Fostering safe food handling: Causal evidence on game- and video-based online interventions

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Abstract

Food-borne disease causes high costs in terms of sick days, hospitalizations, and death. As consumers play an important role in controlling food-borne disease, health authorities aim to promote awareness of food safety and foster risk-reducing behavior among consumers. We design a game-based online intervention and provide causal evidence on its effectiveness in a large survey experiment with adults from the UK and Norway. Consumers either engage in active learning about food safety in an online game, or are exposed just to a brief information video, or are in a control condition. Both interventions improve food safety beliefs to a similar extent relative to the control condition. But only the game intervention leads to significant improvements in self-reported food safety behavior, suggesting that providing information to consumers is not sufficient to change routinized behavior. The novel insight of our study is that repeatedly applying correct behavior in the virtual environment of the online game spills-over to improving real world behavior. Importantly, treatment effects are consistent across age groups and not concentrated on young people only.

Keywords: Food safety; Behaviour; Knowledge; Survey experiments; Serious games; Video-based interventions

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Introduction

According to the WHO, 1 in 10 people in the world suffer from food-borne disease each year (WHO, 2015). While food-borne disease is in particular a problem in developing countries, it also causes high costs, in terms of sick days, hospitalizations and even death, in developed countries. In the US, for example, each year an estimated 9.4 million cases of food-borne disease result in more than 55,000 hospitalizations and more than 1,300 deaths (Scallan et al., 2011). For Europe, the estimates are 23 million cases of food-borne disease and 4,700 deaths each year (WHO, 2019). The actual numbers might be much higher because many cases go unreported (e.g., WHO, 2002; Langsrud et al., 2020).

Around 10 – 30 percent of the cases of food-borne disease can be attributed to food preparation at home (for the US and Europe respectively, see Dewey-Mattia et al., 2018; EFSA and ECDC, 2018). For example, private households are the most common place where food is consumed that leads to salmonellosis outbreaks (EFSA and ECDC, 2018). Improper handling and storage of food at home – such as inadequate cooking, consumption of risky foods, cross contamination, inadequate hand washing routines, and lack of time-temperature control – are frequent (Skuland, 2020; Evans and Redmond, 2019; Young et al., 2017a,b; Byrd-Bredbenner et al., 2013). Such mishandling facilitates bacterial contamination of food, which increases the likelihood of consumers contracting food-borne diseases.

Since consumers play an important role in the prevention of food-borne diseases, promoting awareness and fostering correct risk-reducing behavior has become an important objective for organizations dealing with the protection of citizens' health (Ravarotto et al., 2016). For example, one of the main topics of the WHO food safety day in 2021 was "Know what's safe - Consumers need to learn about safe and healthy food" (WHO, 2021b); and numerous national and international health authorities provide information about food safety to consumers (e.g., CDC, 2021; NHS, 2020; WHO, 2021a).

Yet, despite these hazards and information materials distributed, many people are not aware of food-borne disease and its prevention at home (e.g., Thaivalappil et al., 2019; Lange et al., 2016). But even people who are aware of the risks, do not necessarily follow the authorities' guidelines. That is, food safety information does not always result in proper food handling behavior or in consumers refraining from eating risky food (Brennan et al., 2007). For example, despite numerous campaigns by national food safety authorities and widespread news coverage of past outbreaks, many consumers prefer to eat hamburgers that are rare or not well done (Olsen et al., 2014).

A reason for such behavior is that, in addition to scientific facts, people are influenced by ethical, political, and religious beliefs as well as culture, history, and personal experiences when making their decisions. In the area of domestic food safety, both demographic factors (such as age, gender, and health), as well as psychological factors (such as habits, biased beliefs, overconfidence, trait worry, and internal locus of control) influence behavior (Fischer and Frewer, 2008; Young et al., 2017b,a). Specifically, individuals often adopt food safety beliefs and behaviors from their parents and apply them without much reflection (cf. Lange, 2017). Further, since food preparation involves repetitive behavior that is performed on a daily basis year in, year out, behaviors become habitual and under the control of automatic processes (cf. Aarts and Dijksterhuis, 2000). Consequently, routinised food safety behaviors and beliefs might be difficult to change with information alone.

To break such routines, we design an online game that does not only inform consumers about correct food safety behaviors, but also trains consumers to apply them. In designing and testing the game, we rely on insights from the behavioral sciences. Authorities not only view behavioral insights as crucial for public policy (Shafir, 2012; Oullier, 2013), but a growing number of authorities in Europe actively apply behavioral insights in public policy in order to change consumer behavior as the reports by Lourenco et al. (2016) and Ciriolo et al. (2019) demonstrate.

In their review of the E-bug project – a food safety project designed for young people by Public Health England's Primary Care Unit, which includes interactive, computerized components – Young et al. (2019) argue that effective risk communication on food hygiene will need to rely on the use of relevant and accessible methods in the digital era, such as online games. Yet, a survey by the SafeConsume consortium reveals that most authorities rely on "passive" information, such as webpages and only 10 - 20 percent rely on "active" information over, e.g., social media or an app. Our study demonstrates the potential for well-designed online games to contribute to the prevention of food-borne disease.

In our game intervention, participants first watch an information video. Then they prepare several dishes in an online game where they are repeatedly confronted with food safety related actions. After each round of the game, participants receive feedback on how they handled a number of important food safety actions. The game thus embeds information about food safety in the feedback and in doing so reinforces information about correct behavior. Repeating these correct behaviors in the game is expected to train new habits.

We do not only test whether the game is successful in improving food safety beliefs and behaviors compared to a control condition, but also whether it is more successful than a more traditional intervention with video-based information only. In doing so, we provide insights into the comparative advantage of a game based intervention relative to a pure information intervention. Specifically, existing studies on promoting health related behavior using serious games (see below) tend to focus on the impact of a game and do not include the comparison of game-based and non-game-based approaches (e.g., Chow et al., 2020). Yet, such comparisons are important because there would be no need to impose the extra costs for a game intervention on society and participants (e.g., in terms of programming costs and participants time) if simple information material was equally effective as the game in inducing behavioral change.

Further, we include an additional condition in which we frame the information video in a disgust eliciting way to test whether such a frame further increases the impact of the game on food safety beliefs and behavior. Health campaigns often rely on images or words that evoke disgust (cf. Gagnon et al., 2010; Lupton, 2015) to persuade target audiences by linking health risks with the negative affective reaction that disgust triggers. Appealing to disgust has been shown to be effective at drawing attention to a health threat by eliciting an immediate avoidance reaction (Morales et al., 2012) and by bolstering the claim about the severity of the risk (Dillard and Shen, 2018). Further, disgust has been shown to make information more salient (Chapman et al., 2013) and to enhance memory of it (Leshner et al., 2009; Chapman, 2018; Moeck et al., 2021). In the context of food safety, because disgust is commonly thought to be a behavioral adaptation for avoiding the ingestion of pathogens (e.g., Rozin et al., 2008), information that evokes a disgust reaction may be particularly effective at inducing appropriate behavior.

We run a large survey experiment with 1,087 participants aged 20-50 from the UK and Norway. Data on an additional 886 participants cover the age range up to 89 years, as explained in the results section. Both the video and the game interventions improve food safety beliefs to a similar extent relative to the control condition. But only the game leads to significant improvement of food safety behavior. Our findings have important implications for policymakers attempting to prevent domestic food borne illness. First, they demonstrate that providing information to consumers is not sufficient to change routinized behavior and build new habits. Second, the novel insight of our study is that repeatedly applying correct behavior in the virtual environment of the online game spills-over to improving self-reported behavior in the real world.

Overall, our study demonstrates that a relatively short duration of game play already is enough to change beliefs and behavior in the short run and that it can be an effective tool not only for targeting young people but for reaching the general population. Next to being engaging, a game has advantage that, once developed, it is cheap to roll-out on a large scale and thus has the potential to create a large impact on preventing food borne illness by reaching many consumers.

Related literature Our study contributes to the knowledge base on designing interventions that promote better health-related behaviors, and here specifically to the literature on food safety interventions. The game at the heart of our intervention is an example for a serious game – a game that has an educational purpose and is not just intended to be played for amusement (Abt, 1970). The broad idea of gamification[1] and serious games as tools to induce behavioral change is that the engaging nature of certain game elements helps consumers to change their behavior by influencing psychosocial constructs such as attitudes, intentions,

[1]Gamification is defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 9). Examples are the use of rewards or avatars.

motivations, cognitive skills and affective states. The engagement felt when playing a video game has been found to increase blood pressure and heart rate, and to change facial expressions (Ravaja et al., 2008). People get emotionally aroused by gaming, and both enjoyment and fear can be felt. This engagement and the intrinsic motivation it triggers, provide opportunities for learning. Games have been found to increase both descriptive and conceptual knowledge, problem solving, skills in spatial representation and higher-order thinking when compared with traditional lecturing methods (Ke, 2009; Boyle et al., 2011).

Serious games and gamification are increasingly being used as a behavior change technique, for example, to influence energy saving behavior (Iweka et al., 2019; Wemyss et al., 2019), transportation choice (Lieberoth et al., 2018), exercising (Höchsmann et al., 2019; Patel et al., 2017), or other health related behaviors (for reviews and meta-analyses see, e.g., Johnson et al., 2016; DeSmet et al., 2014; Koivisto and Hamari, 2019). Specifically, serious games, have been applied as educational tools in a variety of settings such as, for example, training of police, firefighters, safety training, well-being at the workplace, and healthcare (e.g., BinSubaih et al., 2009; Martínez-Durá et al., 2011; Backlund et al., 2007; Lowensteyn et al., 2019).

A caveat is that a large fraction of the studies neither involve experimental designs nor quasi experimental methods, rely on small samples, or have other methodological issues (cf. Hamari et al., 2014; Koivisto and Hamari, 2019; Sailer and Homner, in press). To provide causal evidence, we run a randomized experiment with a large number of observations. Moreover, our study goes beyond a simple treatment-control comparison by also comparing a game-based intervention with a pure information-based intervention.

Food safety related educational interventions (for reviews see, e.g., Sivaramalingam et al., 2015; Young et al., 2015) primarily take the form of training (e.g., Harrison, 2012, which developed a hand washing education initiative using a university mascot) or workshops (e.g., Ravarotto et al., 2016, which found application of the consensus conference model as a communication process to be an effective opportunity to engage young consumers and experts on the topic of food safety). Yet, training or workshops can be impractical when it comes to educating large parts of the population about food borne illness. Studies targeting larger audiences often rely on text messages (Trifiletti et al., 2012; Townsend et al., 2006) or videos (Quick et al., 2015).

Previous studies on the effects of serious games on food safety (Mac Namee et al., 2006; Quick et al., 2013; Clark et al., 2020), as well as many food safety interventions in general, focus on children, teenagers, or professionals in the food service sector. Much less is known about how such interventions work among the general adult population, especially when it comes to game-based interventions. For older individuals, habits and non-scientific beliefs might be more persistent and more difficult to change. By targeting adults, our study shows the potential for serious games to educate the general population about food safety and to promote safe food handling behavior.

Methods

Experimental procedures and sample. The study design and hypotheses were pre-registered (for the pre-analyis plan see Koch et al., 2020). A total of 1,087 participants (499 from the UK and 588 from Norway) completed our two-part, online experiment through the survey company Kantar Gallup from January to March 2021. Because the enjoyment of computer games tends to be higher for younger people, we expected that the game might have less of an impact for older people. This motivated our pre-registered restriction to participants aged 20 to 50 years. Data on an additional 886 participants outside the pre-registered age range that became available are analyzed separately (see the end of the Results section). As several of the targeted hygiene behaviors relate to the preparation of meat, we screened participants to prepare at least two warm lunches/dinners with meat or poultry per week on average. The sample was stratified to ensure equal distribution of gender across treatments.

Tables S.1 and S.2 provide more details on the sample (number of participants by country, condition and gender) and Supplementary Section S.1.1 gives further details on sampling. Table S.3 shows that compared to those who drop out, the final sample has individuals who are slightly older, have a somewhat higher income, and live in smaller households. Further, there are differences in what type of meat was consumed in the week prior to the study. We control for these variables in our analyses.

Experimental design. The study consisted of three main parts: A pre-survey, the intervention part, and a post survey. The intervention relied on information videos and a computerized home cooking game (see Figures 1 and 2 for screenshots; the game can be played at `https://webgl.scienceathome.org/safeconsumegame`). Participants were assigned to one of four conditions in a between-subject design, as summarized in Table 1.

In all conditions, participants answered a pre-survey and seven days later a post-survey. In the survey, next to collecting some information on sociodemographic background and certain preferences, subjects reported some recent food safety behaviors and we elicited beliefs in the efficacy of certain food safety actions, as well as beliefs in myths. The questions were either directly taken from or inspired by previous work of the SafeConsume EU consortium (`https://safeconsume.eu/`). To facilitate recall of behaviors, we asked to think of a specific dish they prepared within the last week (cf. Schwarz and Oyserman, 2001).

No further intervention took place in the *Control* condition. In the *Info* condition, after the pre-survey, participants watched a two minute information video about food safety. It addressed five broad categories: personal hygiene (hand washing), kitchen hygiene (cleaning utensils and surfaces), washing fresh vegetables and fruits, *not* rinsing meat or poultry, as well as cooking foods thoroughly. Pictures were accompanied by simple (spoken and written) messages such as: "Washing poultry or meat can spread harmful bacteria through water droplets. So do not wash raw poultry or meat." In the *Game* condition, after answering the pre-survey and watching the information video, participants played a home cooking computer game where they had to prepare four recipes with meat. After completion of a recipe, participants received feedback on how well they handled important food safety actions related to the categories addressed in the information video. The *DisgustGame* condition was identical to *Game*, except that we replaced the information video with a version were the pictures were visually framed to trigger a disgust reaction (cf. Figure 1; Supplementary Figures S.13-S.14 provide further examples). The messages accompanying these pictures were identical to those in the neutral video.

We based the content of the information video on a thorough analysis of food safety issues and food safety advice given by authorities, which were collected and reviewed by the SafeConsume EU consortium. The design of the video drew on the evidence that information can be effectively communicated if it is factual, brief, easy to understand (Jacob et al., 2010) and supported by pictures (Alter and Oppenheimer, 2009). Because messages with argumentative power are more likely to have an effect (Byrne and Hart, 2009), we paired advice on behavior with an argument or fact that supports it (cf. Supplementary Figure S.13).

Through the video, we also addressed several food myths that were a subsample of food myths collected by the SafeConsume EU consortium: Fruit and vegetables that will be peeled do not have to be washed; it is safe to eat a piece of bread that has fallen to the ground if picked up within five seconds; and only poultry meat needs to be well done to be safe to eat. To avoid reinforcing the myths, we did not explicitly mention them in the video.

In the game (see Figure 2 for screenshots), participants had to prepare dishes consisting of chicken, raw vegetables, and bread. The kitchen included a worktop, a sink, hand soap, dish liquid, surface cleaner and paper towels, a rubbish bin, a cutting board and a knife, a pan on the stove, and a food thermometer. Participants had to take meat and fruit/vegetables from a refrigerator and bread from a basket. They had to cut each food item on a cutting board and to heat the meat in the pan before serving the food on a plate. Sometimes, a miaowing cat disturbed the cooking process. If the participant did not remove the cat, it kept walking over the worktop, leaving a trail of cat hair behind (cf. Figure 2).

