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Refutations of Equivocal Claims: No Evidence for an Ironic Effect of Counterargument Number

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Abstract

This study investigated the refutation of equivocal claims using counterarguments. Common sense suggests that more counterarguments should be more effective at inducing belief change. However, some researchers have argued that in persuasive reasoning, using too many arguments might lead to counterproductive skepticism and reactance. Thus, there have been calls to actively curtail the number of counterarguments used in refutations to avoid risking an "overkill backfire effect"—an ironic strengthening of beliefs from too many counterarguments. In three experiments, we tested whether calls to limit the number of counterarguments are justified. We found that a larger number of counterarguments (between four and six) led to as much or more belief reduction compared to a smaller number of (two) counterarguments. This was not merely an effect arising from a simple numerosity heuristic, as counterarguments had to be relevant to affect beliefs: irrelevant counterarguments failed to reduce beliefs even though perceived as moderately persuasive.

Keywords: Misinformation; Debunking; Belief updating; Refutations

General Audience Summary

Previous research has suggested that one should limit the number of arguments one uses when debunking misinformation. The idea was that using too many counterarguments in a refutation might be less persuasive than only using a small number of strong counterarguments. There were even fears that too many counterarguments might carry the risk of an “overkill backfire effect”—an ironic effect where a refutation might increase rather than decrease a person’s belief in the refuted claim. The present study investigated whether limiting the number of counterarguments is indeed necessary. In three experiments, we refuted a number of equivocal claims using either few or many counterarguments. By and large, as long as the counterarguments were relevant, using more counterarguments led to stronger belief reduction. It follows that when trying to refute dubious claims, communicators should use as many relevant counterarguments as possible, without the need to curtail their number.

Refutations of Equivocal Claims: No Evidence for an Ironic Effect of Counterargument Number

In modern society, individuals are often confronted with claims that are equivocal or even false. Many of these claims seem plausible at first glance—for example, that brain training might increase intelligence—and consequently are likely to be accepted initially. Their falsehood may only become evident when scrutinized. To promote informed decision making, it seems important that efforts are made to correct unwarranted belief in such equivocal claims.

Alas, correcting misconceptions and reducing belief in equivocal claims is not at all straightforward (e.g., Ecker, Hogan, & Lewandowsky, 2017; Ecker, Lewandowsky, Cheung, & Maybery, 2015; Marsh, Cantor, & Brashier, 2016; Rapp, Hinze, Kohlhepp, & Ryskin, 2014; Swire, Ecker, & Lewandowsky, 2017; Thorson, 2016; for a review, see Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). One factor that has proven beneficial when correcting misinformation is the provision of fact-based alternative information to replace the misinformation in people's mental models of the world (e.g., Ecker, Lewandowsky, Swire & Chang, 2011; Johnson & Seifert, 1994; Seifert, 2002). What is unclear, however, is how the quantity and quality of the corrective information impacts upon the effectiveness of refutations in more ambiguous cases where there is debate over the weight of evidence on either side of the argument. The main question of the present study therefore was: When it comes to refuting equivocal claims, does more counter-information lead to more belief change, or is correcting equivocal beliefs a case of "less is more"?

At first glance, it seems obvious that more evidence should result in stronger belief reduction. For example, to the extent that people use the number of arguments as a heuristic, more counterarguments should be more persuasive, even if those arguments are weak or lack relevance. Correspondingly, Wang and Chen (2006) reported that when being presented with many versus few arguments, attitude change in participants was largely determined by argument quantity rather than quality (unless participants were highly engaged with the task and had high working memory capacity; i.e., they had both the cognitive resources and motivation to thoroughly consider argument quality). This corresponds with the typical pattern found in the persuasion literature more generally, namely that a greater number of arguments is typically found to be more convincing unless personal involvement is very high (e.g., Burnstein, Vinokur, & Trope, 1973; Petty & Cacioppo, 1984). Such positive effects of argument number are also in line with the information deficit model from the literature on public understanding of science (Blake, 1999; Burgess, Harrison, & Filius, 1998). This model proposes that knowledge drives beliefs and attitudes, and that misguided beliefs thus reflect lack of sufficient factual knowledge. Therefore, providing additional knowledge should lead to better-informed beliefs and behaviors. In essence, this is a Bayesian view of belief change: More evidence should lead to more belief change (see Cook & Lewandowsky, 2016; Harris, Corner, & Hahn, 2013). From this perspective, attempts to refute equivocal claims should involve as many factual counterarguments as possible.

On the other hand, however, there is evidence that people generally have a preference for simple explanatory models (Chater, 1999; Lombrozo, 2007). More specifically in the context of persuasion, some have argued that too many persuasive arguments can lead to skepticism and reactance (e.g., Shu & Carlson, 2014). Others have argued that processing many arguments can be experienced as difficult, and this meta-cognitive difficulty can in turn reduce persuasive impact (Schwarz, Sanna, Skurnik, & Yoon, 2007). Thus, there have been calls to actively curtail the number of counterarguments used in refutations; Cook and Lewandowsky (2011) and Lewandowsky et al. (2012) suggested that providing too many counterarguments in a refutation may lead to an “overkill backfire effect,” an ironic effect whereby a correction inadvertently strengthens a belief rather than reducing it.

Additional support for a *less is more* approach to refutations comes from the *weak evidence* and *strong evidence* effects. The *weak evidence effect* implies that no evidence can be better than weak evidence: Fernbach, Darlow, and Sloman (2011) provided participants with a weak piece of evidence supporting a public policy initiative. Participants judged the policy initiative to be less likely to succeed after receiving weak supporting evidence compared to a no-evidence control condition. This ironic effect was explained by the assumption that self-generation of stronger arguments may have been hindered by participants’ focus on a weak piece of evidence, or by the possibility that participants might conclude that there is no better evidence available if the weak piece of evidence is the only one presented. In a similar vein, a recent study by Perfors, Navarro, and Shafto (in press) demonstrated a *strong evidence effect*, showing that stronger evidence does not always lead to more persuasion. They argued that presentation of only strong arguments can be perceived as biased, and that correction for perceived bias can mean that people partially discount strong evidence, and can be more convinced by weaker, mixed evidence.

While these phenomena arise from different cognitive mechanisms and in different contexts, taken together they challenge the view that more counter-evidence should always serve to more strongly reduce belief. Thus, the aim of the present study was to test whether a greater number of counterarguments would result in stronger reduction of equivocal beliefs, or whether an ironic overkill backfire effect might occur with the presentation of a greater number of counterarguments. Selected claims related to contentious topics and were of the type commonly encountered in the media. We used claims that we deemed to be false or likely-false based on available evidence, but sufficiently plausible to attract mid-range belief ratings that would allow both a reduction and an increase in the beliefs. That is, each claim's validity was intended to be uncertain for most participants. In three experiments, we presented a number of such equivocal claims and measured participants' pre- and post-manipulation beliefs—both directly and indirectly through inferential reasoning questions (following ample precedent; e.g., Ecker et al., 2017)—comparing conditions involving few (i.e., two) versus many (i.e., four or five) counterarguments. As increasing the number of counterarguments *inevitably* has an impact on the variability of argument strength, we sought to corral that variability by manipulating argument strength systematically, thereby also allowing for a test of the effects of relatively weak (and in Experiment 2: irrelevant) counterarguments. However, investigating the effects of argument strength was only a subordinate aim of the study.

Experiment 1

Method

Participants. Power analysis suggested a minimum sample size of N = 48 participants to find an effect of small to moderate size ($\eta_p^2 = .03$) with $\alpha = .05$ and $1-\beta = .80$. A total of 64 undergraduate students from the University of Western Australia participated (44 females and 20 males; mean age M = 21.13 [SD = 7.53] years).

Design and materials. Selection of claims and counterarguments was based on a pilot rating study with N = 13 undergraduate participants. In order to select claims that were on average neither strongly believed nor strongly questioned a priori, 10 claims were selected from an initial pool of 14. The two strongest and the three weakest counterarguments regarding each claim were taken from a pool of between five and eight counterarguments per claim (see Online Supplement for details on pilot rating).

Ten claims were selected for Experiment 1; each claim comprised two components: The first component provided background information constructing an argument; the second component was a summary statement of the claim, which participants were asked to rate their belief in. To illustrate, one claim stated: "*Brain training increases one's intelligence. Dedicated software—programmed for commercial computers and video game consoles—can boost the efficacy of neural networks and trigger the growth of new brain cells. Over time, brain training can improve memory and general reasoning skills, hence increasing IQ. Please rate your agreement with the following statement on a scale of 0 (I do not agree at all) to 10 (I strongly agree): Brain training increases one's memory capacity and intelligence."* (An additional example claim is provided in Table 1; see Online Supplement for all claims).

Each claim was followed by either 0, 2, or 5 counterarguments. The condition with two counterarguments used the strongest available arguments; the condition with five counterarguments used the same two strong arguments, augmented by the three weakest available counterarguments (note that while attracting *relatively* low strength ratings, the "weak" counterarguments were by no means irrelevant or insignificant). An example of a 'brain training' counterargument rated as strong was "*There are practice effects, meaning that doing a 'brain training' task regularly will improve your performance on that task. However, there is no good evidence for an actual and substantial transfer to memory capacity or intelligence."* An example of a counterargument rated as weak was "*Even the best-designed studies only report very small effect sizes, which means that even these studies do not find effects of any practical significance."* Table 1 gives additional examples; see Online Supplement for all arguments used.

When using five counterarguments, we additionally manipulated the order of argument presentation (increasing strength, decreasing strength, or interspersed order) because primacy or recency effects could lead to differential effectiveness of different argument orders (we note that this was an exploratory and subordinate design feature). There were thus five separate conditions, defined by the number and strength of counterarguments, as well as their order. The control condition (C) featured no counterarguments. The SS condition presented two strong counterarguments. There were three "mixed" conditions that all contained two strong and three weak counterarguments; these three conditions differed only in the order in which the arguments were presented, and were labeled SSWWW, WWWSS, and WSWSW. We assigned two claims to each condition in a within-subjects design; the assignment of claims to conditions was counterbalanced across participants in a Latin-square design (i.e., there were five separate versions of the experimental survey, with each claim assigned to each condition exactly once across versions; counterbalancing was partially incomplete as one version was only administered 12 as opposed to 13 times). For each participant, the order of claims/conditions was randomized.

Procedure. Participants were tested individually in the lab using Qualtrics survey software. Participants read each of the 10 claims and provided a belief rating on a 0-10 scale. Each claim and its belief rating was followed by the associated counterarguments; each counterargument's persuasiveness was rated on a 0-10 scale. There was a 10-min retention interval after presentation of all claims and counterarguments, filled with an unrelated task (an experimental survey investigating the effect of anecdotal evidence on climate-change beliefs). Participants then responded to a set of six inferential reasoning questions per claim; these were designed to measure claim belief in an indirect fashion (e.g., *'How likely is it that you would encourage your own friends or relatives to do brain training?'*; Table 1 provides one full set of inference questions; see Online Supplement for all questions; questions were presented in a fixed order). Indirect measures were used to alleviate potential issues with direct belief ratings, such as demand characteristics and disingenuous responding.[1] Finally, participants rated their beliefs in a second direct rating, before being fully debriefed.

Results

Counterargument ratings. We first conducted a manipulation check to confirm that the strong and weak counterarguments were indeed perceived as relatively strong and weak, respectively. The mean counterargument strength ratings for the strong and weak counterarguments were M = 5.97 (SE = 0.12) and M = 5.47 (SE = 0.14), respectively. This was a significant difference, $F(1,63) = 13.36$, $MSE = .60$, $p < .001$, $\eta_p^2 = .17$. Correspondence between these argument-strength ratings collected during the study and the pilot study was confirmed by a fairly strong item-wise correlation between the two sets of ratings, $r(48) = .60$, $p < .001$.

Direct belief-change score. Next, the difference in participants' direct belief ratings pre- and post-presentation of counterarguments was examined. Belief rating 1 was subtracted from belief rating 2 for each claim, and the mean difference was computed for each condition (i.e., averaging across the two claims per condition). Thus, each participant had one belief-change score per condition; on this score, more negative ratings indicate greater reduction in belief. The means and standard errors of the belief-change scores across conditions were M_C = -0.53 (SE = 0.16), M_{SS} = -1.12 (SE = 0.18), M_{SSWWW} = -1.16 (SE = 0.19), M_{WWWSS} = -1.39 (SE = 0.20),

[1] It is acknowledged that indirect measures may not tap into exactly the same beliefs, or may be "contaminated" by other beliefs or constrained by contextual aspects (e.g., asking a person whether the government should subsidize a drug will depend not only on the person's belief about the efficacy of the drug, but also their general attitude towards government-funded health care, or a person might be generally in favor of subsidization but might worry about current budget restrictions and thus be opposed in a specific context, or vice versa).

M_{WSWSW} = -1.41 (*SE* = 0.17). A one-way repeated-measures ANOVA on these scores yielded a main effect of condition, $F(4,252) = 4.97$, $MSE = 1.62$, $p < .001$, $\eta_p^2 = .07$.[2]

Planned contrasts confirmed that the SS condition differed from control, $F(1,63) = 7.26$, $MSE = 1.51$, $p = .01$, as did the three (pooled) mixed conditions, $F(1,63) = 25.13$, $MSE = 1.19$, $p < .001$. The difference between the strong and the three (pooled) mixed conditions was non-significant, $F < 1$. This pattern of results suggests that all four experimental conditions reduced beliefs relative to the no-counterargument control condition, and that the strong and mixed conditions all led to similar belief reduction. There were no differences among the three conditions with five counterarguments, as confirmed by a separate one-way repeated measures ANOVA, $F < 1$.

Indirect belief measure. Inference-question responses were transformed to a common 0-10 scale (also accounting for reverse-coded questions), with greater scores reflecting stronger belief in the equivocal claim. A mean inference score was calculated for each condition by averaging the responses to the 12 relevant inference questions (two claims per condition, six questions per claim). Mean inference ratings were M_C = 5.48 (*SE* = 0.17), M_{SS} = 5.15 (*SE* = 0.20), M_{SSWWW} = 4.58 (*SE* = 0.18), M_{WWWSS} = 4.72 (*SE* = 0.21), M_{WSWSW} = 4.70 (*SE* = 0.21). A one-way repeated-measures ANOVA revealed a significant main effect of condition, $F(4,252) = 4.92$, $MSE = 1.84$, $p < .001$, $\eta_p^2 = .07$.

Planned contrasts demonstrated that the SS condition did not differ from control, $F(1,63) = 1.42$, $MSE = 2.45$, $p = .24$, but the pooled five-counterargument conditions differed from control significantly, $F(1,63) = 19.24$, $MSE = 1.63$, $p < .001$. Inference scores were lower in

[2] Average pre-manipulation belief ratings ranged from 6.33 to 6.62 across conditions. There was no main effect of condition in a separate analysis of pre-manipulation belief scores, and thus no significant baseline difference between conditions, $F < 1$.

the (pooled) mixed conditions than the SS condition, $F(1,63) = 5.08$, $p = .03$. An additional analysis showed no differences among the three conditions with five counterarguments, that is, no effect of argument order, $F < 1$.

Discussion

Experiment 1 showed that the presentation of counterarguments generally reduced belief in equivocal claims, irrespective of whether belief was tested directly or via inference questions. This finding is in line with available evidence from the existing misinformation literature suggesting that the provision of factual alternative information is a crucial component of myth debunking. In the direct belief-change measure, it seemed as if all refutations were more or less equally effective. If this were a reliable finding, it would argue quite counterintuitively that neither the quantity nor average quality of counterarguments matter much for belief reduction as long as some valid counterarguments are presented. This lends some tentative support to the notion that the cogency of counterarguments may matter less than the simple fact that counterarguments are presented, thus demonstrating dissension (cf. Freudenburg, Gramling, & Davidson, 2008; Oreskes & Conway, 2010). However, one could also speculate that a dilution effect (Nisbett, Zukier, & Lemley, 1981) might have offset a positive effect of additional counterarguments: in the conditions with five counterarguments, the weaker arguments may have diluted the effectiveness of the stronger ones, counteracting and potentially canceling out a potential effect of counterargument number.

Supporting the relevance of counterargument number, the indirect belief measure suggested that providing five counterarguments was more effective in reducing belief in equivocal claims than providing just two. This finding is in line with rational belief updating: providing more counterevidence entailed greater reduction in belief. The only discrepancy between the indirect and direct measures involves the SS condition, which differed from the control—but none of the other conditions—in the direct measure but was indistinguishable from the control in the indirect-measure analysis.

Given this slight discrepancy between direct and indirect belief measures, Experiment 2 was run in an attempt to replicate the basic patterns obtained in Experiment 1. Additionally, Experiment 2 served to investigate the efficacy of *irrelevant* counterarguments in the refutation of equivocal claims. To the extent that people rely on numerosity (viz. number of arguments) or dissension heuristics, even irrelevant counterarguments might reduce beliefs.

Indeed, people often use irrelevant arguments in their reasoning, in particular when no relevant arguments are available. In marketing, promoting irrelevant attributes (such as vitamins in shampoo) is a common strategy (e.g., Carpenter, Glazer, & Nakamoto, 1994). Perhaps the most striking demonstration of the use of irrelevant arguments relates to the manufacturing and spreading of doubt about scientific findings by vested interest groups, such as the tobacco industry (Oreskes & Conway, 2010; also see Lewandowsky, Oreskes, Risbey, Newell, & Smithson, 2015). In this context, irrelevant counterarguments might serve specifically to undermine perceived consensus and promote feelings of uncertainty (Freudenburg et al., 2008; McCright & Dunlap, 2010; Michaels, 2006; Oreskes & Conway, 2010). There are thus reasons to believe that irrelevant counterarguments may be somewhat effective for the refutation of claims.

The belief-change data from Experiment 1 tentatively suggested that the mere act of providing a dissenting view may be more influential than the actual quality (and quantity) of counterarguments. By contrast, the literature on the weak evidence effect makes the inverse prediction: If presented by themselves, irrelevant counterarguments could potentially backfire and strengthen belief in the counter-argued claim; if combined with strong counterarguments, they might attenuate or cancel out the belief reduction brought about by the stronger arguments.

Moreover, Experiment 2 aimed to avoid an ambiguity inherent in Experiment 1, where in conditions with five counterarguments, only weak arguments were added to strong ones, making it difficult to differentiate the two possible explanations for the null difference between conditions with two versus five counterarguments; namely, a null effect of the number of arguments or a dilution effect that canceled out an effect of argument number. To this end, Experiment 2 contrasted conditions where strong arguments were supplemented with either weak or strong arguments.

Experiment 2

Method

Participants. Power analysis suggested a minimum sample size of 39 participants to find an effect of small to moderate size ($\eta_p^2 = .03$) with $\alpha = .05$ and $1-\beta = .80$. A total of $N = 56$ undergraduate students from the University of Western Australia participated (30 females and 26 males; mean age $M = 19.14$ [$SD = 2.85$] years).

Design, materials, and procedure. In addition to the counterarguments used in Experiment 1, we formulated counterarguments that were conceptually related to the claims but logically irrelevant. An example of an irrelevant counterargument (relating to the brain training example) was "*The brain has billions of cells and cell connections. It is the most complex system known to mankind and will never fully understand itself. Any claims to the contrary are mere speculation.*" As it proved difficult to generate more than two such counterarguments for all claims, Experiment 2 used either two or four counterarguments (instead of five as in Experiment 1), depending on condition.

There were seven conditions, defined by the number and strength of counterarguments. The control condition (C) featured no counterarguments; the SS, WW, and II conditions presented two strong, weak, or irrelevant counterarguments, respectively; the SSSS, SSWW, and SSII conditions added two strong, weak, or irrelevant counterarguments, respectively, to the SS condition. Each condition used one claim in a within-subjects design; the assignment of claims to conditions was counterbalanced across participants in a Latin-square design in the same manner as in Experiment 1. For each participant, the order of claims/conditions was randomized. An online pilot study with $N = 78$ participants served (1) to select the seven most strongly believed equivocal claims from the set of 10 used in Experiment 1; (2) to select the four strongest and two weakest counterarguments per claim from a set of 7-8 counterarguments (largely identical to the set used in Experiment 1); and (3) to obtain strength ratings for the newly designed irrelevant counterarguments (two per claim; see Online Supplement for all claims, counterarguments, and pilot ratings).[3] The procedure was identical to Experiment 1 (the distractor task was a survey investigating the effects of scientific-certainty information on climate-change beliefs).

