ordinal (range 0–2), we performed a series of cumulative-link mixed models (or *order regression models*) with random effects using the ordinal package in R (Christensen, 2019). Stepwise model comparison showed that a model of the fixed effect of Time (28 days) and Subjects as a random effect did not improve upon the Intercept-only model, $\chi^2(27) = 34.28, p = .16$. Thus, Time was excluded from the procedure. Model comparison showed that a full model, with interactions of Pledge x CO and Pledge x Country included, did not significantly improve upon a simpler model with the Pledge x CO interaction removed, $\chi^2(1) = 2.40, p = .12$. The Pledge x Country also did not improve model fit, $\chi^2(2) = 1.11, p = .57$, when tested against a simpler model of Pledge, Country, and CO as fixed effects, and Subject as a random effect. Country also did not improve model fit, $\chi^2(2) = 3.88, p = .14$. The model of best fit for daily meat cravings included Pledge and CO as fixed effects, and Subjects as a random effect. This model was superior to an Intercept-only model, $\chi^2(2) = 11.72, p = .003$, and a Pledge-only model, $\chi^2(1) = 8.52, p = .004$.

Opposite from predictions (Hypothesis 2b), pledging participants craved meat *more* than control participants, $\beta = 0.52, SE = 0.20, z = 2.60, p = .01, 95\%CI [0.13, 1.25]$. This finding likely reflects an expression of persistent meat attachment among our omnivorous participants who were avoiding meat during the 28-day pledge (see Discussion). We also found that meat cravings tended to decrease by 5% for every unit increase in omnivore conflict, $\beta = -0.05, SE = 0.02, z = -2.88, p = .004, 95\%CI [-0.09, -0.02]$. The variance of the random effect, Subject, was 3.36 ($SD = 1.83$).

Table 2
Model estimates of fixed and random effects on daily meat consumption.

Model 0						Model 1				
Fixed Effects	Estimate	SE	Z	p	95%CI	Estimate	SE	Z	P	95%CI
(Intercept)	-0.76	.07	-10.44	<.001	[-0.91, -0.62]	-0.63	0.10	-6.47	<.001	[-0.82, -0.44]
Pledge						-1.52	0.16	-9.61	<.001	[-1.84, -1.21]
UK						0.56	0.15	3.77	<.001	[0.27, 0.85]
Australia						0.37	0.17	2.22	.03	[0.04, 0.70]
CO						-0.05	0.01	-5.93	<.001	[-0.07,-0.04]
Pledge x UK						1.26	0.22	5.71	<.001	[0.83, 1.69]
Pledge x Australia						0.89	0.28	3.21	<.001	[0.35, 1.43]
Random Effects										
Groups			Variance	SD					Variance	SD
Subjects			1.55	1.24					0.71	0.84

Notes. 7809 observations, 322 Subjects. Reference level = Germany. Conflicted Omnivore (CO) is centered. *Pseudo-R*² (Model 1) = 0.54. The random effect had an ICC of 0.44.