The game involved a number of critical handling points, to which we henceforth refer as *important food safety actions*, or IFSAs. These were: (1) Washing hands with soap before starting to cook and after preparing a food item. (2) Cleaning food preparation tools with water and dish liquid after preparing a food item. (3) Cleaning kitchen surfaces after preparing a food item. (4) Checking with a food thermometer that the chicken has an internal temperature of 74°C before removing it from the pan. (5) Rinsing fruit/vegetables (even if later peeled) before preparing them. (6) Not rinsing raw meat. (7) Not consuming dropped food items.

Before the game, participants watched a video explaining how to play the game. They then completed four recipes. Recipes differed in the raw vegetable or fruit to be prepared and we included both fruit/vegetables that had to be peeled and some that did not. After each recipe, participants received feedback on whether they met the time limit and how well they performed in terms of the IFSAs.

Depending on treatment, the median duration for part 1 was 15 min. for *Control*, 18 min. for *Info*, 65 min. for *Game* and 61 min. for *DisgustGame*. The median duration for part 2 (the post-survey) was 9 min.

Theoretical background and hypotheses

Our primary hypotheses are that the game in combination with the information video in *Game* improves food safety related beliefs (**Hypothesis 1**) and behavior (**Hypothesis 2**) compared to the *Control* condition.

The foundation for Hypothesis 1 is that serious games foster active and problem-based learning and thus affect beliefs. Boyle et al. (2011) link the success of serious games to a number of psychological factors and emphasize that active learning is encouraged through two possible channels. First, the players get repeated feedback that is linked to their own past behavior. Such feedback reinforces knowledge because repeated exposure to a message makes it faster and more effortless to retrieve from memory; and processing fluency makes people more likely to perceive a message to be true (Hasher et al., 1977; Reber and Schwarz, 1999; Alter and Oppenheimer, 2009). Second, the online game requires players to become actively engaged. This engagement is likely to increase attention to the messages that target behavioural change, compared to passively consuming information materials (Deater-Deckard et al., 2013).

The foundation for Hypothesis 2 is the evidence that gamification can foster behavioral change. That is, we expect the game not only to change behavior indirectly over beliefs, but also directly. For example, Cugelman (2013) discusses elements such as committing to achieve a goal, capacity to overcome challenges, feedback on performance, reinforcement through rewards, monitoring progress, social connectivity, and fun and playfulness. Our game challenges participants because they need to keep the time and plan their actions. By connecting the desired behaviors with positive feedback through the scoring system and rewarding correct behavior, the game leverages the underlying psychology of goal setting, rewards, mastery, autonomy, and pursuit of meaning – thereby increasing intrinsic motivation to pursue desired behaviors (cf. Boyle et al., 2011). Further, the game gets participants to repeatedly practice behavior in the virtual environment, which can support forming new habits. The psychology literature emphasizes that in order to create habits it is important to repeatedly apply an action (e.g., washing hands in our context) in response to a cue (touching raw meat) and to receive immediate rewards for taking the action (e.g., Wood and Neal, 2007, 2009). In our game, the reward comes in the form of getting a higher feedback score.

In addition to the two primary Hypotheses 1 and 2, we test a range of secondary hypotheses to better understand the mechanisms behind our results. First, we test whether the game is more effective than a pure information intervention. The game, as well as the information condition affect beliefs and beliefs affect behavior. Yet, because of the active learning process outlined above, we expect the game to have a stronger effect on beliefs than the information condition. In addition, we expect that the game has a direct effect on behavior that is not mediated by beliefs.

To test whether the game is more successful than the information condition, as a first step, we test whether and in which dimensions the information intervention (condition *Info*) is successful. Based on past research that showed, for example, that corrective messages have a moderate positive influence on beliefs in the health domain (Walter and Murphy, 2018), we hypothesize that the pre-post change in food safety related beliefs and behavior, respectively, is larger in the *Info* than in the *Control* condition (**Secondary hypotheses 1 and 2**, respectively). Then, in a next step, we test the hypothesis that the game is more successful in changing beliefs and behavior, respectively, than just providing information. For this we compare the pre-post change in food safety related beliefs and behavior in *Game* with *Info* (**Secondary hypotheses 3 and 4**, respectively).

We consider a second set of mechanisms related to disgust, which is an emotional reaction triggered by aversion towards potentially contaminated objects. Triggers of disgust are bodily products as feces, vomit, urine, mucus, and blood. Disgust is thought to be an evolutionary adaption to prevent exposure to pathogens (e.g., Curtis et al., 2004). It thus seems particularly relevant in the context of food safety.

Drawing on the research related to the "pedagogy of disgust" in public health communication (Lupton, 2015), eliciting a disgust reaction in participants may make our game intervention more effective. It has been shown that decisions can be influenced by presenting information in a way that triggers disgust (Rozin and Fallon, 1987; Haidt et al., 1997). Specifically, in the context of food safety, Nauta et al. (2008) observe that disgust formulated information is effective in changing beliefs and behavior.

What are the potential reasons for disgust being effective in changing behavior? It is well established that information presented in an emotionally evocative way is more memorable (e.g., Bradley et al., 1992), which is, at least in part, because emotionally arousing stimuli increase attention (Talmi and McGarry, 2012). Arousing stimuli have been shown to have an automatic memory enhancement effect, whereas high valence, low arousal stimuli rely on controlled encoding (Kensinger and Corkin, 2004). There is ample evidence that disgust enhances memory consolidation (Croucher et al., 2011; Chapman et al., 2013; Van Hooff et al., 2014). Fear is another negative emotion with similar valence and arousal, but disgusting stimuli lead to greater immediate attention (Chapman, 2018) and also to enhanced memory of stimuli -— an effect that increases with time (Chapman et al., 2013; Moeck et al., 2021).

Potential mechanisms proposed in the literature are that disgust enhances attention (Morales et al., 2012; Van Hooff et al., 2014) and memory (Chapman et al., 2013). In our setting, the more people pay attention to the video, the more information they retain in short-term memory. An additional effect is that disgust acts to enhance recall and recognition of episodic memory on both short (minutes) and longer (days – weeks) time scales (Chapman et al., 2013). Both of these effects serve to increase information retention, recall and recognition and therefore can result in a larger effect on beliefs. Further, exposing participants to the disgust formulated version of the information video may bolster the claim about the severity of the risk (Dillard and Shen, 2018). All of these factors would suggest that the subsequent play of the online game has a larger impact on beliefs and behavior than for those participants exposed to the neutral frame of the video. Hence, we test with the *DisgustGame* condition whether disgust formulated information creates more attention than merely factual presentation of information and in doing so leads to a larger pre-post change in beliefs and behavior than *Game* (**Secondary hypotheses 5 and 6**).

Lastly, even though disgust is thought to be a universal and basic emotion (e.g., Rozin et al., 2008), individual differences in disgust sensitivity exist (Haidt et al., 1994) that could potentially explain heterogeneity in the response to health messages like in our intervention. As disgust sensitive individuals may generally be more receptive to information about food safety, the disgust frame of information may be particularly effective for disgust sensitive individuals. That is, we expect the change in beliefs and behavior investigated under Secondary hypotheses 5 and 6 to be larger for more disgust sensitive individuals (**Secondary hypothesis 7**) and that in *Game* there is a positive moderation effect by disgust sensitivity (**Secondary hypothesis 8**). We capture disgust sensitivity using the 7-item food disgust picture scale (Ammann et al., 2018).

Empirical analysis

Outcome variables. As the main outcome variables we use reported beliefs and behavior in the areas that are targeted in the game and the videos (*targeted behavior* and *targeted food safety efficacy beliefs*). For beliefs, we further use *beliefs in myths*.

Efficacy beliefs refer to an individual's belief that a particular action will affect the likelihood of contracting food-borne disease. We designed the game and video interventions to make people aware that certain actions, such as, for example, rinsing chicken, increase the likelihood of getting food-borne disease. We measured efficacy beliefs targeted by our interventions using 13 questions in the pre- and post-surveys (see Supplementary Table S.17).

Beliefs in myths refer to commonly held 'true-or-false' beliefs with no base in scientific facts. We measured them using 8 questions in the pre- and post-surveys (see Supplementary Table S.16). These myths were collected across Europe and assessed by the SafeConsume EU consortium.

Target behavior refers to self-reported food safety behaviors that were targeted in the intervention. We measured them with 21 questions in the pre- and post-surveys, such as, whether and how a participant checked the temperature of the meat when preparing a dish in the week before the survey or whether a participant rinsed certain fruits and vegetables (see Supplementary Table S.18).

If increased information about food safety triggers greater reflection and an increased general understanding of the causes of food-borne disease, the interventions may make people revise their beliefs or question myths also in areas that are not directly targeted in the intervention. Thus, further outcome variables used in some of the pre-registered exploratory analyses are beliefs and behavior in relevant food safety areas that were not targeted in the interventions (see Supplementary Tables S.16-S.18). For the beliefs, we consider a measure based on seven non-targeted beliefs. For behavior, we consider actions such as seeking information on how to safely handle food, checking the temperature of the fridge, and checking use-by dates of food items.

We standardize all individual items based on the mean and standard deviation of the respective pre-survey measure (cf. Supplementary Figure S.1). That is, comparison with the standardized post-survey measure captures by how many standard deviations the measure changed relative to the pre-survey and thus has the interpretation of an effect size. Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in beliefs or behavior (cf. Supplementary Tables S.17- S.19). We then aggregate items for the respective groups of outcome measures by taking the average over the individual standardized measures.

Empirical strategy. To test our hypotheses, we estimate average treatment effects using difference-in-differences regressions (e.g., Imbens and Wooldridge, 2009) that take the average pre-post difference in the outcome variable in each condition and compare the difference in these differences across two conditions:[2]

$$y_{it} = \beta_0 + \delta_0 \, P_{it} + \beta_1 \, T_i + \delta_1 \, P_{it} \cdot T_i + \gamma \, X_i + \varepsilon_{it},$$

where y_{it} is the outcome variable of interest for a person at date t (we have two observations per person), T_i is a treatment dummy, and P_{it} is a dummy equal to zero for the pre-survey observation and equal to one for the post-survey observation. P_{it} captures any time-related changes that occur across treatments. The interaction between T_i and P_{it} is the difference-in-difference estimate of interest. It captures how the treatment affects changes in the outcome variable between pre- and post-survey observations. We add a set of control variables X_i that include individual and socioeconomic characteristics and further account for experience with cooking and health safety (the list of control variables is given in Supplementary Section S.2.1).

Specifically, to test the main hypotheses (Hypothesis 1 and 2), the treatment dummy is set

[2]In principle, we could include an individual specific intercept, or so-called fixed effect. While this typically reduces standard errors by controlling for certain types of omitted variables, the downside is that inference is "notoriously susceptible to attenuation bias from measurement error" (Angrist and Pischke, 2008, p.225). For this reason, we implement the model without individual fixed effects.

equal to one for *Game* and 0 for *Control*. To test secondary hypotheses 1 and 2, the treatment dummy is set equal to one for *Info* and 0 for *Control*. Similarly, to test secondary hypotheses 3 and 4, the treatment dummy is equal to one if the participant participated in *Info* and 0 if s/he participated in *Game*. Finally, to test secondary hypotheses 5 and 6, the treatment dummy is equal to one if the participant participated in *DisgustGame* and 0 if s/he participated in *Game*. The treatments not mentioned are not included in the respective regressions.

The p-values and effect sizes in the results that we report in the next section refer to our main specifications that estimate the treatment effects without controls, but we also report estimates with a basic and extended set of control variables (see Supplementary Section S.2.1) and run a number of robustness checks (see Supplementary Section S.1.2).

Results

Table S.4 shows the descriptive statistics for the main outcome measures for the pre- and post surveys. Outcome measures at baseline are not perfectly balanced against the control treatment (cf. Table S.5) and there are some imbalances between the treatments for some control variables (cf. Table S.6). The difference-in-differences estimation approach accounts for such imbalances.

The data support Hypotheses 1 and 2, as illustrated in Figure 3 and summarized in the following result:

Result 1 *Relative to Control, Game improves targeted efficacy beliefs by 0.16 standard deviations ($p < 0.001$), beliefs in myths by 0.13 standard deviations ($p = 0.013$), and targeted behavior by 0.20 standard deviations ($p < 0.001$).*

We next turn to our first set of secondary hypotheses (Secondary hypotheses 1-4). While the information video improves food safety related beliefs compared to the control condition, a knowledge-behavior gap (Hornik, 1989) emerges in that information changes beliefs, but not behavior. Given that *Info* and *Game* are both effective in changing food safety related beliefs, it is not surprising that we find no treatment difference in beliefs between these two conditions. Yet, unlike the information video, the game improves behavior and thus bridges the knowledge-behavior gap. We summarize in the following result (cf. Figure 3):

Result 2

1. *Relative to Control, Info improves targeted efficacy beliefs by 0.14 standard deviations ($p < 0.001$), but has no significant impact on beliefs in myths ($p = 0.279$) or targeted behavior ($p = 0.242$).*

2. *Relative to Info, Game has no significant impact on targeted efficacy beliefs ($p = 0.771$) or beliefs in myths ($p = 0.374$), but it improves targeted behavior by 0.13 standard deviations*

($p = 0.013$).

We next turn to our secondary hypotheses related to disgust (Secondary hypotheses 5–8). We hypothesized that disgust formulated information would lead to a stronger learning effect, but expected the effect to be small. In line with this, the estimated treatment effects relative to *Control* for efficacy beliefs, beliefs in myths, and targeted behavior are all higher for *DisgustGame* compared to *Game*, but for the latter two outcomes the differences are not of sufficient magnitude to be statistically significant (0.09 standard deviations and $p = 0.045$ for targeted efficacy beliefs; $p = 0.848$ for beliefs in myths, and $p = 0.542$ for targeted behavior).

Further, the evidence contradicts the hypothesized mechanism of a disgust reaction increasing attention to food safety. We do not find treatment effects being moderated by disgust sensitivity (see Supplementary Table S.7 and Supplementary Section S.1.2.2). Only for one outcome do we find a significant effect, yet it goes against our hypothesis: for participants with disgust sensitivity above the median compared to those below the median, there is a lower treatment effect of *DisgustGame* on beliefs in myths relative to *Game* (-0.299 standard deviations, $p = 0.003$).

Mechanisms. We next test the potential mechanism behind our observed result that the game affects behavior (this analysis is not pre-registered). From a theoretical point of view, the game may either change behavior directly or affect behavior by changing beliefs. Figure 4 illustrates how we can decompose the total treatment effect on behavior (panel A) into a direct effect of being exposed to the treatment and an indirect effect that operates through the mediator efficacy beliefs (panel B). The classic approach to mediation analysis outlined in Baron and Kenny (1986) requires four conditions to be met. First and second, that the overall treatment effect (TE in panel A) and the treatment effect on the mediator (path a in panel B) are significant. We already saw that both conditions hold for *Game* and *DisgustGame* treatments, as illustrated in Figure 3. Third, controlling for the treatment, the effect of the mediator on the outcome (path b in panel B) is significant (for *Game* $\beta = 0.17$, $p < 0.001$; for *DisgustGame* $\beta = 0.19$, $p < 0.001$). Interaction terms between treatments and mediator are insignificant, indicating that treatments do not moderate the mediator-outcome effect (for *Game* $\beta = 0.08$, $p = 0.33$; for *DisgustGame* $\beta = 0.08$, $p = 0.25$). Fourth, a significant indirect effect, or mediated effect (panel B), which we establish by estimating the effects using the procedure of Imai et al. (2010).

