Probable Cause: The Influence of Prior Probabilities on Forecasts and Perceptions of Magnitude

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Consumers' judgments of the magnitude of benefit that a product provides increase their likelihood of purchasing it, and their judgments of the magnitude of harm that accrues from purchasing a product decrease their likelihood of purchasing it. When assessing the magnitude of a product's potential outcome, consumers often encounter information about its probability of occurring. Ten studies demonstrate that this information biases consumers' product decisions. Consumers both expect and perceive larger-probability outcomes to be larger in magnitude—even when they receive identical and objective information about the outcome's actual magnitude. This bias emerges because people believe that larger probabilities emanate from more powerful causal antecedents, and in turn expect more powerful antecedents to produce larger outcomes. Moreover, this bias shapes consumers' product decisions. Of course, it is rational for people to prefer products that promise high-probability benefits and to avoid products that produce high-probability harms. But consumers irrationally *over*weight this probability information because it distorts their judgments of the magnitude of products' benefits and harms, and this distortion biases their purchase decisions.

Keywords: product judgments, lay beliefs, probability perception, magnitude perception

Consumers' well-being depends on which foods they consume, which preventive health products they use, and whether they adhere to prescribed medical treatments for extant illnesses. When consumers believe those products will yield a greater magnitude of benefit, or protect them from a greater magnitude of harm, they are more likely to purchase them (Dahlbäck 1990; Kupor, Daniels, and Zlatev 2019; Slovic 1964; Yates and Stone 1992). When forming these magnitude judgments, consumers are often aware of their probability. For example, patients who experience a side effect from a prescription medication are often aware of that side effect's prior probability of occurring. Similarly, consumers using over-the-counter wellness products are frequently aware of those products' probability of producing a benefit; indeed, this probability information is often prominently featured on those products' packaging, advertisements, as well as other promotional information (see web appendixes A–F).

There are numerous reasonable strategies that consumers could employ to judge the magnitudes of the harms and benefits they experience from various products. For example, consumers who contract a side effect from a prescription drug could utilize over-the-counter diagnostics to assess the magnitude of damage that the side effect has caused, or visit a doctor to obtain a professional assessment. Other approaches are less reasonable. When it is clear that a side effect has caused physiological damage, it

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is particularly irrational to permit unrelated information about the side effect's prior probability of occurring in the first place to shape judgments of the magnitude of damage that it caused. For example, if a side effect increases a consumer's eosinophil count from 397 to 435 per microliter, the side effect's prior probability of increasing eosinophils provides no objective insight into the degree to which that consumer's eosinophil count has now increased, and thus this prior probability should not inform the individual's decision about whether to incur a cost (e.g., buy a medical treatment) to remedy that increase.

Nevertheless, we theorize that such objectively irrelevant information regularly biases consumers' magnitude judgments, and in turn biases their decisions about whether to purchase products to remedy probabilistic harms that have already unfolded. We propose that this bias emerges because people believe larger prior probabilities emanate from more powerful causal antecedents that produce outcomes with larger magnitudes. We unpack this theorizing below.

PROBABILITY-BASED MAGNITUDE JUDGMENTS

Prior literature reveals that numerous factors can bias judgments of outcomes' magnitudes. For example, motivated cognition can distort magnitude judgments: people often perceive an outcome to be larger when a larger magnitude is personally beneficial (Ames and Fiske 2015). The units employed to express a magnitude can also bias magnitude judgments: a magnitude appears larger when it is expressed on a scale with a larger number of units (e.g., when a length is expressed as 100 meters instead of .1 kilometers; Burson, Larrick, and Lynch 2009; Pandelaere, Briers, and Lembregts 2011). And features of the broader evaluation context can distort magnitude judgments: a salient reference outcome can introduce a contrast effect that shifts the perceived magnitude of a focal outcome (Shulman 1992).

Advancing beyond this prior literature, we theorize that information regarding an outcome's prior probability of occurring—information that is frequently present in the evaluation context—regularly distorts magnitude judgments. People think of causes as having power, or energy, that generates outcomes (Buehner, Cheng, and Clifford 2003; Cheng et al. 1996), and assume that the properties of these causes determine the probability that they will cause an outcome (Kahneman and Tversky 1982; Kahneman and Varey 1990). People also believe outcomes match the semantic properties of their antecedents; for example, people believe that *rare* antecedents produce *rare* outcomes, and that *positive* antecedents produce *positive* outcomes (Isaac and Brough 2014; Johnson, Boyd, and Magnani 1994; LeBoeuf and Norton 2012; Reich, Kupor, and Smith 2018). Building on these literatures, we propose that people view more probable outcomes as being generated by more powerful antecedents. Indeed, power means the capacity to reliably and efficaciously accomplish outcomes (Etzioni 1968; Galinsky, Gruenfeld, and Magee 2003; Galinsky et al. 2008); thus, we predict that people perceive an antecedent that can more reliably produce a particular outcome as being more powerful.

We further propose that people believe that more powerful antecedents generate larger outcomes. Consistent with this possibility, research reveals that people often perceive a correlation between an entity's power and its size (e.g., people perceive groups to be more powerful when they are numerically larger, and individuals to be more powerful when their posture occupies a larger space; Eibl-Eibesfeldt 1989; Guinote, Judd, and Brauer 2002; Tiedens and Fragale 2003). We theorize that the relationship people perceive between power and numerical magnitude leads them to perceive that more powerful antecedents produce outcomes with both numerically larger probabilities as well as numerically larger magnitudes. Of course, this theorizing rests on the premise that consumers presuppose that the same antecedent causes both an outcome's probability and magnitude. In reality, this is often not true (Butt, Barthel, and Moore 1988; Cundy and Mackay 2011; Gardiner 2009; Lee et al. 2007; Ngan Kee and Lee 2013; Schwartz 2005). Nevertheless, we predict that people rely on this presupposition because it is much simpler than the alternative (i.e., that outcomes' probability and magnitude are often determined by a complex interaction between a variety of orthogonal causal forces), and because people's finite cognitive resources lead them to prefer more parsimonious accounts (Baddeley 1999; Duncan 1999; Gilovich, Griffin, and Kahneman 2002; LeBoeuf and Norton 2012). As a result, we predict people typically believe outcomes' probability and magnitude emanate from the same antecedent, and that it is precisely when people rely on this default belief that their outcome magnitude judgments are biased by that outcome's prior probability.

In sum, in the numerous instances in which people rely on this default belief, we predict that information about an outcome's probability shapes *expectations* about that outcome's magnitude. We further argue that this probability information also distorts *perceptions* of an outcome's magnitude after that outcome unfolds. This is because people perceive outcomes that have already unfolded in a belief-consistent manner, which causes their perceptions to confirm those a priori beliefs (Kruger et al. 2004; Levin and Gaeth 1988). For example, consumers enjoy movies more when they believe those movies will be enjoyable before viewing them, and they perceive products as higher-quality when they are given reason to believe those products will be high-quality before evaluating them (Klaaren, Hodges, and Wilson 1994; Rao and Monroe 1988, 1989). Drawing on this literature, we predict information about a product

outcome's probability of occurring guides both forecasts of that outcome's magnitude before it unfolds, as well as perceptions of that outcome's magnitude after it unfolds.[1]

Probability-Based Magnitude Forecasts

Consumers' forecasts of product outcome magnitudes often guide their purchase decisions. In the frequent contexts in which consumers are aware of those outcomes' probability of occurring, we predict consumers forecast that more probable outcomes will be larger. For example, imagine a consumer reads that a particular drug causes 4% of users to experience a side effect (as in figure 1A; see web appendixes A–C for additional real examples of probability information communicated in a variety of formats); we predict that this consumer will forecast that the side effect produced by this drug will be larger, compared to if the consumer learned that the side effect affected a smaller percentage of users. Because such magnitude forecasts guide consumers' purchase decisions (Kupor et al. 2019; Li et al. 2012; Magnusson et al. 2003), we further predict that this inference guides consumers' purchase behavior.

Probability-Based Magnitude Perceptions

Consumers' purchase decisions are also often guided by their judgments of the magnitude of product outcomes that have already unfolded. In the frequent contexts in which consumers are aware of an outcome's prior probability of occurring, we predict consumers perceive that outcome as larger in magnitude when it had a larger prior probability of occurring. For example, imagine a consumer sees before-and-after photographs depicting the effect of a treatment that increases skin firmness in 97% of people (see web appendix D); we predict that this consumer will actually *see* the "after" photograph as more different than the "before" photograph, compared to if that consumer had instead read that the treatment increases skin firmness in a smaller percentage of people. Because such magnitude perceptions guide consumers' purchase decisions (Li et al. 2012; Kupor et al. 2019; Magnusson et al. 2003), we further predict that this distorted perception biases consumers' purchase behavior.

Communicating Probability and Outcome Magnitude

Marketers leverage a diversity of formats to communicate probabilities, including percentages (e.g., "potassium has a 10% chance of reducing wrinkles"; see web appendix A), frequencies (e.g., "potassium causes wrinkle reduction in 1 in 10 people"; see web appendix B), and subjectively framed probabilities (e.g., "10% of people say that potassium reduces their wrinkles"; see web appendix C). Across studies, we test our theorizing that probability information biases forecasts of outcome magnitudes regardless of the format in which probability information is communicated.

Marketers also leverage a diversity of formats to communicate outcome magnitudes, including visual outcome formats (i.e., in which consumers view before-and-after photographs depicting the magnitude of an antecedent's outcome; see web appendix D), numeric outcome formats (i.e., in which consumers view the precise numerical magnitude of an antecedent's outcome; see Figure 1B and web appendix E), and arithmetic outcome formats (i.e., in which consumers view the arithmetic magnitude of an antecedent's outcome [e.g., as occurs when consumers learn that an outcome magnitude is "double" or "triple" its preantecedent magnitude]; see web appendix F). Across studies, we test our prediction that perceptions of products' outcome magnitudes (regardless of whether they are conveyed via before-and-after photographs, numeric information, or arithmetic information) will be magnified if marketers suggest that those products have a high probability of yielding any nonzero impact, even though that probability is objectively irrelevant to the outcome's magnitude.

Practical Implications

Information about an antecedent's probability of producing an outcome pervades product packaging, product and service websites, public health information, magazines, and news media content (web appendix A-F). This probability information describes a wide range of antecedents, including services, over-the-counter products, prescription drugs, and diseases (web appendix A-F). Because a primary determinant of consumers' decisions to remedy harms is the perceived magnitude of those harms (Hartmann and Apaolaza-Ibáñez 2012, Li et al. 2012; Kupor et al. 2019; Magnusson et al. 2003; Ming-Sung Cheng et al. 2009), the theorized bias may influence some of consumers' most consequential decisions: for example, patients who learn that a disease is improbable (vs. highly probable) may fail to recognize its severity if they do contract it. These biased magnitude perceptions may lead consumers to unwittingly expose themselves to substantial danger; indeed, perceptions of a harm's magnitude are a

1 In addition to assimilation effects like those we previously described, expectations can also color perception through contrast effects (Hovland, Harvey, and Sherif 1957; Meyers-Levy and Sternthal 1993; Schwarz and Bless 1992). Importantly, however, contrast effects emerge only under a narrow range of conditions (i.e., conditions that unambiguously deviate from expectations by an extreme magnitude; Hovland et al. 1957; Sherif, Taub, and Hovland 1958). We focus our initial empirical investigation on ambiguous experiences (i.e., which produce assimilation effects) because of their frequency and immediate relevance to everyday consumer decision contexts—indeed, much of experience is ambiguous (Hoch 2002). Thus, in our studies, participants formed expectations and then experienced outcomes that were ambiguous (e.g., their visual perception of a hair-growth agent's effect on hair growth over time). We return to this issue in the General Discussion.

FIGURE 1

REAL-WORLD EXAMPLE OF A FORECASTING CONTEXT (FIGURE 1A) AND A PERCEPTION CONTEXT (FIGURE 1B)

A

Side Effects

As with any medication, side effects can occur. The most common side effects include itching and redness, which occurred in 4 percent of users. Darkened eyelids, irritation, dry eyes and red eyelids can also occur. These conditions go away after several weeks of discontinued use.

Increase the Length of Your Lashes

If you desire longer, thicker eyelashes, consider Latisse. We can evaluate your individual situation to see if Latisse is right for you. Contact us for more information about this exciting option.

B

NOTES.—(A) This figure depicts an excerpt from the website of a medical clinic called the Cosmedical Rejuvenation Clinic. The information highlights that "The most common side effects include itching and redness, which occurred in 4 percent of users" (Cosmedical Rejuvenation Clinic 2019). (B) This figure depicts promotional information for a wrinkle-reduction product called JeNu. The information highlights that "100% of women saw wrinkle length improvement. The average improvement was 8.7x" (Trophy Skin 2019). The sales offer noted in this image is no longer valid.

primary driver of consumers' decisions about whether to protect themselves from that harm, and whether to incur a cost to remedy that harm if it does occur (Chen 2011; Kupor et al. 2019; Leonard and VanLandingham 2001; Sjoberg 1999).

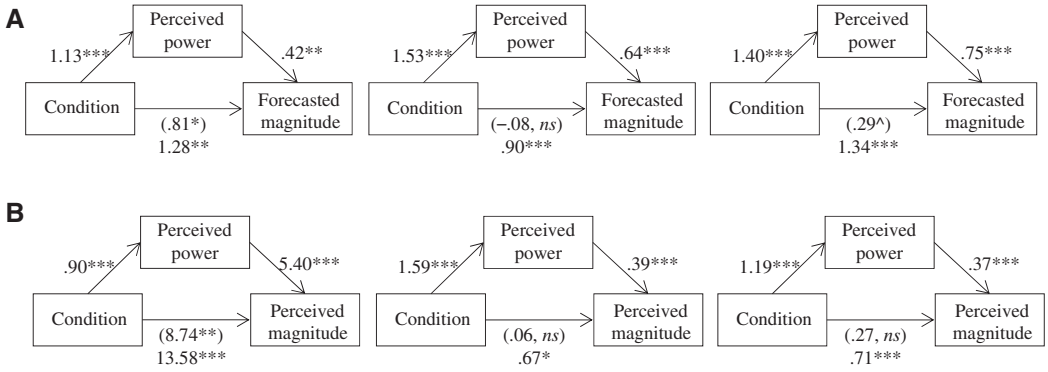
Similarly, a dominant input into consumers' purchase decisions is the perceived magnitude of utility that the product yields (Berry et al. 2003; Kupor et al. 2019; Paxton et al. 1991). As a result, if probability information distorts both consumers' forecasts and perceptions of the magnitude of products' benefits, then this bias may often shape consumers' daily purchase and consumption decisions.

Overview

We present 10 studies examining these predictions. Studies 1A–1F reveal that consumers both forecast that more probable product outcomes will be larger in magnitude, and also perceive them as larger in magnitude after those outcomes unfold. These studies document that this bias is robust across a wide array of forecasting and perception contexts that consumers regularly experience, and reveal that this bias occurs because consumers assume that more probable outcomes have more powerful antecedents. Study 2 finds that people's default belief is that a single causal force produces both an outcome's probability and magnitude, and that this belief

FIGURE 2

MEDIATION IN STUDY 1A (TOP LEFT PANEL), STUDY 1B (TOP MIDDLE PANEL), AND STUDY 1C (TOP RIGHT PANEL)
MEDIATION IN STUDY 1D (BOTTOM LEFT PANEL), STUDY 1E (BOTTOM MIDDLE PANEL), AND STUDY 1F (BOTTOM RIGHT PANEL)



NOTES.—The path coefficients are unstandardized betas. The values in parentheses indicate the effect of condition on the dependent variable after controlling for the mediator. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$ ^ $p < .10$.

underlies our hypothesized effect. Study 3 documents the impact of this bias on consumers' behavioral intentions. Studies 4A and 4B document the impact of this bias on consumers' incentive-compatible behavior.

STUDY 1

Studies 1A–1F offer initial tests of our hypothesis that consumers both forecast (studies 1A–1C) and perceive (studies 1D–1F) outcomes to have larger magnitudes when they have larger prior probabilities. We examine both of these predictions because consumers regularly make decisions both in the presence and in the absence of objective magnitude information (web appendixes A–F).

In order to further test the phenomenon's generalizability, in studies 1A–1C we examine whether the proposed bias emerges across multiple different formats of probability information that marketers frequently leverage, including percentages (study 1A), frequencies (study 1B), and subjectively framed probabilities (study 1C). Within the magnitude perception context, we examine whether the theorized effect generalizes across the different outcome magnitude formats that consumers frequently encounter, including numeric outcome formats (study 1D), visual outcome formats (study 1E), and arithmetic outcome formats (study 1F).

Studies 1A–1F further test the generalizability of the hypothesized phenomenon by examining whether it emerges across a wide range of probability values, response formats, and product outcomes, all designed to be similar to those that consumers regularly encounter (see web appendixes A–F).

Method

Participants. We recruited participants for study 1A from an East Coast university,[2] and participants for studies 1B–1F from Amazon Mechanical Turk (MTurk).[3] One hundred ten participants (mean age = 19; 55% male) participated in study 1A, 202 participants (mean age = 35; 45% male) participated in study 1B, 200 participants (mean age = 38; 44% male) participated in study 1C, 200 participants (mean age = 38; 43% male) participated in study 1D, 200 participants (mean age = 35; 44% male) participated in study 1E, and 202 participants (mean age = 39; 37% male) participated in study 1F.

Study 1A: Forecasting Magnitude from Probabilities Communicated via Percentages. Study 1A had two goals. One was to provide a first test of our theorizing that an outcome's prior probability shapes forecasts of its outcome magnitude in an externally valid context. Because advertisements frequently communicate probability information (e.g., web appendix A-F), we leveraged this externally valid context in study 1A. To that end, we presented participants with an advertisement for the real drug

2 Given limited access to this participant pool, we collected responses from all the students who signed up to complete this lab session (rather than determining an a priori sample size). A sensitivity power analysis in G*Power indicated that this sample size provided 80% power to detect an effect (with a *t*-test) for the difference between conditions of Cohen's $d = .54$ and 60% power to detect an effect of Cohen's $d = .43$.

3 We aimed to recruit 100 participants per cell in studies 1B–1F (as well as in studies 2–4A). A sensitivity power analysis in G*Power indicated that this sample size provided 80% power to detect an effect (with a *t*-test) for the difference between conditions of Cohen's $d = .40$ and 60% power to detect an effect of Cohen's $d = .31$. No conditions or participants were excluded in any studies, and all studies received IRB approval.

Claritin (adapted from Claritin 2003), and manipulated the advertisement's description of the drug's side effects. Specifically, in the smaller (vs. larger) probability condition, we manipulated whether the advertisement stated that 7% (vs. 68%) of users experience coughing (web appendix G). Participants were then asked to imagine that a man named Steve takes Claritin, and that the number of times that he coughs increases as a result. Next, participants indicated how much they thought that Claritin increased the number of times that Steve coughs per year. Participants responded on a 10-point scale, where 1 = About 5% or less, 2 = About 10%, and each consecutive scale point was labeled with intervals of 5% up to 10 = About 50% or more.

The second goal of study 1A was to rule out an alternative explanation—that the current phenomenon could be driven by Gricean norms. In particular, to the extent that people believe that conversation partners generally do not share information irrelevant to the aims of the interaction (Grice 1975), perhaps participants infer that the experimenter (i.e., their conversation partner) would not have provided the probability information unless it was relevant to the ensuing questions, and this inference may lead participants to incorporate the probability information into their magnitude judgments. To eliminate this Gricean demand characteristic, study 1A deactivated Gricean norms using methods from past research: participants read that all of the information in the advertisement might not be relevant to ensuing survey questions, and was presented just in case it was of interest (Hilton and Slugoski 2001; Tetlock, Lerner, and Boettger 1996; Wänke 2007).

Study 1B: Forecasting Magnitude from Probabilities Communicated via Frequencies. Study 1B examined whether participants continue to forecast that a more probable outcome will have a larger magnitude when the probability is presented via a frequency rather than a percentage. Study 1B further examined the phenomenon's generalizability in three additional ways. First, it examined the phenomenon in a different product and outcome context: the impact of tomato consumption on the metabolism. Second, it employed a different response format: rather than reporting their magnitude judgments by entering an objective quantity (i.e., a numeric percentage increase), participants entered a subjective evaluation of magnitude (e.g., on a seven-point scale anchored with subjective adjectives: 1 = Not much at all; 7 = A lot). Third, because consumers frequently encounter probability information in news articles (e.g., web appendixes A-F), we examined whether the proposed phenomenon persists when probability information is embedded in a news article.

In particular, in the smaller (vs. larger) probability condition, participants read that the Vitamin D in tomatoes has a 1 in 25 (vs. 3) chance of increasing a person's metabolism. Participants were asked by how much they thought a tomato would increase an individual's metabolism if an individual ate a tomato and that individual's metabolism increased as a result. Participants responded on a seven-point scale (1 = Not much at all; 7 = A lot).

Of note, the article also included a wide range of unrelated information, including the probability that two other vitamins could cause other outcomes. Between conditions we varied the probability associated with one of these other outcomes, such that all participants viewed the same three probabilities: In the smaller (vs. larger) probability condition, participants read that Vitamin D had a 1 in 25 (vs. 3) chance of increasing the metabolism, whereas the other two vitamins had a 1 in 3 (vs. 25) chance and a 1 in 8 chance of producing their associated outcomes. We reasoned that participants would perceive the probability information about the other antecedents as disconnected from Vitamin D's impact on the metabolism, but would infer that Vitamin D would more greatly increase the metabolism if its probability of having any nonzero impact was larger.

Study 1C: Forecasting Magnitude from Subjective Probabilities. Study 1C examined whether the current phenomenon persists when people view probability information derived from subjective self-report. Study 1C further examined the phenomenon's generalizability by examining it in yet another product and outcome context: participants in the smaller (vs. larger) probability condition read that .01% (vs. 16.98%) of people say that the potassium in bananas causes their teeth to become whiter. All participants then read that an individual ate a banana and the banana's potassium caused that individual's teeth to become whiter. Participants were asked by how much they thought the banana's potassium whitened that individual's teeth. Participants responded on a seven-point scale (1 = Not much at all; 7 = A lot).

Study 1D: Perceiving Numerically Presented Outcome Magnitude Information. Studies 1A–1C examined the impact of an outcome's prior probability on *forecasts* of that outcome's magnitude in the absence of any objective information about its outcome magnitude. By contrast, studies 1D–1F examine whether this probability information also distorts *perceptions* of objective magnitude information.

Study 1D first tested whether the current bias persists when people view an outcome's numeric magnitude. Study 1D tested this prediction in yet another product and outcome context, and with another response format. More specifically, participants in the smaller (vs. larger) probability condition read that when a person eats an orange, the potassium in the orange has a 14% (vs. 66%) chance of increasing the concentration of trypsin in the person's body. Next, participants were asked to imagine that their trypsin count increases from 397 to 436 per microliter after they

eat an orange. Beneath this information, participants indicated the percentage by which their trypsin increased by entering a percentage into an empty field.[4]

Study 1E: Perceiving Visually Presented Outcome Magnitude Information. Study 1E examined whether probability information continues to distort outcome magnitude perceptions when people view before-and-after photographs depicting an outcome's magnitude. Study 1E tested this possibility in yet another product and outcome context, and with another response format. Specifically, participants in the smaller (vs. larger) probability condition read that when a person eats one pound of spinach, the spinach's Vitamin B has a .03% (vs. 22%) chance of increasing the length of that person's eyelashes. All participants then read that a woman's lashes increased in length after she ate one pound of spinach, and viewed pictures of her lashes before and after she ate the spinach (these pictures were sourced from real promotional information advertising a lash-lengthening serum; Rodan + Fields 2018; web appendix G). Participants also read that her lashes were now .75 inches *after* eating the spinach; beneath this information and the before-and-after pictures, participants indicated the length of her lashes *before* she ate the spinach. Participants provided their responses on a seven-point scale, where the leftmost scale point was labeled with "About .60 or more inches long," the scale point to its right was labeled with "About .55 inches long," and each consecutive scale point was labeled with intervals of .05 fewer inches until the rightmost scale point (which was labeled with "About .30 or fewer inches long").[5]

Study 1F: Perceiving Arithmetically Presented Outcome Magnitude Information. Study 1F examined whether probability information continues to bias outcome magnitude judgments when people view arithmetic information specifying an outcome's magnitude. Study 1F further tested the phenomenon's generalizability by employing yet another measurement strategy. Specifically, participants in the smaller (vs. larger) probability condition read that when a person with hair loss eats spinach for a month, the spinach's iron has an 8% (vs. 44%) chance of causing hair growth. All participants then read that a man named Mark is experiencing hair loss, and viewed a photograph of his balding scalp (web appendix G). Participants further read that after the photograph depicting Mark's hair loss was taken, Mark ate spinach for a month and the spinach's iron doubled the amount of hair on his head. Below this photograph and information, participants indicated their perception of how much hair Mark had after the amount of his hair doubled. Participants entered their response by selecting one of seven photographs in which the amount of depicted hair increased from left to right.

In studies 1A–1F, in addition to indicating their magnitude judgments, all participants also indicated how powerful they perceived the antecedent to be (Claritin in study 1A, Vitamin D in study 1B, potassium in studies 1C–1D, Vitamin B in study 1E, and iron in study 1F). Participants reported their responses on a seven-point scale (1 = Not powerful at all; 7 = Extremely powerful).

Results and Discussion

Independent samples *t*-tests found support for the proposed bias (table 1). Outcomes' prior probabilities influenced forecasts of those outcomes' magnitudes in the absence of any information about those magnitudes: in study 1A, participants in the larger (vs. smaller) probability condition forecasted that when Claritin did cause an individual to cough more frequently, it would cause a larger number of coughs, $t(108) = 3.35$, $p = .001$. Similarly, in study 1B, participants in the larger (vs. smaller) probability condition forecasted that when Vitamin D did increase an individual's metabolism, it would increase the metabolism by a larger magnitude, $t(200) = 3.98$, $p < .001$. Similarly, in study 1C, participants in the larger (vs. smaller) probability condition forecasted that when potassium did whiten an individual's teeth, it would cause a larger magnitude of teeth whitening, $t(198) = 5.57$, $p < .001$.

Outcomes' prior probabilities also influenced perceptions of objective information specifying the magnitude of outcomes that occurred (table 1): in study 1D, participants in the larger (vs. smaller) probability condition judged an increase in trypsin from 397 per microliter to 436 per microliter to be a larger percent increase, $t(198) = 4.14$, $p < .001$. In study 1E, participants in the larger (vs. smaller) probability condition perceived the individual's eyelashes as having a smaller initial length, indicating that her lashes underwent a greater magnitude of growth, $t(198) = 2.56$, $p = .011$. In study 1F, participants in the larger (vs. smaller) probability condition selected a picture depicting more hair growth to represent the doubled hair on Mark's head, $t(200) = 3.75$, $p < .001$.

Additional analysis revealed that participants in the larger probability condition perceived the antecedent to be

4 We also included one additional question after the magnitude item, asking participants to report how confident they felt in their ability to correctly compute the magnitude. Participants indicated their responses on a seven-point scale (1 = Not at all; 7 = Very). The manipulation did not influence participants' confidence, which was moderate in both conditions ($M_{Larger} = 4.44$, $SD_{Larger} = 1.84$; $M_{Smaller} = 4.31$, $SD_{Smaller} = 1.78$; $t(198) = .48$, $p = .633$).

5 In addition to testing the phenomenon's robustness to a different measurement strategy, this measurement format allowed us to rule out an alternative explanation based on anchoring and adjustment. According to this alternative explanation, the outcome's larger (vs. smaller) prior probability may have served as a numerical anchor from which participants insufficiently adjusted when judging the outcome's magnitude. Whereas this anchoring alternative predicts that participants who viewed a larger prior probability would report a *larger* (initial) magnitude, our hypothesized effect requires that participants who viewed a larger prior probability would report a *smaller* (initial) magnitude.

TABLE 1

MAGNITUDE JUDGMENTS AND PERCEIVED POWER AS A FUNCTION OF CONDITION IN STUDIES 1A–1F

Study	Dependent variable	Conditions: Smaller probability	Conditions: Larger probability	*t*-test: *t*-test	*t*-test: Effect size	Mediation: 95% confidence interval
Study 1A	Forecasted magnitude					95% CI:
	M	3.21	4.49	$t(108) = 3.35$,	Cohen's $d = .640$	.1411 to .9735
	(SD)	(1.88)	(2.11)	$p = .001$	95% CI = .252 to 1.027	
	Perceived power					
	M	3.60	4.74	$t(108) = 4.00$,	Cohen's $d = .764$	
	(SD)	(1.62)	(1.34)	$p < .001$	95% CI = .372 to 1.155	
Study 1B	Forecasted magnitude					95% CI:
	M	3.19	4.09	$t(200) = 3.98$,	Cohen's $d = .561$	.6532 to 1.3666
	(SD)	(1.65)	(1.58)	$p < .001$	95% CI = .278 to .844	
	Perceived power					
	M	3.33	4.86	$t(200) = 6.57$,	Cohen's $d = .925$	
	(SD)	(1.67)	(1.63)	$p < .001$	95% CI = .633 to 1.217	
Study 1C	Forecasted magnitude					95% CI:
	M	2.28	3.62	$t(198) = 5.57$,	Cohen's $d = .790$	.6716 to 1.4228
	(SD)	(1.59)	(1.78)	$p < .001$	95% CI = .499 to 1.080	
	Perceived power					
	M	2.05	3.46	$t(198) = 5.77$,	Cohen's $d = .818$	
	(SD)	(1.73)	(1.71)	$p < .001$	95% CI = .527 to 1.109	
Study 1D	Perceived magnitude					95% CI:
	M	16.59%	30.17%	$t(198) = 4.14$,	Cohen's $d = .585$	2.3725 to 8.4108
	(SD)	(18.12%)	(27.46%)	$p < .001$	95% CI = .300 to .870	
	Perceived power					
	M	3.87	4.77	$t(198) = 4.12$,	Cohen's $d = .582$	
	(SD)	(1.57)	(1.50)	$p < .001$	95% CI = .298 to .867	
Study 1E	Perceived magnitude					95% CI:
	M	2.67	3.34	$t(198) = 2.56$,	Cohen's $d = .362$	.3524 to .9444
	(SD)	(1.91)	(1.79)	$p = .011$	95% CI = .081 to .643	
	Perceived power					
	M	2.35	3.94	$t(198) = 6.89$,	Cohen's $d = .974$	
	(SD)	(1.66)	(1.59)	$p < .001$	95% CI = .679 to 1.269	
Study 1F	Perceived magnitude					95% CI:
	M	3.44	4.15	$t(200) = 3.75$,	Cohen's $d = .527$	.2406 to .7152
	(SD)	(1.39)	(1.30)	$p < .001$	95% CI = .245 to .810	
	Perceived power					
	M	3.52	4.70	$t(200) = 5.49$,	Cohen's $d = .773$	
	(SD)	(1.68)	(1.39)	$p < .001$	95% CI = .485 to 1.060	

more powerful than participants in the smaller probability condition in studies 1A–1F ($ts \geq 4.00$, $ps \leq .001$; table 1). Further consistent with our theorizing, mediation analysis with bootstrapping (Hayes 2013) revealed that perceptions of the antecedent's power mediated the effect of condition on magnitude judgments in studies 1A–1F (see table 1 for the indirect effect's 95% confidence interval in each study, and see figures 2A and B for each study's mediation figure).

In sum, across different antecedents, different consequences, different information formats, and different measurement strategies, studies 1A–1C reveal that consumers forecast that more probable outcomes will be of greater magnitude if those outcomes do unfold. This bias occurred because people attributed more probable outcomes to more powerful antecedents, which they judged would generate outcomes of greater magnitude. Studies 1D–1F reveal that, through this same process, an outcome's prior probability of occurring biases visual perceptions and numerical judgments of objective information about that outcome's magnitude. Even when participants viewed identical and objective outcome magnitude information, they judged the magnitude to be greater when they learned that the outcome was more probable.

These six studies document the phenomenon's generalizability across numerous different judgment contexts that consumers frequently encounter (see web appendixes A–F). Moreover, they cast doubt on two alternative explanations for the proposed phenomenon: Gricean norms (study 1A) and anchoring and adjustment (study 1E).

STUDY 2

Studies 1A–1F find converging evidence consistent with our theorizing that the proposed phenomenon occurs because consumers assume that more probable outcomes

have more powerful antecedents. This theorizing rests on the premise that consumers presuppose that the same antecedent causes both an outcome's probability and its magnitude. Study 2 tests this premise by examining whether people indeed presuppose that the same antecedent causes both an outcome's probability and its magnitude, and whether this assumption underlies the current bias.

Specifically, in addition to a set of baseline conditions (which mirrored those in studies 1A–1F), study 2 also included a second set of conditions that tied the probability information to an antecedent distinct from the antecedent governing the focal outcome's magnitude. As a result, we predicted that this second set of conditions would prevent the probability information from biasing magnitude judgments.

More specifically, participants read that growing bananas in Calcina soil causes some bananas to contain pimple-reducing folate. In a set of baseline conditions, participants viewed the probability that a Calcina-grown banana contains folate; we reasoned that these participants would, as they appeared to in studies 1A–1F, spontaneously assume that Calcina soil controls both the probability and magnitude of folate growth. Therefore, we predicted these participants would infer that a higher (vs. lower) probability signaled a larger amount of folate in Calcina bananas containing folate, and that this larger dose of pimple-reducing folate would more greatly reduce pimples. In a different set of conditions, participants instead viewed the probability that any banana has been grown by a farmer with access to Calcina soil. We predicted participants would perceive this probability as emanating from farmers' access to Calcina soil, a sociopolitical antecedent disconnected from the biological antecedent in Calcina soil that governs the magnitude of folate growth (see footnote 6 for a pretest confirming this prediction).

Method

Four hundred participants (mean age = 37; 37% male) recruited from MTurk participated in a survey for payment. All participants read that Calcina soil causes some bananas that are grown in it to contain pimple-reducing folate. Participants were randomly assigned to one cell in a 2 (probability size: smaller vs. larger) × 2 (probability information: Calcina-grown banana's probability of containing folate vs. banana's probability of being grown in Calcina soil) design. We told participants in the *Calcina-grown banana's probability of containing folate* condition in the smaller (vs. larger) probability condition that Calcina soil had a 3% (vs. 46%) probability of producing bananas containing folate. By contrast, we told participants in the *Banana's probability of being grown in Calcina soil* condition in the smaller (vs. larger) probability condition that 3% (vs. 46%) of bananas in the world are grown by farmers with access to Calcina soil and thus are grown in Calcina soil.[6]

In order to further test the phenomenon's robustness in environments brimming with a wide range of information, all participants also read a variety of other facts about Calcina soil (e.g., that 58% of people eat bananas grown in Calcina soil, that 40% of food grown in Calcina soil is exported for sale outside of the country in which it is grown, and that 1% of the world's gross domestic product is from crops grown in Calcina soil).

We next assessed participants' magnitude judgments by asking them the extent to which they thought an individual's pimples would decrease if an individual ate a Calcina-grown banana containing folate, and their pimples decreased as a result. Participants provided their responses on a seven-point scale (1 = Not much at all; 7 = A lot).

Results and Discussion

A 2 (probability size: smaller vs. larger) × 2 (probability information: Calcina-grown banana's probability of containing folate vs. banana's probability of being grown in Calcina soil) ANOVA on the magnitude data revealed a significant interaction, $F(1, 396) = 7.67$, $p = .006$. Among participants who read the probability that a banana grown in Calcina soil contains pimple-reducing folate, those in the larger probability condition ($M = 4.10$, SD = 1.64) forecasted a larger decrease than did those in the smaller probability condition ($M = 3.08$, SD = 1.71), $F(1, 396) = 18.84$, $p < .001$ (Cohen's $d = .606$; 95% CI: .324 to .889). As expected, this was not true among participants who read probability information regarding the likelihood of a banana being grown in Calcina soil ($M_{\text{Larger Probability}} =$

6 A key assumption of our experimental design is that participants perceive information about the probability that Calcina soil will cause bananas to contain folate as informative about Calcina soil's power, but they do not perceive information about farmers' access to Calcina soil to be similarly informative about its power. A pretest indicated that study 2's manipulation was an effective manipulation of whether the probability information was perceived to provide insight into Calcina soil's power. In this pretest, 101 participants drawn from the same participant pool were randomly assigned to view information from one of these two conditions. Next, participants were asked whether the probability information provided insight into Calcina soil's power (1 = definitely not; 7 = definitely yes). As expected, analysis revealed that participants were more likely to perceive that the probability information provided this insight when the probability described Calcina soil's probability of producing folate in bananas ($M = 4.94$, SD = 1.99) rather than the probability of a banana having been grown by a farmer with access to Calcina soil ($M = 3.28$, SD = 2.06), $t(99) = 4.12$, $p < .001$. Moreover, in further exploratory analysis, a one-sample t-test revealed that participants in this former condition selected a point significantly larger than the scale midpoint of 4 ($t(50) = 3.37$, $p = .001$), whereas participants in the latter condition selected a point significantly smaller than the scale midpoint of 4 ($t(49) = 2.47$, $p = .017$). Thus, these results suggest that this manipulation effectively operationalized whether the probability information provided insight into the focal outcome's antecedent.

4.08, $SD_{Larger\ Probability} = 1.69$; $M_{Smaller\ Probability} = 3.99$, $SD_{Smaller\ Probability} = 1.65$), $F(1, 396) = .14$, $p = .708$.

Study 2 thus suggests that the belief that a single antecedent causes both an outcome's probability and magnitude is necessary for probability information to bias magnitude judgments. Specifically, when participants read about a probability that they perceived did not share the same antecedent as a focal outcome, that probability did not influence perceptions of the focal outcome's magnitude. In contrast, when participants read about a probability that they perceived did share the same antecedent as a focal outcome, the probability did shape perceptions of the focal outcome's magnitude.

To further test the robustness of this moderation pattern, we also conducted two additional supplementary studies. First, we administered study 2's procedure in the domain of perception (rather than forecast), and found that this same moderation pattern emerged when participants viewed the magnitude of the folate-induced decrease after it unfolded (see web appendix I). In a second supplementary study, we further tested the robustness of this moderation pattern by employing a different design (see web appendix J): participants in one set of conditions received no information about whether an outcome's probability and magnitude emanated from the same antecedent (as in studies 1A–1F), whereas other participants read that an outcome's probability and magnitude emanated from the same antecedent (in a second set of conditions) or from different antecedents (in a third set of conditions). We replicated our findings in the first and second set of conditions, suggesting that participants by default assumed an outcome's probability and magnitude emanated from the same antecedent in the absence of any information to the contrary. However, in the third set of conditions, the presence of information that prevented this assumption disrupted our effect, suggesting that it critically depends on the assumption that an outcome's probability and magnitude share an antecedent. In sum, three studies found converging evidence that people presuppose that the same antecedent causes both an outcome's probability and its magnitude, and that this assumption underlies the current bias.

STUDY 3

Study 3 further examines the practical importance of probability-based magnitude judgments by examining their impact on consumers' intended behavior. Indeed, consumers' judgments of a product's outcome magnitude frequently guide their decisions about whether to purchase that product—for example, consumers who desire to prevent disease are more likely to purchase products that they perceive will provide a greater magnitude of prevention (Cummings et al. 1979; Kupor et al. 2019; Lau et al. 2007; Prislin et al. 1998). In study 3, we therefore examined whether probability-based magnitude judgments shape consumers' intended health product decisions.

In study 3, we also further tested the generalizability of the current phenomenon by employing a different method of manipulating the probability information. Thus far, we have provided numerically larger (vs. smaller) probabilities to participants in the larger (vs. smaller) probability conditions. In study 3, we provided all participants with the same numerical probability, but we manipulated its subjective size by varying the context in which that probability was presented. Specifically, because values appear larger (vs. smaller) when they are plotted in the context of a truncated (vs. expanded) y-axis (Okan et al. 2012; Waters, Fagerlin, and Zikmund-Fisher 2016), we predicted that truncating the y-axis of a graphical presentation of an outcome's prior probability would magnify judgments of that outcome's magnitude, and that these distorted judgments would correspondingly bias consumers' behavioral intentions.

Method

Two hundred five participants (mean age = 37; 37% male) recruited from MTurk participated in a survey for payment. All participants read that when people eat pumpkin seeds, the potassium in the pumpkin seeds has a chance of increasing their bone density. Participants then viewed a bar graph depicting the probability that eating pumpkin seeds will increase a person's bone density. In all conditions, the graph depicted a probability of 6%, and the percentage "6%" was printed above the bar. The only difference between the conditions was the range of values on the y-axis: in the smaller (vs. larger) probability condition, the y-axis ranged from 0% to 100% (vs. 5%; web appendix H).

We assessed participants' magnitude forecasts by asking them how much someone's bone density would increase if a person's bone density did increase as a result of eating pumpkin seeds. Participants responded on a seven-point scale (1 = Not much at all; 7 = A lot). Next, we assessed participants' behavioral intentions with a two-item index (adapted from Baker and Crompton 2000; Kupor and Tormala 2015; Kupor and Tormala 2018). Specifically, participants indicated how likely they would be to eat pumpkin seeds if they wanted to increase their bone density, as well as how likely they would be to recommend eating pumpkin seeds to a friend who wanted to increase their bone density. Participants responded on two separate seven-point scales (1 = Not likely at all; 7 = Very likely). The items were averaged into a composite index of behavioral intentions ($r = .89$).

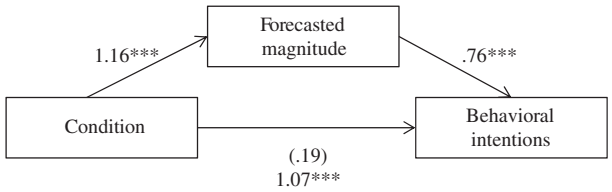
Results and Discussion

As predicted, participants perceived that pumpkin seeds' potassium would more greatly increase a person's bone density if it did have an impact in the larger probability condition ($M = 3.62$, SD = 1.84) than in the smaller probability condition ($M = 2.46$, SD = 1.42), $t(202) = 5.04$, $p < .001$ (Cohen's $d = .705$; 95% CI: .421 to .989). Also as predicted, participants had more favorable behavioral intentions in the larger probability condition ($M = 4.17$, SD = 2.07) than in the smaller probability condition ($M = 3.13$, SD = 1.90), $t(203) = 3.76$, $p < .001$ (Cohen's $d = .525$; 95% CI: .245 to .806). Further consistent with our theorizing, mediation with bootstrapping revealed that magnitude forecasts mediated the effect of condition on behavioral intentions (95% CI: .517 to 1.259; figure 3).

In sum, study 3 suggests that incidental factors that bias perceptions of an outcome's prior probability correspondingly bias judgments of that outcome's magnitude: despite the fact that pumpkin seeds' probability of increasing bone density was objectively identical across conditions, altering participants' subjective perceptions of this probability's size shifted their forecasts of the magnitude by which pumpkin seeds would increase bone density if they did increase bone density. Study 3 further finds that these probability-based magnitude judgments influenced consumers' intentions to consume and recommend the focal product.

FIGURE 3

MEDIATION IN STUDY 3



NOTES.—The path coefficients are unstandardized betas. The value in parentheses indicates the effect of condition on the dependent variable after controlling for the mediator. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$.

STUDY 4A

Studies 4A and 4B documented the impact of the current phenomenon on consumers' incentive-compatible behavior. First, study 4A examined whether an outcome's prior probability continues to bias consumers' judgments of that outcome's magnitude when consumers are directly incentivized to be accurate. Specifically, participants viewed an advertisement that highlighted information about an outcome that had already unfolded—passion fruit that contained eyelash-lengthening biotin as a result of being grown in Monda soil. The advertisement also noted Monda soil's prior probability of producing passion fruit containing eyelash-lengthening biotin. Following the same logic detailed in study 2, we reasoned consumers would infer that Monda soil was more powerful if it had a larger prior probability of producing fruit containing eyelash-lengthening biotin, and that consumers would therefore conclude that Monda soil's outcome was larger (i.e., that it produced more of the eyelash-lengthening biotin in each fruit, which would cause the fruit to produce a greater magnitude of eyelash lengthening).

Method

Two hundred four participants (mean age = 37; 35% male) recruited from MTurk participated in a survey for payment. Participants were randomly assigned to a smaller probability condition or a larger probability condition. In all conditions, participants viewed an advertisement that drew its design from a real Mary Kay promotional campaign advertising an eyelash-lengthening product (Mary Kay 2019). In the smaller (vs. larger) probability condition, the adapted advertisement highlighted that "[g]rowing passion fruit in Monda soil causes 2% (vs. 66%) of passion fruit to contain eyelash-lengthening biotin. Click here for passion fruit that each contain this biotin!" (see web appendix H). Thus, the advertisement highlighted that each of the fruits for sale contained this biotin.

Next, participants read that an individual named Sara had lashes that were .08 millimeters long, and viewed a picture of one of her lashes. Next, participants read that Sara eats a passion fruit grown in Monda soil that contains eyelash-lengthening biotin, and that her eyelashes increase by .02 millimeters as a result. We assessed participants' magnitude perceptions by asking them to select an image that depicted the current length of Sara's lashes. They selected one of 10 images in which the eyelash length depicted in each image increased by .01 millimeters (these images were sourced from real promotional information advertising eyelashes of different lengths; web appendix H). Prior to entering their response, participants read that if they entered the correct response they would receive a bonus; thus, participants were incentivized to be accurate.

After participants entered their responses, we assessed participants' behavioral intentions with the same two-item index described in study 3 (adapted to refer to study 4A's eyelash-lengthening product). Specifically, participants indicated how likely they would be to buy the fruit promoted in the advertisement if they wanted to increase their eyelash length, as well as how likely they would be to recommend the fruit promoted in the advertisement to a friend who wanted to increase their eyelash length. Participants responded on two separate seven-point scales (1 = Not

likely at all; 7 = Very likely). As in study 3, the items were averaged into a composite index of behavioral intentions ($r = .87$).

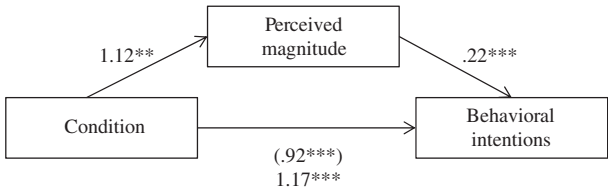
Results and Discussion

As expected, participants in the larger probability condition judged an increase from .08 millimeters to 1 millimeter to be a larger increase ($M = 5.64$, SD = 2.96) than did participants in the smaller probability condition ($M = 4.52$, SD = 2.62), $t(202) = 2.87$, $p = .005$ (Cohen's $d = .402$; 95% CI: .123 to .681). Also as predicted, participants had more favorable behavioral intentions in the larger probability condition ($M = 4.89$, SD = 1.57) than in the smaller probability condition ($M = 3.72$, SD = 1.96), $t(202) = 4.72$, $p < .001$ (Cohen's $d = .662$; 95% CI: .378 to .945). Further consistent with our theorizing, mediation with bootstrapping revealed that magnitude perceptions mediated the effect of condition on behavioral intentions (95% CI: .095 to .461; figure 4).

In sum, study 4A finds that the current phenomenon impacts incentive-compatible judgments in response to probability information presented in the context of a product advertisement, which in turn influence intentions to consume and recommend the focal product.

FIGURE 4

MEDIATION IN STUDY 4A



NOTES.—The path coefficients are unstandardized betas. The value in parentheses indicates the effect of condition on the dependent variable after controlling for the mediator. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$.

STUDY 4B

Study 4B further examined the impact of probability-based magnitude judgments on consumers' real behavior, this time by investigating their impact on consumers' behavior in the field. To that end, we launched advertisements on a social media website that promoted a wrinkle reduction product, and which urged consumers to click on the advertisement in order to purchase this product. We measured *click rate*, a real-world behavior indicative of consumers' willingness to purchase a promoted product (Mitchell and Valenzuela 2005; Zhang and Mao 2016).

The advertisements promoted an outcome that had already unfolded—green tea leaves that contained wrinkle-reducing antioxidants as a result of being grown in Arita soil. The advertisements also noted Arita soil's prior probability of producing green tea leaves containing wrinkle-reducing antioxidants. Following the same logic detailed in study 2, we reasoned consumers would infer that Arita soil was more powerful if it had a larger prior probability of producing the promoted wrinkle-reducing antioxidants, and that consumers would therefore conclude that the soil's outcome was larger (i.e., that it produced more of the wrinkle-reducing antioxidants in each tea leaf, which would cause the leaves to produce a greater magnitude of wrinkle reduction). We verified this reasoning in a pretest (described below), where we also found that these inferences led participants to express greater interest in clicking on the advertisement promoting the wrinkle-reducing antioxidant tea that had a larger probability of being created; therefore, we launched the advertisements in the field. As in the pretest, we predicted that people would be more likely to click on the advertisement when Arita soil had a larger prior probability of producing the promoted wrinkle-reducing antioxidant tea.

Method

Pretest. Two hundred two participants (mean age = 39; 39% male) recruited from MTurk participated in a survey for payment. Participants were randomly assigned to a smaller probability condition or a larger probability condition. In all conditions, participants viewed an advertisement promoting green tea grown in Arita soil. In the smaller (vs. larger) probability condition, the advertisement noted that "[g]rowing tea in Arita soil causes .03% (vs. 99.98%) of green tea leaves to contain wrinkle-reducing antioxidants. Click here for Arita green tea leaves that each contain these antioxidants!" (see web appendix H). