# Testing the adaptability of people's use of attribute frame information

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Abstract

The informational leakage account of attribute framing effects proposes that a communicator's choice of frame provides informational value, such that different frames are not informationally equivalent. Across five studies communicating food risks, we investigated the adaptability of communication recipients' (our participants) use of frame information by manipulating the degree to which the communicator ostensibly had a choice over how the information was framed. Within-participants framing effects were observed across all conditions of all studies. Only in Study 4 (the only study in which communicator choice was manipulated within-participants) was there any evidence for an attenuation of framing effects where the communicator was not responsible for how the information was framed. Overall, regardless of whether or not framing effects are driven by the informational value contained in a communicator's choice of frame, people show little sensitivity to situations where that choice is removed.

Keywords: Communication; Grice; Pragmatics; Framing; European Food Safety Authority

## 1. *Introduction*

Imagine if food experts claimed to be 95% certain that a new food technology did *not* pose harm to human health. How worried would you feel about eating food incorporating such a technology? How likely would you be to consume the food? Would these judgments change if experts claimed to be 5% certain that the food technology *did* pose harm to human health? Whilst we assume here that these two communication 'frames' are mathematically equivalent, you would be following in the footsteps of our participants if you felt more concern, and were less likely to consume the food given the latter (5%) communication frame. This is an example of the oft-replicated attribute framing effect (e.g., Levin & Gaeth, 1998).

Framing effects refer to the phenomenon whereby people's judgements and decisions systematically change depending on the wording of logically equivalent descriptions or questions. The three main classes of framing effect are: *risky choice* (e.g., Tversky & Kahneman, 1981), *goal* (e.g., Meyerowitz & Chaiken, 1987), and *attribute* (e.g., Levin & Gaeth, 1988; see Levin et al., 1998, for a review of all three classes of framing effect). Attribute framing effects derive from alternative (but logically equivalent) descriptions of single attributes. For example, beef that contains 25% fat can be described as "25% fat", or as "75% lean". Despite the logical equivalence of these frames, Levin and Gaeth (1988) observed a 'valence-consistent shift' in preference, such that consumers rated beef more favourably when its description focussed on the positive (75% lean; see also e.g., Sanford et al., 2002). This attribute framing effect has been replicated across numerous domains, including gambling decisions (Levin et al., 1986), surgery evaluations (Wilson et al., 1987), and project funding allocations (Dunegan, 1993; see Table 3 in Levin et al., 1998, for a summary of attribute framing effects).

Framing effects have been considered a core demonstration of human irrationality, since they demonstrate a violation of the invariance principle of rationality (e.g., Tversky & Kahneman, 1986). In terms of explanations, Levin and colleagues (Levin, 1987; Levin et al., 1998) originally proposed an association-valence account of attribute framing effects. This account posits that favorable associations are evoked when attributes are described positively, while unfavourable ones are evoked when attributes are described negatively (see Kreiner & Gamliel, 2018; Teigen, 2015, for somewhat related priming and attention-based accounts). Thus, people evaluate beef labelled as "25% fat" less favourably because the term "fat" evokes negative associations.

In contrast to the aforementioned accounts, the information leakage account (McKenzie & Nelson, 2003; Sher & McKenzie, 2006, 2008) questions the irrational nature of attribute framing effects. The starting point for the information leakage account is the recognition that speakers have a choice over the way in which they frame a description. Consequently, if there is any systematicity in such choices, then, despite being *logically* equivalent, alternative frames will not be *informationally* equivalent. Across four studies, McKenzie and Nelson (2003) and Sher and McKenzie (2006; see also Teigen & Karevold, 2005) observed considerable systematicity in speaker choice of frame. In particular, these studies demonstrated that frame choice can leak information about 'reference points': attributes are more likely to be described in terms of the attribute that is *greater* than a reference point. For example, a 500 ml. glass containing 250 ml. of water is more likely to be described as half-full (rather than half-empty) if it was previously empty, than if it was previously full (McKenzie & Nelson, 2003). More generally, 'good' things are more likely to be communicated using positive frames, and 'bad' things are more likely to be communicated using negative frames (Sher & McKenzie, 2006). As a demonstration, Sher and McKenzie (2006) provided participants with a description about a Research & Development team that was clearly described as either very good or very bad.

Both teams, however, had a previous project success rate of 30/50. Describing the team's track record, participants were eight times more likely to describe the bad team's track record in terms of failures, "Of the last 50 projects undertaken by the team, 20 were failures" (24%) than they were to describe the good team's track record as such (3%). This result demonstrates the informational value of frame choice to subsequent evaluations. If $P$(failureFrame | badTeam) > $P$(failureFrame | goodTeam), the choice of frame is diagnostic to an overall evaluation, and should be incorporated in a rational evaluation of a team, constituting Sher and McKenzie's "implicit recommendation hypothesis" (p. 483).

The informational leakage account therefore posits that attribute framing effects reflect a listener's sensitivity to the information conveyed by a speaker's choice of frame. Note that we cannot presently say that listeners' use of this information is completely rational (i.e., their evaluations incorporate the information from the frame choice to a quantitatively appropriate degree). The demonstration of systematicity in speakers' choices of frames does, however, demonstrate that framing effects do not represent a violation of the principle of invariance, since the information provided should not be considered informationally identical (the information, not just the description, is changed by alternative framings). Leong et al. (2017) provided further evidence that listeners make use of information provided by frame choice. In their Experiment 2, individuals high in domain knowledge demonstrated reduced framing effects compared with those low in domain knowledge. On the information leakage account, the explanation for such a result is that individuals high in domain knowledge learn very little about from the communicator's choice of frame, since they already possess considerable relevant background information.

The informational leakage account outlines the informational value provided by the systematicity in speakers' frame usage. Communication frame thus only provides informative value where communicators have a choice over how to frame a communication. Although Sher

and McKenzie (2006, Footnote 3) explicitly made no assumptions about the role of conversational pragmatics (Grice, 1975/2001) in conjunction with the informational leakage account, participants' susceptibility to framing effects has been shown to be sensitive to manipulations of communicator cooperativeness. Specifically, Keren (2007) observed that framing effects were attenuated where speakers were described as potentially untrustworthy. Such a result potentially indicates that listeners believe communicators will choose frames so as to influence them, and they (listeners) correspondingly adjust their use of frame information.

Whilst Keren (2007) suggested that listeners are sensitive to a possibility that non-cooperative speakers may use frame choice in a manipulative manner (when alerted to this possibility), the present study seeks to test whether listeners are sensitive to non-interpersonal information that seeks to *eliminate* all informativeness of the communication frame. The informational leakage account rests on the recognition that a speaker's choice of frame is systematic and therefore informationally relevant. Consequently, where a speaker no longer has a choice of frame, the framing of a communication is no longer informative. If participants are adaptable in their use of frame information, the prediction is that framing effects will be attenuated in communications where the speaker does not have a choice of frame. Returning to our example outlined at the beginning of this manuscript, we predict that the difference in your worry ratings (and likelihood of consumption ratings) for the two different ways of framing the risk to health will be reduced if you learn that a communication policy mandated that the food experts *had* to communicate their certainty levels with either the more likely ("95% certain that the technology does *not* pose harm to human health") or less likely ("5% certain that the technology *does* pose harm to human health") state of affairs.

Although the informational leakage account (as presently formulated) makes no predictions as to people's sensitivity to such contextual factors ("whether and how listeners…consider informative intentions or conversational norms is a question for future

research to address" [Sher & McKenzie, 2006, Footnote 3, p. 470]), undertaking such research is critical to understanding the full theoretical status of the attribute framing effect, as well as its likely scope and robustness within applied contexts. If framing effects are eliminated in contexts where frames carry no informational relevance, this provides additional evidence for the rationality of participants' use of frame information. Moreover, in applied contexts, where a frame choice is determined by (potentially arbitrary) convention, or mandate, or by the toss of a coin[!], that choice process may be communicated to information recipients, so as to prevent any undue influence of an uninformative communication frame. Conversely, if framing effects persist in contexts where frames carry no informational relevance, this provides evidence against the argument that people's use of frame information is completely rational. Moreover, such a result would highlight the robustness, prevalence and universality of framing effects across contexts, and suggest that even arbitrary frames will likely affect individual's judgments and choices, in a way that is not easily resolved through communication of that frame's origin (e.g., convention or mandate).

In the current studies, we presented participants with information regarding food related risks. This is in response to EFSA (European Food Safety Authority) recommendations that risks should always be framed in terms of the more likely outcome (i.e., all risks will be presented as greater than 50%; Hart et al., 2019). If we provide participants with information about the EFSA guidelines, which informs them that risk communicators have frame choice imposed on them, will framing effects be attenuated in line with the predictions of an *adaptable* informational leakage account? Upon observing no evidence for such an attenuation in Study 1, Studies 2-5 employed alternative materials designed to increase the salience of the manipulation attempting to highlight the communicator's lack of frame choice, including manipulations where the choice of frame explicitly resides with the consumer (Studies 4 & 5).

Study 5 additionally provided initial support for the generalisability of the current results beyond the domain of food risks.

## *2. Study 1*

### *2.1. Method*

Ethical approval for all studies was granted by the Departmental Ethics Chair for Speech, Hearing and Phonetic Sciences (University College London). In all studies, participants were informed in the study information sheet that the scenarios that they were reading were hypothetical and constructed for the purpose of the study, but asked to treat them as though they were real. This information was repeated in the task instructions following indication of consent to participate. At the conclusion of the studies, participants who wished to understand more about the subject of food risk were directed to the website of the Food Standards Agency (https://www.food.gov.uk).

#### *2.1.1. Participants*

200 Native English speakers were paid £1.25 for participating in the 10-minute study, advertised via Prolific (www.prolific.co). Participants were excluded: if their year of birth did not match their reported age, if they reported a native language other than English, for reporting dietary requirements that would mean they would not consume some of the products included

in the study, spending less than three seconds reading the critical manipulation text. Table 1 shows the demographics of participants after exclusions[1].

[1] These exclusion criteria do not affect any of the conclusions from this manuscript.

**Table 1**

***Demographics of participants across all studies.***

| | **Males** | **Females** | **Other gender / Prefer not to say** | **Age range (Median)** | **No choice / Consumer choice condition** | **High choice / Communicator choice condition** | **Number of participants who consume meat more than 4 days a week (the largest group in every study)** |
|---|---|---|---|---|---|---|---|
| **Study 1** | 87 | 88 | 1 | 18-76 (36) | 82 | 94 | 80 |
| **Study 2** | 52 | 142 | 0 | 18-73 (33) | 96 | 98 | 100 |
| **Study 3** | 58 | 137 | 0 | 18-71 (32) | 98 | 97 | 77 |
| **Study 4** | 81 | 122 | 1 | 18-69 (33) | 204 | 204 | 95 |
| **Study 5** | 77 | 128 | 1 | 18-66 (33.5) | 102 | 104 | 91 |

*2.1.2. Design*

A 2 (frame) × 2 (communicator choice) mixed design was employed. Message frame was manipulated within-participants (in a counterbalanced order). The risk communication was framed in either the Positive, 'more likely' frame (e.g. "experts are **80% certain** that consuming crops sprayed with Pesticide G **would not** pose harm to human health"), or the Negative, 'less likely' frame (e.g. "experts are **20% certain** that consuming crops sprayed with Pesticide G **would** pose harm to human health"). Five probability levels were used (Positive: 75% to 95%; Negative: 5% to 25%), and paired randomly with five vignettes (pairing was kept constant across participants; see Table 2). An example vignette is shown in Figure 1 (see Appendix A for all vignettes). High probabilities were paired with desirable outcomes (i.e., no harm), and low probabilities with undesirable outcomes (i.e., harm), reflecting a pattern more likely to emerge in real-world communications about food safety.

**Figure 1**

*An example vignette used in Study 1.*

Imagine that a new pesticide, Pesticide G, has recently been developed to help protect crops from damaging pests. This allows higher returns from the crops grown, which then helps to lower market prices of crops. It is also claimed to be biodegradable so that its usage has minimal impact on the environment (e.g. reducing the risk of other organisms and animals coming into contact with it). A food safety organisation has therefore commissioned a study to evaluate the health risk associated with Pesticide G. Based on their findings, experts are **20% certain** that consuming crops sprayed with Pesticide G **would** pose harm to human health.

The second independent variable, communicator choice, was manipulated between-participants. Participants were randomly assigned to either the No-choice or the High-choice condition. The No-choice condition included an initial statement that informed of a communications guidance that recommends risks are framed in a single direction (closely following Hart et al.'s, 2019, text; see Figure 2). The High-choice condition simply omitted these recommendations, given that the informational leakage account proffers an explanation for standard attribute framing effects (as this condition is designed to demonstrate) in terms of systematicity in the communicator's choice of frame.

The dependent variables were Worry and Likelihood of consumption. Worry was operationalised as "How worried are you about consuming such a product" - rated on a 7-point scale from 1 (*Not worried at all*), to 7 (*Extremely worried*). Likelihood of consumption was operationalised as "How likely would you be to consume the product" – another 7-point scale, from 1 (*Not likely at all*) to 7 (*Extremely likely*).

**Figure 2**

*Regulations provided in the No-choice condition of Study 1.*

Block 1: In order to improve the communication of risk to the public, a new communications guidance was published this year. The key recommendation was for the risk communicator to frame the message as % certainty for the outcome, conclusion or range of values that is considered ***more/less*** likely.

Block 2: A **different** communications guidance was later published to replace the earlier guidance. In this guidance, the key recommendation was for the risk communicator to frame the message as % certainty for the outcome, conclusion or range of values that is considered ***less/more*** likely.

*2.1.3. Materials*

The five vignettes presented five distinct food-related risks, first in one frame and then (after a filler task) in another. These hypothetical food-related risks were linked to food technologies that have, at some stage, been met with controversy, and received considerable media attention (e.g., Barrell, 2019; O'Carroll, 2018; Sissons, 2020; see Table 2). The vignettes are reproduced verbatim in Appendix A. The studies were programmed in Qualtrics (www.qualtrics.com), and pdfs of the full Qualtrics surveys for each of the experiments reported here are available at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a.

**Table 2**

***Food risks included in all studies.***

| **Vignette** | **Chance of harm / Chance of no harm** | |
|---|---|---|
| | *Studies 1-3* | *Studies 4 & 5* |
| Hormone for beef production | 5% / 95% | 25% / 75% |
| Feed additive for pork production | 10% / 90% | 15% / 85% |
| Chemical for washing chickens | 15% / 85% | 20% / 80% |
| Pesticide | 20% / 80% | 10% / 90% |
| New technology for GM food production | 25% / 75% | 5% / 95% |

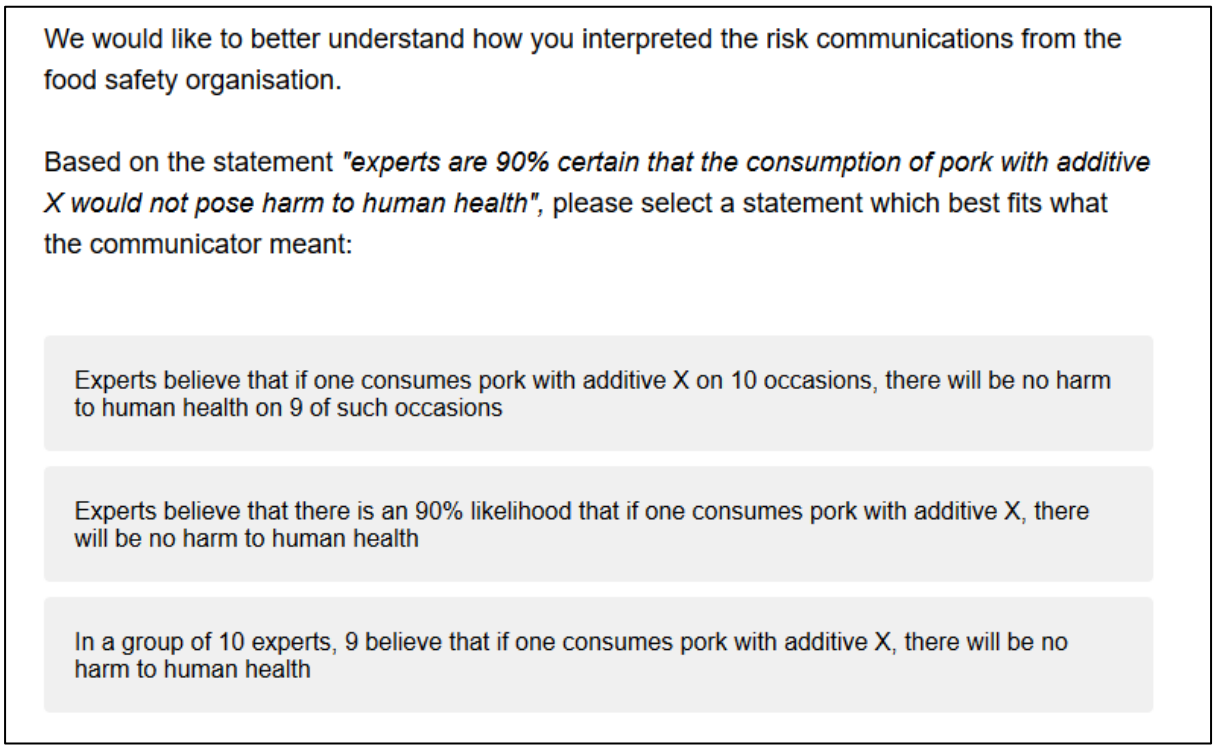
Note: Within a study, the same vignettes were always described with the same percentage risk.

*2.1.4. Procedure*

Participants first provided informed consent to participate in the study. Five vignettes were then presented (in randomised order) in one of the two message frames, with ratings of worry and likelihood of consumption obtained after each one. Participants then completed a 2-5 minute filler task requiring them to make likelihood judgments for the outcomes of different dice rolls in a revised Monopoly game and reported their age and gender, before receiving the vignettes in the opposite frame. Following this, in addition to the central questions of interest, a question was included to assess participants' understanding of the conveyed uncertainty (Frequentist, Bayesian or percentage of experts supporting the conclusion, where Hart et al. [2019] identify the final interpretation as erroneous). The specific question asked is shown in Figure 3. After this, participants were asked to report: their Prolific ID (as per instructions from Prolific); any dietary preferences; the frequency of their consumption of chicken, beef, or pork per week (1 day, 2 days, 3 days, 4 days, more than 4 days); what they thought the aim of the experiment was. Finally, participants were thanked and debriefed.