We find that most of the total treatment effect of *Game* operates as a direct effect on behavior and only around 1/6th of it is mediated through efficacy beliefs (cf. Table 2). The picture is similar for *DisgustGame*, for which the higher total treatment effect on behavior (we find no statistically significant difference, as shown in Figure 3) is distributed proportionally across higher direct and indirect effects. Above we discussed a number of theoretical mechanisms through which serious games can affect behavior directly rather than through beliefs. Our results support the importance of these mechanisms.

Exploratory analysis. We conduct additional pre-registered exploratory analyses. First, given that the game exhibits promising effects on targeted beliefs and behavior, we test whether these lead to spillover effects on food safety related behavior and beliefs in areas that are not targeted in the game. We observe no significant spillover effects on non-targeted behavior and beliefs (cf. Figure 3 and Supplementary Table S.7). This indicates that the game increases attention to specific food safety actions, not food safety knowledge in general.

Second, we analyze treatment effects on individual items (see Supplementary Section S.1.2.1). In line with the analysis of aggregate beliefs, we also do not find treatment differences for individual belief items. Yet, for the targeted behaviors there is a pattern of *Game* and *DisgustGame* having larger treatment effects compared to *Info* – in particular, for the individual items related to handling meat, and rinsing fruits and vegetables even if they are to be peeled.

Third, we explore heterogeneous treatment effects (UK vs. Norway and Men vs. Women). We do not find any significant effects (available upon request).

Finally, we report exploratory results based on an additional 886 participants: The survey company also collected data outside of our pre-registered age range of 20-50 years because they omitted screening on age and this was only noticed after data collection had run for a while. Using the extended sample with 1,973 participants aged 18-89, our main findings are robust, with the exception that we find for the extended sample that *Game* also significantly improves efficacy beliefs relative to *Info* (cf. Supplementary Figure S.8). This result stems from heterogeneous treatment effects by age. We observe that *Game* relative to *Info* has little impact on beliefs for individuals aged 20-30, but has an effect for the older age groups; for targeted behavior the treatment effect is constant across age groups (cf. Supplementary Figures S.9-S.11).

While positive news, the result is surprising. Our motivation for recruiting only $20 - 50$ year old individuals was that we expected older individuals to enjoy less or even have difficulty playing computer games. Indeed, we find that both enjoyment and frequency of computer gaming generally tend to decrease with age (cf. Supplementary Figure S.12). Yet, we find no correlation between age and the rating of how much fun our game was (Spearman $\rho = 0.03$, $p = 0.359$).

Discussion

In the following, we discuss some caveats and limitations of our study.

Effect sizes. The effect sizes of the game on behavior are comparable to those in the literature. For example, a meta-study on food safety interventions by Young et al. (2015) finds effects sizes of 0.2 – 0.24 for randomized controlled trials measuring effects on behavior. A meta-study on the effects of serious game play on health life style behavior by DeSmet et al. (2014) reports an effect size of 0.26 for behavior. The effect sizes on beliefs are small. Yet, our study was conducted during the Corona pandemic where information about hygiene behavior (such as washing hands) was abundant. Further, Didier et al. (2021) observe that participants in the UK and Norway are not only more knowledgeable about how to handle raw chicken, but also apply the correct actions more often than participants in other European countries such as Portugal, France and Romania. Thus, overall, we were intervening at a high level of prior knowledge, which makes finding large effects more difficult.

Difference-in-difference vs. post comparisons. To account for possible changes due to factors other than the intervention, we employed a difference-in-differences approach rather than a post-comparison of treatment and control. Another advantage of a difference-in-difference approach is increased statistical power. Yet, employing this approach, in contrast to a simple post-comparison of treatment and control, has the potential disadvantage that we repeat the measures in the pre- and post-survey. Such a repetition might induce a bias for consistency or a strong(er) experimenter demand effect. That is, when choosing the design there is trade-off between bias and precision. Clifford et al. (2021) carefully examine this trade-off and come to the conclusion that there is a clear gain in precision, while bias is of little concern. A possible reason for the small bias that Clifford et al. (2021) discuss is that participants do not remember the answers they gave in the pre-survey.

Time span. When determining the time span between the intervention and the post-survey, there is a trade-off. A longer time interval increases the likelihood of participants dropping-out. A shorter time interval increases the likelihood that participants just repeat in the survey on behavior what they learned in the intervention. To balance the two concerns, we conducted the post-survey one week after the intervention. Thus, our study measures short-term effects of the intervention.

While participants receive the same information in all conditions, it could be that the game condition helps participants to better remember and hence repeat the information. If this were the case, then, however, we should observe significant differences between the conditions not only for the targeted behaviors, but also – and especially – for the efficacy beliefs and beliefs in myths. This is not the case.

Further conditions. To maximize power for a given budget, we limited ourselves to four conditions. Obviously, other conditions could be interesting as well. For example, a condition in which participants only see the disgust video, but do not play the game. We decided against such a condition because the main aim of the study is to test the effectiveness of the game vis-à-vis a control condition and a conventional information condition. The aim of the disgust condition is to test whether the game can be made *more* effective with certain frames. Indeed our results show that the *DisgustGame* condition consistently (and significantly for targeted efficacy beliefs) outperforms the *Game* condition – suggesting that the disgust frame is successful. But we reject the ex ante hypothesis of moderation by disgust sensitivity. Yet, when interpreting the significant difference between *DisgustGame* and *Control*, we cannot tell whether it is the disgust frame, the game or the combination of the two that drive the difference.

Further, we cannot disentangle which elements of the game make it more successful in changing beliefs and behavior than the information video. Is it the active learning of new behaviors through game play, or the repeated information in form of the feedback? The mediation analysis hints that information is not the main factor for changing behavior. Yet, these factors are difficult to disentangle in a causal way. One way to get some idea about the impact of the different components would be to run a vicarious learning condition, where participants observe on screen the game played by somebody else. Such a condition keeps the information constant relative to *Game*, while manipulating active versus passive learning.

Self-reported behavior. A limitation of our study is that we rely on self reported behavior. To observe real behavior in a large, two country study as ours would be very expensive and time consuming. For example, a study by the SafeConsume EU consortium that observed and interviewed households in six European countries during shopping and preparation of a meal with chicken and vegetables reached only 87 households and paid EUR 60-170 per visited household (Møretrø et al., 2021).

While self-reported food safety behaviors have been found to correlate well with actual observed food safety behavior (e.g., Moore et al., 2019, who compare answers in a questionnaire with actual observed food behavior, including time-temperature control, personal hygiene, cross-contamination, and adequate cooking), future research should validate our findings with observational studies of real behavior even if this is only feasible in smaller samples.

Conclusion

We provide causal evidence on the ability of an online serious game to change beliefs and behavior in the area of domestic food safety. We do so by comparing the effect of a game and a video-based information intervention with each other and with a control condition. We observe that both interventions successfully communicate information. Yet, despite its impact on beliefs, the video-based intervention has no significant effect on changing food safety behavior. In contrast, the game-based intervention significantly improves behavior.

While the knowledge-behavior gap that arises in the video-based intervention is well known in other areas, such as vaccinations and health screenings, the result may appear surprising in the context of food safety. In contrast to vaccinations or screenings, the planning costs of conducting food safety actions are rather low and people have little incentive to procrastinate. This suggests that other forces, such as bad habits, are at play for the observed knowledge-behavior gap in the area of food safety. Indeed, the game, that is able to alleviate the knowledge-behavior gap, provides an engaging environment in which individuals repeatedly apply correct behavior (In our study, 50 percent of the participants agreed with the statement "The game is fun", with the mean on the 5-point Likert scale being significantly higher than the neutral mid-point rating; t-test, $p < 0.001$, $N = 545$). By doing so, the game trains correct behavior and facilitates the creation of appropriate food preparation habits. What is interesting about our findings is that exposing consumers to repeated targeted behavior in a virtual environment for a limited time is able to change reported real-life behavior in the right direction. That is, not only repetition in real life, but also repetition in a game has the power to change behavior.

Our study further sheds light on whether framing information in a disgusting way can enhance the effects of the game-based intervention. While a disgust frame, relative to the neutral frame, improves targeted efficacy beliefs, it does not additonally change behavior and beliefs in myths. Further, we find no evidence of individual differences in disgust sensitivity being a moderator. Thus, the results contradict the hypothesized mechanism of disgust triggering heightened attention to food safety. A plausible ex post rationalization of the findings is that the disgust frame perhaps made the video more amusing and memorable. Future studies should look further into such mechanisms.

Since consumers play an important role in controlling the risk of contracting food-borne disease, promoting awareness and fostering correct risk-reducing behavior has become an important objective for health authorities (Ravarotto et al., 2016). Our study provides evidence that it is promising for health authorities, like the European Food Safety Authority (EFSA) and national food safety authorities, to develop and distribute digital games that target problematic food safety behaviors and get users to repeatedly train correct behavior in the virtual environment. Our results show that such a game-based intervention can be successful not just in young people but across the adult population.

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Data availability. Codes and data are accessible at [upon publication, codes and data will be posted to a repository such as Mendeley Data and a link will be provided].

Ethics. As a low risk study on human behavior, the study was exempted from review by the Health Research Authority in the UK, by the Norwegian Centre for Research Data, and Nofima's ethical board in Norway. Participants gave informed consent.

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Tables

Table 1: Overview of treatments and time line

	Date 1			Date 1 + 7 days
Treatment	Pre-Survey	Information Video	Game	Post Survey
Control	✓			✓
Info	✓	Neutral frame		✓
Game	✓	Neutral frame	✓	✓
DisgustGame	✓	Disgust frame	✓	✓

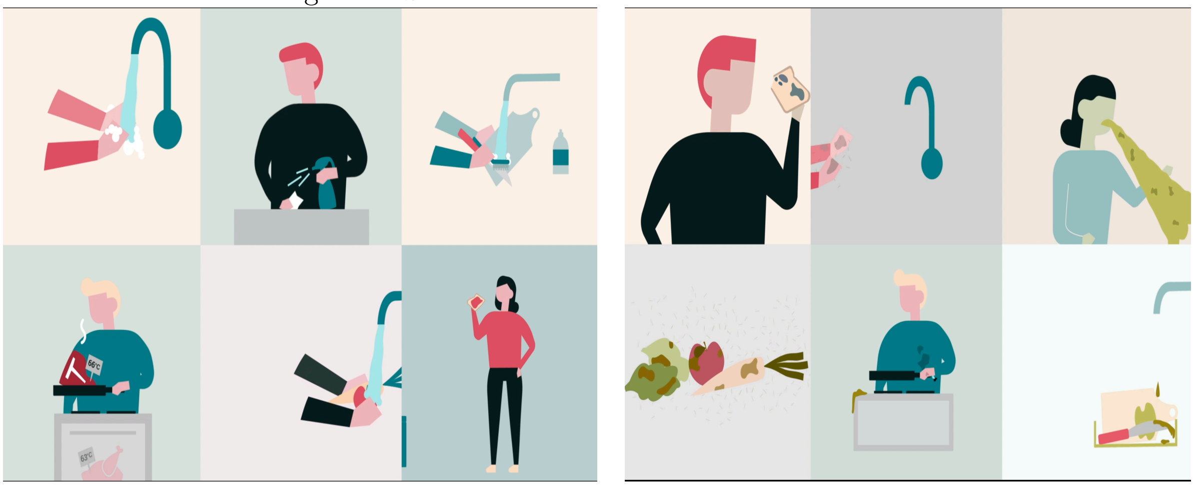
Table 2: Mediation of the Game treatment effects on behavior trough efficacy beliefs

	Total effect[a]	Direct effect	Indirect effect[b]	Percentage mediated[c]
Game	0.20***	0.17***	0.03***	15.51***
DisgustGame	0.23***	0.19***	0.04***	17.58***

[a] Total effect of treatment on targeted behavior. [a] Effect mediated through targeted efficacy beliefs, [C] Indirect effect as percentage of the total effect. * p<.1, ** p<.05, *** p<.01 based on bootstrapped confidence intervals using the `medeff` package for STATA (Hicks and Tingley, 2011). Controls (not reported): targeted efficacy beliefs and behavior at baseline and the basic and extended control variables listed in Supplementary Section S.2.1.

Figures

Figure 1: Screenshots from the information videos



Example pictures of the neutral video   Example pictures of the disgust video

Figure 2: Screenshot of the game

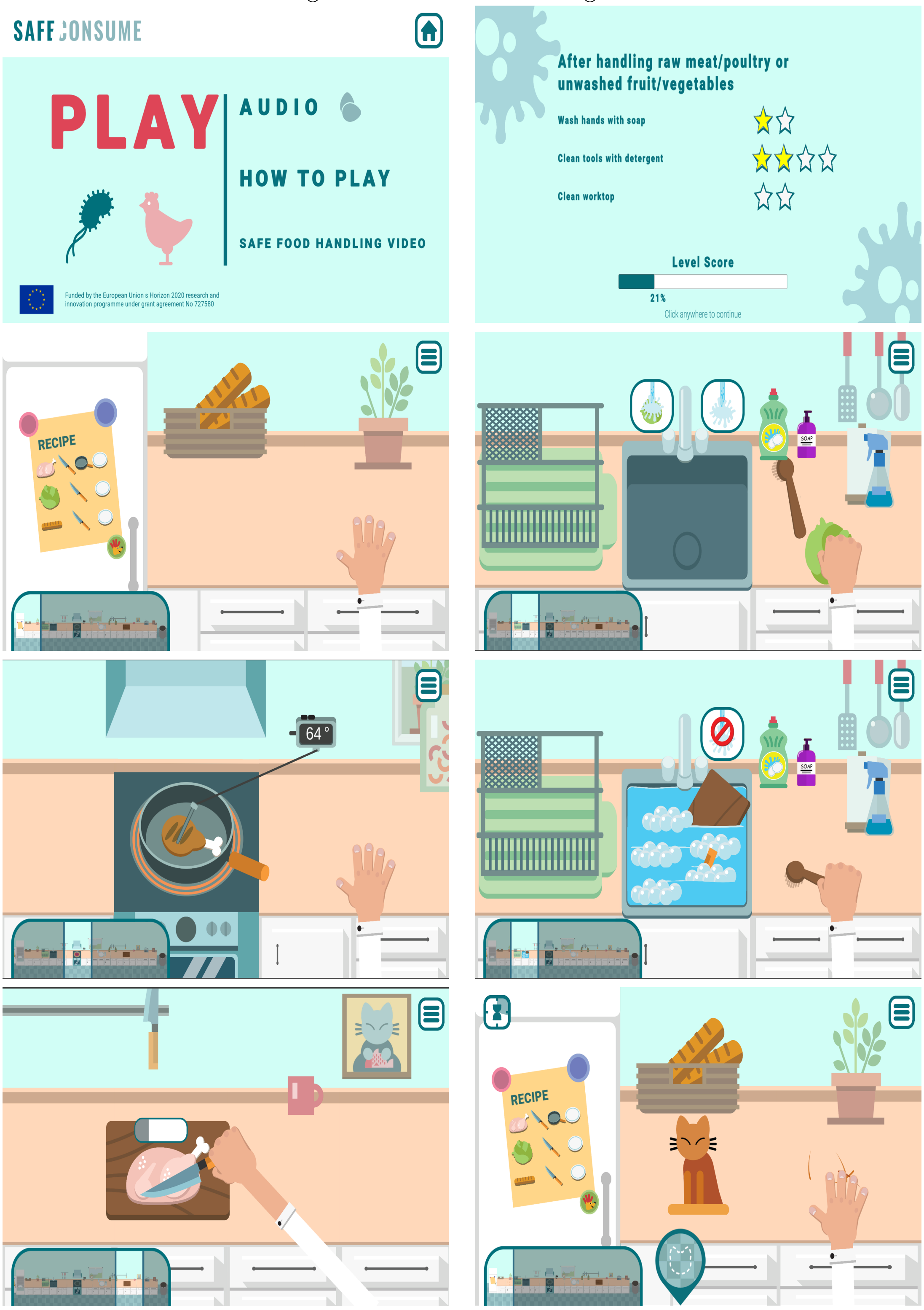
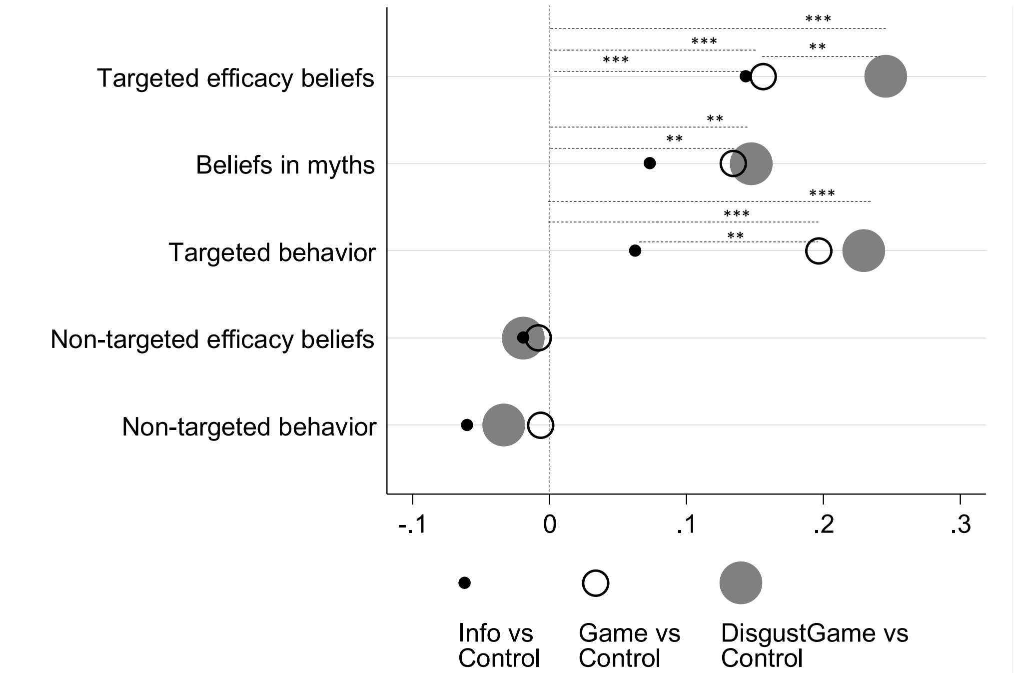
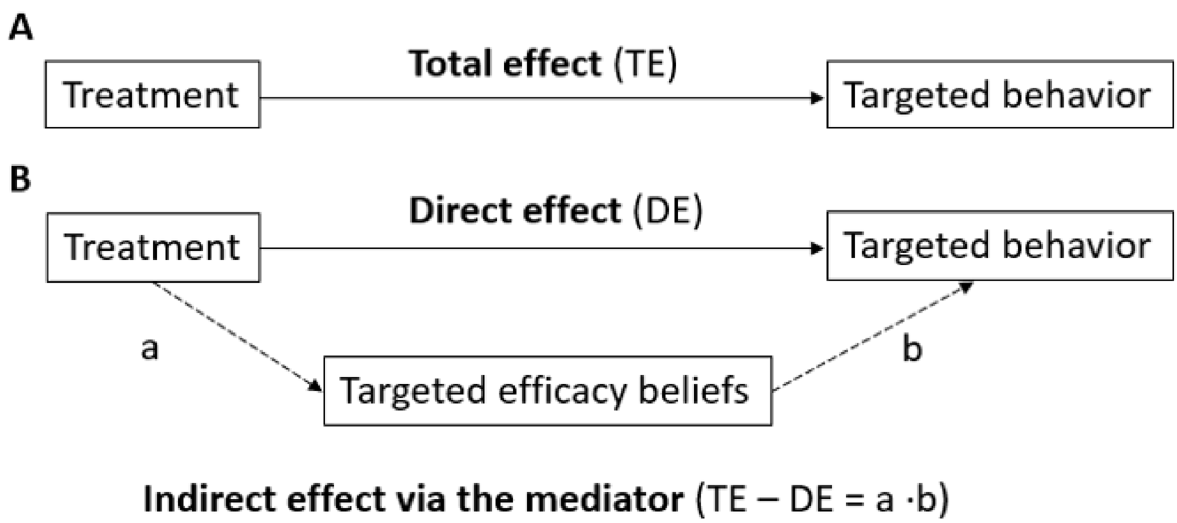


Figure 3: Average treatment effects for the main outcomes



Note: Difference-in-differences estimates. * p<.1, ** p<.05, *** p<.01. Based on Supplementary Table S.7.

Figure 4: Mediation



Online Supplement for

Fostering safe food handling: Causal evidence on game- and video-based online interventions

‡

September 2021

‡

S.1 Further analyses

S.1.1 Details on sampling

Kantar Gallup contacted 12,000 panelists in Norway and the UK, out of which 4,122 responded to the initial invitation (34 percent of invitees). Among these, 1,275 did not meet the eligibility requirements and were screened out. This left 2,847 participants who started the study, out of which 1,621 (Norway: 882, UK: 739) completed the required first part of their respective condition (57 percent completion rate). 1,087 (Norway: 588, UK: 499) participants (33 percent attrition) completed the second part of the study (the post-survey).

S.1.2 Robustness checks

Our difference in difference estimation approach accounts for potential imbalances at baseline. To identify the causal effect, the approach assumes that, in the absence of treatment, the treatment and control follow the same trend. Adding additional controls can account for possible differences in the trend. Tables S.8-S.10 show that including controls does not affect the estimated treatment effects. For some participants, household income is not available and we hence excluded this measure from the control variables. Adding them reduces the sample size but does not affect the average treatment effects, as shown in Tables S.11 and S.12. These tables also report coefficients on the control variables.

As an additional robustness check, we use Propensity Score Matching to match individuals based on their likelihood, conditional on observables, of being in the treatment condition and estimate the difference in difference. Again, the estimated average treatment effects are robust (cf. Tables S.8-S.10).

To assess robustness of our findings to parametric assumptions, we re-estimate our main specification using bootstrapped standard errors (cf. Table S.14). As ordinary least squares regression is sensitive to outliers, we also perform Quantile Difference in Differences estimation to obtain difference in difference estimates for the median and find that our qualitative results are robust. (cf. Table S.14).

A subtle issue related to the targeted behaviors could potentially bias our findings. Some questions were conditional on the behavior of the person in the week before. First, for those individuals who had not prepared meat in the week before, we asked about questions about meat preparation in a typical week rather than last week. Second, for targeted behaviors 1-3, we asked participants to consider a specific situation within the last week where they cooked a warm lunch or dinner with $< meat >$. If they had previously answered that they had prepared chicken during the last week then $< meat >$ was replaced with *chicken*. If they had not prepared chicken, but indicated that they prepared minced meat last weak, then $< meat >$ was replaced with *minced meat*, otherwise $< meat >$ was replaced with *meat or poultry*. For participants in the minced meat category or who had not prepared any meat, the pre-post comparison of the target behavior 3 (Did you rinse a piece of raw meat) potentially are blurred because we do not expect that people would rinse minced meat. Excluding such observations reduces the sample from 1,087 to 913 participants but does not affect the conclusions from the main analysis (cf. Table S.13).

S.1.2.1 Individual outcomes

In the main analysis we used aggregated responses for blocks of questions. In Figures S.2 - S.7 we estimate the average treatment effects (ATE) at the individual item level. The purpose of these additional analyses is not to test a broader set of independent hypotheses but to assess the robustness of our main analysis and to provide insights that allow a better understanding of the potential mechanisms driving the main findings.

For the directly targeted efficacy beliefs in Figure S.2, there is no clear difference between *Info* and *Game*, in line with the main findings. But the ATEs for *DisgustGame* – marked by the large gray circle – are consistently higher than the ATEs for the other two treatments (with the exception of the item on rinsing unwashed vegetables and fruit; but here the ATEs are all close to each other and not statistically distinguishable). For the beliefs in myths in Figure S.4, there is a similar tendency of the ATEs for *DisgustGame* to be largest, yet the differences to the other treatments are less consistent.

For the indirectly targeted or non-targeted efficacy beliefs in Figure S.3, there is no clear pattern of differences in ATEs across treatments, in line with the main findings.

For the targeted behaviors in Figures S.5 and S.6, there is a pattern of the *Game* and *DisgustGame* treatments having larger ATEs compared to *Info*. In particular, there are significant positive ATEs for the individual items related to handling meat (cf. Figure S.5) and rinsing fruits and vegetables even if they are to be peeled (cf. Figure S.6).

S.1.2.2 Moderation

An alternative to the test of Secondary hypotheses 7 and 8 that we offer in the main text based on the difference-in-differences framework is to estimate a classical moderation model based on the post-survey outcomes:

$$Y_i = \beta_0 + \beta_1 Z_i + \beta_2 Mo_i + \beta_3 Z_i\, Mo_i + \beta_4 X_i + \epsilon_i,$$

where Y_i is the outcome (targeted efficacy beliefs, beliefs in myths, or targeted behavior), Z_i is a treatment dummy that indicates whether a participant was in the control condition or in the treatment condition of interest, Mo_i is the moderator variable (disgust sensitivity), $Z_i\, Mo_i$ is the interaction between the previous two variables, and X_i is a set of control variables (targeted efficacy beliefs or beliefs in myths and behavior at baseline and the basic and extended control variables listed in Section S.2.1).

If the treatment effect varies in magnitude as a function of the value of the moderator, we should find a significant coefficient b_3. We reject moderation for all outcomes (cf. Table S.15)

S.2 Further details on methods

S.2.1 List of control variables

- BCOV 1. Age
- BCOV 2. Female: dummy=1 if the participant is female
- BCOV 3. Single household: dummy=1 if the participant lives in a single-person household
- BCOV 4. Dummies for highest level of education (Primary school, High-school/Tertiary education, University, Postgraduate)
- BCOV 5. Dummies for household income. Purchasing power adjusted (PPP) compared to EU27 as baseline, EUR based on 2019 PPP adjustment factors for NOK and GBP.[1]
  - Income 1: Less than 13,279 EUR (NO: 200,000 NOK)/ 13,883 EUR (UK: 15,000 GBP)
  - Income 2: Above category 1 & less than 26,559 EUR (NO: 400,000 NOK)/ 25,831 EUR (UK: 28,000 GBP)
  - Income 3: Above category 2 & less than 39,883 EUR (NO: 600,000 NOK)/ 36,902 EUR (UK: 40,000 GBP)
  - Income 4: Above category 4 & less than 53,118 EUR (NO: 800,000 NOK)/ 50,740 EUR (UK: 55,000 GBP)
  - Income 5: Above category 5
- BCOV 6. FreqMeatPre: How often the participant prepares a warm lunch or dinner with meat (including poultry) on average
- BCOV 7. Disgust sensitivity: measured by the 7-item food disgust picture scale of (Ammann et al., 2018)
- BCOV 8. FreqComputerGames: Frequency of playing computer games
- BCOV 9. WorkedFoodSector: Dummy for whether the participant has ever worked in the food industry or in gastronomy/food service, coded 1 if yes and 0 if no/don't know.

[1] Source: Statistics Norway, PPP adjustment factor for "A01 Actual individual consumption", https://www.ssb.no/en/statbank/table/13007/.

- BCOV 10. HealthSector: Dummy for whether the participant has ever worked as a health professional (health worker, nurse, doctor, physician, nutritionist, . . .), coded 1 if yes and 0 if no/don't know.
- BCOV11. HadFoodPoison: Dummy for whether the participant has ever had food poisoning, coded 1 if yes and 0 if no/don't know.
- BCOV 12. Risk tolerance: measured by the question of (Dohmen et al., 2011)

Extended set of control variables (variables in addition to basic control variables):

- ECOV 1. No of kids: Number of children (0,1,2,3, 3 or more)[2]
- ECOV 2. Stressed: How often the participant felt stressed when cooking because of time pressure (pre-survey)
- ECOV 3. ConcernedFoodPois: Food-related risk tolerance: Are you a person who is concerned about getting sick from food poisoning or are you not concerned about getting sick from food poisoning? Scale: 0: "not at all concerned about getting sick" . . . 10: "very concerned about getting sick"
- ECOV 4. HamburgerPref: Preference for eating hamburger meat pink inside rather than well done, measured by a question showing two different hamburgers (A: pink inside, B: well done). Scale: I would only eat hamburger A (1), I would prefer by a large margin to eat hamburger A (2), I would slightly prefer to eat hamburger A (3), I would like both hamburgers equally (4), I would slightly prefer to eat hamburger B (5), I would prefer by a large margin to eat hamburger B (6), I would only eat hamburger B (7)
- ECOV 5. PrefHygienic: Importance of the meal being prepared under hygienic circumstances.
- ECOV 6. PrefFast: Importance of the meal being fast to prepare
- ECOV 7. PrefKitchenClean: Importance of not messing up the kitchen when cooking
- ECOV 8. PrefNoWaste: Importance of avoiding food waste

Comments:

- ECOV 5-8 are based on questions about what is important when shopping for, preparing, and cooking a meal: Scale: Not important (1), Low importance (2), Neutral (3), Slightly important (4), Very important (5).
- BCOV 12 and ECOV 3/ ECOV 3 and 4, respectively, might be collinear. Thus, we might include only one question in the main analysis and use the other question(s) to assess robustness.

[2]Contrary to expectations, the survey company could not provide us with the pre-registered variable "ECOV 1. Age of the youngest child (if child at home)". We use the number of children instead.

S.2.2 Ex ante power analysis

The minimum detectable effect size is 0.251 for comparisons of two conditions (N=250 per treatment) with a two-tailed t-test with alpha=0.05 and power=0.8. If the two game treatments are pooled (N_1=500 and N_2=250), the minimum detectable effect size is 0.217. If, in addition, the control condition is pooled with the information treatment (N_1=500 and N_2=500), the minimum detectable effect size is 0.177.

S.3 Tables

Table S.1: Sample

				Control		Information		Game		DisgustGame	
	All	NO	UK	NO	UK	NO	UK	NO	UK	NO	UK
Part 1	1,621	882	739	242	194	231	176	170	175	239	194
Duration[a]		42	36	16	14	21	16	72	59	62	61
Part 2	1,087	588	499	146	126	145	125	139	124	158	124
Duration[a]		10	8	10	9	10	8	10	8	9	8
Attrition	534	294	240	96	68	86	51	31	51	81	70

Out of 12,000 panelists, 4,122 responded to the initial invitation. 1,275 did not meet the eligibility requirements and were screened out, leaving 2,847 who started the study.

[a] Median duration in minutes.

