7-2021

Crisis communication, anticipated food scarcity, and food preferences: Preregistered evidence of the insurance hypothesis

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Published in Food Quality and Preference, 2021, 91, 104213. DOI: 10.1016/j.foodqual.2021.104213

September 20, 2020

Abstract

Whereas large-scale consumption of energy-dense foods contributes to climate change, we investigated whether exposure to climate change-induced food scarcity affects preferences toward these foods. Humans? current psychological mechanisms have developed in their ancestral evolutionary past to respond to immediate threats and opportunities. Consequently, these mechanisms may not distinguish between cues to actual food scarcity and cues to food scarcity distant in time and space. Drawing on the insurance hypothesis, which postulates that humans should respond to environmental cues to food scarcity through increased energy consumption, we predicted that exposing participants to climate change-induced food scarcity content increases their preferences toward energy-dense foods, with this effect being particularly pronounced in women. Three exper-iments?including one preregistered laboratory study?confirm this notion. Our findings jointly demonstrate that receiving information about food shortages distant in time and space can influence current food preferences.

Keywords: climate change, media exposure, insurance hypothesis, food preferences, food insecurity

Corresponding author: Michal Folwarczny (michalf@tuta.io). **Author contributions:** MF developed the study concept. MF, TO and JLO developed the study design. NPL provided ideas for the study design. MF collected the data and performed data analysis under JLO and JDC's supervision. JDC streamlined the R code. MF drafted the first manuscript. TO contributed substantially with respect to the writing and conceptualization of subsequent drafts. All the authors contributed to and accepted the final manuscript. **Data deposition:** Materials necessary to reproduce all findings can be accessed via a repository at the Open Science Framework (https://osf.io/vkdha). **Funding:** This project was funded by the Icelandic Research Fund (Doctoral Student Grant to Michal Folwarczny number 206880-051), the AUFF Visiting Researcher Grant to Michal Folwarczny and AUFF Starting Grant to Tobias Otterbring.

INTRODUCTION

The current literature points at energy-dense foods—often derived from animal sources—as some of the most significant culprits of climate change; consequently, avoiding such foods is an important step toward developing sustainable and healthy food systems (Willett et al., 2019). However, despite the logical appeal, the current media appeals and experts' recommendations to eat more low-calorie fruits and vegetables instead of energy-dense alternatives may be ineffective in encouraging pro-environmental food choices: the number of overweight and obese people has been rising for decades, and energy-dense foods are the prime contributors to this trend (WHO, 2018).

Numerous psychological barriers hinder behaviors aimed at mitigating climate change, such as the optimism bias and various social norms (Gifford, 2011). But observing climate change can also affect psychological functioning through, for instance, increased anxiety and worry (Doherty & Clayton, 2011). However, to date, the role of exposure to climate change cues in shaping food preferences has been neglected in the literature. The present research aims to fill this gap by investigating whether watching climate change content depicting its consequences for food security can affect consumers' current food preferences.

Climate Change and Food Insecurity

Climate change has been extensively described as harming the food supply (Schmidhuber & Tubiello, 2007; Wheeler & Braun, 2013); yet, the harm comes in the future, perhaps as far away as a generation or two later (Battisti & Naylor, 2009). However, climate change reports frequently highlight the issue of rising food insecurity worldwide, and modern mass media makes these threats salient to individuals—indeed, over 60% of Americans and Australians have declared themselves to be somewhat or very concerned about climate change (Clayton, 2019). Humans in their distant evolutionary past rarely experienced times of food abundance; rather, they wandered between periods of food sufficiency and food insecurity. Thus, it is likely that consumers in today's marketplace are using decision-making mechanisms that evolved to facilitate the consumption of foods that, throughout human history, increased the odds of survival during periods of food unavailability (Rozin, 1996).

Food Insecurity and Food Preferences

According to the insurance hypothesis (Nettle et al., 2017), humans and other vertebrates possess evolutionary mechanisms protecting them against food shortages. When environmental cues suggest that access to food is uncertain, these mechanisms prompt people to eat and store more fat as a buffer against impending caloric deficits. Indeed, studies conducted in different countries link actual food insecurity to choosing energy-dense foods instead of fruits and vegetables (Gulliford et al., 2003; Kendall et al., 1996; Robaina & Martin, 2013).

Notably, psychological mechanisms, which were developed in our distant evolutionary past, are primarily designed to respond to immediate threats and opportunities and cannot differentiate between cues that have consequences for an individual in the coming days or weeks from similar cues that have—like in the case of climate change—consequences in the distant future (Griskevicius et al., 2012; Ornstein & Ehrlich, 1990). By the same token, cues to climate change-induced food insecurity occurring in distant parts of the world may activate the same mechanisms as cues to actual food insecurity in one's own neighborhood. Therefore, drawing from the insurance hypothesis (Nettle et al., 2017), we contend that perceivable cues to climate change-induced food insecurity may prompt people to prefer energy-dense foods over low-calorie alternatives, despite the absence of an adaptive function for such preferences today.

Because the energetic value of food is conventionally expressed in calories, and these play a role in food choices (Gerend, 2009; Girz et al., 2012; Wisdom et al., 2010), our main hypothesis is that people exposed to climate change-induced food insecurity content prefer foods they deem to be higher in calories. Moreover, carrying extra fat reserves poses survival-related costs, and these costs have presumably been higher for males than females in the past due to sex-specific roles in society. In particular, men, being responsible for hunting and fighting, could not afford as much extra weight as women in ancestral times (Nettle et al., 2017; Silverman & Eals, 1992). Therefore, our secondary hypothesis states that women exposed to climate change-induced food insecurity content prefer higher-calorie foods more than men.

OVERVIEW OF STUDIES

Study 1 provided initial support of our two key predictions and confirmed that the sample size estimated a priori was sufficient. Study 2 replicated the results from our first study, while simultaneously ruling out a potential confound from Study 1, thereby strengthening the confidence in our findings. Because both initial studies were run online on Amazon Mechanical Turk (MTurk), we preregistered Study 3 (https://osf.io/3rbk2), which was conducted in a laboratory facility, to test the robustness, generalizability, and replicability of our findings.

Raw data, analysis code, and materials are publicly available at the Open Science Framework (OSF; https://osf.io/vkdha). As the studies were programmed in a freeware software (PsyToolkit; Stoet, 2010, 2017), the source code for direct replication has also been published on OSF. Studies 1-2 follow the same analytic approach as the preregistered Study 3. Coefficients, standard errors, and confidence intervals reported in Studies 1-3 were multiplied by 100 for readability (see the Supplementary Information available on OSF for additional results and raw coefficients). We did not measure anticipated food insecurity after watching the videos in Studies 1-3, as these measures could have prompted participants in the control conditions to think about food scarcity and therefore alter their subsequent responses.

Stimuli Development

Nine experts (four certified nutritionists and five athletes who measured the calorie content of foods daily) evaluated the calorie content and healthfulness of 60 food pictures. All pictures were adjusted to 480 × 320 resolution and were similarly illuminated. We estimated the intraclass correlation coefficient (ICC; Shrout & Fleiss, 1979) between these raters by fitting the mean-rating, absolute agreement, two-way random effects model (Koo & Li, 2016). The results suggested moderate to good reliability ($ICC = .82$, $CI_{95} = [.73, .88]$). We then divided standard deviations by means to obtain coefficients of variations in calorie estimates for each food item. We chose 30 foods below the median coefficient of variation for Studies 1-3. That yielded a final set of food images ranging from 166 to 711 calories (*M* = 367, *SD* = 122; see the OSF webpage for the full set of images).

Using vibby.com—an online tool for creating clips from media streaming sites—we composed 100-seconds videos depicting either climate change-induced food insecurity (experimental condition) or the rise of obesity in the world (control condition; links available through OSF). Each video consisted of three short clips that were played continuously.

We extensively pretested the stimuli videos to ensure that they differed on the desired key dimension—anticipated food insecurity—while producing comparable results of the measures of other potentially confounding variables. In the main pretest study, we measured anticipated food insecurity, as well as positive and negative affect, elicited by the videos. Participants from the United States recruited via MTurk (*N* = 54) rated anticipated food insecurity on a randomized-order scale (1 = *strongly disagree*, 7 = *strongly agree*). The scale consisted of six items ("The availability of my favorite foods will decrease next decade"; "The beverages I drink will be less affordable by 2030"; "I will see less food variety in grocery stores in the future"; "Certain foods I eat now will disappear at some stage of my life"; "My future diet will be more monotonous"; "I will have to eat less protein-rich dishes for some time") that we averaged (α = .92). Participants who watched the experimental (food insecurity) video, considered future food resources to be more insecure (food insecurity condition: *M* = 4.59, *SD* = 1.48; control condition: *M* = 3.75, *SD* = 1.35), $t(52) = -2.03$, $p = .047$, $d = .58$. We used the Positive and Negative Affect Schedule (PANAS) to evaluate positive and negative affect elicited by either video on a five-point scale (Watson et al., 1988). We randomized the order of all items: 10 for positive (α = .93) and 10 for negative (α = .94) affect and averaged the items for each subscale. The groups did not differ in terms of negative (food insecurity condition: *M* = 1.82, *SD* = .84; control condition: *M* = 1.55, *SD* = .85), $t(52) = -1.15$, $p = .257$, or positive affect (food insecurity condition: M = 2.69, SD = .95; control condition: M = 2.79, SD = 1.06), t(52) = 0.39, p = .701. We supported these findings with an ancillary pretest study that revealed no differences in the measures of emotions, anxiety, stress, and hunger (details available through Supplementary Information File available on OSF).

Measures

As indicated in our stimuli development description, the experts' ratings yielded foods ranging from 166 to 711 calories (M = 367, SD = 122); hence, we created a response slider scale from 0 to 1000 calories with one-point intervals. Participants in Studies 1-3 responded on this sliding scale as we wanted to capture their subjective perceptions of the caloric content of foods to test the hypothesis that they will prefer foods they deem to be higher in calories in the experimental (climate change-induced food insecurity) condition. Participants stated preferences by answering the question, *"Would you eat this food now?"* on a similar sliding scale ranging from *definitely not* (-1) to *definitely yes* (1) with .01 intervals. Hunger plays a vital role in food-related decision-making (Orquin & Kurzban, 2016). Thus, we measured hunger on a four-item scale (1 = *disagree strongly*, 7 = *agree strongly;* Otterbring & Sela, 2020).

STUDY 1

Participants and Procedure

The Cognition and Behavior Lab's Human Subjects Committee at Aarhus University approved the data collection for all studies (approval no. ID276). We ran a stochastic power simulation in R (Bolker, 2007) to estimate the required sample size to detect the main effect of treatment. We found that at least 82 participants were necessary to achieve .95 power, assuming Cohen's d of .35 (the simulation code is available on OSF).

To account for potential missing data, we recruited 98 participants for Study 1 (48 women, M_{age} = 31.9 years, SD = 9.5, range = 18-69 years) from the United States via Amazon MTurk. Participants received a small monetary compensation.

Package 'simr' for R (Green & MacLeod, 2016) was used to estimate the observed power for the interaction effect of treatment and calorie estimates on food preferences in line with our hypothesis. The sample size in Study 1 was sufficient to detect this interaction (observed power = .80, CI_{95} = [.79, .81]).

Participants first read and accepted the online consent form. Upon pressing the "start" button, they were randomly assigned to watch either the climate change-induced food insecurity video or the control video. After seeing their assigned video, they estimated the calorie content and stated their preferences for the 30 food alternatives. The order of each block (calories or preferences) and the order of foods within the blocks were both randomized. Lastly, participants provided demographic information and rated their levels of hunger.