**Figure 3**

*Participants were asked how they understood the risk communications in Studies 1 and 2. The three options represent Frequentist, Bayesian and 'Percentage of Experts supporting the conclusion' interpretations respectively.*




*2.2. Results*

The data for all studies reported are available at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a.

A framing effect was observed across both the worry and consumption likelihood ratings, such that participants were more worried and less likely to consume products when risks were framed negatively, as (less than 50%) chance of harm, than when framed positively, as (greater than 50%) chance of no harm (see Figure 4), Worry: $F(1, 174) = 122.01$, $p < .001$, $eta_p^2 = .41$; Consumption likelihood: $F(1, 174) = 108.20$, $p < .001$, $eta_p^2 = .38$. This effect was

observed alongside the predicted effect of vignette (seeing as the probabilities of harm are different across the vignettes), Worry: $F(2.98, 519) = 122.12$, $p < .001$, $eta_p^2 = .39$; Consumption likelihood: $F(3, 521.99) = 79.80$, $p < .001$, $eta_p^2 = .31$ (Greenhouse-Geisser corrections applied here and elsewhere, wherever there is evidence for violation of the equality of variance assumption). The frame × vignette interaction was non-significant for Worry, $F(3.77, 656.37) = 1.72$, $p = .14$, $eta_p^2 = .01$, but significant for Consumption likelihood, $F(4, 696) = 2.58$, $p = .04$, $eta_p^2 = .02$.[2]

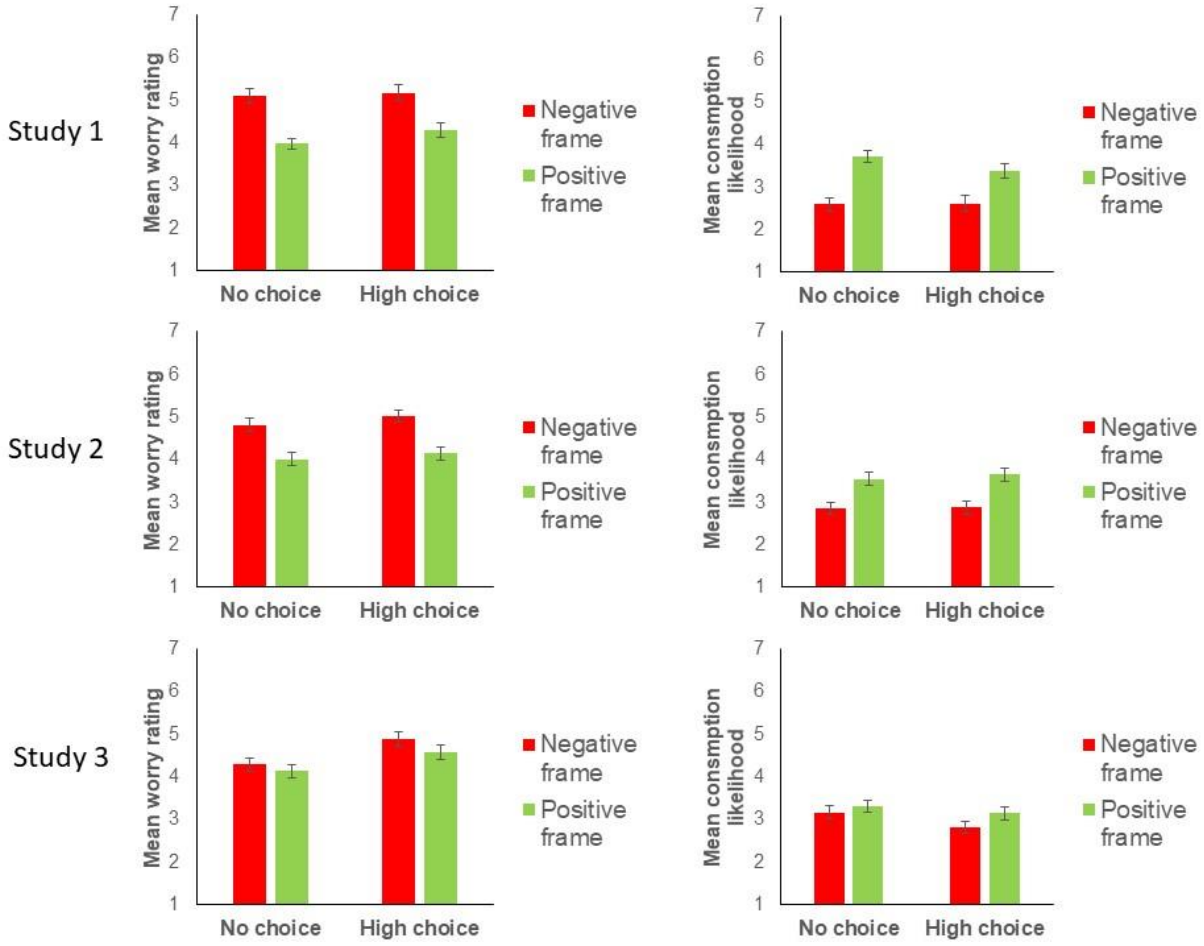
Crucially, there was no evidence that the effect of frame was attenuated in the No-choice condition. In the worry data, the frame × choice interaction was not significant, $F(1, 174) = 1.71$, $p = .19$, $eta_p^2 = .01$, whilst the significant frame × choice interaction in the consumption likelihood ratings, $F(1, 174) = 4.00$, $p = .047$, $eta_p^2 = .02$, represented an unpredicted opposite effect, with a larger effect of frame in the low choice condition (see Figure 4). To foreshadow future results, this latter was observed in no other studies. Given, additionally, that it was not hypothesised, we are wary of over-interpreting this result. No 3-way interactions were observed ($F$s < 1).

Turning to participants' interpretations of the risk communications, the majority, 132 (72%), endorsed the Bayesian interpretation, whilst only 16 (9%) endorsed the erroneous 'percentage of experts' interpretation.

[2] Because our focus here is on the attenuating effect of the choice variable on framing effects, we do not describe the frame × vignette interactions in the main text, but they are presented graphically at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a (additional analyses). In brief, across the five studies, the largest framing effects appear to be observed for the 80% risk.

**Figure 4**

*Mean worry ratings (left panel) and mean consumption likelihood ratings (right panel) across all conditions of Studies 1-3. Error bars are plus and minus 1 standard error.*




3. *Study 2*

Study 1 presented the framing regulation as a *recommendation.* Study 2 sought to strengthen this manipulation by framing the regulation as a *requirement*.

### *3.1. Method*

Participants were recruited as in Study 1 (see Table 1 for demographics). There were four changes to the method from Study 1. Figure 5 illustrates the strengthening of the No-choice condition, by emphasising that the use of the particular frame is a *requirement*, rather than a recommendation. In addition, this requirement was made more salient to participants and their understanding was checked by asking them a manipulation check immediately after they read the guidance (for both frames). Participants were asked "Which of the following communications would be in line with the guideline prescribed above?" And asked to select either "The experts are 70% certain that consuming product ABC would pose no harm to human health" or "The experts are 30% certain that consuming product ABC would pose harm to human health."

**Figure 5**

*Regulations provided in the "no choice" condition of Study 2.*

Block 1: In order to improve the communication of risk to the public, a new communications guidance was published this year. The guidance was formulated using evidence from the scientific literature and contains guidelines for risk communicators to better communicate their conclusions. The guidance hopes to increase the transparency of scientific findings, in a bid to build trust and credibility with the public. Hence, risk communicators **are required** to follow the guidelines prescribed by the communications guidance. The key guideline of the guidance was for the risk communicator to frame the message as % certainty for the outcome, conclusion or range of values that is considered ***more/less*** likely.

Block 2: Following a review of the current communication guidance, a different communications guidance was published to replace it. The new guidance is based on the recent findings of scientific studies that suggest slight changes to the original guidelines. Once again, risk communicators are **required** to follow the guidelines prescribed by the communications guidance. In this guidance, the key guideline was for the risk communicator to frame the message as % certainty for the outcome, conclusion or range of values that is considered ***less/more*** likely.

Additionally, a second manipulation check was included at the top of the same page where participants were asked for their interpretation of risk communications (Figure 3). Participants were asked "How much freedom do you think the risk communicator had when deciding whether to present the risks about the foods in terms of risks of harm, OR risks of **no** harm" (emphasis in original). Participants responded on a seven-point scale between '1 (*None at all*)' and '7 (*Complete freedom*).' All other elements of the method were as in Study 1.

Finally, the ‘Monopoly’ filler task was replaced with one which required participants to report the extent of lava flows following a volcanic eruption.

### *3.2. Results*

#### *3.2.1. Manipulation checks*

In the low choice condition, the majority of participants, 61 (64%), correctly answered which communication would be in line with the EFSA guidance for *both* frame levels. No participants were excluded from subsequent analyses on the basis of these responses, but all significance patterns are unchanged if the 35 who answered one (n = 27) or both (n = 8) questions incorrectly are excluded.

Participants did perceive the communicator to have more freedom over frame choice in the High-choice condition ($M$ = 4.93; $SD$ = 1.62) than the No-choice condition ($M$ = 3.47; $SD$ = 1.78), $t(192) = 5.98$, $p < .001$, although this difference was not as great as might have been expected.

#### *3.2.2. Primary analyses*

A framing effect was observed across both the worry and consumption likelihood ratings, such that participants were more worried and less likely to consume products when risks were framed negatively, as (less than 50%) chance of harm, than when framed positively, as (greater than 50%) chance of no harm (see Figure 4), Worry: $F(1, 192) = 107.06$, $p < .001$, $eta_p^2 = .36$; Consumption likelihood: $F(1, 192) = 75.27$, $p < .001$, $eta_p^2 = .28$. This effect was observed alongside the predicted effect of vignette (seeing as the probabilities of harm are different across the vignettes), Worry: $F(3.03, 581.40) = 86.88$, $p < .001$, $eta_p^2 = .31$; Consumption

likelihood: $F(2.96, 567.68) = 56.78$, $p < .001$, $eta_p^2 = .23$. The frame × vignette interaction was significant for both Worry, $F(3.65, 701.39) = 6.22$, $p < .001$, $eta_p^2 = .03$, and Consumption likelihood, $F(3.64, 699.60) = 3.06$, $p = .02$, $eta_p^2 = .02$.

Crucially, there was no evidence that the effect of frame was attenuated in the No-choice condition, with non-significant frame × choice interactions for both worry, $F(1, 192) = 0.17$, $p = .68$, $eta_p^2 < .01$, and consumption likelihood ratings, $F(1, 192) = 0.18$, $p = .68$, $eta_p^2 < .01$. No 3-way interactions were observed ($F$s < 1).

In an exploratory analysis, we correlated the size of individual framing effects (difference scores between ratings in the Positive frame versus Negative frame) with participants' 'perceived freedom' ratings from the manipulation check question. The greater freedom the communicator was perceived to have in their communication, the greater the size of the framing effect (consistent with participants' adaptable use of frame information). This relationship was significant for worry ratings, $r = .196$, $p = .006$, but not for consumption likelihood ratings, $r = .132$, $p = .067$.

Turning to participants' interpretations of the risk communications, the majority, 141 (73%), endorsed the Bayesian interpretation, whilst only 19 (10%) endorsed the erroneous 'percentage of experts' interpretation.

### *4. Study 3*[3]

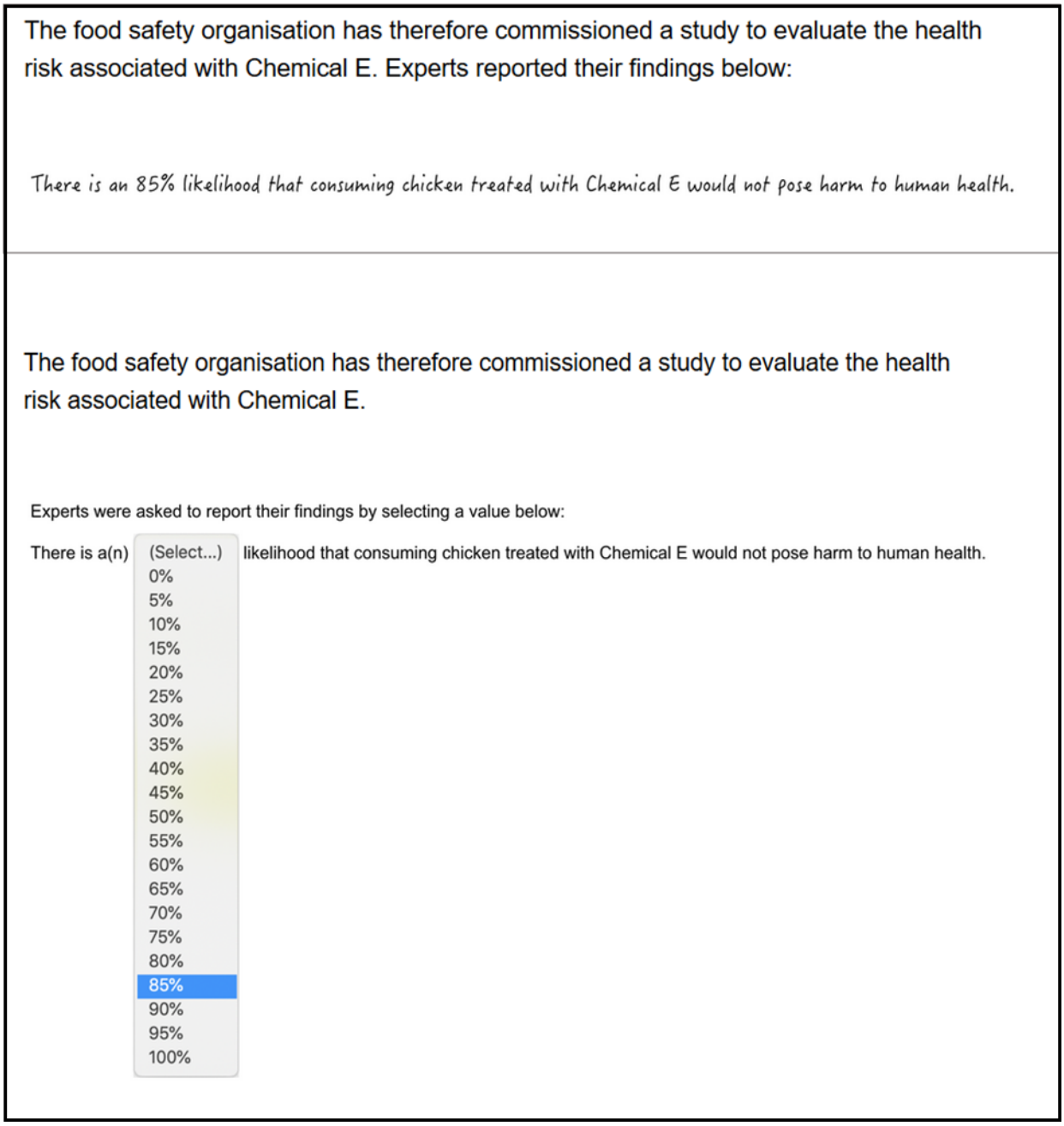
Study 3 attempted a more heavy-handed manipulation of choice, by showing participants alternative response options for how risk experts could present their risk. In the standard, High-choice condition, participants read a full sentence ostensibly written by the risk expert,

[3] Study 3 was run concurrently with Study 1, as an alternative way of addressing the same research question. Study 2 followed. The labelling of studies here reflects the fact that Study 2 was the closest follow-up of Study 1.

suggesting that the expert was free to express the risk in whatever format they saw fit. In the No-choice condition, participants were shown that the experts were only provided with one frame with which they could provide their risk estimate, simply by choosing a suitable probability value (see Figure 6).

**Figure 6**

*The risk communications in the High-choice (top) and No-choice (bottom) conditions of Study 3.*



*4.1. Method*

Participants were recruited as in Study 1 (see Table 1 for demographics). The only change from Study 1, was that communicator choice was manipulated as in Figure 6, such that there was no inclusion of any additional text pertaining to regulations for risk communication format. As in Study 1, there was no manipulation check in Study 3. Study 3 also did not include the question asking participants for their interpretation of the risk communication (Figure 3). Given the consistency of responses – and low percentage of participants providing the unintended answer – to this question in Studies 1 and 2, we also did not reproduce this question in subsequent studies.

*4.2. Results*

A framing effect was observed across both the worry and consumption likelihood ratings, such that participants were more worried and less likely to consume products when risks were framed negatively, as (less than 50%) chance of harm, than when framed positively, as (greater than 50%) chance of no harm (see Figure 4), Worry: $F(1, 193) = 6.45$, $p = .012$, $eta_p^2 = .03$; Consumption likelihood: $F(1, 193) = 7.27$, $p < .01$, $eta_p^2 = .04$. This effect was observed alongside the predicted effect of vignette (seeing as the probabilities of harm are different across the vignettes), Worry: $F(3.25,626.92) = 45.67$, $p < .001$, $eta_p^2 = .19$; Consumption likelihood: $F(3.25,627.14) = 31.95$, $p < .001$, $eta_p^2 = .14$. The frame × vignette interaction was significant for both Worry, $F(4,772) = 4.21$, $p = .002$, $eta_p^2 = .02$, and Consumption likelihood, $F(4, 772) = 2.66$, $p = .032$, $eta_p^2 = .014$.

Crucially, there was no evidence that the effect of frame was attenuated in the No-choice condition, with non-significant frame × choice interactions for both worry, $F(1, 193) = 0.80$, $p = .37$, $eta_p^2 < .01$, and consumption likelihood ratings, $F(1, 193) = 1.10$, $p = .30$, $eta_p^2$

< .01. No 3-way interactions were observed (*p*s > .32).[4] It should be noted that the framing effect observed in Study 3 was of a far smaller magnitude than that observed in any other study reported here. This makes the lack of a significant attenuation in the No-choice condition somewhat less noteworthy within this particular study. Although the robustness of the trend could not be established, the seeming attenuation of the framing effect in the No-choice condition (as compared with the High-choice condition) observed in Figure 3 is borne out in a comparison of the effect sizes observed when analysing the High-choice and No-choice conditions separately (High choice: $eta_p^2 = .07$ [$p < .01$]; $eta_p^2 = .09$ [$p < .01$]; No-choice: $eta_p^2 = .01$ [$p = .30$]; $eta_p^2 = .01$ [$p = .29$] for the worry and consumption likelihood ratings respectively).