Table S.2: Gender composition

				Control		Information		Game		DisgustGame	
	All	NO	UK	NO	UK	NO	UK	NO	UK	NO	UK
Female	553	301	252	72	63	74	64	71	62	84	63
Male	534	287	247	74	63	71	61	68	62	74	61
All	1,087	588	499	146	126	145	125	139	124	158	124

Table S.3: Balance: Pre-survey only vs completed study

Variable	Sample	Pre-survey only	Difference
Female	0.509	0.551	0.042
	(0.500)	(0.498)	(0.113)
Age	37.341	35.629	-1.712***
	(8.702)	(8.966)	(0.000)
Fulltime	0.638	0.610	-0.028
	(0.481)	(0.488)	(0.276)
Income1	0.099	0.088	-0.011
	(0.299)	(0.283)	(0.476)
Income2	0.042	0.026	-0.016
	(0.201)	(0.161)	(0.104)
Income3	0.100	0.094	-0.006
	(0.300)	(0.292)	(0.699)
Income4	0.172	0.187	0.015
	(0.378)	(0.391)	(0.477)
Income5	0.377	0.251	-0.127***
	(0.485)	(0.434)	(0.000)
Parttime	0.102	0.107	0.005
	(0.303)	(0.309)	(0.776)
Selfemployed	0.047	0.049	0.002
	(0.212)	(0.215)	(0.876)
Retired	0.006	0.002	-0.005
	(0.080)	(0.043)	(0.136)
Unemployed	0.086	0.090	0.004
	(0.280)	(0.286)	(0.773)
Studies	0.086	0.094	0.007
	(0.281)	(0.292)	(0.638)
Homemaker	0.024	0.026	0.002
	(0.153)	(0.160)	(0.783)
PrimarySchool	0.106	0.092	-0.014
	(0.308)	(0.289)	(0.368)
HighSchoolTertiary	0.420	0.414	-0.006
	(0.494)	(0.493)	(0.829)
Postgraduate	0.274	0.253	-0.021
	(0.446)	(0.435)	(0.357)
Householdsize	2.629	2.794	0.165**
	(1.198)	(1.228)	(0.011)

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Table S.3 – continued from previous page

Variable	Sample	Pre-survey only	Difference
Noofkids	0.322	0.455	0.133***
	(0.716)	(0.822)	(0.001)
FreqMeatPre	4.896	4.963	0.067
	(0.936)	(0.970)	(0.189)
ReadyMealPre	1.999	2.030	0.031
	(1.012)	(1.012)	(0.564)
InfoSeekPre	1.439	1.644	0.205***
	(0.846)	(1.075)	(0.000)
MincedMeatPre	2.098	2.380	0.283***
	(0.919)	(1.043)	(0.000)
ChickenPre	2.386	2.521	0.134**
	(0.968)	(1.081)	(0.015)
OtherMeatPre	2.397	2.549	0.152***
	(0.993)	(1.110)	(0.007)
StressedPre	1.735	2.071	0.336***
	(1.087)	(1.310)	(0.000)
Observations	1,087	534	1,621

Table S.4: Descriptive statistics for the main outcomes

	Targeted efficacy beliefs		Beliefs in myths		Targeted behavior		Non-targeted efficacy beliefs		Non-targeted behavior	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Control (N=272)										
	0.00	- 0.06	- 0.02	- 0.08	0.02	0.01	- 0.05	- 0.06	0.01	0.03
	(0.34)	(0.31)	(0.52)	(0.58)	(0.44)	(0.44)	(0.57)	(0.59)	(0.59)	(0.56)
Info (N=270)										
	- 0.01	0.07	0.03	0.04	- 0.00	0.05	0.01	- 0.02	0.04	0.00
	(0.31)	(0.34)	(0.55)	(0.58)	(0.42)	(0.46)	(0.53)	(0.55)	(0.58)	(0.59)
Game (N=263)										
	0.00	0.09	0.01	0.08	- 0.02	0.17	0.01	- 0.00	- 0.01	0.00
	(0.34)	(0.40)	(0.54)	(0.57)	(0.42)	(0.46)	(0.53)	(0.51)	(0.60)	(0.59)
DisgustGame (N=282)										
	0.00	0.18	- 0.02	0.07	0.01	0.23	0.02	- 0.00	0.02	0.01
	(0.33)	(0.40)	(0.55)	(0.60)	(0.42)	(0.46)	(0.48)	(0.54)	(0.56)	(0.57)
N=	1,087	1,087	1,087	1,087	1,087	1,087	1,087	1,087	1,087	1,087

The individual components of the aggregate outcome measures are standardized based on the pre-survey mean and standard deviation in parentheses.

Table S.5: Balance of main outcomes at baseline

Targeted efficacy beliefs	Myth beliefs	Targeted behavior	Non-targeted efficacy beliefs	Non-targeted behavior
Info vs Control				
-0.01	0.04	-0.02	0.06	0.03
Game vs Control				
0.04*	0.06	0.06	0.05	-0.02
DisgustGame vs Control				
0.09***	0.04	0.10	0.06	0.01

Differences (t-test): * p<.1, ** p<.05, *** p<.01

Table S.6: Balance of covariates at baseline

Variable	Control	Info	Game	DisgustGame	Info vs Control	Game vs Control	DisgustGame vs Control
Female	0.496	0.511	0.506	0.521	0.015	0.009	0.025
	(0.500)	(0.500)	(0.500)	(0.500)	(0.030)	(0.031)	(0.030)
Age	38.430	37.689	36.236	36.989	-0.741	-2.194***	-1.441***
	(8.637)	(8.560)	(8.676)	(8.795)	(0.522)	(0.529)	(0.524)
Fulltime	0.680	0.641	0.616	0.617	-0.039	-0.064**	-0.063**
	(0.467)	(0.480)	(0.487)	(0.487)	(0.029)	(0.029)	(0.029)
Income1	0.089	0.080	0.114	0.112	-0.009	0.025	0.023
	(0.285)	(0.271)	(0.318)	(0.316)	(0.018)	(0.019)	(0.019)
Income2	0.042	0.046	0.045	0.036	0.004	0.002	-0.006
	(0.202)	(0.210)	(0.207)	(0.186)	(0.013)	(0.013)	(0.012)
Income3	0.106	0.101	0.093	0.100	-0.005	-0.012	-0.006
	(0.308)	(0.301)	(0.291)	(0.300)	(0.020)	(0.019)	(0.020)
Income4	0.148	0.151	0.195	0.192	0.003	0.047*	0.044*
	(0.356)	(0.359)	(0.397)	(0.394)	(0.023)	(0.024)	(0.024)
Income5	0.428	0.366	0.362	0.356	-0.062**	-0.066**	-0.072**
	(0.495)	(0.482)	(0.481)	(0.479)	(0.032)	(0.031)	(0.031)
Parttime	0.081	0.107	0.095	0.124	0.027	0.014	0.043**
	(0.273)	(0.310)	(0.294)	(0.330)	(0.018)	(0.017)	(0.018)
Selfemployed	0.044	0.044	0.038	0.060	0.000	-0.006	0.016
	(0.206)	(0.206)	(0.191)	(0.238)	(0.013)	(0.012)	(0.013)
Retired	0.007	0.007	0.004	0.007	0.000	-0.004	-0.000
	(0.086)	(0.086)	(0.062)	(0.084)	(0.005)	(0.005)	(0.005)
Unemployed	0.085	0.096	0.103	0.060	0.012	0.018	-0.024
	(0.278)	(0.295)	(0.304)	(0.238)	(0.017)	(0.018)	(0.016)
Studies	0.070	0.070	0.099	0.106	0.001	0.029*	0.037**
	(0.255)	(0.256)	(0.299)	(0.309)	(0.016)	(0.017)	(0.017)
Homemaker	0.018	0.026	0.038	0.014	0.008	0.020*	-0.004
	(0.134)	(0.159)	(0.191)	(0.118)	(0.009)	(0.010)	(0.008)
Primaryschool	0.107	0.111	0.095	0.110	0.004	-0.012	0.003
	(0.309)	(0.315)	(0.294)	(0.313)	(0.019)	(0.018)	(0.019)
Highschooltertiary	0.434	0.411	0.433	0.401	-0.023	-0.000	-0.033
	(0.496)	(0.492)	(0.496)	(0.490)	(0.030)	(0.030)	(0.030)
Postgraduate	0.268	0.252	0.285	0.291	-0.017	0.017	0.022
	(0.444)	(0.434)	(0.452)	(0.455)	(0.027)	(0.027)	(0.027)
Householdsize	2.662	2.629	2.601	2.622	-0.032	-0.061	-0.039

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Table S.6 – continued from previous page

Variable	Control	Info	Game	DisgustGame	Info vs Control	Game vs Control	DisgustGame vs Control
	(1.184)	(1.207)	(1.152)	(1.244)	(0.073)	(0.072)	(0.073)
Noofkids	1.305	1.322	1.354	1.309	0.017	0.048	0.003
	(0.669)	(0.697)	(0.746)	(0.750)	(0.042)	(0.043)	(0.043)
Freqmeatpre	4.923	4.848	4.894	4.918	-0.075	-0.029	-0.004
	(0.958)	(0.965)	(0.913)	(0.906)	(0.058)	(0.057)	(0.056)
Readymealpre	1.945	2.033	1.977	2.039	0.088	0.032	0.094
	(0.990)	(1.067)	(0.948)	(1.037)	(0.063)	(0.059)	(0.061)
Infoseekpre	1.449	1.426	1.475	1.408	-0.023	0.027	-0.041
	(0.861)	(0.826)	(0.868)	(0.830)	(0.051)	(0.053)	(0.051)
Mincedmeatpre	2.114	1.989	2.129	2.156	-0.125**	0.015	0.042
	(0.923)	(0.905)	(0.898)	(0.941)	(0.056)	(0.056)	(0.056)
Chickenpre	2.404	2.341	2.384	2.415	-0.064	-0.020	0.010
	(0.966)	(0.980)	(0.953)	(0.973)	(0.059)	(0.059)	(0.058)
Othermeatpre	2.412	2.330	2.338	2.500	-0.082	-0.073	0.088
	(0.993)	(1.019)	(0.958)	(0.991)	(0.061)	(0.060)	(0.060)
Stressedpre	1.684	1.770	1.715	1.770	0.087	0.031	0.086
	(1.070)	(1.146)	(1.054)	(1.076)	(0.067)	(0.065)	(0.064)
Observations	544	540	526	564	1,084	1,070	1,108

Table S.7: DID estimates for the main outcomes

Targeted efficacy beliefs	Beliefs in myths	Targeted behavior	Non-targeted efficacy beliefs	Non-targeted behavior
Game vs Control (N=535)				
0.16***	0.13**	0.20***	-0.01	-0.01
(0.04)	(0.07)	(0.05)	(0.07)	(0.07)
Info vs Control (N=542)				
0.14***	0.07	0.06	-0.02	-0.06
(0.04)	(0.07)	(0.05)	(0.07)	(0.07)
Game vs Info (N=533)				
0.01	0.06	0.13**	0.01	0.05
(0.04)	(0.07)	(0.05)	(0.06)	(0.07)
DisgustGame vs Control (N=554)				
0.25***	0.15**	0.23***	-0.02	-0.03
(0.04)	(0.07)	(0.05)	(0.07)	(0.07)
DisgustGame vs Game (N=545)				
0.09**	0.01	0.03	-0.01	-0.03
(0.04)	(0.07)	(0.05)	(0.06)	(0.07)
DisgustGame vs Control (disgust sens., N=554)[a]				
0.04	-0.11	-0.02	0.03	-0.23**
(0.06)	(0.10)	(0.08)	(0.10)	(0.10)
DisgustGame vs Game (disgust sens., N=545)[a]				
0.00	-0.30***	-0.05	-0.10	-0.30***
(0.07)	(0.10)	(0.08)	(0.09)	(0.10)
Game/DisgustGame (pooled) vs Control (N=817)				
0.20***	0.14**	0.21***	-0.01	-0.02
(0.04)	(0.06)	(0.05)	(0.06)	(0.06)
Game/DisgustGame (pooled) vs Info (N=815)				
0.06	0.07	0.15***	0.01	0.04
(0.04)	(0.06)	(0.05)	(0.06)	(0.06)

Differences-in-differences estimates with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01 [a]Differences-in-differences-in-differences estimate of the difference in treatment effect for above vs below median disgust sensitivity. Regressions with control variables are reported in Tables S.8 – S.10.

Table S.8: DID estimates for targeted efficacy beliefs

	(1)	(2)	(3)	PSM[b]
Game vs Control (N=535, N=527 with controls[a])				
	0.16***	0.16***	0.16***	0.16***
	(0.04)	(0.04)	(0.04)	(0.04)
Info vs Control (N=542, N=536 with controls[a])				
	0.14***	0.15***	0.15***	0.15***
	(0.04)	(0.04)	(0.04)	(0.04)
Game vs Info (N=533, N=525 with controls[a])				
	0.01	0.01	0.01	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
DisgustGame vs Control (N=554, N=547 with controls[a])				
	0.25***	0.24***	0.24***	0.25***
	(0.04)	(0.04)	(0.04)	(0.04)
DisgustGame vs Game (N=545, N=536 with controls[a])				
	0.09**	0.07*	0.07*	0.05
	(0.04)	(0.04)	(0.04)	(0.05)
Game/DisgustGame (pooled) vs Control (N=817, N=805 with controls[a])				
	0.20***	0.20***	0.20***	0.21***
	(0.04)	(0.04)	(0.03)	(0.04)
Game/DisgustGame (pooled) vs Info (N=815, N=803 with controls[a])				
	0.06	0.05	0.05	0.05
	(0.04)	(0.03)	(0.03)	(0.04)
Controls	No	Basic	Extended	No

Differences-in-differences estimates with standard errors in parentheses:
* p<.1, ** p<.05, *** p<.01. [a] Single-household status are not available for all subjects.
[b] Propensity score matching DID estimate.

Table S.9: DID estimates for beliefs in myths

	(1)	(2)	(3)	PSM[b]
Game vs Control (N=535, N=527 with controls[a])				
	0.13**	0.14**	0.14**	0.14*
	(0.07)	(0.07)	(0.06)	(0.07)
Info vs Control (N=542, N=536 with controls[a])				
	0.07	0.07	0.07	0.06
	(0.07)	(0.06)	(0.06)	(0.07)
Game vs Info (N=533, N=525 with controls[a])				
	0.06	0.07	0.07	0.08
	(0.07)	(0.06)	(0.06)	(0.07)
DisgustGame vs Control (N=554, N=547 with controls[a])				
	0.15**	0.16**	0.16**	0.17**
	(0.07)	(0.07)	(0.06)	(0.07)
DisgustGame vs Game (N=545, N=536 with controls[a])				
	0.01	0.02	0.02	- 0.01
	(0.07)	(0.07)	(0.06)	(0.07)
Game/DisgustGame (pooled) vs Control (N=817, N=805 with controls[a])				
	0.14**	0.15***	0.15***	0.16**
	(0.06)	(0.06)	(0.05)	(0.06)
Game/DisgustGame (pooled) vs Info (N=815, N=803 with controls[a])				
	0.07	0.07	0.07	0.08
	(0.06)	(0.06)	(0.05)	(0.06)
Controls	No	Basic	Extended	No

Differences-in-differences estimates with standard errors in parentheses:
* p<.1, ** p<.05, *** p<.01. [a] Single-household status are not available for all subjects.
[b] Propensity score matching DID estimate.