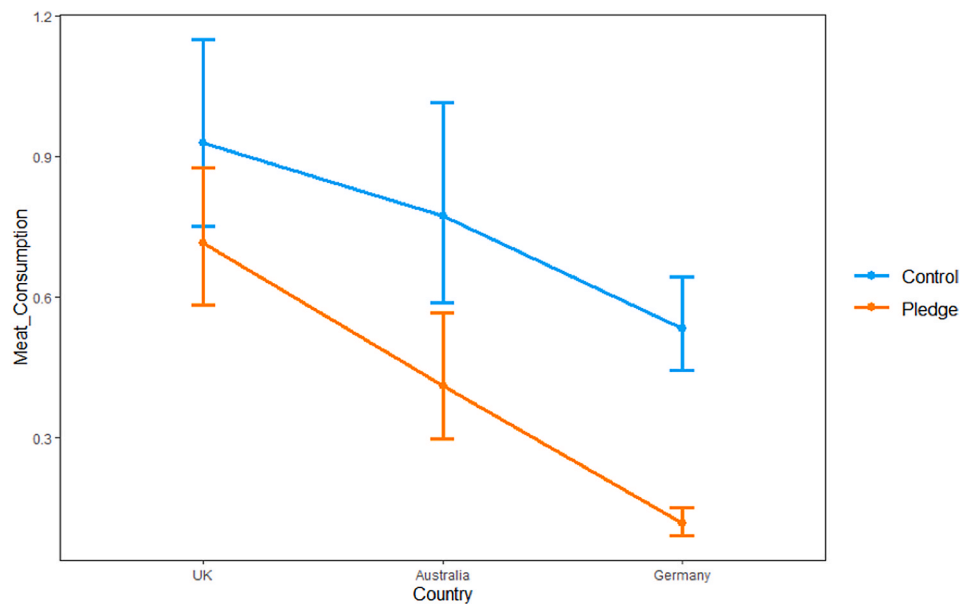


Fig. 1. Interactive effects of Pledge and Country on Daily Meat Consumption. Zero (bottom of y-axis) represents a tendency to consume no meat on a given day. Error bars ± 1 SD.

Table 3
Estimates for mixed-effect model on 24-h meat consumption at intake, outtake, and 1-month follow-up.

Fixed Effects					
	Estimate	SE	t	p	95%CI
(Intercept)	1.93	.03	62.59	<.001	[1.86, 1.98]
Pledge	-0.06	.02	-3.21	.001	[-0.09, -0.02]
Intake	-0.01	.02	-0.70	.48	[-0.04, 0.02]
Follow-up	-0.04	.02	-2.57	.01	[-0.07, -0.01]
CO	-0.01	.001	-5.88	<.001	[-0.01, -0.004]
UK	0.06	.01	4.70	<.001	[2.41, 7.53]
Australia	0.07	.02	4.03	<.001	[0.04, 0.09]
Pledge x Intake	0.05	.02	2.44	.02	[0.01, 0.10]
Pledge x Follow-up	0.07	.02	3.01	.003	[0.02, 0.12]
Random Effects					
Groups			Variance	SD	
Subjects			0.02	0.14	

Note. Reference level for country = Germany. Reference level for time-points = Outtake.

3.2.4. Meat commitment and justifications

To test Hypotheses 2c-d, we used linear mixed-effect modeling, much like we did for 24-h meat consumption. For meat commitment, we first tested a model with Pledge and Timepoint (intake, outtake, follow-up),

and their interaction, as fixed effects, and Subject as a random effect. This model allowed us to test Hypothesis 2c, but it did not improve upon the Intercept-only model, $\chi^2(5) = 1.67, p = .89$, which means that neither Pledge, Timepoint, nor their interaction predicted changes in meat commitment. Thus, Hypothesis 2c was not supported.

Next, for exploratory purposes, we tested a model with the fixed effects of CO and Country,⁷ alongside Subject as a random effect on meat commitment. This model showed improvement on the Intercept-only model, $\chi^2(7) = 57.89, p < .001$. Closer inspection of model estimates showed that the effect of Country was not statistically significant ($p = .93$), thus, it was excluded from the model. The best fit model included CO only as a fixed effect, and Subject as a random effect.⁸ This model significantly improved upon the Intercept-only model, $\chi^2(1) = 54.02, p < .001$. Estimates of this final model⁹ indicated that for every unit

⁷ Due to experimenter error, the Meat Commitment scale was omitted from the surveys run in Germany. Thus, the factor Country only contained two levels for the analysis of meat commitment.

⁸ We also compared the final model with a model that includes the Pledge x CO and Pledge x Country interactions, which did not show any improvement, $\chi^2(8) = 3.32, p = .91$.