Results

Counterargument ratings. We first conducted a manipulation check to confirm that the strong and weak counterarguments were indeed perceived as relatively strong and weak, respectively. The mean counterargument strength ratings for the strong and weak counterarguments were $M = 6.03$ ($SE = 0.13$) and $M = 4.53$ ($SE = 0.19$), respectively. Irrelevant

[3] As Experiments 1 and 2 each used their own pilot rating, and because Experiment 1 used two strong and three weak arguments, whereas Experiment 2 used four strong and two weak arguments, some arguments classified as “weak” in Experiment 1 were classified as “strong” in Experiment 2, and vice versa. In total, of the 35 arguments used in Experiment-1 claims also used in Experiment 2, 17 were classified consistently, 7 weak claims were classified as strong in Experiment 2, and 1 strong claim was classified as weak. Ten arguments used in Experiment 1 were not amongst the strongest or weakest arguments in the pilot rating of Experiment 2.

counterarguments were rated with $M = 4.84$ ($SE = 0.24$). A one-way repeated measures ANOVA showed a significant main effect, $F(2,110) = 19.94$, $MSE = 1.74$, $p < .001$, $\eta_p^2 = .27$, with strong counterarguments rated stronger than both weak, $F(1,55) = 55.55$, $MSE = 1.12$, $p < .001$, and irrelevant counterarguments, $F(1,55) = 24.32$, $MSE = 1.61$, $p < .001$, and no difference between the latter two, $F < 1.1$. Correspondence between argument-strength ratings of Experiment 2 and its pilot study was again demonstrated by a strong correlation, $r(54) = .71$, $p < .001$.

Direct belief-change score. Belief-change scores were calculated from the direct belief ratings pre and post manipulation. The means and standard errors of the belief-change scores across conditions were $M_{C} = -0.93$ ($SE = 0.30$), $M_{SS} = -1.21$ ($SE = 0.28$), $M_{WW} = -1.11$ ($SE = 0.22$), $M_{II} = -0.84$ ($SE = 0.26$), $M_{SSSS} = -1.57$ ($SE = 0.21$), $M_{SSWW} = -1.61$ ($SE = 0.27$), and $M_{SSII} = -1.21$ ($SE = 0.27$); see Figure 1. We analyzed these data in two ways; first, as a 2 (number of counterarguments: 2 vs. 4) × 3 (strength of counterarguments: strong, weak, irrelevant) design without the control condition, and second, as a one-factorial design with the control condition, with follow-up contrast analysis.

The 2 × 3 repeated-measures ANOVA yielded a main effect of number of counterarguments, $F(1,55) = 4.83$, $MSE = 2.93$, $p = .03$, $\eta_p^2 = .08$. The main effect of counterargument strength was non-significant, $F(2,110) = 1.42$, $MSE = 3.22$, $p = .25$ ($F < 1$ for the interaction). A one-way repeated-measures ANOVA including the control condition showed no significant main effect, $F(6,330) = 1.66$, $MSE = 2.90$, $p = .13$; a planned contrast showed that the control condition differed from the (pooled) SSSS and SSWW conditions, $F(1,55) = 5.74$, *MSE* = 2.84, *p* = .02.[4] (Other planned contrasts were control vs. pooled SS and WW conditions; control vs. II, and SS vs. SSII, which were all obviously non-significant).

Indirect belief scores. A mean inference score was calculated for each condition by averaging the responses to the 6 relevant inference questions. Mean inference scores across conditions were: M_{C} = 5.04 (*SE* = 0.31), M_{SS} = 4.88 (*SE* = 0.30), M_{WW} = 4.91 (*SE* = 0.28), M_{II} = 5.28 (*SE* = 0.28), M_{SSSS} = 4.85 (*SE* = 0.27), M_{SSWW} = 4.80 (*SE* = 0.30), and M_{SSII} = 4.87 (*SE* = 0.26). Despite the trend for a numerical "backfire effect" of the II condition (i.e., slightly higher inference score than control) and the fact that SSSS and SSWW conditions had the lowest claim belief —in line with the direct belief-change measure—neither 2 × 3 nor one-factorial analyses revealed any significant effects or differences among conditions (all $F < 1.2$).

Discussion

Overall, the results of Experiment 2 pointed in the same direction as Experiment 1, namely that providing more counterevidence tends to weaken belief in equivocal claims, as reflected in the main effect of argument number. Unlike in Experiment 1, only the direct measure showed an effect in Experiment 2, for reasons that are not entirely clear. Moreover, in Experiment 2, only presentation of four (as opposed to two) counterarguments significantly reduced belief in the claims relative to control. Experiment 2 additionally demonstrated that counterarguments had to be relevant to lead to belief change. Irrelevant counterarguments did not seem to dilute the effectiveness of stronger counterarguments when combined with these, and they were entirely ineffective in reducing belief in the claims when presented in isolation. This is an interesting finding given that the irrelevant counterarguments were rated as just as convincing

[4] Average pre-manipulation belief ratings ranged from 6.71 to 7.30 across conditions. There was no main effect of condition in a separate analysis of pre-manipulation belief scores, and thus no significant baseline difference between conditions, $F < 1$.

as the “weak” counterarguments in the direct strength rating. Surprisingly, despite the substantial difference in rated strength between strong and weak arguments, the weak counterarguments seemed just as effective as strong counterarguments in reducing belief. However, we caution against drawing strong conclusions regarding argument strength, given that the assessment of argument strength was only a subordinate aim of the present study, given that the strength manipulation was not very strong, and given that strength and number factors were not fully crossed.

Experiment 3

The effect of counterargument number pointed in the same direction in Experiments 1 and 2; however, the evidence remained somewhat inconclusive. In particular, in Experiment 1, five counterarguments did not lead to significantly more belief change than two, and in Experiment 2, two counterarguments did not lead to a significant belief change relative to control (the apparent belief change in the control condition was substantial, perhaps because of demand effects arising in a within-subjects design). We tackled those problems in Experiment 3 by conducting a large online study with a between-subjects design. We focused exclusively on the effect of the number of counterarguments without manipulating argument strength. Experiment 3 used three claims; however, each participant was presented with just one of these three claims, and received either 0, 2, or 6 counterarguments.

Method

Participants. We tested $N = 541$ U.S. participants using Amazon MTurk ($n \approx 60$ per cell; $n \approx 180$ per condition; 264 female, 273 male, 4 undisclosed gender; mean age $M = 40.32$ [$SD = 12.25$] years).

Materials and procedure. We selected three claims (those relating to sugar-induced hyperactivity, and the benefits of brain training and fish oil, respectively; see Online Supplement) and the six “strong” and “weak” counterarguments associated with each claim, from Experiment 2. There were three conditions, defined by the number of counterarguments. The control condition featured zero counterarguments; in the 2-CA condition, the counterarguments were randomly drawn from the available pool of six. In the 6-CA condition, all available counterarguments were presented. Thus, the average strength of arguments was comparable across the 2-CA and 6-CA conditions. The procedure was similar to Experiment 1, but participants were tested online, each participant received just one claim, and the retention interval, filled with an unrelated distractor task (a word puzzle), was just 30 s.

Results

Direct belief-change score. Belief-change scores were calculated from the direct belief ratings pre and post manipulation. The means and standard errors of the belief-change scores across conditions were M_{C} = -0.34 (SE = 0.13; n = 179), $M_{\text{2-CA}}$ = -0.94 (SE = 0.13; n = 182), and $M_{\text{6-CA}}$ = -1.56 (SE = 0.13; n = 180); see Figure 2. A one-way ANOVA yielded a main effect of number of counterarguments, $F(2,538) = 22.77$, $MSE = 2.93$, $p < .001$, $\eta_p^2 = .08$.[5] Planned contrasts indicated that the 2-CA condition differed from control, $F(1,538) = 11.03$, $p < .001$, and the 6-CA condition differed from both control, $F(1,538) = 45.54$, $p < .001$, and the 2-CA condition, $F(1,538) = 11.91$, $p < .001$.

An additional analysis on the post-manipulation belief ratings, including the initial belief rating as a covariate, found that post-manipulation belief was stronger when initial claim belief

[5] Average pre-manipulation belief ratings ranged from 7.35 to 7.39 across conditions. There was no main effect of condition in a separate analysis of pre-manipulation belief scores, and thus no significant baseline difference between conditions, $F < 1$.

was high, $F(1,535) = 1005.96$, $MSE = 2.87$, $p < .001$, $\eta_p^2 = .65$, but that this effect did not interact significantly with argument number, $F(2,535) = 2.58$, $MSE = 2.87$, $p = .08$. In other words, post-manipulation belief was determined mainly by pre-manipulation belief and the number of counterarguments, without those factors interacting.

Indirect belief scores. A mean inference score was calculated for each condition by averaging the responses to the 6 relevant inference questions across claims. Mean inference scores were: $M_C = 5.10$ ($SE = 0.18$), $M_{2\text{-CA}} = 4.59$ ($SE = 0.18$), and $M_{6\text{-CA}} = 4.41$ ($SE = 0.18$); see Figure 3. A one-way ANOVA yielded a main effect of number of counterarguments, $F(2,538) = 4.06$, $MSE = 5.58$, $p = .02$, $\eta_p^2 = .01$. Planned contrasts indicated that the 6-CA condition differed from control, $F(1,538) = 7.56$, $p < .01$, whereas the 2-CA condition did not differ clearly from either control, $F(1,538) = 4.11$, $p = .04$, or the 6-CA condition, $F < 1$.

Discussion

The results of Experiment 3 again confirmed that providing more counterarguments to equivocal claims leads to greater belief reduction. The between-subjects design reduced demand characteristics and potential effects of growing disinterest in the materials that may have influenced the results from the within-subject design used in Experiments 1 and 2. The results of Experiment 3 also suggest that the effect of argument number is comparable across undergraduate and more-varied online participant samples. The experiment also yielded results that were nearly identical between direct and indirect measures of belief change.

General Discussion

In this paper, we set out to investigate the issue of reducing beliefs in equivocal claims in three experiments. Our research was guided by the question of whether more counter-information leads to greater belief change, or whether less information can be more successful in the correction of equivocal claims. Specifically, we tested whether ironic effects of argument number would occur when refuting equivocal claims. It is of theoretical interest to ascertain whether there might be a non-monotonic relation between counterargument number and corrective impact, and whether a larger number of counterarguments might be less effective due to factors such as enhanced skepticism and reactance. From an applied perspective, it is important to establish whether presentation of too many counterarguments might carry the risk of an overkill backfire effect (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012), and thus whether there is a small, optimal number of counterarguments (see Shu & Carlson, 2014) that should be used when designing effective refutations and public information campaigns.

In Experiment 1, five counterarguments reduced beliefs in equivocal claims to a similar extent as two counterarguments; however, only five counterarguments led to reduced claim support on the inferential reasoning measure. In Experiment 2, only four, not two, reasonably strong counterarguments reduced claim belief relative to control, without however affecting the indirect measure. Experiment 3 showed that six counterarguments led to more belief change than two, a result that was mirrored in the indirect measure. Although there were some discrepancies across measures, the findings from all three experiments point to the same conclusion: There was no overkill backfire effect, and a larger number of counterarguments was conducive to greater belief revision.