Table S.10: DID targeted behavior

	(1)	(2)	(3)	PSM[b]
Game vs Control (N=535, N=527 with controls[a])				
	0.20***	0.20***	0.20***	0.21***
	(0.05)	(0.05)	(0.05)	(0.06)
Info vs Control (N=542, N=536 with controls[a])				
	0.06	0.07	0.07	0.08
	(0.05)	(0.05)	(0.05)	(0.05)
Game vs Info (N=533, N=525 with controls[a])				
	0.13**	0.14***	0.14***	0.13**
	(0.05)	(0.05)	(0.05)	(0.06)
DisgustGame vs Control (N=554, N=547 with controls[a])				
	0.23***	0.22***	0.22***	0.23***
	(0.05)	(0.05)	(0.05)	(0.05)
DisgustGame vs Game (N=545, N=536 with controls[a])				
	0.03	0.02	0.02	0.03
	(0.05)	(0.05)	(0.05)	(0.06)
Game/DisgustGame (pooled) vs Control (N=817, N=805 with controls[a])				
	0.21***	0.21***	0.21***	0.22***
	(0.05)	(0.04)	(0.04)	(0.05)
Game/DisgustGame (pooled) vs Info (N=815, N=803 with controls[a])				
	0.15***	0.15***	0.15***	0.15***
	(0.05)	(0.05)	(0.04)	(0.05)
Controls	No	Basic	Extended	No

Differences-in-differences estimates with standard errors in parentheses:
* p<.1, ** p<.05, *** p<.01. [a] Single-household status are not available for all subjects.
[b] Propensity score matching DID estimate.

Table S.11: DID regression coefficients: Efficacy beliefs and beliefs in myths

	Efficacy beliefs			Beliefs in myths		
	Game vs Control	Information vs Control	DisgustGame vs Control	Game vs Control	Information vs Control	DisgustGame vs Control
ATE[a]	0.17***	0.14***	0.25***	0.15**	0.10	0.16**
	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.07)
Age	0.00	0.00	0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female	0.05*	0.05**	0.07***	0.04	0.01	0.05
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
Single household	-0.02	0.03	0.05*	-0.04	0.01	-0.02
	(0.03)	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)
Primary school	-0.08	-0.04	-0.08	-0.08	-0.22**	-0.09
	(0.06)	(0.06)	(0.06)	(0.11)	(0.10)	(0.10)
High-school/Tertiary	-0.04	-0.02	-0.04	-0.10	-0.10	-0.01
	(0.04)	(0.03)	(0.04)	(0.07)	(0.07)	(0.07)
University	-0.02	-0.03	-0.04	-0.01	-0.08	-0.05
	(0.04)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)
Postgraduate	-0.09*	-0.08*	-0.10**	-0.05	-0.07	0.01
	(0.05)	(0.04)	(0.05)	(0.09)	(0.08)	(0.09)
Income1	0.09*	0.02	0.00	0.01	-0.01	-0.01
	(0.05)	(0.05)	(0.04)	(0.07)	(0.08)	(0.07)
Income2	0.10*	0.03	0.11**	0.07	0.08	0.05
	(0.06)	(0.05)	(0.05)	(0.08)	(0.09)	(0.09)
Income3	0.01	-0.01	-0.03	0.02	-0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.07)
Income4	0.02	-0.02	-0.01	0.02	-0.10	-0.01
	(0.04)	(0.04)	(0.04)	(0.07)	(0.06)	(0.06)
Income5	0.02	0.07**	0.05	0.02	0.00	0.04
	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)
FreqMeatPre	0.01	0.01	0.00	-0.01	-0.03	0.00
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Disgust sensitivity	0.01	0.03***	0.00	0.04*	0.04**	-0.03

Differences-in-differences regressions with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

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Table S.11 – continued from previous page

	Efficacy beliefs			Beliefs in myths		
	Game vs Control	Information vs Control	DisgustGame vs Control	Game vs Control	Information vs Control	DisgustGame vs Control
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
FreqComputerGames	0.00	0.01	-0.01	-0.01	0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
WorkedFoodSector	0.02	0.06**	0.05*	-0.09**	-0.07*	-0.18***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)
HealthSector	0.00	0.04	0.00	-0.01	0.07	0.07
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)
HadFoodPoison	0.01	0.02	0.03	-0.01	0.05	0.06
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
Risk tolerance	-0.02***	-0.01**	-0.01*	-0.03***	-0.04***	-0.05***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
No of kids	-0.00	0.02	0.00	-0.06	-0.04	-0.09**
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
Stressed	-0.01	0.00	-0.01	-0.09***	-0.10***	-0.12***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
ConcernedFoodPois	0.00	0.00	0.01***	-0.01	-0.01	-0.01
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
HamburgerPref	-0.00	0.01	0.02***	0.03**	0.05***	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
PrefHygienic	0.06***	0.04***	0.06***	0.11***	0.07***	0.08***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.02)
PrefFast	-0.02	-0.05***	-0.04***	-0.00	-0.04**	-0.02
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
PrefKitchenClean	0.01	0.00	-0.00	0.00	-0.04***	-0.04**
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
PrefNoWaste	0.02	0.03**	0.05***	-0.01	0.02	0.06**
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Information[b]		-0.00			0.07	
		(0.03)			(0.04)	
Game[b]	0.00			0.03		

Differences-in-differences regressions with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

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Table S.11 – continued from previous page

	Efficacy beliefs			Beliefs in myths		
	Game vs Control	Information vs Control	DisgustGame vs Control	Game vs Control	Information vs Control	DisgustGame vs Control
	(0.03)			(0.05)		
DisgustGame[b]			0.00			-0.00
			(0.03)			(0.05)
Post-survey[c]	-0.08***	-0.08***	-0.08***	-0.08	-0.08	-0.08
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)
Constant	-0.30**	-0.28**	-0.46***	-0.03	0.39*	0.13
	(0.13)	(0.12)	(0.12)	(0.22)	(0.20)	(0.20)
N	948	938	958	948	938	958
Adj. R^2	0.11	0.10	0.16	0.12	0.18	0.19

Differences-in-differences regressions with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Smaller sample than main sample as income and single-household status are not available for all subjects.

Table S.12: DID regression coefficients: Targeted behavior

	Targeted behavior		
	Game vs Control	Information vs Control	DisgustGame vs Control
ATE[a]	0.22***	0.08	0.21***
	(0.05)	(0.05)	(0.05)
Age	-0.00	-0.00**	-0.00
	(0.00)	(0.00)	(0.00)
Female	0.05	0.05*	0.05*
	(0.03)	(0.03)	(0.03)
Single household	-0.07*	0.03	-0.01

Differences-in-differences regressions with standard errors in parentheses:

* p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

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Table S.12 – continued from previous page

	Targeted behavior		
	Game vs Control	Information vs Control	DisgustGame vs Control
	(0.04)	(0.04)	(0.04)
Primary school	-0.13	-0.12	-0.17**
	(0.08)	(0.08)	(0.07)
High-school/Tertiary	-0.13***	-0.09**	-0.14***
	(0.05)	(0.05)	(0.05)
University	-0.11**	-0.00	-0.06
	(0.04)	(0.04)	(0.04)
Postgraduate	0.00	0.09	-0.06
	(0.06)	(0.06)	(0.06)
Income1	-0.03	0.04	0.08
	(0.06)	(0.06)	(0.06)
Income2	0.04	0.11*	0.04
	(0.07)	(0.06)	(0.07)
Income3	-0.03	-0.09	0.05
	(0.05)	(0.05)	(0.06)
Income4	-0.01	-0.08	0.04
	(0.05)	(0.05)	(0.04)
Income5	0.04	0.09**	0.10**
	(0.04)	(0.04)	(0.04)
FreqMeatPre	0.00	0.02	0.03*
	(0.01)	(0.01)	(0.01)
Disgust sensitivity	-0.00	0.00	0.00
	(0.01)	(0.02)	(0.02)
FreqComputerGames	0.01	0.01	0.03***
	(0.01)	(0.01)	(0.01)
WorkedFoodSector	-0.03	-0.07**	-0.03
	(0.03)	(0.03)	(0.03)
HealthSector	0.03	0.09**	0.04
	(0.04)	(0.04)	(0.04)

Differences-in-differences regressions with standard errors in parentheses:

* p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

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Table S.12 – continued from previous page

	Targeted behavior		
	Game vs Control	Information vs Control	DisgustGame vs Control
HadFoodPoison	0.05*	0.04	0.07***
	(0.03)	(0.03)	(0.03)
Risk tolerance	-0.00	-0.01*	-0.02***
	(0.01)	(0.01)	(0.01)
No of kids	0.07***	0.09***	0.01
	(0.02)	(0.02)	(0.02)
Stressed	-0.01	-0.01	-0.03**
	(0.01)	(0.01)	(0.01)
ConcernedFoodPois	0.04***	0.02***	0.04***
	(0.01)	(0.01)	(0.01)
HamburgerPref	-0.01	-0.00	0.01
	(0.01)	(0.01)	(0.01)
PrefHygienic	0.16***	0.12***	0.12***
	(0.02)	(0.02)	(0.02)
PrefFast	-0.03**	-0.04**	-0.05***
	(0.02)	(0.02)	(0.02)
PrefKitchenClean	-0.00	0.01	-0.02
	(0.01)	(0.01)	(0.01)
PrefNoWaste	0.00	0.01	0.02
	(0.02)	(0.02)	(0.02)
Information[b]		0.01	
		(0.04)	
Game[b]	-0.01		
	(0.04)		
DisgustGame[b]			0.00
			(0.04)
Post-survey[c]	-0.01	-0.01	-0.01
	(0.04)	(0.04)	(0.04)
Constant	-0.72***	-0.67***	-0.62***

Differences-in-differences regressions with standard errors in parentheses:

* p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

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Table S.12 – continued from previous page

	Targeted behavior		
	Game vs Control	Information vs Control	DisgustGame vs Control
	(0.14)	(0.16)	(0.15)
N	947	938	958
Adj. R^2	0.23	0.16	0.19

Differences-in-differences regressions with standard errors in parentheses:

* p<.1, ** p<.05, *** p<.01.

[a]Average treatment effect. [b]Treatment dummy. [c]Dummy for post-survey observation.

See Section S.2.1 for explanations of the control variables.

Income and single-household status are not available for all subjects.

Table S.13: DID estimates: Targeted behavior (robustness to excluding certain subjects)

Full sample	Sample with exclusions[a]
Game vs Control (N=535[a])	
0.20***	0.20***
(0.05)	(0.06)
Info vs Control (N=542[a])	
0.06	0.05
(0.05)	(0.06)
Game vs Info (N=533[a])	
0.13**	0.15**
(0.05)	(0.06)
DisgustGame vs Control (N=554[a])	
0.23***	0.24***
(0.05)	(0.06)
DisgustGame vs Game (N=545[a])	
0.03	0.04
(0.05)	(0.06)
DisgustGame vs Control (disgust sens., N=554[a])[b]	
-0.02	0.02
(0.08)	(0.08)
DisgustGame vs Game (disgust sens., N=545[a])[b]	
-0.05	0.02
(0.08)	(0.08)
Game/DisgustGame (pooled) vs Control (N=817[a])	
0.21***	0.22***
(0.05)	(0.05)
Game/DisgustGame (pooled) vs Info (N=815[a])	
0.15***	0.17***
(0.05)	(0.05)

Differences-in-differences estimates with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01.
[a]Excluding subjects who prepared only minced meat or no meat in the weeks prior to the pre- or post-survey. [b]Differences-in-differences-in-differences estimate of the difference in treatment effect for above vs below median disgust sensitivity.

Table S.14: DID estimates: bootrapped standard errors and quantile regressions

Targeted efficacy beliefs	Beliefs in myths	Targeted behavior	Targeted efficacy beliefs	Beliefs in myths	Targeted behavior
DID bootstrapped std.err.[a]			Quantile DID[b]		
Game vs Control (N=535)					
0.16***	0.13*	0.20***	0.18***	0.03***	0.15**
(0.04)	(0.07)	(0.05)	(0.05)	(0.00)	(0.07)
Info vs Control (N=542)					
0.14***	0.07	0.06	0.16***	0.02	0.02
(0.04)	(0.07)	(0.05)	(0.06)	(0.02)	(0.07)
Game vs Info (N=533)					
0.01	0.06	0.13***	0.02	0.01	0.13*
(0.04)	(0.07)	(0.05)	(0.05)	(0.02)	(0.08)
DisgustGame vs Control (N=554)					
0.25***	0.15**	0.23***	0.27***	0.06**	0.20***
(0.04)	(0.07)	(0.05)	(0.06)	(0.02)	(0.07)
DisgustGame vs Game (N=545)					
0.09**	0.01	0.03	0.09*	0.02	0.06
(0.04)	(0.07)	(0.05)	(0.05)	(0.02)	(0.08)
Game/DisgustGame (pooled) vs Control (N=817)					
0.20***	0.14**	0.21***	0.22***	0.04***	0.17***
(0.04)	(0.06)	(0.05)	(0.04)	(0.00)	(0.06)
Game/DisgustGame (pooled) vs Info (N=815)					
0.06	0.07	0.15***	0.05	0.02**	0.15**
(0.04)	(0.06)	(0.05)	(0.05)	(0.01)	(0.07)

Differences-in-differences estimates with bootstrapped standard errors in parentheses : * p<.1, ** p<.05, *** p<.01. Regressions with control variables are available upon request.
[a] With bootstrapped standard errors (1,000 replications).
[b] Quantile difference-in-difference regression for the median.

Table S.15: Moderation analysis

	Eff.beliefs[a]	Bel. in myths[b]	Behavior[c]
Game vs Control (N=526)			
Game[c]	0.17***	0.17***	0.20***
	(0.03)	(0.04)	(0.03)
Disgust sensitivity	-0.001	-0.04	0.01
	(0.02)	(0.03)	(0.02)
Game · (Disgust sensitivity)[d]	-0.02	0.03	0.02
	(0.03)	(0.04)	(0.03)
Info vs Control (N=536)			
Info[c]	0.15***	0.09**	0.07***
	(0.02)	(0.04)	(0.03)
Disgust sensitivity	0.001	-0.04	0.02
	(0.02)	(0.03)	(0.02)
Info · (Disgust sensitivity)[d]	0.03	0.07*	-0.01
	(0.03)	(0.04)	(0.03)
DisgustGame vs Control (N=547)			
DisgustGame[c]	0.24***	0.16***	0.23***
	(0.03)	(0.04)	(0.03)
Disgust sensitivity	-0.0003	-0.04	0.002
	(0.02)	(0.03)	(0.02)
DisgustGame · (Disgust sensitivity)[d]	-0.04	-0.01	-0.01
	(0.03)	(0.04)	(0.03)

Outcome measures: [a] targeted efficacy beliefs, [b] beliefs in myths, [c] targeted behavior.
Coefficients with standard errors in parentheses: * p<.1, ** p<.05, *** p<.01.
[c] Treatment dummy. [d] Interaction of treatment dummy and disgust senssitivity
Controls (not reported): targeted efficacy beliefs or beliefs in myths and behavior at baseline and the basic and extended control variables listed in Supplementary Section S.2.1.

S.4 Outcome variables

Table S.16: Items in “Beliefs in myths”

Description	Recoded
Targeted beliefs in myths	
Fruit and vegetables that will be peeled don’t have to be washed	Yes[a]
Any food that has fallen to the floor and did not stay there longer than 5 seconds, is still edible	Yes[a]
Only poultry, not other meats, need to be well-done to be safe to eat	Yes[a]
Non-targeted beliefs in myths	
Washing your kitchen too often creates a sterile environment that is bad for building up a good immune system	Yes[a]
A small amount of alcohol is good to avoid food poisoning	Yes[a]
If the food smells and taste fine it is safe to eat	Yes[a]
Eggs with brown shells are safer than eggs with white shells	Yes[a]
Vegetarians don’t get food poisoning	Yes[a]

Scale: Agree with statement: Yes (1) No (2). [a] Recoded 0=Yes, 1=No.

Table S.17: Items in "Efficacy beliefs"

Description	Recoded
Targeted efficacy beliefs	
Directly targeted	
Peeling unwashed vegetables/fruit	Yes[a]
Rinsing unwashed vegetables/fruit	No
Picking up within 5 seconds any food that has fallen to the ground	Yes[a]
Heating hamburger meat such that only the inside is pink	Yes[a]
Cooking chicken to an inside temperature of 63 degrees Celsius	Yes[a]
Rinsing a whole chicken before preparation	Yes[a]
Rinsing hands under running water without using soap	Yes[a]
Washing hands with soap under running water	No
Washing cutting boards and kitchen tools in between preparing different food items	No
Rinsing a whole melon	No
[c] Cooking an egg until soft-boiled (that is, the white is firm and the yolk is soft)	Yes[a]
Indirectly targeted	
Checking whether a food item smells fine	Yes[a]
Checking with a fork whether the chicken is well done	Yes[a]
Non-targeted efficacy beliefs	
Using brown eggs rather than white eggs	Yes[b]
Only eating organic food	Yes[b]
Only eating home grown food	Yes[b]
Only eating food produced in [UK/Norway]	Yes[b]
Drinking a small amount of alcohol with a meal	Yes[b]
Switching to a vegetarian diet	Yes[b]
Only eating raw food	Yes[a]

Scale: Increases risk by a (1) large (2) small amount, Has no effect on risk (3), Decreases risk by a (3) small (4) large amount [a] Reverse coded, [b] Recoded 3-absolute distance from (3) [c] Targeted only in the video.

Table S.18: Items in "Targeted behavior"

Description	Recoded
Targeted behavior 1-3[a] (Scale 1)	
Did you wash your hands with soap?	No
Did you clean the kitchen surface?	No
Did you rinse a piece of raw meat?	No
Targeted behavior 4-5 (Scale 2)	
I used a food thermometer	No
I did not check whether the meat is done	Yes[b]
Targeted behavior 6-21 (Scale 3)	
A whole raw chicken	Yes[c]
Raw chicken breasts	Yes[c]
Raw beef	Yes[c]
A whole lettuce	No
A whole watermelon	No
An apple	No
A mango	No
An eggplant	No
An onion	No
String beans	No
Brussels sprouts	No
Potatoes	No
Carrots	No
Berries	No
An avocado	No
Bean sprouts	No

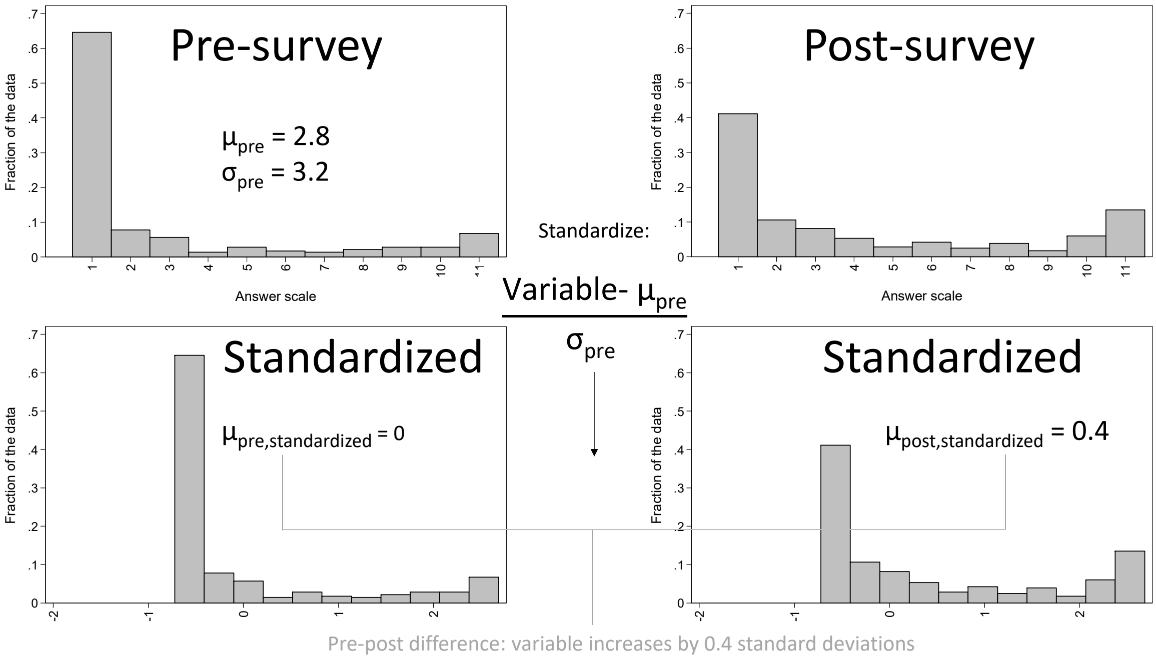
Scale 1: Never (1), Once (2), Twice (3), 3-4 times (4), 5 times or more (5). Scale 2: Yes (1), No (2). Scale 3: How likely would you be to rinse before further preparation/consumption? No chance or almost no chance (1 in 100) (1) ... Certain or practically certain (99 in 100) (11). [a] One pre-registered behavior question (Did you clean the kitchen surface?) was accidentally omitted by the survey company and this was only noticed half-way into the data collection. We perform the main analysis without it and report in additional analyses for this measure in Supplementary Figure S.5. [b] Recoded 0=Yes, 1=No. [c] Reverse coded.

Table S.19: Items in "Non-targeted behavior"

Description	Recoded
Non-targeted behavior 1[a] (Scale 1)	
Checked the temperature of the fridge last week?	Yes[a]
Non-targeted behavior 2-3[a] (Scale 2)	
Check the use-by-date of food item when you shop?	No
Check the use-by-date of food item when you are about to prepare food?	No
Non-targeted behavior 4[a] (Scale 3)	
Last week, how often did you seek information about how to safely handle food?	No

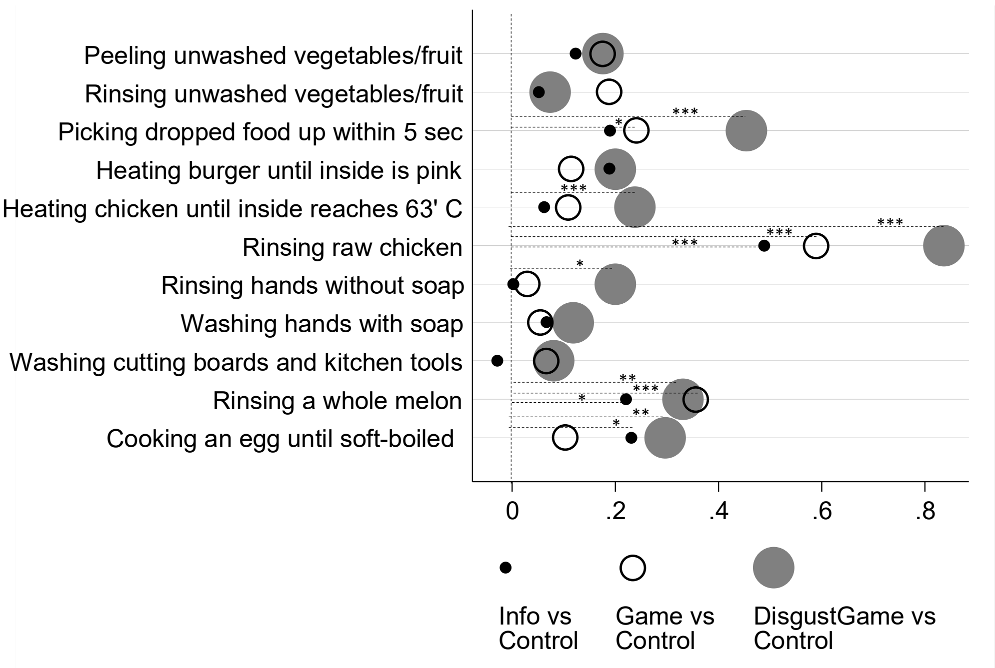
Scale 1: Yes (1), No (2). Scale 2: No chance or almost no chance (1 in 100) (1) ... Certain or practically certain (99 in 100) (11). Scale 3: Never (1), Once (2), Twice (3), 3-4 times (4), 5 times or more (5). [a] Recoded 0=Yes, 1=No. [c] Reverse coded.

Figure S.1: Illustration of standardization procedure



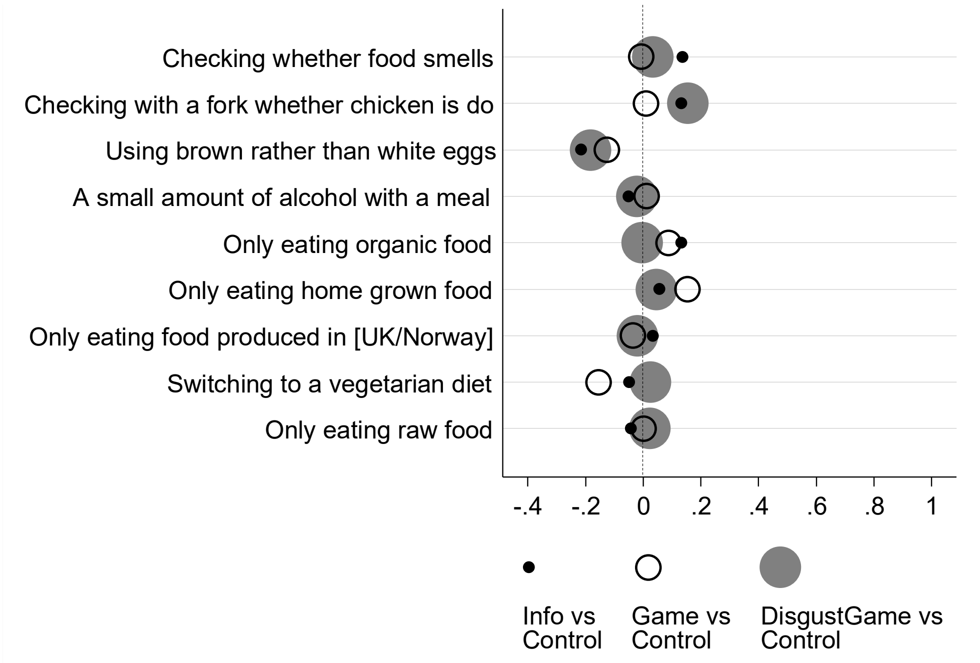
S.5 Analysis of individual items

Figure S.2: DID estimates for targeted efficacy beliefs



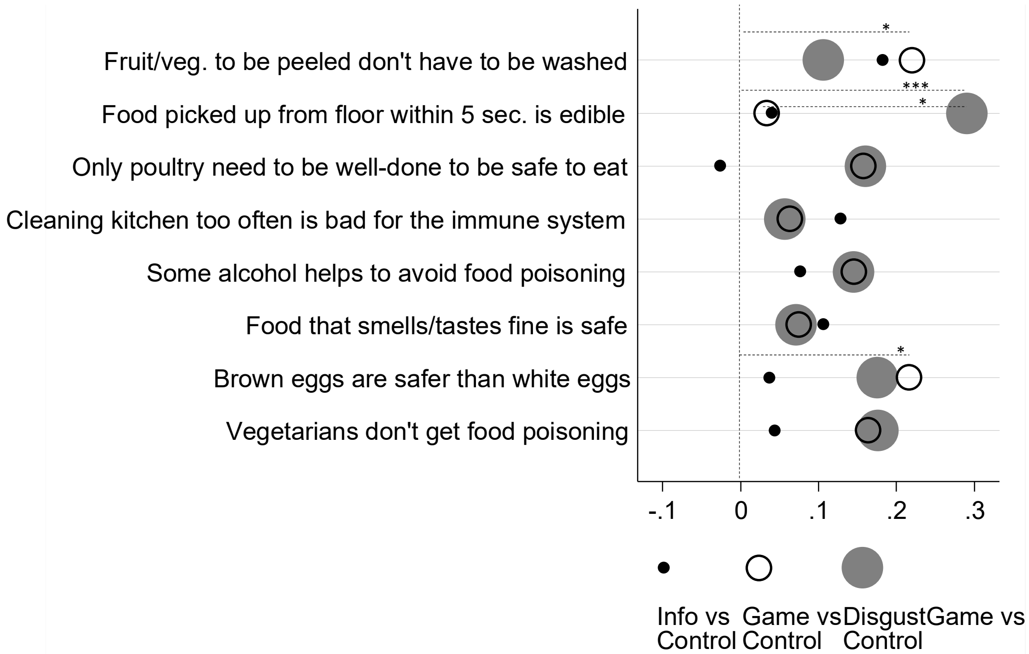
Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in beliefs (cf. Table S.17).

Figure S.3: DID estimates for indirectly or non- targeted efficacy beliefs



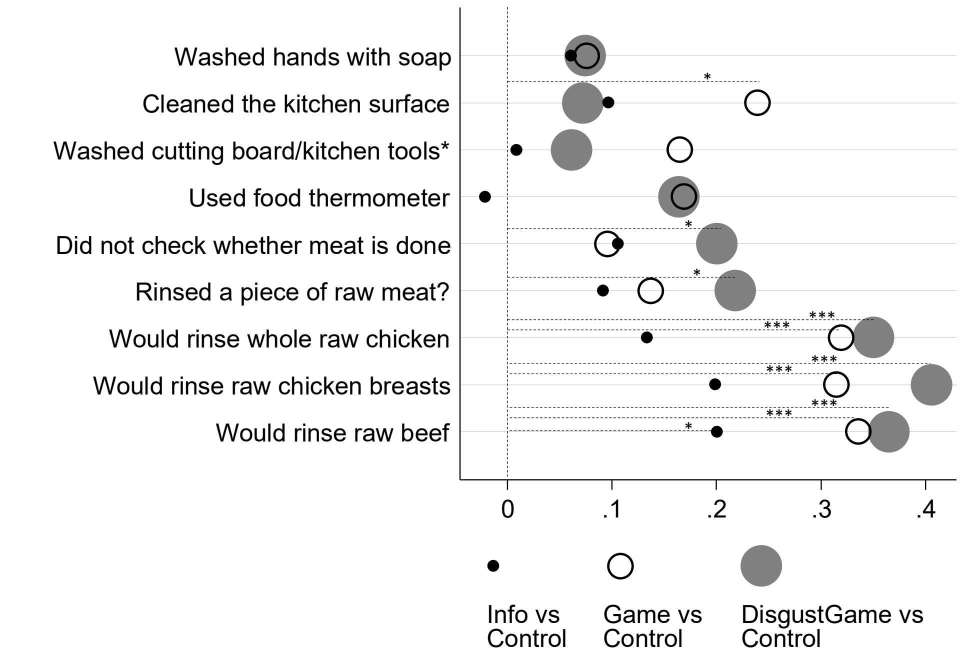
Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in beliefs (cf. Table S.17).

