Psychology & Health

ISSN: 0887-0446 (Print) 1476-8321 (Online) Journal homepage: https://www.tandfonline.com/loi/gpsh20

Reducing demand for ineffective health remedies: overcoming the illusion of causality

Douglas MacFarlane, Mark J. Hurlstone & Ullrich K. H. Ecker

PSYCHOLOGY & HEALTH
2018, VOL. 33, NO. 12, 1472–1489
https://doi.org/10.1080/08870446.2018.1508685

Reducing demand for ineffective health remedies: overcoming the illusion of causality

Douglas MacFarlane, Mark J. Hurlstone and Ullrich K. H. Ecker

School of Psychological Science, University of Western Australia, Perth, Australia

ABSTRACT

Objective: We tested a novel intervention for reducing demand for ineffective health remedies. The intervention aimed to empower participants to overcome the illusion of causality, which otherwise drives erroneous perceptions regarding remedy efficacy.
Design: A laboratory experiment adopted a between-participants design with six conditions that varied the amount of information available to participants ($N = 245$). The control condition received a basic refutation of multivitamin efficacy, whereas the principal intervention condition received a full contingency table specifying the number of people reporting a benefit vs. no benefit from both the product and placebo, plus an alternate causal explanation for inefficacy over placebo.
Main outcome measures: We measured participants' willingness to pay (WTP) for multivitamin products using two incentivized experimental auctions. General attitudes towards health supplements were assessed as a moderator of WTP. We tested generalisation using ratings of the importance of clinical-trial results for making future health purchases.
Results: Our principal intervention significantly reduced participants' WTP for multivitamins (by 23%) and increased their recognition of the importance of clinical-trial results.
Conclusion: We found evidence that communicating a simplified full-contingency table and an alternate causal explanation may help reduce demand for ineffective health remedies by countering the illusion of causality.

ARTICLE HISTORY
Received 11 January 2018
Accepted 25 July 2018

KEYWORDS
Illusion of causality; behaviour change; demand reduction; consumer behaviour; intervention; health education

Irrational health behaviours

Irrational health behaviours—health-promoting actions that are objectively irrational when viewed against the weight of scientific consilience—present numerous harms to individuals. Example, harms include side effects, financial costs, interactions with conventional medications and opportunity costs of delaying evidence-based treatment. The present research deals with one type of irrational health behaviour, namely the consumption of health remedies that are claimed to have benefits despite contrary

CONTACT Douglas MacFarlane douglas.macfarlane@research.uwa.edu.au School of Psychological Science, University of Western Australia, M304, 35 Stirling Hwy, Perth 6009, Australia
This article has been republished with minor changes. These changes do not impact the academic content of the article.
Supplemental data for this article can be accessed here.

scientific consilience. Regarding health remedies, consilience may refer to (i) compelling evidence either supporting or rejecting a remedy's efficacy, (ii) compelling evidence that a remedy causes harm or (iii) a lack of compelling evidence to back up the health claims being made. One remedy not supported by scientific consilience is multivitamin supplementation for healthy individuals: numerous randomised controlled trials have found that multivitamins provide no health benefits (Guallar, Strangers, Mulrow, Appel, & Miller, 2013; Jenkins et al., 2018) and may even be detrimental to health (Mursu, Robien, Harnack, Park, & Jacobs, 2011). Evidence-based interventions are thus needed to help people avoid the negative consequences of such behaviour.

Designing effective evidence-based interventions to overcome irrational behaviours requires addressing the barriers preventing the uptake of desired rational behaviours (McKenzie-Mohr & Schultz, 2014). One major psychological barrier that prevents people from making evidence-based consumer choices is the illusion of causality. The illusion occurs when people perceive a causal relationship between an action and a subsequent outcome (Blanco, Matute, & Vadillo, 2011) even when the two events are unrelated, such as taking vitamin C and subsequently recovering from a cold (Hemila & Chalker, 2013). The strength of the illusion increases the more an action coincidentally occurs in close temporal proximity to an outcome. The resulting causal illusion is further strengthened when one has personal control over the action preceding the outcome (Yarritu, Matute, & Vadillo, 2014).

Assisting people to overcome illusions of causality is a challenge. Research has shown that simply giving people the facts is not sufficient (Yarritu & Matute, 2015), and even extended scientific training does not guarantee that people will not succumb to the illusion of causality (Shtulman & Valcarcel, 2012). Part of the reason for this may be that people are generally only exposed to—or are more likely to remember—positive outcomes (Kelley & Long, 2014). Consider the unsubstantiated link between taking vitamin C at the onset of a cold and a faster recovery. The myth that vitamin C can speed up recovery is perpetuated by people more readily recalling instances when they took vitamin C and subsequently recovered from a cold, compared to instances when they did nothing and recovered all the same. We argue that to overcome the illusion of causality, people need timely access to the 'full picture,' namely the evidence from all four outcomes of a randomised controlled trial. Specifically, people need to know the number of people who (i) took the product and experienced the benefit, (ii) took the product and experienced no benefit, (iii) did not take the product but still experienced the benefit and (iv) did not take the product and experienced no benefit. Information from all four cells in the matrix is needed to confidently conclude whether a benefit is caused by the product (a positive contingency), or whether there was some other causal factor (a null contingency).

Previous research has found that simply providing a contingency table of clinical results does not assist people to make reliable causal judgments because interpretations of contingency tables can be faulty, especially when the data being conveyed are complex (Batanero, Cañadas, Díaz, & Gea, 2015) or when the outcomes challenge prior beliefs (Kahan, Peters, Cantrell & Slovic, 2013). In contrast, one promising study by Barberia, Blanco, Cubillas, and Matute (2013) found that providing students with detailed explanations of the 'full picture' in an 80-minute class did reduce the illusion of causality. However, this intervention is not particularly efficient given the significant time and resources required, which is a problem considering the continual need to communicate the scientific consilience regarding an ever-expanding range of health products.