*5. Study 4*

Thus far, framing effects have not been reliably attenuated in contexts where a risk communicator's choice over communication format has been reduced, either through instruction (Studies 1 & 2) or by design (Study 3). The only hint of sensitivity to a communicator's lack of choice came in Study 2 where a correlation was observed between quantitative ratings of the degree of freedom a communicator was perceived to have and the size of framing effect observed. Regardless of participants' subjective ratings, however, we argue that the No-choice conditions in these studies *should* have been perceived as reducing

[4] In a further study, we intended to test the central hypothesis within a surgery domain (following Marteau, 1989), employing a similar choice manipulation to that in Study 3. That study is not reported here because a framing effect was not observed in the standard, high choice, condition, thus rendering it unsuitable to test our central research question. This study did additionally contain the same choice manipulation check as in Study 2, only in this instance there was no evidence that the manipulation had been successful.

the informational value of the communication frame. Framing effects were, however, unattenuated in these conditions, despite the attenuation of the informational value of communication frame.

Study 4 provided a further test of the influence of communicator choice on framing effects by manipulating whether the risk *communicator* or the risk *consumer* (Alex) had control over the frame of the risk communication. Moreover, this was manipulated *within-participants.* Study 4 therefore sought to determine whether participants could be sensitive to the different informational value of the frames across the two choice conditions where the difference between conditions was salient to them. This salience was further enhanced by removing the filler task in this study. Although we maintain an interest in whether participants are sensitive to the *objective* difference between choice conditions, we additionally included a manipulation check in this study. Finally, to enhance the generalisability of the results reported in this manuscript, each food risk was paired with a different harm probability compared with Studies 1-3 (see Table 1)[5]. Study 4 was pre-registered at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a.

### *5.1. Method*

#### *5.1.1. Participants*

We aimed to collect 197 participants via Prolific (www.prolific.co). This provided 95% power to detect a small effect size ($f = 0.1$) for the critical frame × choice condition interaction term (Faul et al., 2007), assuming a correlation of .7 between the repeated

[5] Note that there was an error in the pre-registered description of the method, which failed to note this change. The change is evident in the pdf of the Qualtrics survey, uploaded as part of the pre-registration.

measures (in line with the results observed in Studies 1-3). To allow for attention check failures, we advertised the study to 220 participants. In line with the pre-registered exclusion criteria, four participants were excluded for providing a year of birth that was incompatible with their current age in years. In line with Studies 1-3, 12 additional participants were excluded for reporting dietary requirements that would mean they would not consume some of the products included in the study[6]. 204 participants were retained for analysis (see Table 1 for demographics). Participants were paid £1.50.

*5.1.2. Design and Materials*

A 2 (frame) × 2 (choice) × 5 (vignette) repeated measures design was utilised, with the same (Worry and Consumption likelihood) dependent variables as Studies 1-3. Instead of utilising a filler task, participants were informed that the food safety organisation was trialling the effect of different types of risk communication. Specifically, they read:

> "Imagine a food safety organisation, whose mission is to act as an independent scientific source of advice, information and risk communication to improve consumer knowledge about food. This means that it is responsible for communicating the results of its work in various food safety domains (e.g. additives, pesticides, food technologies), and explaining its risk assessment findings to the public.

[6] Exclusions relating from dietary requirements were not explicitly noted in the pre-registration for either Study 4 or Study 5. All significance patterns hold if these participants are not excluded, unless indicated otherwise. An analysis including all participants can be accessed at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a (additional analyses).

> In order to fulfil its remit, the organisation wants to test the effect of various different types of risk communication on people's responses. You will therefore read a series of hypothetical communications (some of which may look quite similar), and be asked to make some judgments based on these. Please treat the scenarios as though they were real. Please read the information you are given carefully and take your time."

Participants viewed the four risk communication formats in blocks, and between each block they read:

> "In the following communications the food safety organisation is trialling a slightly different method of risk communication. Please read the communications carefully, and treat the scenarios as though they were real."

Frame was manipulated as in Studies 1-3. Following a series of pilot studies checking the efficacy of the (communicator's) choice manipulation (solely collecting data on the manipulation check), in the Consumer-choice condition participants were informed that the food safety organisation gives its consumers the choice of how to view the evidence. Specifically, participants (in the negative frame condition) read (Technology vignette):

> Imagine that a new technology, Technology J, has recently been used in the creation of genetically modified foods (GM foods). GM foods are foods produced from organisms whose DNA has been changed using the methods of genetic engineering. Growing GM crops using Technology J requires fewer inputs (e.g., water, pesticides) and less land. As such, consumers would be able to buy food products at lower prices.
>
> The food safety organisation has therefore commissioned a large body of excellent scientific work to evaluate the health risk associated with Technology J. Specifically, the work solely aimed to estimate the chance that the technology either would or

> would not pose a risk to human health. They published an accurate synthesis of the results on their website.
>
> **[IMPORTANT:** Psychologists have shown that the way statistics are presented can sometimes affect people's decision making. Visitors to the website are therefore asked how they would like to view the statistics. They are asked to choose one of the options below:
>
> 1) Show the probability that the Technology *would* pose a risk to human health.
> 2) Show the probability that the Technology would *NOT* pose a risk to human health.]
>
> Alex is a friend of yours with no special knowledge about food or food risks.
>
> Alex visits the website and [clicks on Option 1. Alex] reads the following:
>
> Taken together, the scientific evidence shows that there is a **5% probability** that consuming GM foods produced by Technology J **would** pose harm to human health.

By specifying 'Alex' as the consumer, rather than allowing our participants to choose the presentation format, we retained experimental control and the orthogonal manipulation of frame and choice. Alex's choice of Option 1 or 2 was consistent with the risk communication displayed at the end of the vignette. The brackets were not present in the vignettes as participants saw them, but illustrate the text that was omitted in the Communicator-choice condition.

The order in which participants viewed the negative and positive frames was counterbalanced between participants, but participants always viewed the Communicator-choice condition (both negative and positive frames) before the Consumer-choice condition. This was necessary because the Consumer-choice condition changes the default interpretation of the communication. Note that Consumer-choice is intended to have the same functional role as the No-choice condition in Studies 1-3. Stressing that Alex has no special expertise in food or food risks should reduce the informational value conveyed by the communication frame.

We included manipulation checks for the choice manipulation, as well as comprehension checks for the frame manipulation. For the latter, we wanted to determine that participants viewed the potential outcomes (harm and no harm) as exclusive and exhaustive. Participants were thus asked:

> Please indicate another correct way of communicating "there is an 80% probability that consuming chicken treated with Chemical E would not pose harm to human health."

They chose from three options (where the first two were presented in a randomised order). Option 1 was the interpretation we intended:

1) "There is a 20% probability that consuming chicken treated with Chemical E WOULD pose harm to human health."
2) "We do not know the probability that consuming chicken treated with Chemical E would pose harm to human health."
3) "Other (please explain):_____"

Participants completed one choice manipulation check at the end of the two blocks (positive & negative frames) presenting the Communicator-choice condition, and one at the end of the two blocks presenting the Consumer-choice condition. Specifically, participants were asked:

> One of the scenarios you have just read is reproduced below. In this text, Alex was presented with the scientific evidence *in terms of the probability that the Technology would NOT pose harm to human health*. Who was responsible for Alex receiving the information in this format, rather than in terms of the probability that the Technology WOULD pose harm to human health?
>
> - The food safety organisation.
> - Alex

The order of the options was randomised.

Below this question the vignette referring to Technology J was reproduced. This was presented in whichever frame participants most recently viewed.

### *5.1.3. Procedure*

Participants provided informed consent, and then immediately provided their year of birth, and completed a captcha question. Participants then read the text introducing the food safety organisation. They subsequently provided worry and consumption likelihood ratings for the five food risks shown in Table 1, in the Communicator-choice condition, with either the negative or positive frame. They subsequently rated the same five food risks in the opposite frame, before receiving the first 'choice' manipulation check. Following this, they rated the same five food risks two more times (once in a negative, and once in a positive frame) in the Consumer-choice blocks, before completing the second 'choice' manipulation check, followed by the framing comprehension check. Participants subsequently provided their age, gender, native language, Prolific ID, and indicated any dietary preferences (plus how many times a week [1 day, 2 days, 3 days, 4 days, more than 4 days] they consumed chicken, beef or pork), before providing any additional thoughts they had about the study. Finally, participants were debriefed and redirected back to www.prolific.co to claim payment.

### *5.2. Results*

#### *5.2.1. Manipulation and comprehension checks – planned analyses*

Only 45% of participants (91/204) answered all three questions (the two questions about the choice manipulation and the question about the frame manipulation) as intended, where missing responses were coded as incorrect.