Figure S.4: DID estimates for beliefs in myths



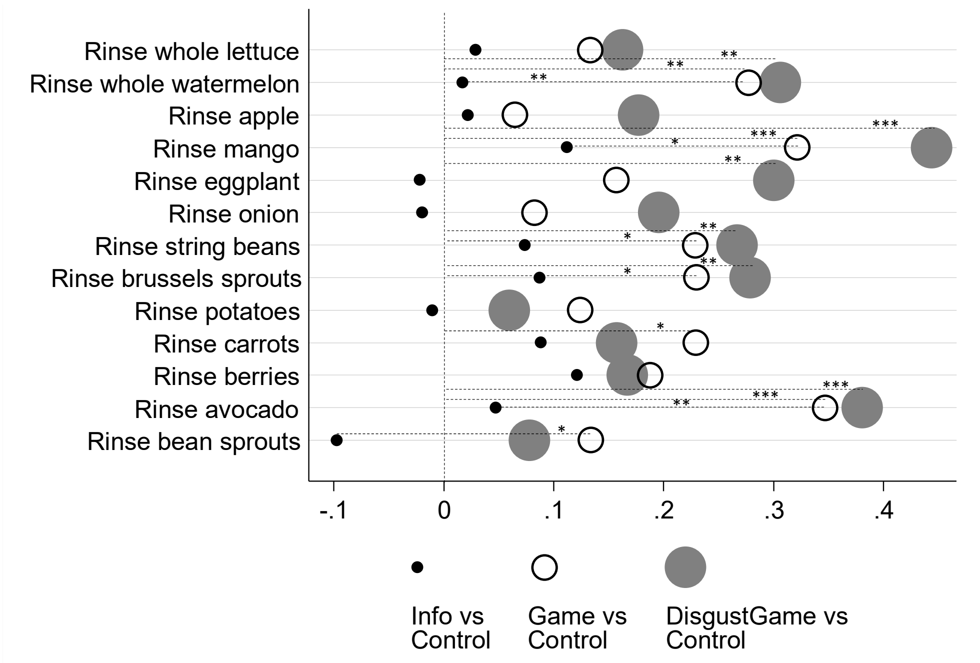
Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in beliefs (cf. Table S.16).

Figure S.5: DID estimates for targeted behavior



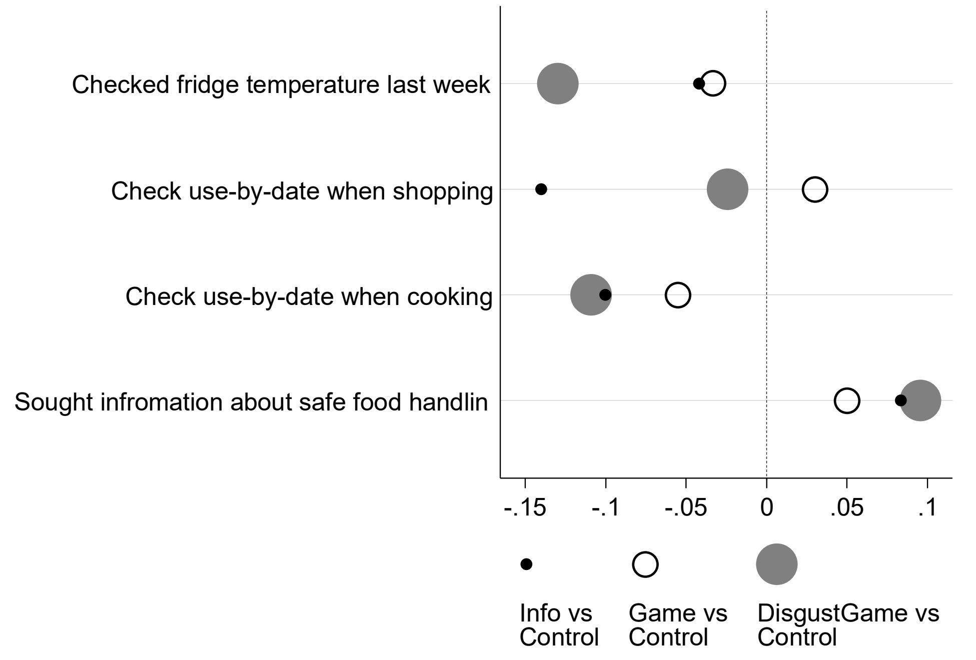
Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in behavior (cf. Table S.18). *This pre-registered behavior question was accidentally omitted by the survey company and this was only noticed half-way into the data collection.

Figure S.6: DID estimates for targeted behavior



Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in behavior (cf. Table S.18).

Figure S.7: DID estimates for non-targeted behavior

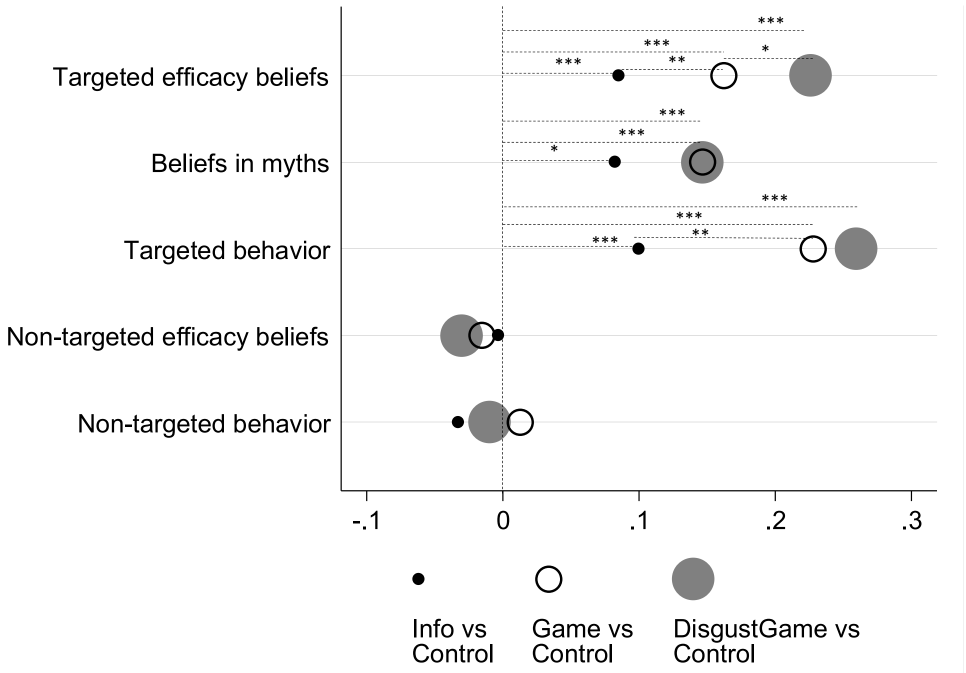


Notes: Whenever relevant, items are recoded so that a positive change between pre- and post-survey responses indicates an improvement in behavior (cf. Table S.19).

S.6 Extended sample and age effects

Figure S.9-S.11 shows that treatment effects are failry consistent across the age range. To avoid clutter, the figures show the 95-percent confidence band only for the control treatment (cf. Supplementary Table S.20). It is worth noting, however, that confidence bands become quite wide for some of the treatments above age 65 (not shown in the figures) because there are relatively few participants in this category and they are not balanced across treatments.

Figure S.8: Average treatment effects for the main outcomes (extended sample including individuals older than 50)



Note: Differences-in-differences estimates. * p<.1, ** p<.05, *** p<.01.

Figure S.9: Pre-post change in targeted efficacy beliefs by age

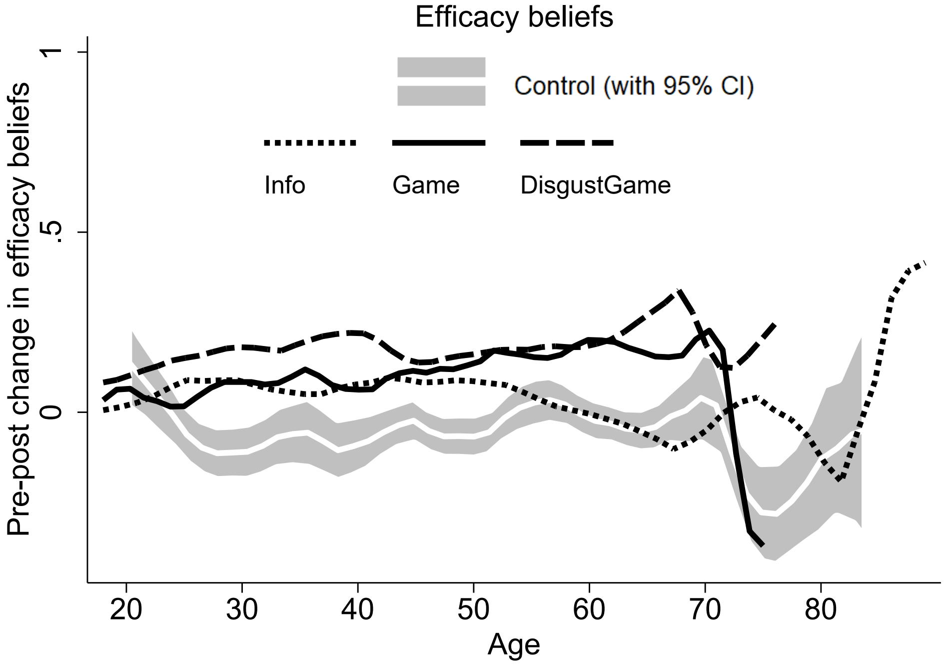


Figure S.10: Pre-post change in beliefs in myths by age

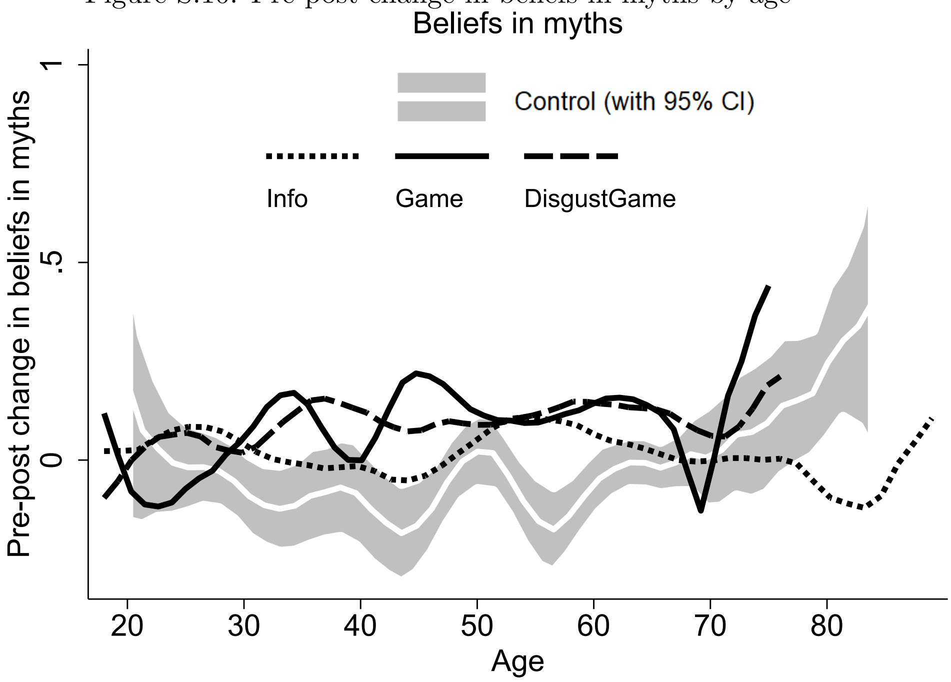


Figure S.11: Pre-post change in targeted behavior by age

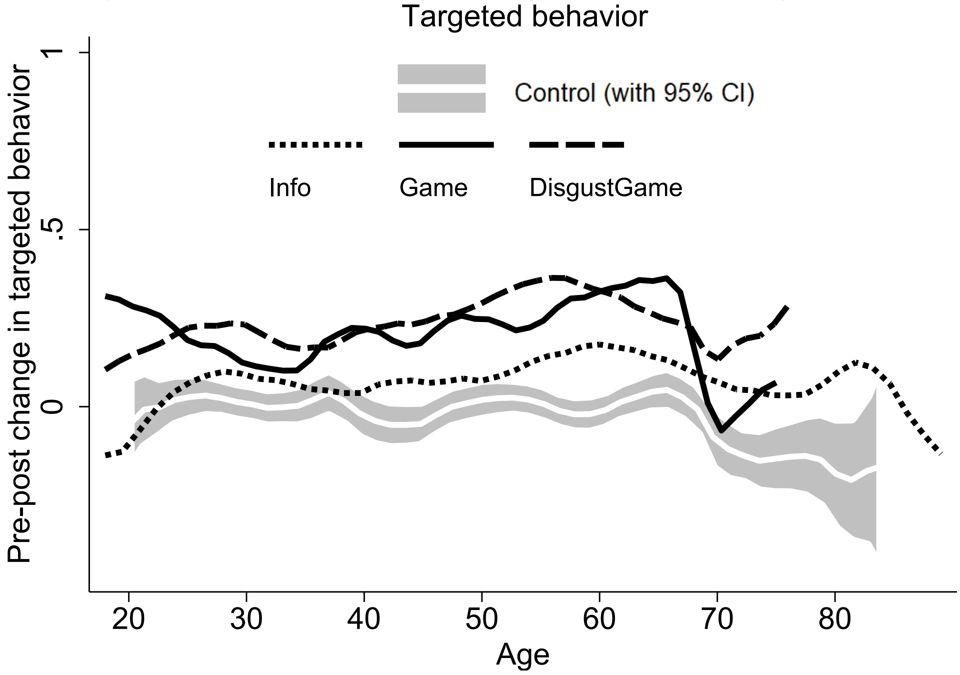
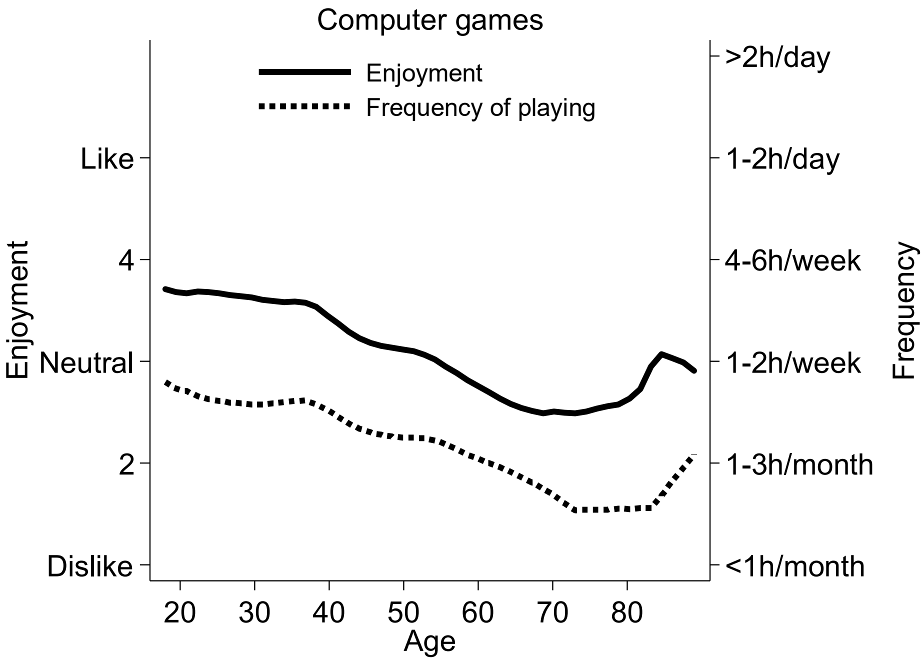


Table S.20: Age distribution (extended sample including individuals older than 50 years)

Age	Control	Info	Game	DisgustGame	All
18 - 30	65	72	88	80	305
31-40	73	87	84	94	338
41-50	134	113	96	114	457
51-60	121	130	105	108	464
61-70	120	108	54	39	321
71- 89	34	45	3	6	88
N	547	555	430	441	1973

Figure S.12: Enjoyment and frequency of gaming



S.7 Screenshots

Figure S.13: Screenshot from the information video

Figure S.14: Screenshot from the information video with disgust frame