To overcome these barriers when communicating clinical findings to the public, we propose that contingency table information should be simplified to represent small manageable frequencies rather than large and complex raw numbers. Research has shown that when people are given complex proportions they tend to misinterpret the figures by employing several cognitive biases, such as denominator neglect or availability bias (Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007; Slovic, Finucane, Peters, & MacGregor, 2007). We hypothesised that communicating the information from all four randomised controlled trial outcomes in a simplified contingency table will circumvent such cognitive biases, and may thus be a more efficient, and cost-effective, intervention than those used in previous studies. Thus, the aim of the present study was to investigate whether a simplified contingency table, accompanied by a scientifically valid explanation, can promote behaviour change.

To test this hypothesis, the present study sought to measure actual behaviour rather than intention or attitude. This is important because people's beliefs are not always reflected in their behaviours (Bickman, 1972; Geller, 1981). This may be due, in part, to external barriers, such as cost and convenience, preventing a person's behaviour from aligning with their beliefs (Gifford, 2014). Consequently, relying on self-reported attitudes can lead researchers to over-report the effectiveness of an intervention (Kormos & Gifford, 2014). For example, Rousu and Thrasher (2014) investigated the effect of health warning labels on cigarette packages and found that self-reported attitude changes were two times greater when compared to the change in demand indicated by auction bids on a packet of cigarettes. For this reason, the present experiment used two incentivized experimental auctions to measure participants' willingness to pay (WTP) for a commercially available multivitamin supplement and thus assess the effectiveness of a novel intervention on real consumer demand.

The present laboratory experiment adopted a between-participants design with six conditions. Conditions provided participants with varying amounts of information (detailed descriptions in the method section; also see Figure 1). Most conditions provided information on the results of clinical trials showing that multivitamins were not effective. Briefly described, the control condition provided irrelevant information combined with a weak refutation of multivitamin efficacy. The 'quarter-contingency' condition provided the same weak refutation plus information from only one quarter of a contingency table—the number of people reporting a health benefit from multivitamins. The 'half-contingency' condition provided the same weak refutation plus half a contingency table—the number of people who did and did not report a benefit from multivitamins. The 'full-contingency' condition provided a strong refutation plus a full contingency table—the number of people reporting a benefit vs. no benefit from both multivitamins and placebo. The principal intervention—the 'full-contingency-plus' condition—replicated the full-contingency condition but also included an alternate explanation for lack of efficacy over placebo. The 'positive-contingency' condition was the exception in that it provided a full-contingency table but with the placebo results

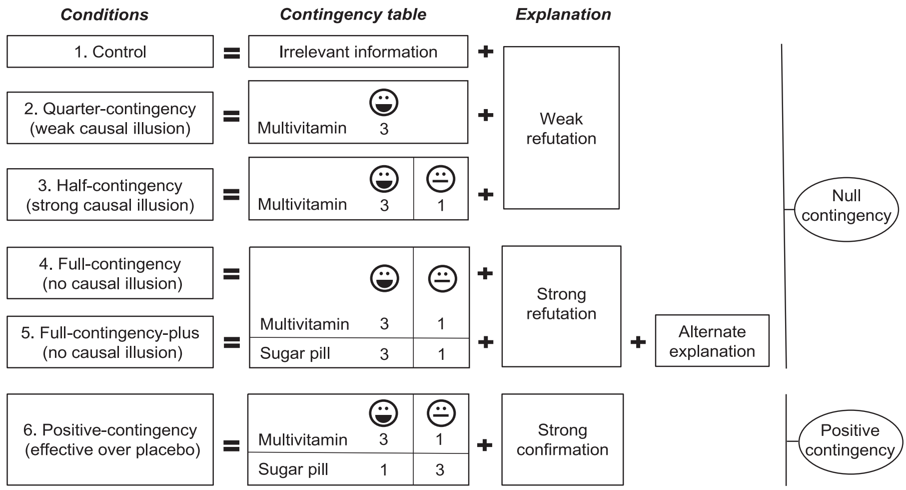

Figure 1. Visual summary of the information provided to participants in each condition. Shared boxes indicate where information was identical across conditions. In the contingency table, the number below the smiling face represents the relative frequency of people who reported experiencing a health benefit, and the number below the sullen face represents the relative frequency of people who did not report experiencing a benefit. The explanation provided an interpretation of the corresponding contingency table given the information available (i.e. weakly or strongly refuting the efficacy of multivitamins when results indicated the null contingency, or strongly confirming the efficacy of multivitamins when results indicated the positive contingency). In the quarter-contingency condition, presenting only one cell of information as a table was not logical so instead, participants received a statement to the same effect: 'Countless people have experienced a health benefit after taking multivitamins'.

reversed to indicate that multivitamins were actually effective. To reflect the positive results, this condition also included a strong confirmation that multivitamins were effective.

The primary aim of the experiment was to assess the effectiveness of the principal intervention to reduce demand for an ineffective health product. To assess this, WTP for two multivitamin products was then measured across two experimental auctions. The main auction enabled participants to bid on one multivitamin product, whereas the second auction enabled participants to simultaneously bid on two similar products, but only one containing added multivitamins. We theorised that the strength of the illusion of causality would vary across conditions, thus influencing people's WTP for multivitamin products. We expected our strongest experimental intervention to have the greatest impact on reducing WTP. The secondary aim of the experiment was to test whether the effects of this principal intervention might generalise to future health purchases.

For the main auction, we made three predictions. *Hypothesis* I: Compared to control, the principal intervention (the 'full-contingency-plus condition') would result in a significant reduction in average bid amount for the multivitamin product. *Hypothesis* II: The average bid amounts would vary relative to the strength and direction of the illusion of causality conveyed across the remaining experimental conditions. Specifically, we hypothesised that (a) the quarter-contingency condition should have little impact on WTP compared to control because information referring to one cell in a contingency table creates only a weak illusion of causality; (b) the half-contingency condition should increase WTP compared to control because it creates a strong illusion of causality; (c) the full-contingency condition should reduce WTP compared to control because it provides the 'full picture' required to dispel the illusion of causality; and (d) the positive-contingency condition should increase WTP compared to control because the information suggests a true benefit over placebo. *Hypothesis* III: Compared to the other conditions, participants in the two full-contingency conditions would show (a) a greater rate of identifying that there was insufficient information to determine the efficacy of the fictitious health product; and (b) a higher rating of the importance of placebo-comparison information for making future health-related purchases.

For the second auction, we formulated *Hypothesis* IV: Compared to control, (a) participants in the principal intervention condition would reduce their WTP for a product containing added multivitamins relative to a similar product without; and (b) this relative WTP should vary according to the strength and direction of the illusion of causality conveyed across the remaining experimental conditions.

Method

The research was conducted using recommendations for obtaining quality evidence for behavioural interventions (Dombrowski, Sniehotta, Avenell & Coyne, 2007). Specifically, the intervention was designed with a theoretical basis, tested via a randomised controlled trial, and reported with due regard to accepted CONSORT standards of reporting for randomised controlled trials (Boutron, Moher, Altman, Schulz, & Ravaud, 2008). Ethics approval to conduct the experiment was granted by the Human Ethics Office of the University of Western Australia in accordance with the requirements of the Australian National Statement on Ethical Conduct in Human Research (NHRMC, 2007).

Participants

In total, 247 undergraduate students from the University of Western Australia took part in the experiment in exchange for course credit. One participant was excluded for accidentally reading the debrief sheet prior to testing. Several a-priori exclusion criteria were set (these are specified in the supplemental materials); based on these criteria, one participant was removed for overly inconsistent responding. The final sample thus included N = 245 participants (163 females, 82 males; age M = 20.98 years; SD = 6.45). Sample size was determined by an a-priori power analysis (G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007) that suggested a minimum sample size of 240 to detect a medium-sized effect (f = .25) with α = .05, $1-\beta$ = .80.

Predictors and materials

Participants responded to questions on four potential predictors of WTP: previous multivitamin consumption; belief in the efficacy of multivitamin supplements for maintaining general health; general attitudes toward health supplements and alternative medicines (hereafter referred to as the 'general-attitude score'); and current state of health (as people may only consider using multivitamins when they feel unwell). Full details of the predictor measures are provided in the supplemental materials.

Willingness-to-pay

To assess WTP, data were collected using two variations of the Becker–Degroot–Marschak auction mechanism (Becker, Degroot, & Marschak, 1964; Thrasher, Rousu, Hammond, Navarro, & Corrigan, 2011). In the first auction (WTP-1), participants were given \$5 and an opportunity to place a bid on a tube of effervescent multivitamin tablets. They were shown a plain-packaged picture of the product and some descriptive text about multivitamins, including some common health claims and a popular pseudo-scientific causal explanation as to why supplements are thought to provide health benefits (see online supplement for details). Participants were asked to bid only the amount that reflected how much they were willing to pay for that product. Participants were told that this was different to other auctions in that they could only bid once, and that it was in their best interest to bid the amount they were willing to pay. Participants were required to enter their bid amount b in cents $b \in (0, 500)$. They knew that this amount would be compared against a random number $r \in (0, 500)$ drawn from a uniform distribution, and that if $b \geq r$, they would win the auction and purchase the product for amount b but keep $500 - b$ of their endowment; otherwise they would lose the auction but keep the full \$5 endowment. Prior to the first auction, participants were given the chance to participate in two hypothetical practice auctions using an imagined \$1 to bid for a bottle of water.

The second auction (WTP-2) was a variation on the first. Specifically, participants were given an additional \$2 endowment which they could use to bid on two products simultaneously, namely a packet of gummy sweets, and a packet of gummy sweets with added multivitamins. Participants were required to enter two bid amounts in cents, $b_1 \in (0, 200)$ and $b_2 \in (0, 200)$, subject to the constraint that $b_1 + b_2 \leq 200$. The two bid amounts were compared against two uniformly distributed random numbers $r_1 \in (0, 200)$ and $r_2 \in (0, 200)$. The participants knew that they would win and purchase both products if $b_1 \geq r_1$ and $b_2 \geq r_2$; neither product if $b_1 < r_1$ and $b_2 < r_2$; or only one product if $b_1 \geq r_1$ but $b_2 < r_2$, or $b_1 < r_1$ but $b_2 \geq r_2$. At the end of the experiment participants kept $200 - o_1 b_1 - o_2 b_2$, where o_1 is the outcome (1 if successful; 0 otherwise) of bid b_1, and o_2 is the outcome (1 if successful; 0 otherwise) of bid b_2. This second auction was included to emulate the real-world scenario where consumers face a choice between a product and a similar product containing an additional supplementary ingredient (e.g. an added vitamin).

Interventions

Participants were randomly allocated to either a control or one of five intervention conditions (see Figure 1). The intervention conditions all provided participants with two information components: (i) a contingency table and (ii) an explanation. The contingency table component conveyed information about the clinical outcomes of previous randomised controlled trials that have tested the efficacy of multivitamins. The amount of information conveyed in each condition was varied in order to manipulate the strength of the illusion of causality. The information was presented as simple frequencies (e.g. clinical trials show 3 out of 4 people experience a benefit). The explanation component consisted of a statement that either refuted or confirmed the efficacy of multivitamins.

The *control* condition only provided irrelevant information about the multivitamin product on offer in the first auction: 'Product A, which you will soon bid on, is available to purchase from various retail outlets in Perth.' The control also provided a weak refutation regarding the general efficacy of multivitamins: 'There is currently insufficient clinical evidence to support a recommendation for or against the use of multivitamins and mineral supplements for the general population'. This weak refutation was based on a tentative 'diplomatic' type of refutation commonly used in real-world attempts to debunk claims about ineffective health products. In this case, it was adapted from a statement published on the National Institute of Health (NIH) website (NIH, 2016a).

The *quarter-contingency* condition provided participants with a quarter of the null contingency table—the number of people who took a multivitamin and reported a health benefit. As it was not logical to present only one cell of information as a table, participants instead received a statement to the same effect: 'Countless people have experienced a health benefit after taking multivitamins.' This condition imitates both the claims made by supplement companies and the relative scarcity of information often available when people make health purchases. This condition included the same weak refutation as the control condition.

The *half-contingency* condition provided participants with half of the null contingency table, specifying the number of people who took a multivitamin and who did and did not report a health benefit. A short interpretation of the numbers was also provided: 'So, 3 out of 4 people experienced a health benefit after taking a multivitamin.' This condition also imitates real-world advertiser claims although it provides a more powerful illusion of causality than the quarter contingency because it appears that a majority of people experience a benefit after taking a product. This condition included the same weak refutation as the control condition.

The *full-contingency* condition provided participants with all four randomised controlled trial outcomes of the null contingency table. A short interpretation of the numbers in the table was provided: 'So, 3 out of 4 people experienced the same health benefit after taking a multivitamin as after taking a sugar pill.' As the full contingency table clearly demonstrated that taking multivitamins resulted in the same health outcomes as a placebo, participants in this condition received a strong refutation: 'Therefore, the clinical evidence clearly shows that, for the general population, there is no health benefit from taking multivitamin supplements.'

The *full-contingency-plus* condition was our principal intervention. This condition provided participants with the same information as the full-contingency condition with the addition of a scientific explanation underlying the perceived causal event, that is, explaining why multivitamins are no more effective than taking a sugar pill: 'This is because, unless a person has a specific medical deficiency, most modern diets provide ample vitamins for the body to maintain healthy function.' Previous research has shown that providing alternate explanations to perceived causal events helps people overcome the illusion of causality (Vadillo, Matute, & Blanco, 2013). An additional precedent for including the alternative causal explanation is based on the literature on refuting misinformation, where the provision of an alternative, factual framework is considered a crucial component of an effective correction (Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012).

Finally, the *positive-contingency* condition provided participants with all four randomised controlled trial outcomes of a positive contingency table, demonstrating that more people experienced a benefit after taking multivitamins than after taking a sugar pill. A short interpretation of the numbers in the table was also provided: 'So, 3 out of 4 people experienced a health benefit after taking a multivitamin but only 1 out of 4 experienced a health benefit after taking a sugar pill.' As the positive contingency table clearly communicates that multivitamins are effective, participants in this condition received a strong confirmatory explanation: 'Therefore, the clinical evidence clearly shows that, for the general population, there is a health benefit from taking multivitamin supplements.' This condition allowed us to assess whether participants would respond correctly to contingency tables that provide evidence for efficacy.

Fictitious efficacy rating

To assess whether the two full-contingency interventions generalised to reduce the proportion of participants that fell prey to the illusion of causality, following the auction, participants were introduced to a fictional nausea drug 'Product Z.' To create an illusion of causality, participants were only given a half-contingency table, which showed that 4 out of 5 people experienced a health benefit from taking Product Z. Participants were asked to rate the effectiveness of Product Z as either *not effective*, *mildly effective*, *very effective*, or to indicate there was *insufficient information* to make a judgement of effectiveness. We hypothesised that the full-contingency table conditions would reduce the proportion of individuals who failed to identify there was insufficient information to determine causality.

Factors influencing future health purchases

To assess whether the two full-contingency interventions generalised to help participants make better future health purchases, participants were asked to rate the importance of 15 health-related factors using a 5-point Likert scale (1 = *not important at all*, 5 = *extremely important*). This questionnaire was designed to assess whether the full-contingency table increased participants' valuation of information critical to assessing a product's efficacy. The critical item was 'placebo comparison' information (i.e. 'the number of people who did, and did not, experience a benefit when taking a sugar pill'). The remaining 14 items were distractors (e.g. the importance of 'advertising claims'). Item order was randomised.

Procedure

The experimental sessions were held in a computerised laboratory. In each session, between one and six participants completed the experiment in parallel. Upon entering the laboratory, participants were shown open money tins containing the cash endowments. The experimenter followed a set verbal protocol to make clear that (i) participants would receive real money and/or health products at the end of the experiment, depending on the outcome of the auctions, and that (ii) the results of the survey were important for research so participants should take their time and respond as honestly as possible. Participants then completed the experiment on one of six computer terminals, separated by privacy blinds. Participants first responded to questions on demographics and the predictor measures before being shown the information about the multivitamin product. The experimental software randomly allocated participants to one of the six different conditions. Next, participants were introduced to the first auction and indicated their WTP for the multivitamin product. After bidding in the first auction, participants were introduced to the second auction and indicated their WTP for the two gummy sweet products. Participants then responded to the fictional product question and the questions regarding their future health purchases. At the conclusion of the experiment, participants received the leftovers of their cash endowments and any purchased health products, before being fully debriefed.

Data analysis

All analyses were conducted in R (R Core Team, version 3.3.2, 2016). Associations between WTP-1 and the four predictors (estimated usage, efficacy belief, general attitude scores, and current state of health) were analysed using Spearman's correlation coefficient. For WTP-1, to examine the impact of the interventions on bid amounts, we conducted a hierarchical multiple regression analysis with auction bid as the dependent variable, and general attitude score and the between-participants factor of condition (control, quarter-contingency, half-contingency, full-contingency, full-contingency-plus, positive-contingency) as the two predictor variables. Hierarchical regression was employed over other methods due to the results of a pilot study, which revealed that the general-attitude score was a strong predictor of WTP (see supplemental materials). This approach provided a robust model for isolating the effect of the experimental intervention from a pre-existing moderator of demand. Dummy coding was used to indicate the conditions and specify the control as the baseline. Effect sizes were calculated for each comparison using Pearson's correlation coefficient. For WTP-2, to test whether condition influenced bid amounts in the second auction, we calculated a ratio for each participant by dividing their bid for the multivitamin gummy sweets by their bid for the regular gummy sweets (thus, the higher the ratio the greater the preference for the multivitamin product). To test whether participants' bid ratio was influenced by condition, we conducted a non-parametric Kruskal–Wallace test.