In contrast to our expectation derived from previous literature (Freudenburg et al., 2008; McCright & Dunlap, 2010; Michaels, 2006; Oreskes & Conway, 2010), we found no evidence for the efficacy of irrelevant counterarguments. In fact, irrelevant arguments seemed to lead neither to a reduction nor increase in belief, whether presented in isolation or in conjunction with stronger arguments. This also implies that we found no evidence of a dilution effect (Nisbett et al., 1981; also see De Vries, Terwel, & Ellemers, 2014; Meyvis & Janiszewski, 2002). This is particularly interesting given the fact that participants in Experiment 2 perceived the irrelevant counterarguments to be as convincing as the weak counterarguments (which as discussed earlier were “weak” only in a relative sense and had virtually the same effect on people’s beliefs as their stronger counterparts). In other words, the impact of an argument on a person’s belief was to an extent decoupled from how convincing an argument appeared to be. For scientists and policy-makers trying to communicate valid research findings and evidence-based policies, this is an encouraging finding, as counterarguments that at face value are perceived as somewhat convincing do not seem to cause belief change unless they have substantial relevance to the to-be-refuted claim. We acknowledge that this conclusion is speculative and the situation may be different with stronger claims and when worldviews become involved. In other words, the present findings should not be taken to imply that irrelevant arguments generally have no impact on beliefs—inadmissible evidence in courts or ad-hominem attacks are examples of irrelevant information that may well influence people’s decision making (Barnes, Johnston, MacKenzie, Tobin, & Taglang, 2018; Pickel, 1995).

The fact that irrelevant counterarguments were found to have no impact suggests that the observed effects of argument number were not purely a result of a numerosity heuristic. Rather, the results support the basic assumption of rational belief updating, namely that more evidence against a claim leads to a stronger belief reduction. This is in line with a benchmark finding from the literature on the continued influence effect of misinformation, namely that the provision of alternative factual information is crucial when retracting misinformation (Ecker et al., 2011; Johnson & Seifert, 1994; Seifert, 2002). Our finding also meshes well with studies from the educational literature suggesting that the provision of factual information can go a long way in reducing misconceptions. For example, Ranney and Clark (2016) reported that acceptance and understanding of anthropogenic global warming (AGW) can be substantially increased by simple interventions explaining the greenhouse mechanism largely responsible for AGW. Moreover, a refutational format of interventions similar to the present paradigm, where misconceptions are explicitly addressed and refuted with factual information, has been shown to be particularly well-suited to reduce misconceptions in classroom settings (Guzzetti, Snyder, Glass, & Gamas, 1993; Kowalski & Taylor, 2009).

In summary, our study yielded no evidence for an overkill backfire effect, but on the contrary suggests a *more is more* approach to the refutation of equivocal claims. Future research should investigate the generality of this proposal. In particular, it is unclear to what extent the provision of more counterarguments will be effective when refuting claims that are strongly supportive of a person's worldview, and that therefore are likely to be believed more strongly than the equivocal claims used here. Some researchers have argued that people's pre-existing attitudes determine how they process counter-attitudinal corrections of misconceptions they hold (Ecker & Ang, in press; Hart & Nisbet, 2012; Lewandowsky, Stritzke, Oberauer, & Morales, 2005; Nyhan & Reifler, 2010; Nyhan, Reifler, & Ubel, 2013; but see also Wood & Porter, in press). For example, political ideology can lead people to resist belief change, or can even lead to belief change in the direction counter to the evidence presented. This suggests that people's pre-existing attitudes and worldviews may be the greatest obstacle to corrections of misconceptions, and thus it may be the case that providing more information when refuting equivocal claims will be helpful only when the presented information is assessed with an open mind. To illustrate, Levitan and Visser (2008) suggested that open-mindedness was associated with stronger engagement with counter-attitudinal persuasive messages, and stronger attitude change in response to strong persuasive messages. This suggests that even the *more is more* approach to the refutation of equivocal claims may well be futile when people engage in motivated reasoning to defend their worldviews (see Ecker, Swire, & Lewandowsky, 2014; Kunda, 1990).

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Author contributions:

UE conceived and designed the studies, supervised data collection, analyzed and interpreted the data, and wrote the manuscript.

SL contributed to planning and design, and contributed to the manuscript.

KJ and AM contributed to the literature review, collected the data, analyzed and interpreted the data, and contributed to the manuscript.

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Table 1. *Example Claim, with Associated Counterarguments and Inference Questions, Used in Experiments (E) 1-3.*

Claim

Fish oil is derived from the tissue of oily fish, and contains omega-3 fatty acids which are known to reduce inflammation throughout the body. The Heart Foundation recommends that adults consume at least 500mg of omega-3 every day from oily fish or fish oil supplements to maintain heart health. *Please rate your agreement with the following statement on a scale of 0 (I do not agree at all) to 10 (I strongly agree): Fish oil is good for heart health.*

Strong Counterarguments

1. (E1/E2/E3) A study in September 2012 re-examined data from 20 previous clinical trials involving nearly 70,000 patients. They found that compared to placebos, omega-3 supplements were not associated with a lower risk of heart attack, stroke, or sudden cardiac death.
2. (E2/E3) $15 billion per year is spent in the US alone on fish oil supplements. It is of commercial interest to promote fish oil as being beneficial for heart health.
3. (E2/E3) Individuals who consume the recommended dose of fish oil can expect to spend between $360 and $4500 per year. It is therefore likely that people who choose to buy fish oil supplements are of higher socioeconomic status, with a healthier diet and lifestyle, than those who do not. Hence, these people might be healthier to start with.
4. (E1/E2/E3) There have been major systematic reviews in the Archives of Internal Medicine, the Annals of Internal Medicine, and the Journal of the American Medical Association, which have all failed to support a clear effect of regular omega-3 consumption.

Weak Counterarguments

1. (E1/E2/E3) Although fish oil supplements have a favourable effect on 'good cholesterol' levels, a direct mechanism for how omega 3 fatty acids actually provide cardiac protection has never been agreed upon.
2. (E1/E2/E3) While the amount of oil consumed is small, if taken regularly, fish oil supplements add significantly to the total fat consumed. The additional energy can contribute to weight problems that can offset some of the potential benefits of fish oil consumption.
3. (E1) At high doses, the side effects of fish oil include thinning of the blood, nausea and may also reduce immune system activity, reducing the body's ability to fight infection. The side effects of small doses over long periods of time remain unknown.

Irrelevant Counterarguments

1. (E2) What matters is exercise. The positive effects of exercise are well documented and go beyond cardiovascular benefits.
2. (E2) Genetic factors play a major role for cardiovascular disease. The likelihood of having a heart attack is much higher if family members have heart issues. You can't change your genes.

Inference Questions

1. How much do you think the risk of heart disease can be reduced by regular intake of fish oil? (0-20%)
2. When buying a nutritional supplement, how much would you be willing to pay extra for a product that contains fish oil? (0-20%)
3. How much do you think fish oil could potentially reduce public health expenditure over the next 10 years? (0-1%)
4. Should the government subsidise and promote regular intake of fish oil supplements? [Absolutely not (0) – Absolutely (10)]
5. How likely is it that you would encourage your own friends or relatives to use fish oil? [(Very unlikely (0) - Very likely (10)]
6. How would you rate the long-term benefits associated with fish oil? [Very low (0) - Very high (10)]

Figure 1.

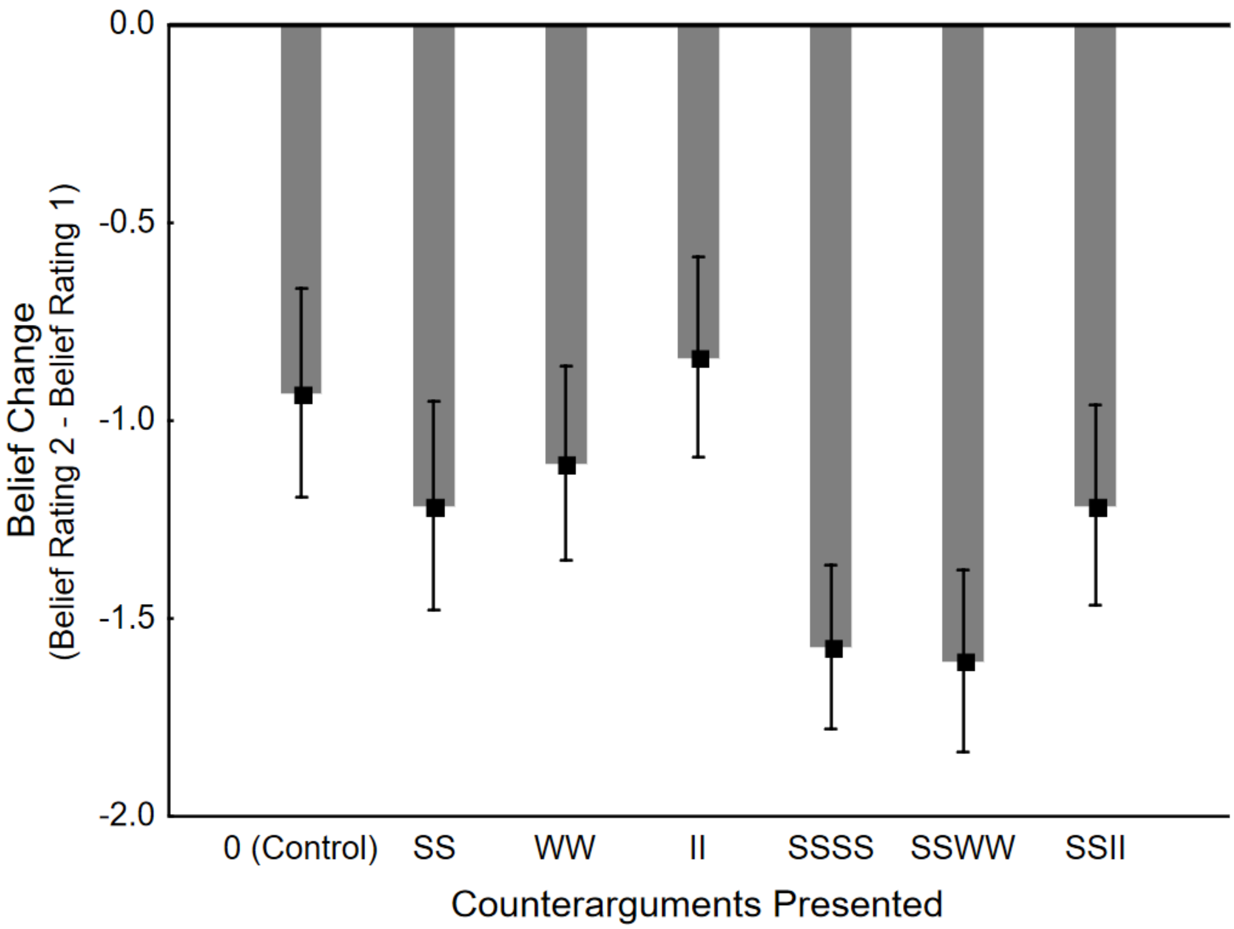

Figure 1. Belief-change ratings across experimental conditions in Experiment 2. *Note.* S, strong counterargument; W, weak counterargument; I, irrelevant counterargument. Error bars indicate within-subjects standard error of the mean.

Figure 2.

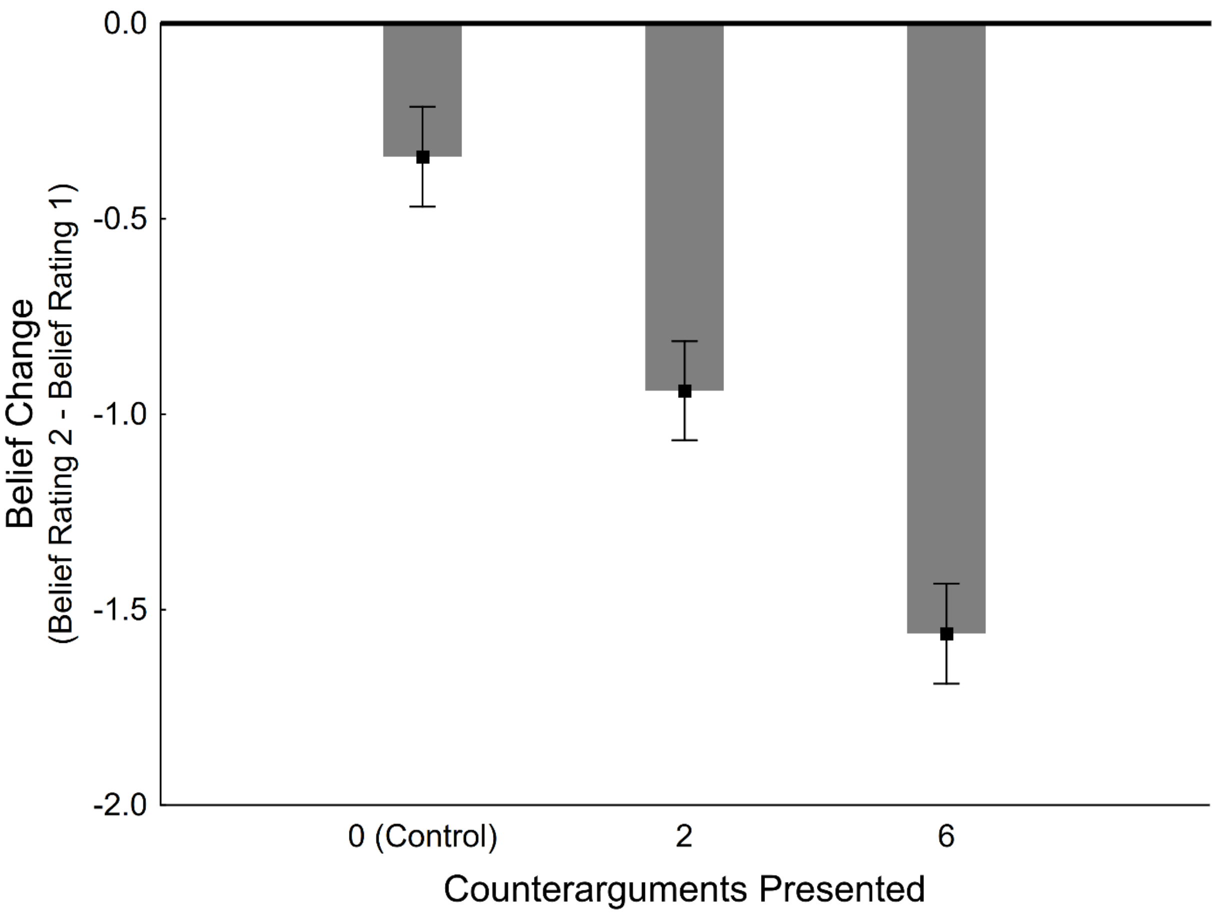

Figure 2. Belief-change ratings across experimental conditions in Experiment 3. Error bars indicate standard error of the mean.

Figure 3.

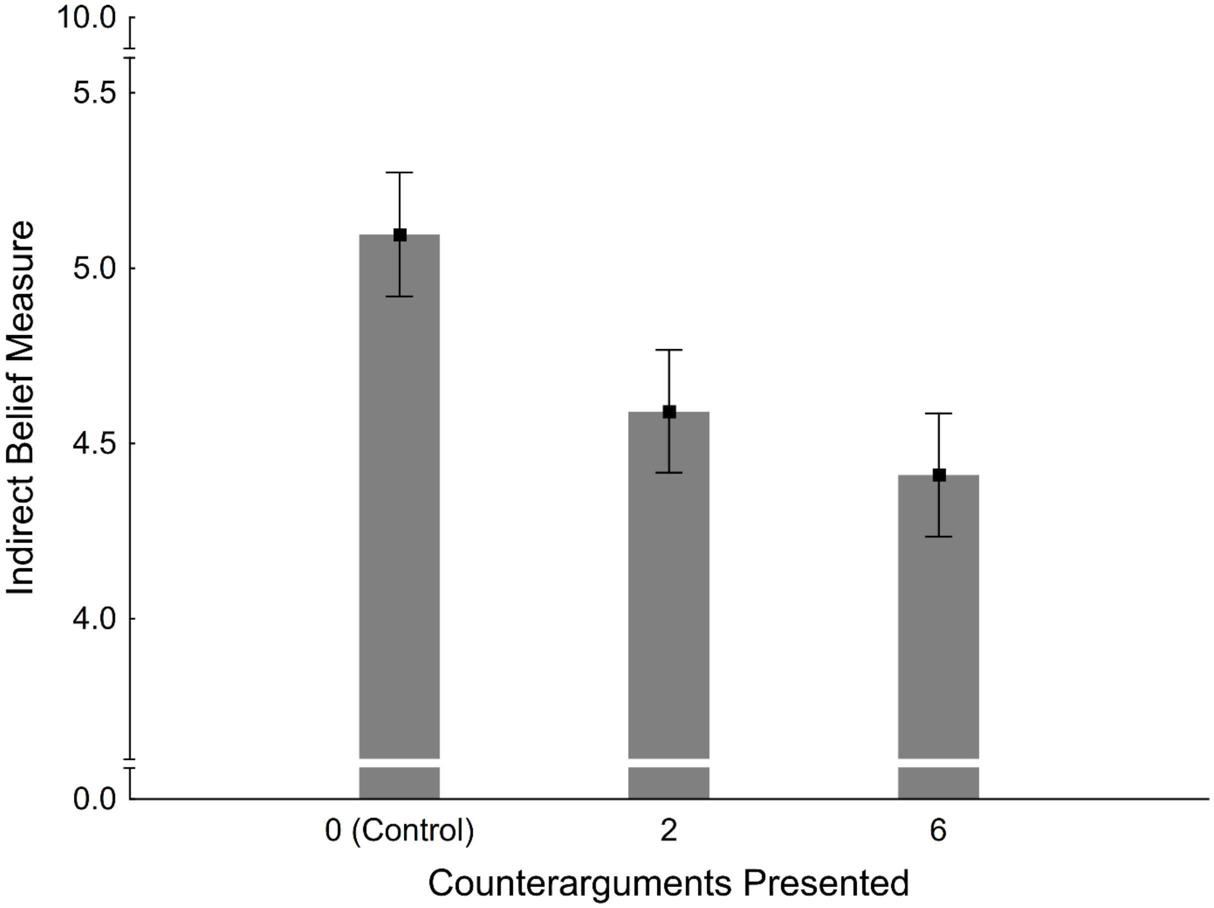

Figure 3. Indirect belief ratings across experimental conditions in Experiment 3. Error bars indicate standard error of the mean.

Online Supplement

Claims used in Experiment 1 (* indicates use in Experiment 2; # indicates use in Experiment 3)

1. *#Fish oil is derived from the tissue of oily fish, and contains omega-3 fatty acids which are known to reduce inflammation throughout the body. The Heart Foundation recommends that adults consume at least 500mg of omega-3 every day from oily fish or fish oil supplements to maintain heart health. [*Fish oil is good for heart health.]*
2. *#Sugar (such as sucrose) increases blood sugar levels, which leads to temporary hyperactivity and other behavioural problems in children. The more a child consumes, the more they are likely to be affected. This can easily be observed at children's birthday parties and other social events where sugary food is freely available. [*Sugar causes hyperactivity in children.]*
3. Prison is the most effective way of dealing with criminality. It keeps criminals off the street and acts as a deterrent to those who may potentially commit a crime. Community/rehabilitation programs are a soft option, and are not a true punishment. Tough laws improve public safety. [*Prison sentences are the best solution to crime.]*
4. *Cancer is the leading cause of death worldwide, accounting for approximately 13% of all deaths. Major risk factors include age, obesity, poor diet, and tobacco and alcohol use. It is recommended that all individuals above the age of 40 have regular cancer screenings, so that an early diagnosis can be made. [*Broad cancer screenings are greatly beneficial.]*
5. *Vitamin D is important for health, and is primarily obtained through exposure to sunlight. Sun protection campaigns have been so successful that it has triggered an

epidemic of vitamin D deficiency. Vitamin D deficiency has been linked to many cancers, heart disease, bone disease, and depression. [*Most people should spend more time in the sun to avoid vitamin D related health problems.]*

6. *#Brain training increases one's intelligence. Dedicated software—programmed for commercial computers and video game consoles—can boost the efficacy of neural networks and trigger the growth of new brain cells. Over time, brain training can improve memory and general reasoning skills, hence increasing IQ. [*Brain training increases one's memory capacity and intelligence.]*
7. Hydraulic fracturing (otherwise known as "fracking") is a technique used to release natural gas from rock formations underground. Water containing sand and chemicals is injected at high pressure to fracture shale rocks. Fracking technology has been used for over a decade, and shale gas is a cleaner alternative to coal. Engineering societies state that fracking is safe as long as "best practices are implemented and robustly enforced through regulation". [*Fracking is a safe technology.*]
8. *Thiomersal (or thimerosal in America) is a preservative which has been added to vaccines since the 1930s. It is an organic compound containing almost 50% mercury. In 1999 the American Academy of Paediatrics and the US Public Health Service issued a joint statement recommending the removal of thiomersal from vaccines as a precautionary measure, following a US Food and Drug Administration review. [*Thiomersal in vaccines is toxic and could potentially cause harm.*]
9. *Antioxidants are molecules which inhibit the oxidation of other molecules, and act as powerful disease-preventing agents. Oxidation is a chemical reaction which produces free radicals. It is these free radicals which damage cells, and play a role

in heart disease, cancer, and other diseases. [*Antioxidants are important for good health.*]