#### *5.2.2. Worry and consumption likelihood – planned analyses*

A framing effect was observed across both the worry and consumption likelihood ratings, such that participants were more worried and less likely to consume products when risks were framed negatively, as (less than 50%) chance of harm, than when framed positively, as (greater than 50%) chance of no harm (see Figure 7), Worry: $F(1, 203) = 67.27$, $p < .001$, $eta_p^2 = .25$; Consumption likelihood: $F(1, 203) = 93.64$, $p < .001$, $eta_p^2 = .32$. This effect was observed alongside the predicted effect of vignette (seeing as the probabilities of harm are different across the vignettes), Worry: $F(1.9, 375.8) = 299.22$, $p < .001$, $eta_p^2 = .60$; Consumption likelihood: $F(2.1, 423.4) = 230.62$, $p < .001$, $eta_p^2 = .53$. The frame × vignette interaction was significant for both Worry, $F(3.7, 746.7) = 8.52$, $p < .001$, $eta_p^2 = .04$, and Consumption likelihood, $F(3.7, 753.2) = 4.92$, $p = .001$, $eta_p^2 = .02$.

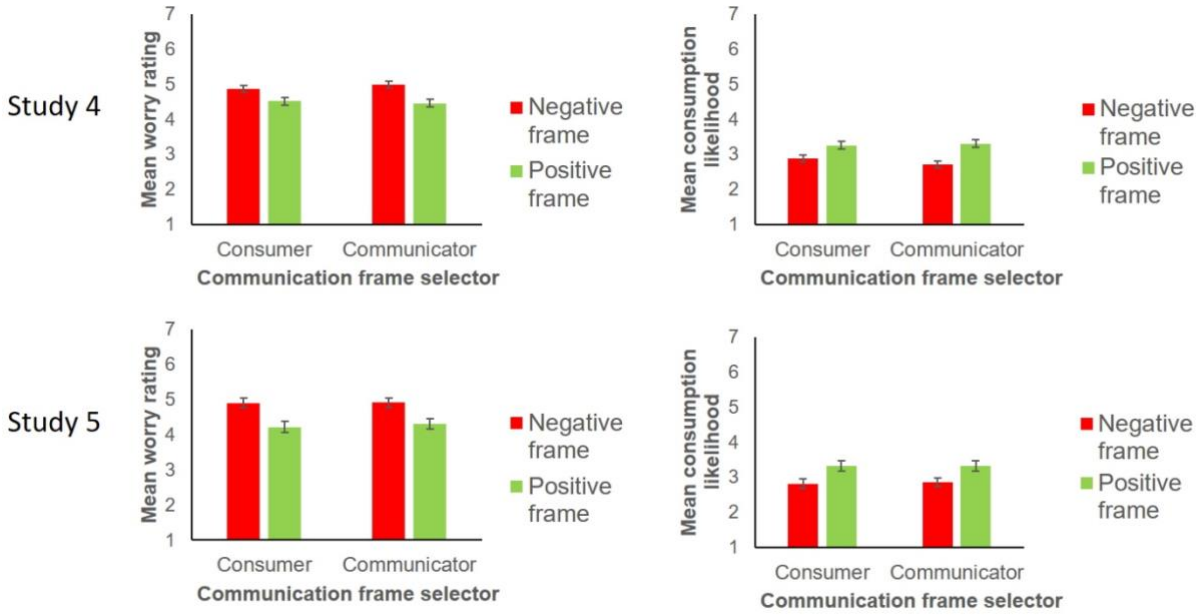
Crucially, the framing effect *was* attenuated in the Consumer-choice condition (see Figure 7), with a significant frame × choice interaction for both Worry, $F(1, 203) = 5.58$, $p = .02$, $eta_p^2 = .03$, and Consumption likelihood, $F(1, 203) = 9.87$, $p = .002$, $eta_p^2 = .05$. There was an unpredicted choice × vignette interaction for consumption likelihood ratings, $F(3.7, 751.8) = 2.85$, $p = .03$, $eta_p^2 = .01$, with no additional effects observed (all $p$s > .07; $F < 1$ for the 3-way interaction for both worry and consumption likelihood ratings).

Following our pre-registration, we tested for a 3-way interaction in a frame × choice × correct ANOVA, where 'correct' was a binary between-participants variable indicating whether participants answered all 3 manipulation checks correctly or not. The 3-way interaction was not significant for worry, $F(1, 202) = 0.57$, $p = .45$, $eta_p^2 < .01$, but it was for consumption likelihood ratings[7], $F(1, 202) = 4.34$, $p = .04$, $eta_p^2 = .02$. Given the interaction between frame and choice in the overall ANOVA, this interaction test holds less relevance. It is interesting to note, however, that the 3-way interaction for consumption likelihood ratings actually suggested a stronger frame × choice interaction where participants answered the manipulation check questions *incorrectly*, $F(1, 112) = 9.69$, $p = .002$, $eta_p^2 = .08$, than when they answered them *correctly*, $F(1, 90) = 0.73$, $p = .40$, $eta_p^2 < .01$ (a trend that was also observed in the worry ratings - incorrect: $eta_p^2 = .04$, $p < .05$; correct: $eta_p^2 = .02$; $p = .22$), though the shape of the interaction was always consistent with an attenuation of a framing effect in the Consumer-choice condition.

[7] This analysis did not achieve statistical significance when non meat-eaters were included in the sample ($p = .06$).

**Figure 7**

*Mean worry ratings (left panel) and mean consumption likelihood ratings (right panel) associated with food risks from Studies 4 and 5. Error bars are plus and minus 1 standard error.*




*5.2.3. Worry and Consumption Likelihood – Exploratory Analysis*

The significant frame × choice interaction demonstrated that framing effects were attenuated where the risk expert did not choose the frame of communication. Figure 7 suggests that, although attenuated, the framing effect was not eliminated where the frame was chosen by the consumer (Alex). A 2(frame) x 5(vignette) ANOVA including only the trials where Alex chose the frame confirmed that a framing effect persisted for both worry, $F(1, 203) = 53.15$, $p < .001$, $eta_p^2 = .21$, and consumption likelihood ratings, $F(1, 203) = 59.06$, $p < .001$, $eta_p^2 = .23$.

*6. Study 5*

Study 4 observed the first evidence for an attenuation of the framing effect in a condition where the choice of frame is removed from the food safety experts (namely, the Consumer-choice condition). As well as putting the choice in the hands of a third person, Study 4 manipulated choice within-participants. Thus, it is unclear whether the attenuation of the framing effect was brought about by the new 'Alex' manipulation, or resulted from the within-participants design. The primary aim of Study 5 was to distinguish between these two possibilities. In addition to the standard analyses, the size of the choice × frame interaction in Studies 4 and 5 will be compared to determine the significance of the experimental design employed. In the event that choice influences the framing effect in a within-participant design, but not a between-participant design, this informs us that information recipients *can* recognise the importance of the choice manipulation, but only when it is made salient in such a design, thus it does not appear to be spontaneously considered when receiving information in a particular frame.

Whilst our manuscript is focussed around food risks, there are no theoretical reasons why our results should not generalise to other domains. In Study 5, we additionally sought to obtain preliminary, indicative evidence pertaining to the likely generalisability of these results. We therefore include a single item (with a 20% / 80% probability) from another domain – vaccine side effects in health risks. For this item, we were solely interested in whether the size of the frame × choice interaction differed from that obtained in the food domain. Study 5 was pre-registered at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a.

### *6.1. Method*

#### *6.1.1. Participants*

We aimed to collect 198 participants via Prolific (www.prolific.co). This provided 95% power to detect a small effect size ($f = 0.1$) for the critical frame × choice condition interaction term (Faul et al., 2007). To allow for attention check failures, we advertised the study to 220 participants, but 222 completed the survey. In line with the pre-registered exclusion criteria, four participants were excluded for providing a year of birth that was incompatible with their current age in years. 12 additional participants were excluded for reporting dietary requirements that would mean they would not consume some of the products included in the study. 206 participants were retained for analysis (see Table 1 for demographics). Participants were paid £1.00.

#### *6.1.2. Design, Materials and Procedure*

A 2 (choice) × 2 (frame) × 5 (vignette) mixed design was utilised, with choice manipulated between-participants, and worry and consumption likelihood as dependent variables. Other than manipulating choice as a between-participants variable (as in Studies 1-3), all other aspects of the method were identical to Study 4, except for one additional question. At the end of each frame block, participants rated an additional risk in the domain of health risk. Specifically, participants read:

> Imagine that a new vaccine was recently developed that provides complete protection against a disease, Cimexauris. Imagine that Cimexauris is a seasonal disease that results in complete loss of hearing for a year.
>
> A medical safety organisation has therefore commissioned a large body of excellent scientific work to evaluate the health risks associated with the vaccine. Specifically, the work aimed to estimate the chance that the vaccine either would or would not pose

a risk to human health. The organisation published an accurate synthesis of the results on their website.

**[IMPORTANT:** Psychologists have shown that the way statistics are presented can sometimes affect people's decision making. Visitors to the website are therefore asked how they would like to view the statistics. They are asked to choose one of the options below:

1) Show the probability that the Vaccine *would* pose a risk to human health.
2) Show the probability that the Vaccine *NOT* pose a risk to human health.]

Alex is a friend of yours with no special knowledge about Cimexauris, vaccines, or vaccine risks.

Alex visits the website and [clicks on Option 1]. Alex reads the following:

Taken together, the scientific evidence shows that there is a **20% probability** that the vaccine **would** pose harm to human health.