To assess whether the contingency-table interventions generalised into more rational future health decisions, we conducted planned comparisons between so-called 'condition groups'. To explain, for these analyses we grouped the conditions according to our a-priori predictions, namely, the 'full-contingency group' (full-contingency and full-contingency-plus conditions), the 'constrained-information group' (control, quarter-contingency and half-contingency conditions), and the 'positive-contingency group' (positive-contingency condition). To determine whether the full-contingency group and the constrained-information group differed in the assessment of the fictional product's efficacy, we ran a Pearson's chi-squared test. To simplify our analysis, we first re-coded the responses into two possible categories: correct ('insufficient information to determine efficacy') and incorrect ('very effective', 'not effective' or 'mildly effective'). Regarding the survey on factors important for future health purchases, to test whether condition group influenced ratings of placebo-comparison information, we ran an asymptotic Kruskal–Wallace test. Planned comparisons were conducted using Mann–Whitney *U* tests with sequential Bonferroni adjustment.

Pilot study

Prior to the current experiment, we conducted an online pilot study on US participants recruited via Amazon's Mechanical Turk (see supplemental materials), which yielded two key findings. First, we obtained convergent evidence that the auction mechanism indexes consumer demand for vitamin supplements in the form of positive correlations between hypothetical WTP and the predictor measures of estimated usage, efficacy belief, and general attitudes (the fourth, current-health predictor, was added only for the main study). Second, based on the fictional health product scenario and future health purchases questionnaire, we obtained strong evidence that individuals are vulnerable to the illusion of causality, and that they place relatively little emphasis on clinical information when making health purchases. Thus, the pilot study confirmed that our survey instruments are suitable for answering the current research questions.

Results

Willingness-to-pay

As anticipated, based on the results of our pilot study, WTP-1 was positively associated with estimated usage of multivitamins, $N = 158$, $r_s = .19$, $p = .016$; efficacy belief, $N = 233$, $r_s = .29$, $p < .001$; and general-attitudes, $N = 245$, $r_s = .38$, $p < .001$. The control predictor of current health state was not correlated with WTP-1, $N = 245$, $r_s = .05$, $p = .41$.

In regard to WTP-1, Figure 2 shows the mean WTP across conditions, whereas Table 1 shows the results of the multiple regression analysis. Participants' general-attitude score was significantly related to their WTP, $F(1, 243) = 43.45$, $p < .001$, indicating that participants with more favourable attitudes toward health supplements exhibited significantly higher WTP for the multivitamin product. After controlling for the influence of the general-attitude score, experimental condition also significantly predicted WTP, $F(5, 238) = 7.00$, $p < .001$, indicating that participants' WTP for multivitamins varied reliably across conditions.

More specifically, there was a significant difference in WTP between the full-contingency-plus condition and control, $t(238) = -2.51$, $p = .013$, 95% CI [−111.39, −13.40], $r = .16$. We thus found statistical confirmation of Hypothesis I. However, WTP in the remaining intervention conditions did not differ significantly from control: quarter-contingency, $t(238) = -0.21$, $p = .832$, [−54.19, 43.62], $r = .01$; half-contingency, $t(238) = 1.83$, $p = .069$, [−3.48, 94.15], $r = .12$; full-contingency, $t(238) = -1.35$, $p = .179$,

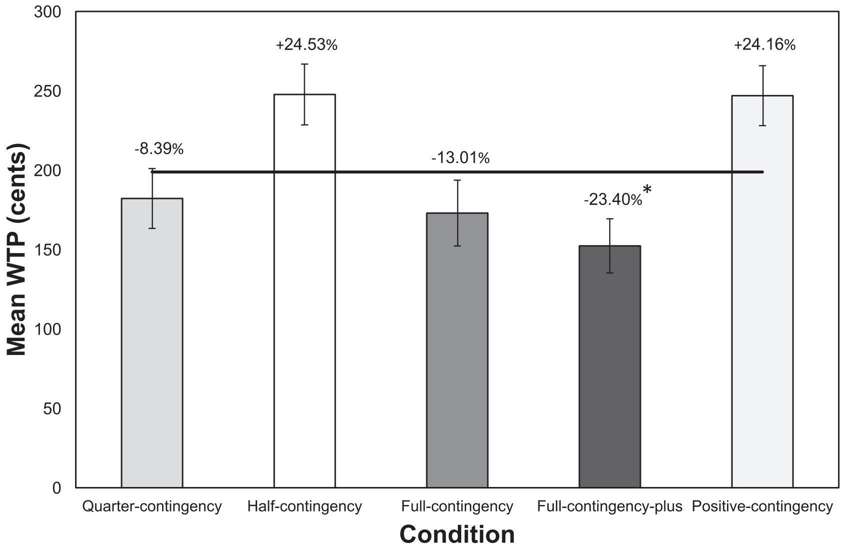

Figure 2. Willingness to pay (WTP-1)—represented by mean bid amount—as a function of condition for the first auction. The sample size for each intervention condition was $n = 41$, compared to $n = 40$ for the control condition. The black horizontal line represents the mean bid amount for the control condition ($M = 198.88$c). Percentages indicate mean WTP change relative to control. Only the full-contingency-plus condition significantly reduced WTP compared to control, whereas the effects of the other intervention conditions were non-significant. Error bars represent standard errors. $^*p = .013$.

Table 1. Hierarchical multiple regression analysis: General-attitude score and condition predict willingness to pay (WTP-1) in the first auction.

	ΔR^2	B	$SE\ B$	β	p
Step 1	0.15				<.001
Constant		−57.24	39.76		.151
General-attitude score		87.71	13.30	0.39	<.001***
Step 2	0.10				<.001
Constant		−71.67	41.20		.0832
General-attitude score		93.11	12.82	0.41	<.001***
Quarter-contingency vs. Control		−5.29	24.82	−0.07	.832
Half-contingency vs. Control		45.34	24.78	0.20	.069
Full-contingency vs. Control		−33.41	24.80	−0.45	.179
Full-contingency-Plus vs. Control		−62.39	24.87	−0.27	.013*
Positive-contingency vs. Control		47.11	24.78	0.63	.059

Note. $B = b$-value, $SE\ B =$ standard error, $\beta =$ standardised Beta.
$^*p < .05$, $^{***}p < .001$.

[−82.26, 15.44], $r = .09$; and positive-contingency, $t(238) = 1.90$, $p = .059$, [−1.70, 95.91], $r = .12$. We thus reject Hypotheses II(a − d).