10. Many have questioned whether a carbon tax is having a significant effect in reducing greenhouse gas emissions, while individuals and businesses suffer the costs. Some have suggested it to be little more than another money-making government scheme. [*The carbon tax (aka carbon 'cap and trade' scheme) is an ineffective burden on the Australian economy.]*

Inference Questions used in Experiments 1-3 [(R): reverse-coded]

7. Fish oil
    a. How much do you think the risk of heart disease can be reduced by regular intake of fish oil? 0 – 20%)
    b. When buying a nutritional supplement, how much would you be willing to pay extra for a product that contains fish oil? (0 – 20%)
    c. How much do you think fish oil could potentially reduce public health expenditure over the next 10 years? (0 – 1%)
    d. Should the government subsidise and promote regular intake of fish oil supplements? (0 – Absolutely not, 10 – Absolutely)
    e. How likely is it that you would encourage your own friends or relatives to use fish oil? (0 – Very unlikely, 10 – Very likely)
    f. How would you rate the long-term benefits associated with fish oil? (0 – Very low, 10 – Very high)
8. Sugar
    a. How much do you think symptoms of hyperactivity can be reduced by avoiding sugar? (0 – 20%)

b. When buying food for a child's birthday party, how much would you be willing to pay extra for sugar-free cake and lollies? (0 – 20%)
c. How much do you think sugar could potentially add to public health expenditure on disorders relating to hyperactivity (such as ADHD)? (0 – 1%)
d. Should the government fund more research and awareness campaigns relating to the link between sugar intake and behavioural problems in children? (0 – Absolutely not, 10 – Absolutely)
e. How likely is it that you would encourage your own friends or relatives to avoid sugar to reduce their child's hyperactivity? (0 – Very unlikely, 10 – Very likely)
f. How would you rate the long-term benefits on behaviour associated with cutting sugar? (0 – Very low, 10 – Very high)

9. Prison
    a. How much do you think harsher prison sentences could reduce serious crime? (0 – 20%)
    b. How much would you be willing to pay in extra tax to fund harsher prison sentencing to improve public safety? (0 – 2%)
    c. How much do you think harsher prison sentences could potentially decrease expenditure on policing and victim support over the next 10 years? (0 – 1%)
    d. Should the government fund prison extensions to allow longer and harsher sentencing? (0 – Absolutely not, 10 – Absolutely)
    e. How likely is it that you would encourage your own friends or relatives to support tougher laws and harsher sentencing of convicted criminals? (0 – Very unlikely, 10 – Very likely)

f. How would you rate the long-term benefits associated with prison sentences? (0 – Very low, 10 – Very high)

10. Cancer screening

a. How much do you think cancer-related mortality rates can be reduced by regular broad cancer screening? (0 – 20%)

b. When buying health insurance, how much would you be willing to pay extra for a product that includes access to broad cancer screenings? (0 – 20%)

c. How much do you think broad cancer screening could potentially reduce public health expenditure over the next 10 years? (0 – 1%)

d. Should the government invest more money to subsidise and promote cancer screening for all over-40-year-olds? (0 – Absolutely not, 10 – Absolutely)

e. How likely is it that you would encourage your own friends or relatives to participate in broad cancer screenings? (0 – Very unlikely, 10 – Very likely)

f. How would you rate the long-term benefits associated with broad cancer screening? (0 – Very low, 10 – Very high)

11. Vitamin D

a. How much do you think the risk of disease could be reduced by spending more time in the sun to avoid vitamin D deficiency? (0 – 20%)

b. When buying sun protection products, how much would you be willing to pay extra for products that do not impact as much on vitamin D production? (0 – 20%)

c. How much do you think vitamin D deficiency could potentially increase public health expenditure over the next 10 years? (0 – 1%)

   d. Should the government fund information campaigns to promote more sun exposure to reduce vitamin D deficiency? (0 – Absolutely not, 10 – Absolutely)
   e. How likely is it that you would encourage your own friends or relatives to increase the amount of time they spend outside to promote vitamin D production? (0 – Very unlikely, 10 – Very likely)
   f. How would you rate the long-term risks associated with limited sun exposure and resulting vitamin D deficiency? (0 – Very low, 10 – Very high)

12. Brain training
   a. With regular training, estimate how much a person's memory capacity and intelligence could be improved through brain training? (0 – 20%)
   b. When buying a game console, how much would you be willing to pay extra for a bundle including state-of-the-art brain training software? (0 – 20%)
   c. How much do you think brain training could reduce public health expenditure on mental illness (e.g. ADHD, dementia) over the next 10 years? (0 – 1%)
   d. Should the government increase education and health funding to implement brain training in schools, hospitals, and aged care facilities? (0 – Absolutely not, 10 – Absolutely)
   e. How likely is it that you would encourage your own friends or relatives to do brain training? (0 – Very unlikely, 10 – Very likely)
   f. How would you rate the long-term benefits associated with brain training? (0 – Very low, 10 – Very high)

13. Fracking
   a. How much do you think fracking will increase the total impact of mining on workers' health and the environment? (0 – 20%) (R)

b. When buying gas, how much would you be willing to pay extra for non-fracking gas? (0 – 20%) (R)
c. How much do you think fracking could potentially increase public health and environment-protection expenditure over the next 10 years? (0 – 1%) (R)
d. Should the government fund more research into the safety of fracking? (0 – Absolutely not, 10 – Absolutely) (R)
e. How likely is it that you would encourage your own friends or relatives to learn about the safety issues of fracking? (0 – Very unlikely, 10 – Very likely) (R)
f. How would you rate the long-term risks associated with fracking? (0 – Very low, 10 – Very high) (R)

14. Thiomersal

a. How much do you think the risk of negative side effects of vaccinations could be reduced by banning thiomersal? (0 – 20%)
b. When getting a vaccination for yourself or a dependent, how much would you be willing to pay extra for products that do not contain thiomersal? (0 – 20%)
c. How much do you think thiomersal could potentially add to public health expenditure over the next 10 years? (0 – 1%)
d. Should the government fund more research into the adverse effects of thiomersal in vaccines? (0 – Absolutely not, 10 – Absolutely)
e. How likely is it that you would encourage your own friends or relatives to avoid vaccines containing thiomersal? (0 – Very unlikely, 10 – Very likely)
f. How would you rate the long-term risks associated with thiomersal? (0 – Very low, 10 – Very high)

15. Antioxidants

a. How much do you think the risk of disease can be reduced by regular intake of antioxidants? (0 – 20%)
b. When buying groceries, how much would you be willing to pay extra for products that are high in antioxidants? (0 – 20%)
c. How much do you think antioxidants could potentially reduce public health expenditure over the next 10 years? (0 – 1%)
d. Should the government subsidise and promote a high regular intake of antioxidants? (0 – Absolutely not, 10 – Absolutely)
e. How likely is it that you would encourage your own friends or relatives to increase their intake of antioxidants? (0 – Very unlikely, 10 – Very likely)
f. How would you rate the long-term benefits associated with antioxidants? (0 – Very low, 10 – Very high)

16. Carbon tax

a. How much do you think the carbon tax (aka carbon 'cap and trade' scheme) will decrease carbon emissions over the next 5 years? (0 – 20%) (R)
b. How much would you be willing to pay extra in taxes and on general goods and services to maintain a price on carbon? (0 – 20%) (R)
c. How much do you think a price on carbon could potentially decrease public health and environment-protection expenditure over the next 40 years? (0 – 1%) (R)
d. Should the government increase funding to compensate businesses that suffer from the carbon tax? (0 – Absolutely not, 10 – Absolutely)
e. How likely is it that you would encourage your own friends or relatives to support the price on carbon? (0 – Very unlikely, 10 – Very likely) (R)

f. How would you rate the long-term benefits associated with a price on carbon? (0 – Very low, 10 – Very high) (R)

Counterarguments used in Experiment 1 (S = strong, W = weak)

1. Fish oil
    a. S1: A study in September 2012 re-examined data from 20 previous clinical trials involving nearly 70 000 patients. They found that compared to placebos, omega 3 supplements were not associated with a lower risk of heart attack, stroke, or sudden cardiac death.
    b. S2: There have been major systematic reviews in the Archives of Internal Medicine, the Annals of Internal Medicine, and the Journal of the American Medical Association, which have all failed to support a clear effect of regular omega 3 consumption.
    c. W1: While the amount of oil consumed is small, if taken regularly, fish oil supplements add significantly to the total fat consumed. The additional energy can contribute to weight problems that can offset some of the potential benefits of fish oil consumption.
    d. W2: Although fish oil supplements have a favourable effect on 'good cholesterol' levels, a direct mechanism for how omega 3 fatty acids actually provide cardiac protection has never been agreed upon.
    e. W3: At high doses, the side effects of fish oil include thinning of the blood, nausea and may also reduce immune system activity, reducing the body's ability to fight infection. The side effects of small doses over long periods of time remain unknown.

2. Sugar
    a. S1: Studies using placebo control groups have been unable to find any behaviour differences between children who have consumed sugar, and those who have not.
    b. S2: No one has been able to explain exactly *how* sugar might have an effect on children's behaviour. If high blood sugar levels were the cause, children would be likely to be hyperactive after eating a baked potato, which causes a similar spike in blood sugar levels as sugar.
    c. W1: US allergy specialist Benjamin Feingold first suggested in 1973 that hyperactivity in children is linked to what they eat, and proposed a diet for preventing this. There are no studies which support this.
    d. W2: People often confuse proximity with causality when it comes to food and behaviour. When children are having fun at birthday parties or on holiday, sugary food is often served. But it is the atmosphere which makes children hyperactive, rather than the food.
    e. W3: The notion that food has a direct connection to behaviour has been called "the biggest myth of all" by U Texas psychiatry professor Steven Pliszka.
3. Prison
    a. S1: Often individuals sentenced to prison have mental health issues or drug addictions, and will not receive the help they need in jail.
    b. S2: Offenders given community penalties have significantly lower reoffending rates than similar offenders who have served short prison sentences, according to Ministry of Justice research. Those in community programs are approximately 20 times less likely to be in jail 3 years later.

c. W1: Community programs give individuals a chance to be productive and contribute to their community, raising self-esteem and future employability.

d. W2: A recent cost-benefit analysis of how non-violent offenders are treated within Australia's justice system challenges the idea of spending billions to house criminals. The state governments save more than $100,000 every time an alcohol or drug addicted offender is ordered into out-patient rehabilitation instead of being sent to jail.

e. W3: Community programs would not create "colleges of crime." Among prison inmates, main topics of conversation include crime and drugs, and it is a good place to 'make connections.'