As with the food risk items, participants rated worry and consumption likelihood as dependent variables, although these were rephrased as: "How worried are you about receiving such a vaccine?" (from 1 [*Not at all worried*] to 7 [*Extremely worried*]) and "How likely are you to take such a vaccine?" (from 1 [*Not at all likely*] to 7 [*Extremely likely*]).

### *6.2. Results*

#### *6.2.1. Manipulation and comprehension checks – planned analyses*

A majority, 132 (64%), of participants answered both questions (one about the choice manipulation and the question about the frame manipulation[8]) as intended, $\chi^2(1) = 16.33$, $p < .001$, where missing responses were coded as incorrect. This proportion was greater in the Communicator-choice condition (74%) than the Consumer-choice condition (54%), $\chi^2(1) =$

[8] The pre-registration erroneously stated that three questions were included as manipulation checks. There were only two in Study 5 because 'choice' was manipulated between-participants.

9.05, $p < .01$, presumably reflecting the fact that the Communicator-choice condition more closely reflects most standard scenarios.

*6.2.2. Worry and consumption likelihood for food risks – planned analyses*

A framing effect was observed across both the worry and consumption likelihood ratings, such that participants were more worried and less likely to consume products when risks were framed negatively, as (less than 50%) chance of harm, than when framed positively, as (greater than 50%) chance of no harm (see Figure 7), Worry: $F(1, 204) = 82.68$, $p < .001$, $eta_p^2 = .29$; Consumption likelihood: $F(1, 204) = 42.69$, $p < .001$, $eta_p^2 = .17$. This effect was observed alongside the predicted effect of vignette (seeing as the probabilities of harm are different across the vignettes), Worry: $F(2.8, 579.8) = 175.26$, $p < .001$, $eta_p^2 = .46$; Consumption likelihood: $F(3.0, 618.3) = 121.51$, $p < .001$, $eta_p^2 = .37$. The frame × vignette interaction was significant for Worry, $F(3.8, 765.0) = 3.17$, $p = .02$, $eta_p^2 = .02$, but not Consumption likelihood, $F(3.5, 718.1) = 1.57$, $p = .19$, $eta_p^2 < .01$.

Crucially, unlike Study 4, but consistent with Studies 1-3, there was no evidence that the effect of frame was attenuated in the Consumer-choice condition, with non-significant frame × choice interactions for both worry, $F(1, 204) = 0.38$, $p = .54$, $eta_p^2 < .01$, and consumption likelihood ratings, $F(1, 204) = 0.11$, $p = .74$, $eta_p^2 < .01$. No 3-way interactions were observed ($p$s > .37).

Following our pre-registration, we tested for a 3-way interaction in a frame × choice × correct ANOVA, where 'correct' was a binary between-participants variable indicating whether participants answered both manipulation checks correctly or not. The 3-way interaction was not significant for either worry, $F(1, 202) = 1.97$, $p = .16$, $eta_p^2 = .01$, or consumption likelihood, $F(1, 202) = 0.28$, $p = .60$, $eta_p^2 < .01$, ratings. Moreover, as in Study 4, although all were non-significant (all $p$s > .24), the trend in the effect sizes was for a *larger* frame × choice interaction where participants answered the manipulation check questions

*incorrectly* ($eta_p^2$ = .02; $eta_p^2$ = .003 for worry and consumption likelihood[9] respectively) than where they answered them correctly ($eta_p^2$ = .003; $eta_p^2$ < .001).

A primary objective of Study 5 was to determine whether the within-participants design results in a reliably larger effect of the choice manipulation on framing effects. To investigate this, the frame × choice effect sizes were compared (following Rosenthal, 1991). Specifically, the Fisher $z_r$, associated with the effect sizes of the respective interactions, was compared between Study 4 and Study 5 (effect sizes were transformed following Cohen, 1988; Lenhard & Lenhard, 2016)[10]. The size of the interaction did not differ significantly for either the consumption likelihood ($p$ = .06)[11] or the worry ratings ($p$ = .22). It is important to note, however, that (despite the pre-registration of this analysis) the study was not well-powered for this test, with post hoc power analyses demonstrating power of less than 50% to detect these effects (see Cohen, 1988).[12]

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[9] When non meat-eaters were included in the analysis, the effect sizes for consumption likelihood were the same size ($eta_p^2$ = .001) across these sub-groups of participants.

[10] The meta-analytic comparison yielded the same results if performed on the *p*-values (following Rosenthal, 1991).

[11] The effect sizes did differ significantly ($p$ = .02) for consumption likelihood ratings when non meat-eaters were included in the analysis (see https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a).

[12] Following the theme of comparisons across within and between-participant designs, given that there was no filler task in this study, an anonymous reviewer suggested that the within-participants manipulation of choice might have drawn attention, at the expense of attention to the choice manipulation text. Following their recommendation, we conducted a fully between-participants analysis (though including vignette as a within-participants variable) on the first choice condition viewed by participants. The findings were the same as in the mixed ANOVA, with robust framing effects ($eta_p^2$ = .07 and .05 [*ps* < .01; worry & likelihood consumption respectively]) and no frame × choice interactions ($eta_p^2$s < .01; *F*s < 1).

*6.2.3. Worry and consumption likelihood for food risks – exploratory analyses*

Having observed no significant difference between the size of the interaction effects between Studies 4 and 5, we conducted an additional analysis to determine whether the two studies combined yielded evidence for an attenuation of framing effects in the Consumer-choice condition. We combined the results of the two analyses, by combining the *p*-values as Z scores, to obtain the Z score associated with the overall interaction effect across the two studies (following Rosenthal, 1991): $\frac{Z_4+Z_5}{\sqrt{2}}$ . For Worry, this yielded $Z_{4,5} = 2.09$, $p = .04$, and for Consumption likelihood, $Z_{4,5} = 2.42$, $p = .02$ indicating that a combination of the two studies revealed evidence for an attenuation of the framing effect in the Consumer-choice condition, with no evidence for a reliable difference in the size of the effect between Studies 4 and 5.[13]

Our pre-registration included a planned analysis to investigate the framing effect solely in the Consumer-choice condition, in the event of observing a significant choice × frame interaction in Study 4. No such interaction was observed in Study 4, but the meta-analysis just reported suggests that, together, Studies 4 and 5 provide evidence for an attenuation of the framing effect in the Consumer-choice condition. Here, we therefore use the formula outlined above (following Rosenthal, 1991) to test the significance of the framing effect in the Consumer-choice condition across both Studies 4 and 5, combined. As Figure 7

[13] When non meat-eaters were included in the analysis, only worry ratings were included in this analysis (due to the significant difference observed in the effect sizes for likelihood ratings – Footnote 11). In this analysis, no evidence was observed for an overall frame × choice interaction when the results of the two studies were combined ($Z_{4,5} = 1.7$, $p = .09$).

suggests, a significant framing effect was observed for both worry, $Z_{4,5} = 9.09$ , $p < .001$, and consumption likelihood, $Z_{4,5} = 8.29$, $p < .001$, ratings.

*6.2.4. Generalisability to vaccine risks – planned analyses*

This analysis compared the vaccine vignette with the '20% probability' food vignette ('chemical for washing chickens'[14]) in a domain × frame × choice mixed ANOVA. As we were interested in whether the size of the frame × choice interaction differed between these domains, we were specifically interested in the 3-way interaction. The 3-way interaction was not significant, either for worry, $F(1, 204) = 0.04$, $p = .84$, $eta_p^2 < .001$, or consumption likelihood ratings, $F(1, 204) = 0.06$, $p = .80$, $eta_p^2 < .001$.

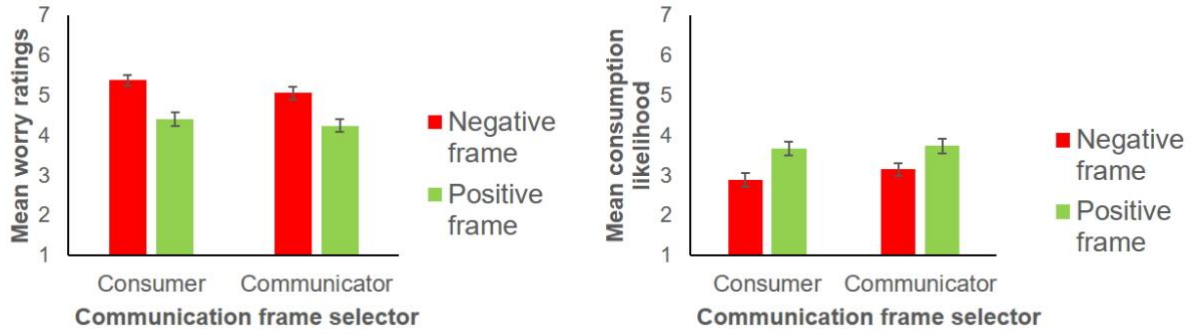
*6.2.5. Generalisability to vaccine risks – exploratory analyses*

The results from the vaccine vignette are presented in Figure 8, demonstrating (once again) a significant framing effect for both Worry, $F(1, 204) = 79.79$, $p < .001$, $eta_p^2 = .28$, and Consumption likelihood, $F(1, 204) = 48.00$, $p < .001$, $eta_p^2 = .19$, but no frame × choice interaction (Worry: $F(1, 204) = 0.66$, $p = .42$, $eta_p^2 < .01$; Consumption likelihood: $F(1, 204) = 0.84$, $p = .36$, $eta_p^2 < .01$).