In regard to WTP-2, participants' bid ratios were not significantly different across conditions, $H(5) = 2.61$, $p = .76$. We thus reject Hypotheses IV(a − b).

Generalisation of condition effects

Differences in participants' responses to the generalisation questions across the three condition groups provided partial support for Hypothesis III. Regarding the fictional product, there was no difference between the full-contingency and the constrained-information groups, $\chi^2(1) = 0.25$, $p = .61$. The odds ratio was 1.16 (0.62, 2.19), meaning that the odds of an effect reducing the illusion of causality were comparable between these condition groups. We thus reject Hypothesis III(a). Regarding the importance of placebo-comparison information, we found an effect of condition group on ratings of placebo-comparison information, $H(2) = 7.59$, $p = .02$. *Post-hoc* tests revealed that placebo-information was rated as more important in the full-contingency group (Mdn = 4) than in the constrained-information group (Mdn = 3), $W_s = 4040$, $p = .048$, $r = -.15$, and the positive-contingency group (Mdn = 3), $W_s = 2090$, $p = .048$, $r = -.15$. The rating did not differ between the constrained-information and positive-contingency groups, $W_s = 2630$, $p = .61$, $r = -.03$. We thus found statistical confirmation of Hypothesis III(b), meaning that the full-contingency conditions improved participants' valuation of placebo information, which is critical for making rational consumer decisions regarding health products.

Discussion

Summary of findings

The present experiment used an incentivized auction mechanism to examine the factors that predict people's WTP for multivitamins and the influence of a novel intervention for reducing consumer demand. The results of the first auction revealed that three factors predicted a greater WTP: (i) more frequent estimated usage, (ii) higher efficacy belief and (iii) a higher general-attitude score. The results from the first auction also showed that providing participants with the full-contingency-plus intervention significantly reduced their WTP for multivitamins compared to control (Hypothesis I). By contrast, the other variations of the contingency table (quarter, half, full and positive) had no statistically significant effect on WTP compared to control (Hypothesis II). The second auction explored the impact of each intervention on WTP when consumers have the option to bid on two comparable products (only one of which contained added multivitamins) simultaneously but found no significant differences in WTP across conditions (Hypothesis IV). A secondary aim was to assess whether our intervention had a general effect on people's decisions regarding future health purchases (Hypothesis III). At variance with our expectations, participants exposed to the two full-contingency conditions were not significantly better than participants in the other conditions at identifying the lack of sufficient information to assess the efficacy of a fictional product. However, participants exposed to the two full-contingency conditions did rate the importance of placebo-comparison information as higher than those in the other conditions.

Our results demonstrate the potential impact of a novel intervention for reducing demand for products that have no health benefits. We have provided preliminary evidence that this intervention may be more effective at reducing WTP for ineffective products than the 'diplomatic' refutation commonly used by health authorities (e.g. 'there is currently no evidence that product X produces health benefits'). Furthermore, our results are likely more ecologically valid than previous studies—which have predominantly used measures found to often over-estimate the effects of interventions, such as self-reported attitude change (Webb & Sheeran, 2006) or peoples' own estimated valuations (List & Gallet, 2001)—because the effect was demonstrated using a naturalistic auction mechanism.

The present experiment serves as a proof of concept that employing *simplified* frequency values within a contingency table can help overcome the illusion of causality. This finding provides evidence that health authorities may benefit from simplifying clinical outcomes to empower people to make rational health decisions, without of course distorting the clinical findings. This may be especially feasible in cases where there is overwhelming scientific consilience regarding a particular health remedy. If our results can be replicated, this would suggest that health authorities should aim to help people overcome the illusion of causality by communicating both the full picture of randomised controlled trial outcomes and providing a valid alternative causal explanation. We now consider why both components may be necessary.

Why might the intervention work?

The 'full-picture' component may operate in two ways. First, it could remove one potential barrier to accepting clinical-trial information, namely the impact of a perceived experienced benefit. The full picture provides a simple counter-explanation, highlighting that a person may have experienced the same benefit even after placebo treatment. Second, the full picture may empower participants to overcome their tendency to rely on intuitive thinking (Lindeman, 2011) by increasing their own understanding of the scientific approach, and consequently their acceptance of clinical-trial information. The full picture fosters comprehension of the logic behind randomised controlled trials by highlighting why all four cells of a contingency table are critical, and by simplifying large complex results into a meaningful pattern of comprehensible units (i.e. a small number of individuals that can be easily visualized). The latter explanation was supported by our finding that the full-contingency conditions subsequently increased participants' rating of the importance of placebo-comparison information for making health-related consumer decisions. The intervention may thus empower people to better comprehend *null-contingency* findings of clinical trials.

The 'alternate causal explanation' component may operate by replacing participants' previously held pseudoscientific beliefs about why a product might be effective, such as 'supplements boost the immune system.' This component may serve to fill the mental gap created when a prior belief is challenged by scientific evidence (Ecker, Lewandowsky, & Tang, 2010; Johnson & Seifert, 1994). The importance of this step was supported by the finding in the first auction that a full-contingency table on its own did not significantly reduce WTP. Thus, interventions based on contingency information may only be effective when accompanied by an alternative explanation that serves to replace previously held, but unfounded, causal explanations.

Despite the success of the first auction, we were unable to detect a significant effect of our principal intervention in the second auction (Hypothesis IV). There are several explanations for this. First, both products were identical except that one contained something additional (in this case vitamins) and may have thus been perceived by participants to offer better value for money. Thus, the effect of the intervention may have been offset by a purely economic value judgement. Second, participants may have concluded that a supplement might still be worth taking despite the lack of efficacy, as it may provide some benefit not yet proven by science. This reasoning seems especially plausible given that no information was provided on potential harms of multivitamin supplementation. Alternatively, as the intervention information was not repeated prior to the second auction, participants may not have generalised the intervention information to the second auction; instead, participants may have ascribed the intervention information only to the specific multivitamin product in the first auction. Indeed, our secondary analyses provided some evidence for this explanation. Specifically, participants in the two full-contingency conditions were not significantly better than those in the other conditions at correctly identifying that there was insufficient information to assess the efficacy of the fictional product. This may suggest that illusions of causality are particularly persuasive in novel situations.