⁹ This final model was corrected for normality ($p = .13$) by excluding scores below 10 and above 45 (range 7–49), which were identified as outliers.

increase in omnivore conflict, meat commitment decreased by $\beta = -0.67$, $SE = 0.09$, $t = -7.37$, $p < .001$, 95%CI [-0.85, -0.49]. For the random effect of Subjects, variance = 19.02, $SD = 4.36$, $ICC = 0.67$, pseudo- R^2 (total) = 0.75.

A similar procedure was used for 4N-meat justifications. A mixed-effect linear model with Pledge and Timepoint, and their interaction, as fixed effects, and Subject as a random effect, improved upon the Intercept-only model, $\chi^2(5) = 31.23$, $p < .001$. Adding the random effect improved the model compared to a model with no random effect, $\chi^2(1) = 153.28$, $p < .001$. Inspection of the model estimates revealed that only Timepoint had a significant effect and, thus, we fitted a simpler model with Timepoint as a fixed effect and Subjects as a random effect, which had a better fit relative to an Intercept-only model, $\chi^2(2) = 27.29$, $p < .001$. Estimates of the final model¹⁰ indicated that participants tended to justify meat consumption less in the follow-up survey than at intake, $\beta = -1.23$, $SE = 0.58$, $t = -2.12$, $p = .035$, 95%CI [-2.36, -0.09]. There was no significant difference in meat justification between intake and outtake, $\beta = -0.82$, $SE = 0.54$, $t = -1.53$, $p = .12$, 95%CI [-1.87, 0.23], or between outtake and follow-up, $\beta = -0.41$, $SE = 0.58$, $t = -0.70$, $p = .48$, 95%CI [-1.54, 0.73]. For the random effect of Subject, variance = 24.95, $SD = 5.00$, $ICC = 0.64$, pseudo- R^2 (total) = 0.64. Thus, we did not find support for Hypothesis 2d. Instead, there was a general reduction in 4N-meat justification endorsement at one-month follow-up, relative to intake, among both pledging and control participants.

For exploratory purposes, we also tested a model that added CO and Country as fixed effects alongside Timepoint and Subject. Estimates of this model are presented in Table 4. As can be seen, for every unit increase in omnivore conflict, endorsement of meat justifications decreased by approximately a half-unit, and German participants endorsed the 4Ns less than Australian participants, but not significantly less than UK participants. Australian participants endorsed the 4Ns more than UK participants, $\beta = 3.18$, $SE = 1.34$, $t = 2.38$, $p = .02$, 95%CI [0.56, 5.80].

In sum, Hypotheses 2c-d were not supported. Pledge did not impact on meat commitment or 4N endorsement. However, the more conflicted participants were about their meat consumption, the less committed they were to eating meat, and the less they endorsed the 4Ns. Furthermore, German participants tended to exhibit the lowest levels of meat commitment and 4N endorsement. All participants reported reductions in 4N endorsement one month after outtake, relative to intake.

3.2.5. Pledgers' starting intentions, meat consumption and cravings

Table 5 presents the relationships between starting intentions, meat consumption rates (sum of 28 days), and average daily meat cravings for

Table 4
Estimates for the mixed-effect model of 4N-Meat justification.

Fixed Effects					
	Estimate	SE	t	p	95%CI
(Intercept)	69.52	2.36	29.51	<.001	[64.91, 74.14]
Outtake	-0.92	0.53	-1.72	.09	[-1.96, 0.13]
Follow-up	-1.20	0.57	-2.09	.04	[-2.32, -0.07]
CO	-0.56	0.08	-6.62	<.001	[-0.72, -0.39]
UK	1.79	0.94	1.90	.06	[-0.05, 3.63]
Australia	4.97	1.31	3.80	<.001	[2.41, 7.53]
Random Effects					
Groups			Variance	SD	
Subjects			24.95	5.00	

Note. Reference level = Germany. Reference level for time-points = Intake. $ICC = 0.57$.

¹⁰ This final model was corrected for normality ($p = .68$) by excluding scores below 40 and above 70 (range 16–111), which were identified as outliers.

Table 5
Descriptives and relationships between starting intentions, meat consumption (sum of 28 Days), and averaged craving scores among pledgers.