**Figure 8**

*Mean worry ratings (left panel) and mean consumption likelihood ratings (right panel) for the vaccine question in Study 5. Error bars are plus and minus 1 standard error.*

[14] The pre-registered description of methods erroneously stated that this was the 'pesticide' item.




*7. General Discussion*

Five studies replicated the oft-observed attribute framing effect, employing a rarer within-participants manipulation. Such a result underlines the robustness of these effects (see also Aczel et al., 2018). Whilst EFSA should be aware that their recommendation for communication frame (Hart et al., 2019) will systematically affect people's interpretation and use of risk communications, such a recommendation will, at least, ensure that effects are consistent. Framing in terms of the more likely outcome will result in interpretations and decisions that pay most heed to the more likely outcome.

The research question of central interest was whether framing effects would be attenuated where the choice of presentation frame was removed from (or attenuated for) risk communicators. Given that such choice is critical to a communication frame carrying informational value, framing effects should no longer be observed in fully rational agents. Across our five studies people displayed very limited sensitivity to this contextual manipulation (see Table 3 for a summary of the key findings). Where 'choice' was manipulated between-participants (Studies 1, 2, 3, 5), we observed no evidence for an attenuation of framing effects where choice was removed from the risk communicator. Where the difference between the two contexts was made salient to participants (via the within-participant manipulation employed in

Study 4), there was a small attenuation of the framing effect in the Consumer-choice condition (although a framing effect did still persist).

In order to establish the importance of the within-participants manipulation for participants' sensitivity to choice, we compared the effect size for the interaction across Studies 4 and 5. A combination of the results of Studies 4 and 5 yielded evidence (according to our $p < .05$ criterion) for an attenuating effect of Consumer-choice on framing effects. These results (in conjunction with those observed for Study 4 alone), in addition to the correlation observed between quantitative ratings of the degree of freedom a communicator was perceived to have and the size of framing effect observed (Study 2), potentially suggest that communication recipients *can* recognise the relevance of communicator choice and adapt their use of frame information accordingly. Future research should seek to push such results further, and outline the conditions which maximise such sensitivity to communicator choice. We particularly encourage such research endeavours given the small numerical difference in 'perceived freedom of choice' ratings observed in Study 2 (where the 'No choice' condition was rated as close to the midpoint on the 'no freedom in communication choice at all' to 'complete freedom' scale). We have generally downplayed the importance of this small difference given: 1) the consistency of our results (e.g., across participants answering manipulation check questions correctly and incorrectly in Studies 4 & 5); 2) the 'objective' difference in choice across our 'No choice' and 'High choice' (or 'Consumer choice' and 'Communicator choice') conditions. Although an objective difference does seem to exist *within our study vignettes,* these are, nonetheless, *hypothetical* scenarios. One direction that future research might therefore take would be to investigate framing effects in natural, non-laboratory (i.e., 'real') contexts, where there truly are objective differences in the degree of communicator choice over framing effects. From the current studies, however, the overwhelming result is that framing effects remain

robust in scenarios where there is greatly reduced (if any) informational value in the communication frame.

**Table 3**

***A qualitative summary of the key manipulations and results obtained across the five studies.***

| | How frame choice removed from communicator | 'Choice' manipulated between or within-participants | Main effect of frame? | Framing effect attenuated by removing the choice of frame from the communicator? | Simple effect of frame where the choice of frame removed from the communicator? |
|---|---|---|---|---|---|
| Study 1 | *Instruction* | *Between* | ✓ | X | ✓ |
| Study 2 | *Instruction* | *Between* | ✓ | X | ✓ |
| Study 3 | *Frame provided* | *Between* | ✓ | X | ✓ |
| Study 4 | *Consumer choice* | *Within* | ✓ | ✓ | ✓ |
| Study 5 | *Consumer choice* | *Between* | ✓ | X | ✓ |

Note: A ✓ represents an effect that is significant at $p < .05$, whilst an X represents an effect that is not significant at $p < .05$.

*7.1. Reconciling the current results with the information leakage account of attribute framing*

The current results question the degree to which people's use of frame information is adaptable. We here outline an explanation for our results which is not only consistent with the central tenet of the information leakage account, but also has considerable precedent in the judgment literature.

The explanation proposes that the information leakage is, itself, leaky. That is, whilst frames typically convey pragmatic information to the recipient, recipients are generally insensitive to the situational specificity of this, such that this typical feature of information frames is overgeneralised to all situations. In this way, information leakage has commonalities with many previously documented judgmental heuristics (e.g., Kahneman et al., 1982; Tversky & Kahneman, 1974), whereby biases emerge when heuristic use is overextended to situations where it is no longer appropriate. For example, typically more probable things are encountered more regularly than less probable things (the availability heuristic). People, however, fail to recognise where availability is altered by additional features (e.g., media coverage), leading to systematic biases. We propose an analogous account for attribute framing: people are sensitive to the fact that a communicator's frame choice typically conveys information, but often fail to recognise where this is not the case because the communicator has not chosen the communication frame. Some readers might consider that the choice in our No-choice condition from Studies 1-3 was not eliminated, but transferred, from the risk communicator themselves to the organisation eliciting the report. Such an argument is in line with the current proposal, given the set-up of the studies. The organisation does not know what the risk is going to be, and therefore has no way of knowing, in advance, what reference point it will be above, or what 'implicit recommendation' should be made. The only individual, in these scenarios, with that knowledge is the risk communicator. Consequently, from an informational perspective, the framing effect *should* have been attenuated in the No-choice conditions. In Studies 4 and

5, the risk communicator ostensibly made the risk information available in both frames, so the consumer of the information could choose the frame they preferred. Even highlighting that the purpose of this presentation was to guard against framing effects, this did not attenuate such effects in a between-participants manipulation, and failed to *eliminate* framing effects using a within-participants manipulation.

### *7.2. Conclusion*

The current studies demonstrated robust framing effects, even in within-participant designs (see also Aczel et al., 2018). McKenzie and Nelson's (2003) informational leakage account suggested a rational basis to such effects. Whilst we do not question the potential rational *basis* of such effects, we do highlight a limitation to this rationality: framing effects persist in situations where frames ostensibly convey no informational value.

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## Appendix A

Study Vignettes. These are verbatim from Studies 1 and 2, with very minor differences in Studies 3-5 – predominantly to enable the manipulation of "choice" (full versions of all vignettes can be found at https://osf.io/gs4yf/?view_only=e0db3c4231b244d58b32798fc96dbf1a). The letter label of the product (e.g., Hormone A) was different in the positive frame (specifically, it was changed for the next letter in the alphabet). The emphasised text (in bold) was emphasised in the study materials. The text to the left of '/' represents the negative frame, whilst the text to the right of the '/' represents the positive frame.

*Hormone-Treated Product*

Imagine that a new hormone, Hormone A, has recently been proposed to be used in beef production. The economic reason for this practice is that it will allow cows to grow bigger more rapidly whilst consuming less feed, which in turn reduces the costs of production (and hence lowers market prices). It is also argued that beef treated with Hormone A is less fatty and contains lower levels of cholesterol. A food safety organisation has therefore commissioned a study to evaluate the health risk associated with Hormone A. Based on their findings, experts are **5%/95% certain** that consuming beef treated with Hormone A **would/would not** pose harm to human health.

*Product with Feed Additive*

Imagine that a new feed additive, Additive C, was recently proposed to be used to increase the production of pork. Studies have found that Additive C helps increase protein synthesis, thereby reducing the fat content of the meat and the costs of production. Consumers can thus

enjoy leaner pork with lower prices. A food safety organisation has therefore commissioned a study to evaluate the health risk associated with Additive C. Based on their findings, experts are **10%/90% certain** that consuming pork treated with Additive C **would/would not** pose harm to human health.

*Chemical-Treated/Washed Product*

Imagine that a new chemical, Chemical E, has been developed to rinse whole chickens in order to kill microorganisms and bacteria on the surface of the meat. This practice reduces the overall costs of meat production since less effort is required for bacterial control along the meat supply chain. As a result, consumers can buy chicken with lower prices. A food safety organisation has therefore commissioned a study to evaluate the health risk associated with chemical-washed chicken. Based on their findings, experts are **15%/85% certain** that consuming chicken treated with Chemical E **would/would not** pose harm to human health.

*Product with Pesticides*

Imagine that a new pesticide, Pesticide G, has recently been developed to help protect crops from damaging pests. This allows higher returns from the crops grown, which then helps to lower market prices of crops. It is also claimed to be biodegradable so that its usage has minimal impact on the environment (e.g. reducing the risk of other organisms and animals coming into contact with it). A food safety organisation has therefore commissioned a study to evaluate the health risk associated with Pesticide G. Based on their findings, experts are **20%/80% certain** that consuming crops sprayed with Pesticide G **would/would not** pose harm to human health.

*Product Processed with New Food Technology*

Imagine that a new technology, Technology J, was recently developed to help in the creation of genetically modified foods (GM foods). GM foods created using Technology J would require fewer inputs (e.g., water or pesticides) and less land to grow. As such, consumers would be able to purchase food products at a lower price. A food safety organisation has therefore commissioned a study to evaluate the health risk associated with Technology J. Based on their findings, experts are **25%/75% certain** that consuming GM foods produced by Technology J **would/would not** pose harm to human health.