Results and Discussion

We averaged items on the hunger scale (α = .88). The experimental group reported higher hunger scores (climate change-induced food insecurity condition: M = 5.23, SD = 1.37; control condition: M = 4.48, SD = 1.75), $t(96)$ = -2.37, p = .020. Next, we performed a linear mixed-effects analysis of the relationship between calorie estimates and treatment as predictors (fixed effects) and food preferences as a dependent variable with the 'lme4' package for R (Bates et al., 2014). Participants and food images were treated as random effects in the model. As the groups reported different hunger levels, hunger was added to the model as a covariate.

The main effects of calories (p = .955) and treatment (p = .190) on food preferences were insignificant. However, the main effect of hunger on food preference was highly significant ($p <$ 0.001), meaning that hungry participants preferred foods they deemed to be higher in calories. More importantly, and in line with our main hypothesis, we found an interaction between treatment and calorie estimates: participants in the experimental (climate change-induced food insecurity) group preferred foods they deemed to be higher in calories, b = 0.029, SE = 0.011, CI_{95} = [0.008, 0.049], $t(2815.52)$ = 2.74, p = 0.006. Next, we added participants' sex to the model to test our secondary hypothesis. The results confirmed the secondary hypothesis as well:

men preferred lower-calorie foods than women in the experimental group, b = -0.063, SE = 0.021, CI_{95} = [-0.103, -0.021], t(2821.52) = -3.00, p = 0.003.

STUDY 2

Participants and Procedure

In Study 2, we recruited 110 participants (49 women, M_{age} = 36.8 years, SD = 10.8, range = 22-74 years) from the United States via Amazon MTurk. Participants received a small monetary compensation.

The procedure in Study 2 was similar to Study 1. However, we added a third group, where participants did not watch any video after accepting the consent form. This group proceeded directly to the main task (i.e., evaluating calorie content and stating preferences toward each food alternative) and was included to ensure that the effects found in Study 1 were due to participants in the experimental condition *in*creasing their preferences for calorie-dense foods rather than participants in the control condition *de*creasing their preferences for such foods.

Results and Discussion

First, we averaged items on the hunger scale (α = .92). Neither of the three groups differed in hunger (F < 1); thus, hunger was not added to the model as a covariate in the subsequent analyses. Next, we compared the control groups (one group was exposed to the control video depicting the rise of obesity in the world, and another proceeded directly to evaluating food pictures). The results indicated no main effect of treatment (p = .650), calories (p = .206), or their interaction on food preferences (p = .997). This means that the control groups did not differ on any dependent measure. Consequently, both control groups were merged in order to facilitate parsimonious analysis (Griskevicius et al., 2010).

We performed the same analysis as described in Study 1. The main effects of calories (p = .089) and treatment (p = .069) were marginally significant. Importantly, replicating the results from Study 1, we found a significant interaction between treatment and calorie estimates.

Participants in the experimental (climate change-induced food insecurity) group preferred foods they deemed to be higher in calories, b = 0.022, SE = 0.009, CI_{95} = [0.003, 0.040], $t(2905.42)$ = 2.31, p = 0.021. Our secondary hypothesis was also supported, as men again preferred lower-calorie foods compared to women in the experimental group, b = -0.069, SE = 0.019, CI_{95} = [-0.102, -0.015], $t(2916.47)$ = -3.62, p < 0.001. Given that the pretest revealed higher anticipated food insecurity in the group that watched the climate change-induced food insecurity content and considering that Study 2 found no differences between the two control conditions, either in food preferences or hunger, these findings provide converging evidence that the most likely explanation for the effects is an increased preference for energy-dense foods in the experimental condition (rather than a decreased preference for such foods in the control conditions).

STUDY 3

Participants and Procedure

Following the preregistered protocol, we recruited 100 participants (44 women, M_{age} = 23.6 years, SD = 5.3, range = 18-64 years) from the campus and participant pool at a Danish university, most of whom were students. Every participant was paid DKK 30.

This study was conducted in a laboratory facility. Participants were asked to sit in front of a computer and firstly filled out consent and payment forms. They then read instructions on a computer screen and took part in the same version of the experiment, as described in Study 1.