	1.	2.	3.	M	SE
1. 28-Day Meat Consumption	-	.32**	-.59**	14.01	1.15
2. Meat Cravings		-	-.33**	0.49	.03
3. Starting Intentions			-	21.73	.57

Note. The Bootstrap technique applied with a sample of 1000. ** $p < .01$.

all pledgers. As can be seen, the more participants perceived themselves motivated and able to eat meat-free at the start of the pledge (a) the less meat they consumed, and (b) the less they craved meat. Additionally, the more participants reported craving meat during the 28 days, the more meat they ate. Regarding Country, German pledgers ($M = 24.92$, $SD = 5.80$) reported higher starting state intentions than UK pledgers ($M = 18.10$, $SD = 6.90$), $t(128) = -6.06$, $p < .001$, but not significantly higher than the Australian pledgers ($M = 23.50$, $SD = 7.36$), $t(88) = 0.99$, $p = .32$. Australian pledgers also reported higher starting intentions than UK pledgers, $t(94) = 3.42$, $p = .001$.

Thus, starting intentions coincided significantly with the meat-consumption reductions we observed during the 28-day pledge and lower levels of meat cravings.

4. Discussion

Meat-free pledges are an increasingly popular strategy to promote meat reduction, however, experimental studies of their efficacy are lacking. The present study experimentally assigned participants from three countries (UK, Germany, Australia) to commit to a month without meat, or not, and tracked their eating behavior for 28 days using daily surveys sent to participants' mobile devices. Information about participants' attitudes towards meat was collected at the start, end, and one-month post-intervention. Pledging led to reductions in daily meat consumption levels, across the 28 days, in all three sites, relative to control participants, who were not invited to abstain from meat. Against expectations, the level of conflict participants experienced towards meat did not moderate participants pledging performance (though it did when meat consumption was extended to include fish and seafood; see Supplementary Materials). Participants' cultural background, however, did interact with pledging performance, with German participants exhibiting the greatest levels of meat reduction when pledging, relative to Australian and UK pledgers, who showed smaller, albeit significant, reductions. Finally, though pledging resulted in lower levels of meat consumption for many participants, engaging in a meat-free month did not generate significant changes in meat commitment or sustain meat reduction one-month post-intervention.

Though omnivore conflict did not moderate the performance of pledgers, we did observe main effects of omnivore conflict on meat consumption levels and meat cravings, across the 28-day intervention. People who experience conflict or dissonance about meat resort to a broad array of dissonance-reduction tactics to resolve their conflicted state, including making efforts to reduce consumption (see Bastian & Loughnan, 2017; Onwezen & van der Weele, 2016; Rothgerber, 2020). In the present study, omnivore conflict was associated with lower levels of meat consumption and meat cravings. Omnivore conflict did not reliably moderate the effect of pledging on daily meat consumption suggesting that meat-free pledges might be beneficial to a wider range of consumers, beyond those who express conflict about their meat consumption.

German pledgers exhibited the most sizable reductions in meat consumption during the 28 days, compared to UK and Australian pledgers. This moderating effect of country is likely partly explained by the fact that the German sample had a larger proportion of semi-vegetarians than the other sites, but might also reflect genuine difference in meat reduction at the national level. Germany is a global leader

in the production and consumption of meat alternatives (Bielinska et al., 2020; Mensink et al., 2016; Ruby, 2012), and meat abstinence is particularly popular among German young adults (Saari et al., 2021), which comprised the bulk of our German sample. While it is true that reduction trends are also occurring in the UK and Australia (e.g., The Vegan Society, 2021), German participants were likely better positioned both in terms of the consumer environment supporting their efforts to reduce and their capacity to do so. Indeed, at intake, our German pledgers reported greater intent and capacity to follow through on their pledge, relative to UK and Australian pledgers.