4. Cancer screening

    a. S1: Some screening tests expose the body to potentially harmful radiation, which can contribute to the development of cancer.

    b. S2: The popular "5-year survival rate" statistic used to promote cancer screenings is flawed. For example, if 100 people are diagnosed at age 70 based on a screening test, and they all die at 80, the percentage of people who have survived 5 years past diagnosis is 100%. Yet if 100 people are diagnosed at age 77 based on symptoms, and they still die at 80, the percentage who have survived 5 years is 0%. Yet, not a single life was saved or prolonged.

    c. W1: Screenings for rare types of cancers are not regularly performed. Even if an individual has all the regular recommended screenings, they still may have a rarer form of the disease.

    d. W2: If the cancer is not treatable, the person may have lived a happier life not knowing their diagnosis and prognosis.

e. W3: Screenings can discover non-progressive cancers. These are abnormalities that meet the definition of cancer, but will never progress to harm the patient in their lifetime. Any painful treatment received as a result of this is needless. While in the UK, mammography is estimated to save 1,300 lives p.a., an estimated 4,000 women suffer from unnecessary treatment and surgery.

5. Vitamin D
    a. S1: Some groups of people are at higher risk of vitamin D deficiency, such as naturally dark people who cover their skin for cultural reasons. Such individuals can talk to their doctors about a vitamin D supplement. It is not necessary to spend more time in the sun.
    b. S2: While some sun exposure is vital to good health, in most parts of Australia we only need a very small amount. During summer, adequate vitamin D levels are met by just a few minutes daily exposure to our face, arms and hands before 10am and after 3pm.
    c. W1: Vitamin D levels are unlikely to be affected significantly by normal use of sunscreen. Hence one does not need to stay in the sun longer even when using sunscreen.
    d. W2: Australia is the world's skin cancer capital. Given that skin cancer is the most preventable type of cancer, it is recommended that sun protection is always utilised. The harms of sun exposure far outweigh the risks of vitamin D deficits.
    e. W3: Our bodies can store vitamin D to last between 30 and 60 days. This means that your body can mobilise its own reserves if you do not receive sufficient amounts temporarily.

6. Brain training
    a. S1: There are practice effects, meaning that doing a 'brain training' task regularly will improve your performance on that task. However, there is no good evidence for an actual and substantial transfer to memory capacity or intelligence.
    b. S2: Studies claiming that 'brain training' improves intelligence all have methodological problems (e.g. lack of adequate control groups).
    c. W1: Even the best-designed studies only report very small effect sizes, which means that even these studies do not find effects of any practical significance.
    d. W2: Some authors reporting benefits of 'brain training' have conflicts of interest (e.g. they sell 'brain training' software).
    e. W3: Effects may only exist in young children or neuropsychologically impaired patients, not in average teenagers and adults.
7. Fracking
    a. S1: Small earthquakes triggered by fracking in the UK have caused alarm. On 1 April 2011, Blackpool, UK, was struck by a magnitude 2.3 earthquake that was clearly the result of fracking.
    b. S2: In mid-2012, the Occupational Safety and Health Administration and the National Institute for Occupational Health and Safety issued a hazard alert. This stated that workers have an increased risk of developing silicosis (a lung disease similar to asbestosis, which may show up 20 years after exposure) due to exposure to airborne silica during the fracking process.
    c. W1: Law makers in France and Bulgaria have voted to ban fracking. The Industry minister of France stated that in some cases the technique causes “irreversible pollution”, and was not worth the risk.

d. W2: The exact chemicals used for fracking largely remain secret due to gas company exemptions from environmental laws. If we do not know what is being pumped into the ground, this makes the process of accountability even more difficult.

e. W3: There is a risk that groundwater in the surrounding areas could be contaminated with methane and other fracking chemicals, although most geologists say this is unlikely.

8. Thiomersal

   a. S1: In 2006 an expert panel concerned by the World Health Organisation concluded that there was “no evidence of toxicity in infants, children or adults exposed to thiomersal in vaccines”.

   b. S2: Without thiomersal, the vaccine is likely to be even *more* toxic, as fungi and bacteria can grow.

   c. W1: While methyl mercury builds up in the body, ethyl mercury (which is in thiomersal) is excreted rapidly. The body normally processes ethyl mercury within 7-10 days.

   d. W2: People’s exposure to mercury used to be higher in the 20th century than it is today. For example, mercury was used to make thermometers, lamps, laboratory instruments, batteries, and was also utilised in many industrial processes.

   e. W3: While the potential toxicity of thiomersal and mercury accumulation has been demonstrated in animal models, it is unclear if these results can be transferred to humans.

9. Antioxidants
    a. S1: It has not been proven whether daily consumption of antioxidant food or pills elevates or decreases risk of disease, as it is difficult to get complete data about the actual frequency and doses that people consume.
    b. S2: According to the US National Institute of Health, more than half of US adults take some form of vitamin or mineral supplement at a total cost of $23 billion a year. It is in the interest of business that antioxidants are promoted to be good for health.
    c. W1: Many clinical trials have revealed that antioxidants lead to virtually no improvement in the functioning of our cardiovascular system. There is less data regarding cancer, but the most recent large scale trial was halted when no benefit was shown.
    d. W2: The fact that antioxidant dietary supplementation might lead to more (not less) cancer should come as no surprise to cancer therapists, who know that ionising radiation treatment kills cancer cells largely through creation of oxidants called reactive oxygen species (ROS).
    e. W3: Vitamin E, which is promoted as an antioxidant, is an essential part of a healthy diet, and a deficiency leads to neurological problems. Yet, new studies have created doubt whether Vitamin E is in fact an antioxidant.
10. Carbon tax
    a. S1: Data from Canada and Europe have shown Sreductions in carbon emissions after the introduction of carbon taxes, and preliminary data show it is having the exact same effect in Australia.
    b. S2: Research has shown that the introduction of the carbon tax has encouraged people to reduce their carbon footprint. This effect has been found despite

compensation measures, which indicates that putting a price on carbon has contributed to a genuine awareness about the need to change behaviour.

c. W1: For most people and businesses, there will be no significant financial loss due to reductions in other taxes and compensation payments.

d. W2: The net cost to the final consumer associated with the carbon tax has been dramatically over-stated. In fact, consumers will be unlikely to feel the impact of carbon pricing on most everyday products. The Consumer Price Index in Australia rose an average of 2.1% in the first two quarters after the introduction of the carbon tax, compared to an average 3.2% rise for the same quarters in the year before. There were detectible price rises for electricity and natural gas, but these will most likely be a one-off phenomenon felt in the first year of the scheme with minimal impact in subsequent years.

e. W3: In Canada and Europe, the economy grew after the carbon tax was introduced, despite fears it would lead to recession.

Counterarguments used in Experiment 2 (S = strong, W = weak, I = irrelevant)

5. Fish oil

    1. S1: A study in September 2012 re-examined data from 20 previous clinical trials involving nearly 70,000 patients. They found that compared to placebos, omega-3 supplements were not associated with a lower risk of heart attack, stroke, or sudden cardiac death.
    2. S2: $15 billion per year is spent in the US alone on fish oil supplements. It is of commercial interest to promote fish oil as being beneficial for heart health.
    3. S3: Individuals who consume the recommended dose of fish oil can expect to spend between $360 and $4500 per year. It is therefore likely that people who choose to buy fish oil supplements are of higher socioeconomic status, with a

healthier diet and lifestyle, than those who do not. Hence, these people might be healthier to start with.

4. S4: There have been major systematic reviews in the Archives of Internal Medicine, the Annals of Internal Medicine, and the Journal of the American Medical Association, which have all failed to support a clear effect of regular omega-3 consumption.
5. W1: Although fish oil supplements have a favourable effect on 'good cholesterol' levels, a direct mechanism for how omega 3 fatty acids actually provide cardiac protection has never been agreed upon.
6. W2: While the amount of oil consumed is small, if taken regularly, fish oil supplements add significantly to the total fat consumed. The additional energy can contribute to weight problems that can offset some of the potential benefits of fish oil consumption.
7. I1: What matters is exercise. The positive effects of exercise are well documented and go beyond cardiovascular benefits.
8. I2: Genetic factors play a major role for cardiovascular disease. The likelihood of having a heart attack is much higher if family members have heart issues. You can't change your genes.

6. Sugar
    1. S1: People often confuse proximity with causality when it comes to food and behaviour. When children are having fun at birthday parties or on holiday, sugary food is often served. But it is the atmosphere which makes children hyperactive, rather than the food.
    2. S2: No one has been able to explain exactly *how* sugar might have an effect on children's behaviour. If high blood sugar levels were the cause, children

would be likely to be hyperactive after eating a baked potato, which causes a similar spike in blood sugar levels as sugar.

3. S3: Studies using placebo control groups have been unable to find any differences between children who have consumed sugar, and those who have not.
4. S4: Even studies including children with attention-deficit/hyperactivity disorder (ADHD) have not detected an effect of sugar consumption on behaviour.
5. W1: US allergy specialist Benjamin Feingold first suggested in 1973 that hyperactivity in children is linked to what they eat, and proposed a diet for preventing this. There are no studies which support this.
6. W2: The notion that food has a connection to behaviour has been called “the biggest myth of all” by U Texas psychiatry professor Steven Pliszka.
7. I1: Many educational studies raise concern about children spending too much time indoors and being exposed to age-inappropriate video games, internet content, and TV shows.
8. I2: Children’s brains are still developing. Some parts of the frontal cortex continue to mature well into adulthood. The exact mechanisms and consequences of this developmental trajectory are not very well understood.

7. Cancer screening
    1. S1: Mass screening can discover non-progressive cancers. These are abnormalities that meet the definition of cancer, but will never progress to harm the patient in their lifetime. Any painful treatment received as a result of this is needless. While in the UK mammography is estimated to save 1,300

lives p.a., an estimated 4,000 women suffer from unnecessary treatment and surgery.

2. S2: Countries with publicly funded mass screening, and countries that do not promote mass screening have the same mortality rates for many cancers. Advances in treatment (rather than screening) are primarily responsible for the decline in cancer deaths seen over the last 20 years.
3. S3: While a rebate is sometimes available, many people incur an out-of-pocket cost for screenings, in particular without private health cover. With repeat visits, mass screenings can become very costly.
4. S4: Mass screenings only target common cancers, and screening tests for rare types of cancers are not regularly performed. Even if an individual has all the regular recommended screenings, they still may have a rarer form of the disease.
5. W1: The popular "5-year survival rate" statistic used to promote mass cancer screening is flawed. For example, if 100 people are diagnosed at age 74 based on a screening test, and they all die at 80, the percentage of people who have survived 5 years past diagnosis is 100%. Yet if the same 100 people were diagnosed at age 76 based on symptoms (and still die at 80), the percentage who have survived 5 years is 0%. Yet, not a single life was saved or prolonged.
6. W2: Mass screenings will find untreatable cancers. If the cancer is not treatable, the person may have lived a happier life not knowing their diagnosis and prognosis.
7. I1: There are increasing privacy-protection concerns that governments and corporations are creating the 'transparent citizen' by accumulating more and

more data on people’s health, finances, consumption behaviour and movements.

8. I2: Some people just don’t want to know about potential illness because they object to standard medical treatment anyway. You can’t force people to behave rationally.

8. Vitamin D
    1. S1: While some sun exposure is vital to good health, in most countries people only need a very small amount. Adequate vitamin D levels are met by just a few minutes daily exposure to our face, arms and hands before 10am and after 3pm.
    2. S2: Given that skin cancer is the most preventable type of cancer, it is recommended that sun protection is always utilized. The harms of prolonged sun exposure far outweigh the risks of vitamin D deficits.
    3. S3: Rather than spending more time in the sun, supplements and a diet rich in vitamin D can help maintain sufficient vitamin D levels.
    4. S4: Vitamin D levels are unlikely to be affected significantly by normal use of sunscreen. Hence one does not need to stay in the sun longer even when using sunscreen.
    5. W1: Prolonged sun exposure suppresses the immune system, which can offset the benefits of optimal vitamin D levels.
    6. W2: Most people don’t need to worry about vitamin D. Some groups of people are at higher risk of vitamin D deficiency, such as naturally dark people who cover their skin for cultural reasons. But for others, it is not necessary to spend more time in the sun.

7. I1: New generations of sun protection products offer better protection from UVB as well as UVA rays.
8. I2: It is premature to make recommendations. Research is still not 100% sure how exactly all the vitamins and micro-nutrients work.

9. Brain training
    1. S1: Some authors reporting benefits of 'brain training' have conflicts of interest (e.g. they sell 'brain training' software).
    2. S2: There are practice effects, meaning that doing a 'brain training' task regularly will improve your performance on that task. However, there is no good evidence for an actual and substantial transfer to memory capacity or intelligence.
    3. S3: Even the best-designed studies only report very small effect sizes, which means that even these studies do not find 'brain training' effects of any practical significance.
    4. S4: Studies claiming that 'brain training' improves intelligence all have methodological problems (e.g. lack of adequate control groups).
    5. W1: Memory capacity and intelligence are strongly determined by our genes, and playing computer games will not have any impact.
    6. W2: 'Brain training' effects may only exist in young children or neuropsychologically impaired patients, not in average teenagers and adults.
    7. I1: The brain has billions of cells and cell connections. It is the most complex system known to mankind and will never fully understand itself. Any claims to the contrary are mere speculation.
    8. I2: It’s not that simple. Dementia is predicted to be the leading cause of death by 2030.

10. Thiomersal

1. S1: Toxicity is dependent upon concentration. Many substances we consume are toxic in ‘sufficient’ amounts. The minute amount of thiomersal within vaccines is 10 times below the lowest level calculated to potentially cause harm.
2. S2: In 2006 an expert panel concerned by the World Health Organisation concluded that there was “no evidence of toxicity in infants, children or adults exposed to thiomersal in vaccines”.
3. S3: In terms of relative cause for concern, the consumption of fish such as tuna or swordfish is by far the most significant source of mercury poisoning. Roughly 75% of all human exposure comes from eating fish.
4. S4: While methyl mercury builds up in the body, ethyl mercury (which is in thiomersal) is excreted rapidly. The body normally processes ethyl mercury within 7-10 days.
5. W1: Some common symptoms of mercury poisoning are skin discoloration, itching / burning in the hands and feet, and loss of hair and nails. These have never been noted as a side effect for vaccines.
6. W2: While the potential toxicity of thiomersal and mercury accumulation has been demonstrated in animal models, it is unclear if these results can be transferred to humans.
7. I1: The local reaction at the injection site is often not caused by the active vaccine agent but the aluminium salts that are contained in many vaccines as so-called “adjuvants” that serve to enhance the immune response to the vaccine.

8. I2: The active components in vaccines are weakened or inactivated such that they cannot cause disease.

11. Antioxidants

1. S1: According to the US National Institute of Health, more than half of US adults take some form of vitamin or mineral supplement at a total cost of $23 billion a year. It is in the interest of business that antioxidants are promoted to be good for health.
2. S2: It is clear that fruits and vegetables are good for you, but scientists are still debating *why*. Vegetables such as Brussels sprouts and broccoli, which have been linked with anti-cancer benefits, may actually generate these benefits through their ability to promote *pro-oxidative* cellular processes, rather than anti-oxidative ones.
3. S3: Many clinical trials have revealed that antioxidants lead to virtually no improvement in the functioning of our cardiovascular system. There is less data regarding cancer, but the most recent large scale trial was halted when no benefit was shown.
4. S4: It has not been proven whether daily consumption of antioxidant food or pills elevates or decreases risk of disease, as it is difficult to get complete data about the actual frequency and doses that people consume.
5. W1: The fact that antioxidant dietary supplementation might lead to more (not less) cancer should come as no surprise to cancer therapists, who know that ionising radiation treatment kills cancer cells largely through creation of oxidants called reactive oxygen species (ROS).

6. W2: A study in 2009 found that physical exercise prevents type-2 diabetes, yet only if the participants *did not* consume daily doses of antioxidant vitamin C and E supplements.
7. I1: Sufficient fluid intake is the only thing most people lack. Drinking more water improves metabolic functions, liver function, endocrine gland function, and regulates appetite.
8. I2: Oxygen is the element that enables us, the highest known form of life, to exist. We don't need to fight it.

Experiment 1 – Pilot ratings

Thirteen undergraduate students from the University of Western Australia participated in the pilot rating. Materials were presented in an online survey format using Qualtrics software (www.qualtrics.com). Fourteen claims were presented, and participants rated their belief in each on a 0-10 scale. Following each claim, participants were presented with a set of between five and eight counterarguments, and rated the strength (i.e., persuasiveness) of each counterargument on a scale from 0 to 10.

The descriptive statistics obtained from the pilot study are presented in Table 1. The ten claims selected from the pilot study for use in the main study had a mean pre-counterarguments belief rating of $M = 6.81$ ($SE = 0.22$). The average strength ratings of the strong and weak counterarguments chosen for the main study were $M = 6.67$ ($SE = 0.24$), and $M = 5.58$ ($SE = 0.27$), respectively.

Experiment 2 – Pilot ratings

We tested 91 participants via the crowdsourcing platform Crowdflower (www.crowdflower.com). Participants were from Australia, the U.S., Canada, New Zealand, and the UK. We excluded 13 participants based on a-priori criteria including unrealistic completion time (< 10 minutes; median was 28 minutes) and extreme response uniformity (participants showing long “runs” of the same response and/or falling 1.5 *SD*s below the mean of the standard deviation distribution based on all responses), leaving a final sample of *N* = 78 participants (48 females, 30 males; mean age was *M* = 38.79 [*SD* = 11.53] years).

Participants were presented with the ten claims used in Experiment 1, and 9-10 counterarguments for each claim. Counterarguments included the five used in Experiment 1, plus 2-3 arguments that had received intermediate strength ratings in the pilot test of Experiment 1, as well as two newly designed irrelevant arguments. Participants rated their belief in each claim, and the strength of each counterargument, on a scale from 0 to 10. For Experiment 2, we selected the seven claims with the highest belief ratings (to allow for belief reduction through the counterarguments), as well as the four strongest and the two weakest counterarguments (as there were only two irrelevant counterarguments per claim, those were not selected based on the pilot rating).

The descriptive statistics obtained from the pilot study are presented in Table 2. The seven claims selected for use in the main study had a mean pre-manipulation belief rating of *M* = 7.20 (*SE* = 0.27). The average strength rating of the strong counterarguments was *M* = 6.24 (*SE* = 0.12; based on the two strongest arguments) or *M* = 6.00 (*SE* = 0.11; based on the four strongest arguments), the rating was *M* = 4.88 (*SE* = 0.17) for the weak and *M* = 5.16 (*SE* = 0.21) for the irrelevant counterarguments.

Table 1. Mean claim belief ratings and mean counterargument strength ratings for the two strongest and three weakest counterarguments relating to each claim in the pilot study for Experiment 1.

	Belief Rating		Strong CA Strength		Weak CA Strength	
Claim	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Vitamin D	6.00	0.66	6.92	0.37	6.05	0.62
Thiomersal	6.18	0.58	7.05	0.46	5.36	0.46
Prison	6.25	0.63	6.92	0.46	5.94	0.46
Fracking	6.38	0.50	7.54	0.40	6.49	0.45
Brain Training	6.45	0.37	6.95	0.55	5.88	0.59
Carbon Tax	6.67	0.61	6.38	0.63	5.72	0.71
Antioxidant	6.92	0.51	6.38	0.45	5.69	0.39
Fish Oil	7.46	0.33	6.31	0.41	5.59	0.51
Cancer	7.83	0.53	5.21	0.74	3.94	0.61
Sugar	7.92	0.37	7.04	0.48	4.95	0.38

Note. CA, counterargument.

Table 2. Mean claim belief ratings and mean counterargument strength ratings for the two / four strongest, two weakest, and the two irrelevant counterarguments relating to each claim in the pilot study for Experiment 2.

	Belief Rating		Strong CA Strength (2 CAs)		Strong CA Strength (4 CAs)		Weak CA Strength (2 CAs)		Irrelevant CA Strength (2 CAs)	
Claim	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Vitamin D	5.90	0.28	6.83	0.25	6.28	0.26	5.12	0.26	5.13	0.30
Sugar	6.88	0.25	6.19	0.26	5.92	0.28	4.41	0.29	5.42	0.31
Thiomersal	7.03	0.27	6.19	0.26	6.02	0.27	5.26	0.29	4.88	0.28
Brain Training	7.35	0.25	5.79	0.28	5.49	0.27	4.08	0.28	4.38	0.32
Cancer	7.35	0.22	6.44	0.25	6.38	0.27	5.15	0.31	5.08	0.35
Antioxidant	7.87	0.21	6.08	0.24	5.86	0.24	5.15	0.25	4.97	0.34
Fish Oil	8.00	0.21	6.15	0.27	6.03	0.27	5.02	0.24	6.21	0.28

Note. CA, counterargument.