Results and Discussion

We followed the preregistered data analysis plan. The items on the hunger scale were averaged (α = .89), and we found that the experimental and control groups did not differ in hunger (t < 1); thus, hunger was not added to the model as a covariate in the subsequent analyses. The main effects of calories (p = .248) and treatment (p = .168) on food preferences were insignificant. Crucially, consistent with Studies 1-2 and offering preregistered support for our main hypothesis, the interaction between treatment and calorie estimates was yet again significant: participants in the experimental (climate change-induced food insecurity) group preferred foods they deemed to be higher in calories, $b = 0.027$, $SE = 0.011$, $CI_{95} = [0.005, 0.049]$, $t(2968.19) = 2.35$, $p = 0.019$. Women did not prefer higher-calorie foods more than men in the experimental group, $b = -0.033$, $SE = 0.023$, $CI_{95} = [-0.078, 0.012]$, $t(2968.58) = -1.43$, $p = 0.152$. However, as per the comparisons in Table 1, we observed a trend in the same direction to the previous studies (see Figure 1 for the pooled results and Table 1 for a summary of the key findings across all studies).

Table 1

The main (interaction: calories × treatment) and secondary hypothesis (interaction: calories × treatment × sex) tests results

Fixed effects	*b (SE)*	*t*	*p*	*95% CI*
Calories × Treatment				
Study 1	.029 (.011)	*t*(2815.52) = 2.74	.006	[.008, .049]
Study 2	.022 (.009)	*t*(2905.42) = 2.31	.021	[.003, .040]
Study 3	.027 (.011)	*t*(2968.19) = 2.35	.019	[.005, .049]
Calories × Treatment × Sex (men)				
Study 1	-.063 (.021)	*t*(2821.52) = -3.00	.003	[-.103, -.021]
Study 2	-.069 (.019)	*t*(2916.47) = -3.62	< .001	[-.106, -.032]
Study 3	-.033 (.023)	*t*(2968.58) = -1.43	.152	[-.078, .012]

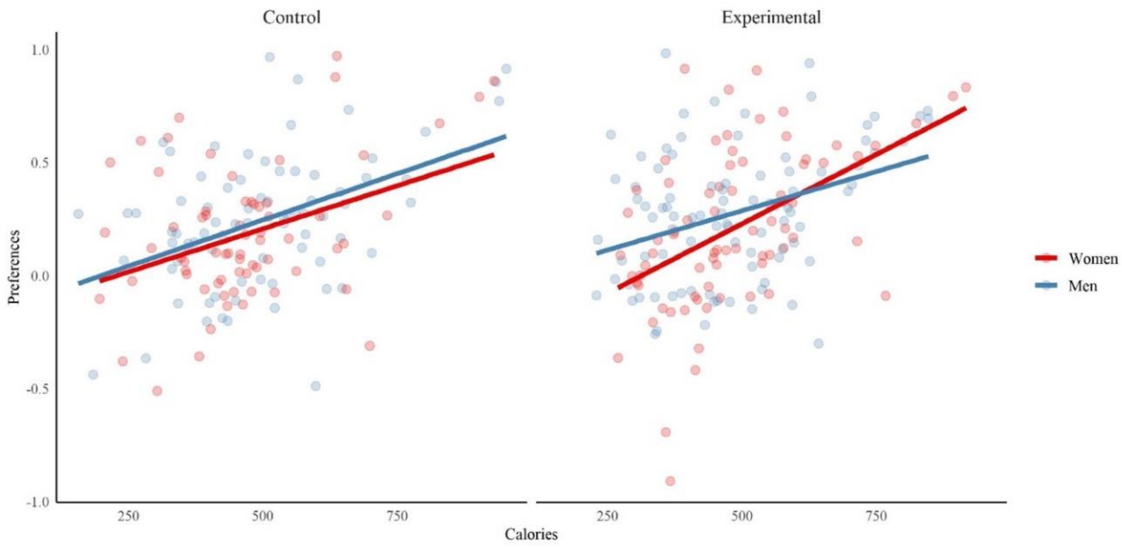

Figure 1. Mean food preferences as a function of mean calorie estimates for all participants in Studies 1 through 3 (N = 308). This plot suggests that women depreciate low-calorie foods and prefer high-calorie foods to a larger extent than men after exposure to climate change-induced food insecurity content.