Potential limitations

One potential limitation of the study may have been the creation of demand characteristics through two avenues. First, the possibility of winning both multivitamin products may have driven down the bid price and contributed to general bidding noise. Indeed, this possibility was considered prior to running the experiment and was the reason why the second auction (WTP-2) was only presented and explained after the main auction (WTP-1). Second, as students knew they were contributing to research, this might have led them to behave more rationally than otherwise, which may have reduced external validity (Nessim & Dodge, 1995). However, the effects were likely negligible, as previous research has shown that the Becker–Degroot–Marschak auction mechanism elicits WTP estimates comparable to real transactions (Miller, Hofstetter, Krohmer, & Zhang, 2012).

Another potential limitation may stem from recruiting only university students. Previous research has suggested that university samples can be relatively atypical of the global population, which would necessarily limit the applicability of findings to the broader populace (Henrich, Heine, & Norenzayan, 2010). However, as young, health-conscious adults present a key target audience for supplement consumption, the sample participants were likely suitable for the present study. Furthermore, one study designed to empirically test differences in auction behaviour between student and non-student populaces found no significant variation in WTP in an auction for a vitamin-supplemented rice product (Depositario, Nayga, Wu, & Laude, 2009). Nevertheless, it will be informative for future work to establish whether the intervention effect does indeed generalise to a broader populace, and to a range of different irrational remedies.

Implications

Our results provide a contribution to the literature by demonstrating a novel application for evidence-based behaviour change campaigns; that is, they could be used to reduce demand for irrational health remedies. This departs from the previous emphasis on reducing demand for products that are plainly harmful, such as cigarettes, alcohol, and junk food. This novel application is of practical significance because irrational health remedies present a mostly overlooked threat to public health. For example, dietary supplements have been linked to an increase in mortality (Mursu et al., 2011), a reduction in effectiveness of life-saving drugs (Byard & Musgrave, 2010) and a host of unwanted side effects (Bjelakovic et al., 2014).

Our results are also noteworthy because they suggest a comparable impact to an already established health intervention. The effect we observed—a 23% decrease in WTP for a multivitamin product—is comparable to the effect reported by Thrasher et al. (2011), who observed an 18% decrease in WTP for cigarettes from an intervention that combined plain packaging with health warning labels. Our results are promising given the impact that health warning labels have had on reducing public demand for cigarettes. To illustrate, one study found that nearly 44% of former smokers reported that health warning labels had helped them quit smoking (Department of Health and Aged Care, 2000). Our study provides preliminary evidence for a comparable intervention for health and science communicators to reduce demand for products that falsely claim to provide health benefits.

Concluding remarks

The current study presents preliminary evidence that consumer choices are influenced by the illusion of causality. We have demonstrated that targeting this illusion by giving people a simplified contingency table that summarises the full outcomes of a randomised controlled trial, plus a scientifically valid causal explanation for why a health product is ineffective, may reduce consumer demand for products that claim to have a health benefit despite contrary scientific consilience. This intervention may therefore offer an effective lever by which health authorities and science communicators can reduce demand for irrational health remedies.

Acknowledgements

We are grateful to Simon Farrell and Carmen Lawrence for their comments during the design of the study.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was facilitated by an Australian Government Research Training Program Scholarship awarded to the first author.

ORCID

Douglas MacFarlane http://orcid.org/0000-0003-4378-9294
Ullrich K. H. Ecker http://orcid.org/0000-0003-4743-313X

References

Batanero, C., Cañadas, G. R., Díaz, C., & Gea, M. M. (2015). Judgment of association between potential factors and associated risk in 2×2 tables: A study with psychology students. *The Mathematics Enthusiast*, *12*, 347.

Barberia, I., Blanco, F., Cubillas, C. P., & Matute, H. (2013). Implementation and assessment of an intervention to debias adolescents against causal illusions. *PLoS One*, 8 e71303. doi:10.1371/journal.pone.0071303

Becker, G. M., Degroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, *9*, 226.

Bickman, L. (1972). Environmental attitudes and actions. *The Journal of Social Psychology*, *87*, 323–324. doi:10.1080/00224545.1972.9922533

Bjelakovic, G., Gluud, L. L., Nikolova, D., Whitfield, K., Wetterslev, J., Simonetti, R. G., … Gluud, C. (2014). Vitamin D supplementation for prevention of mortality in adults. *Cochrane Database Systematic Review*, CD007470. doi:10.1002/14651858.CD007470.pub3

Byard, R. W., & Musgrave, I. (2010). Herbal medicines and forensic investigations. *Forensic Science, Medicine, and Pathology*, *6*, 81–82.

Boutron, I., Moher, D., Altman, D. G., Schulz, K. F., & Ravaud, P. (2008). Methods and processes of the CONSORT group: Example of an extension for trials assessing nonpharmacologic treatments. *Annals of Internal Medicine*, 148, 60–66. doi:10.7326/0003-4819-148-4-200802190-00008-w1

Department of Health and Aged Care. (2000). *Evaluation of the health warnings and explanatory health messages on tobacco products*. Retrieved from http://webarchive.nla.gov.au/gov/20140801095002/http://www.health.gov.au/internet/main/publishing.nsf/Content/tobacco-warn-review

Depositario, D. P. T., Nayga, R. M., Wu, X., & Laude, T. P. (2009). Should students be used as subjects in experimental auctions? *Economics Letters*, *102*, 122–124. doi:10.1016/j.econlet.2008.11.018

Dombrowski, S. U., Sniehotta, F. F., Avenell, A., & Coyne, J. C. (2007). Current issues and future directions in Psychology and Health: Towards a cumulative science of behaviour change: Do current conduct and reporting of behavioural interventions fall short of best practice? *Psychology & Health*, 22, 869–874. doi:10.1080/08870440701520973

Ecker, U. K. H., Lewandowsky, S., & Tang, D. T. W. (2010). Explicit warnings reduce but do not eliminate the continued influence of misinformation. *Memory & Cognition*, *38*, 1087–1100. doi:10.3758/MC.38.8.1087

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioural and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–195.