Opposite to what was predicted, pledging participants experienced greater daily meat cravings than those not pledging. We forecasted that pledgers would be successful in satiating themselves on a vegetarian diet and thus not experience higher levels of cravings than control participants. This prediction was partly based on some evidence that dietary reductions in food intake can suppress cravings for foods, or at least not increase them, over long periods of restraint (see Harvey et al., 1993; Weingarten & Elston, 1991). In hindsight, it should not come as a surprise that many meat avoiders experienced a temporary increase in meat cravings within the one-month period. People develop strong attachments to meat (Graça et al., 2015), and ex-vegetarians, who resume eating meat, often report experiencing cravings (Menzies & Sheeshka, 2012; Rosenfeld & Tomiyama, 2019). Perhaps, if the period of observation was extended beyond 28 days, we may have observed cravings declining or stabilizing—a possibility awaiting future investigation.

Finally, no long-term changes in meat consumption and attitudes occurred. Instead, at one-month follow-up, we observed that meat consumption rates were not lower than intake levels, and attitudes towards eating meat remained fairly stable across the three time points. Unexpectedly, all participants, regardless of condition, reported reductions in their beliefs about the necessity, normality, naturalness, and niceness of eating meat one-month post-intervention. The broad, long-term reduction in 4N endorsement might be an artifact of the methodological decision to provide all participants information about vegetarian eating. It could also reflect independent exposure of participants to counter-arguments or, possibly, an inclination to reconsider 4N beliefs with repeat encounters.

The present findings join with those drawn from longitudinal surveys of meat-free pledging (e.g., Grassian, 2020) by highlighting the role of starting motivations in the fulfillment of meat-reduction pledges. We found that pledgers who, at the start, reported to have the intention and means to accomplish the task, tended to be more successful, and craved meat less, during the 28 days. These findings align with the COM-B model of behavioral change (Graça et al., 2019; Michie et al., 2011), as we observed that pledging itself can serve as an external prompt (opportunity) to foster meat reduction. Yet, we also observed that motivated and capable pledgers ate significantly less meat than less motivated and capable pledgers.

4.1. Strengths and limitations

The current study had several methodological strengths. First, it utilized daily measures of actual food consumption rather than relying on self-reports of behavioral intentions or pledging adherence (cf., e.g., Harguess et al., 2020; Stea & Pickering, 2018; Vainio et al., 2018). No self-report methodology can fully mitigate the tendency for participants to engage in strategic reporting, yet experience sampling does offer an improvement upon traditional self-report methods (Ellis, 2020). Utilizing this method yielded a rich dataset of daily eating behaviors. A second methodological strength was that participants were experimentally assigned to condition, to allow causal inferences to be drawn about the efficacy of pledging. This is not usually possible in naturalistic studies of meat-free pledging, which focus exclusively on pledgers and lack an appropriate control group.

One limitation of the design was that all participants were provided information and resources to support efforts to eat meat-free. Arguably,

this information may have alerted some control participants to the research focus on meat consumption. The reason all participants were provided this information was to (a) ensure pledge participants had the essential tools needed to follow through on their commitments, and (b) avoid creating a confound between conditions with regards to the knowledge of how to eat meat-free. The downside of this decision was that some control participants may have acted upon this material, and, as a result, made efforts to reduce their meat consumption, mirroring the behavior of those pledging. However, this concern is somewhat attenuated by the fact that (a) pledgers consumed significantly less meat than control participants, and (b) the 24-h meat-consumption scores for control participants at outtake did not differ from their scores at intake, whereas the difference was significant for pledgers. Nonetheless, future studies could contrast the effects of meat-free commitments with and without the provision of capacity resources.

Another limitation was that most samples were disproportionately populated by females, which is common in university psychology samples (Gregor & O'Brien, 2015). This limits the conclusions that can be drawn about the effects of pledging on non-female-identifying individuals. The lack of male-identifying participants is also an issue with real meat-reduction campaigns. Grassian (2020) reported that 80% of individuals who engaged with the sampled UK vegan, vegetarian and reduction campaigns, identified as female. Such campaigns also tend to engage predominantly white individuals (e.g., 96% in Grassian's UK sample). The present samples were somewhat ethnically diverse, though still predominantly white. Thus, future research is needed to extend the investigation to additional groups, particularly non-white, non-female-identifying individuals from a variety of age groups and cultures, beyond those studied here. Finally, future work should extend the assessment of long-term dietary change beyond a single, 24-h recall measure.

4.2. Future directions

Future research should consider how the short-term behavioral changes arising within pledge campaigns might be sustained over the long term. A meta-analysis of the effects of commitment-making in environmental action (e.g., recycling) found that, whether alone or paired with other mechanisms (e.g., incentives), commitments tend to increase the target behavior, relative to non-intervention control conditions (Lokhorst et al., 2013). However, few studies have collected post-intervention data to examine the sustaining power of these interventions (see Ellis & Piwek, 2018, for a similar claim regarding physical fitness interventions). Sustaining long-term reductions in meat consumption will likely require a multitude of strategies that endeavor to offer consumers the knowledge, skills, opportunities, and social support needed to prolong dietary commitments (Amiot et al., 2018; Atkins & Michie, 2013, 2015; Graça et al., 2019). Aspects of such a multi-component strategy might include *implementation intentions*, *reminders*, *ensuring enjoyment with eating*, and *group commitments*.

Implementation intentions might involve if-then plans for pledgers to address obstacles they face in implementing their intentions to eat meat-free; e.g., "If I'm preparing my shopping list for the week, I will include ingredients for at least three meatless meals"; "If I'm craving meat, I will first look for a tasty meat substitute" (see Loy, Wieber, Gollwitzer, & Oettingen, 2016). Reminding individuals of their commitments might be an effective way for campaigns to make commitments salient and spark cognitive elaboration on the reasons for maintaining the commitment (Lokhorst et al., 2013). Ensuring that meat reducers are finding alternatives that they enjoy is a key to maintaining plant-forward transitions, since new behaviors often fail to take hold if they are not enjoyable (Sansone et al., 1992). Finally, having pledgers recruit members of their household or network to share in their commitment may be an important mechanism for building a sustained environment of support (Atkins & Michie, 2013, 2015; Lacroix & Gifford, 2019). Eating is a highly social activity for many people (Arbit

et al., 2017; Delormier et al., 2009; Rosenfeld, 2018), and many meat avoiders report that they face challenges coordinating their meat-free meals with close others (Asher et al., 2014; Markowski & Roxburgh, 2019; Menzies & Sheeshka, 2012; Pfeiler & Egloff, 2020; Rosenfeld & Tomiyama, 2019). Thus, group pledges should be tested as a potential means for promoting long-term maintenance of commitments, both in the context of meat consumption and beyond.

Finally, research on pledging should continue to consider how to best frame pledge commitments vis-à-vis different audiences. Undoubtedly, the current participants experienced greater than normal pressure to engage with the pledge, since they were participating in a scientific study and received financial incentives for their participation. Of course, in the real world, individuals freely elect to participate in meat-free pledges often with some degree of prior experience (Grassian, 2020). Further empirical attention is needed to better understand how to make pledges both attractive and effective.

4.3. Conclusion

What people eat has implications not only for individuals, but also the environment and others around the world. Eating less meat can arguably protect against fatal and costly diseases, help address the climate crisis, and mitigate social justice issues like world hunger. We observed that pledging can be an effective tool for promoting meat reduction, particularly in countries where plant-based eating is currently trending. However, pledging mainly serves as a temporary opportunity to reduce. Further mechanisms are needed to sustain commitments beyond the boundaries of the initial pledge.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2021.105726>.

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Ethical statement

Ethics approval was obtained at all three recruitment sites, including Lancaster University (FST Research Ethics Committee, ref: FST17038), Johannes Gutenberg-Universität Mainz, and La Trobe University. All participants gave informed consent before taking part. See manuscript for further information about informed consent procedures.

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