GENERAL DISCUSSION

Building on the insurance hypothesis (Nettle et al., 2017), we predicted that watching food insecurity content will make people prefer energy-dense foods. Three experiments, including one preregistered study, confirmed this notion by showing that food insecurity content makes people prefer high-calorie foods and that this effect is particularly powerful in women. As such, our results provide converging evidence for both our key predictions, particularly so regarding our main hypothesis.

Earlier research indicates that viewing specific body types may shift food preferences (Banovic & Otterbring, 2020; Campbell & Mohr, 2011; Mori et al., 1987; Otterbring & Shams, 2019). We attempted to control for this potentially confounding factor. First, the extensive pretesting revealed no differences between the videos used in the control and experimental condition in any of our key measures except for anticipated food insecurity. Second, comparisons between the two control groups in Study 2, where participants in one of these groups were exposed to a video featuring obese individuals while participants in the other group did not watch any video, indicated no differences on any measure between these groups. Therefore, it is unlikely that the confounding effects from the control video constitute the main driver of the effects reported herein. Rather, the most plausible and parsimonious explanation is that the video used in the experimental (climate change-induced food insecurity) condition increased participants' preferences for calorie-dense foods.

Seen through the lens of the insurance hypothesis (Nettle et al., 2017), humans have evolved mechanisms that are activated as a response to environmental cues associated with food scarcity. Consequently, people seem to prefer high-calorie foods that are a better buffer against the upcoming food unavailability compared to low-calorie alternatives. The findings of the present research broaden the applicability of the insurance hypothesis by showing that it applies not only to actual but also to anticipated food insecurity. In fact, the mere exposure to distant food shortages may be enough to lead to an instant desire to consume energy-dense foods.

The insurance hypothesis was primarily developed to explain sex differences in the prevalence of obesity among food-insecure populations (Nettle et al., 2017). While we have not entirely explained this phenomenon, we provided preliminary evidence that women may prefer energy-dense over low-calorie foods to a larger extent than men when exposed to food insecurity content. One plausible account explaining these differences can be sex-specific roles held in the past when women were responsible for foraging/gathering, and men were primarily concerned with hunting (Silverman & Eals, 1992). Thus, the cost of carrying extra weight could have been higher for men than for women. Consequently, evolution likely fashioned different weight management strategies for both sexes during periods when access to food was uncertain.

The case of food insecurity communication also supports the evolutionary mismatch hypothesis (Li et al., 2018), which highlights that when evolved psychological mechanisms take in evolutionarily novel input or when the associated adaptive consequences have changed, the mechanisms may instead produce maladaptive responses (Gidlöf et al., 2020). Whereas ancestral cues to food scarcity were associated with impending scarcity, climate change-induced scarcity occurs much later and does not pose any immediate risk to individuals; thus, it does not necessitate an immediate response to promote survival. As such, modern-day food insecurity cues promoted in media may induce the favoring and overconsumption of high-calorie foods among populations who are not at risk of famine, thereby contributing to aversive health outcomes.

Several questions warrant future exploration. First, research should investigate whether other events threatening food availability, such as Brexit, pandemics, or trade wars, may also produce similar effects. Second, the role of anticipated food insecurity in shaping food choices and its potential contribution to obesity should be scrutinized. Third, studies may examine whether anticipated food insecurity affects decision-making in other contexts, such as financial risk-taking or voting behaviors. For instance, food cravings make people less generous (Briers et al., 2006). Likewise, anticipated food insecurity may affect people's willingness to cooperate or share economic resources.

In conclusion, this research shows that receiving information about food shortages distant in time and space can influence current food preferences. These findings contribute to the host of largely overlooked effects of anticipated food insecurity on human psychology and food preferences. As such, the present work takes a first step in highlighting the importance of considering our evolved psychology in shaping current food preferences (see Rozin & Todd, 2015, for a discussion of the role of our evolved mechanisms in food choices), and warrants future investigation of the potential effect of anticipated food insecurity in various decision-making domains.

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