Geller, E. S. (1981). Evaluating energy conservation programs: Is verbal report enough? *Journal of Consumer Research*, *8*, 331–335.

Gifford, R. (2014). Environmental psychology matters. *Annual Review of Psychology*, *65*, 541–579.

Gigerenzer, G., Gaissmaier, W., Kurz-Milcke, E., Schwartz, L. M., & Woloshin, S. (2007). Helping doctors and patients make sense of health statistics. *Psychological Science in the Public Interest*, 8, 53–96.

Guallar, E., Strangers, S., Mulrow, C., Appel, L. J., & Miller, E. R. (2013). Enough is enough: Stop wasting money on vitamin and mineral supplements. *Annals of Internal Medicine*, *159*, 850–851.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Beyond WEIRD: Towards a broad-based behavioral science. *Behavioral and Brain Sciences*, *33*(2-3), 111–135. doi:10.1017/s0140525x10000725

Hemila, H., & Chalker, E. (2013). Vitamin C for preventing and treating the common cold. *Cochrane Database Systematic Reviews*, CD000980. doi:10.1002/14651858.CD000980.pub4

Jenkins, D. J. A., Spence, J. D., Giovannucci, E. L., Kim, Y. I., Josse, R., Vieth, R., … Sievenpiper, J. L. (2018). Supplemental vitamins and minerals for CVD prevention and treatment. *Journal of the American College of Cardiology*, 71, 2570–2584. doi:10.1016/j.jacc.2018.04.020

Johnson, H. M., & Seifert, C. M. (1994). Sources of the continued influence effect: When misinformation in memory affects later inferences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1420. doi:10.1037/0278-7393.20.6.1420

Kahan, D. M., Peters, E. D., Cantrell, E., & Slovic, P. (2013). Motivated numeracy and enlightened self-government. (Public Law Working Paper No. 307). Yale Law School. Retrieved from SSRN: http://dx.doi.org/10.2139/ssrn.2319992

Kelley, A. M., & Long, C. P. (2014). Learning by seeing before learning by doing: The role of observation and intervention in learning direct and inverse relationships. *Journal of Psychology*, *2*, 45–69.

Kormos, C., & Gifford, R. (2014). The validity of self-report measures of proenvironmental behavior: A meta-analytic review. *Journal of Environmental Psychology*, *40*, 359–371. doi:10.1016/j.jenvp.2014.09.003

Lewandowsky, S., Ecker, U. K. H., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and its correction: Continued influence and successful debiasing. *Psychological Science in the Public Interest*, *13*, 106–131. doi:10.1177/1529100612451018

Lindeman, M. (2011). Biases in intuitive reasoning and belief in complementary and alternative medicine. *Psychology & Health*, 26, 371–382. doi:10.1080/08870440903440707

List, J. A., & Gallet, C. A. (2001). What experimental protocol influence disparities between actual and hypothetical stated values? *Environmental and Resource Economics*, *20*, 241–254.

McKenzie-Mohr, D., & Schultz, P. W. (2014). Choosing effective behavior change tools. *Social Marketing Quarterly*, *20*, 35–46. doi:10.1177/1524500413519257

Miller, K. M., Hofstetter, R., Krohmer, H., & Zhang, Z. J. (2012). Measuring consumers' willingess to pay: Which method fits best? *GfK Marketing Intelligence Review*, *4*, 42–49.

Mursu, J., Robien, K., Harnack, L. J., Park, K., & Jacobs, D. R. J. (2011). Dietary supplements and mortality rate in older women: the Iowa Women's Health Study . *Archives of Internal Medicine*, *171*(18), 1625–1633.

Nessim, H., & Dodge, R. (1995). *Pricing policies and procedures*. London: MacMillan Press.

National Health and Medical Research Council. (2007). *National statement on ethical conduct in human research* (2007) – Updated December 2013 (the National Statement), Commonwealth of Australia, Canberra.

National Institute of Health. (2016a). *Vitamins and minerals.* Retrieved from https://nccih.nih.gov/health/vitamins.

National Institute of Health. (2016b). *Americans spent $30.2 billion out-of-pocket on complementary health approaches* [Press release]. Retrieved from https://nccih.nih.gov/news/press/cost-spending-06222016

R Core Team (Version 3.3.2) [Computer Software] (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Rousu, M. C., & Thrasher, J. F. (2014). Examining the relationship between psychosocial and behavioral proxies for future consumption behavior: Self-reported impact and bidding behavior in an experimental auction study on cigarette labeling. *Health Education Research*, *29*, 183–194. doi:10.1093/her/cyt114

Shtulman, A., & Valcarcel, J. (2012). Scientific knowledge suppresses but does not supplant earlier intuitions. *Cognition*, *124*, 209–215. doi:10.1016/j.cognition.2012.04.005

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2007). The affect heuristic. *European Journal of Operational Research*, *177*, 1333–1352. doi:10.1016/j.ejor.2005.04.006

Thrasher, J. F., Rousu, M. C., Hammond, D., Navarro, A., & Corrigan, J. R. (2011). Estimating the impact of pictorial health warnings and "plain" cigarette packaging: Evidence from experimental auctions among adult smokers in the United States. *Health Policy*, 102, 41–48. doi:10.1016/j.healthpol.2011.06.003

Vadillo, M. A., Matute, H., & Blanco, F. (2013). Fighting the illusion of control: How to make use of cue competition and alternative explanations. *Universitas Psychologica*, *12*, 261–2270.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin*, *132*, 249–268. doi:10.1016/j.jenvp.2013.04.003

Yarritu, I., Matute, H., & Vadillo, M. A. (2014). Illusion of control: The role of personal involvement. *Experimental Psychology*, *61*, 38–47.

Yarritu, I., & Matute, H. (2015). Previous knowledge can induce an illusion of causality through actively biasing behavior. *Frontiers in Psychology*, 6, 1–12. doi:10.3389/fpsyg.2015.00389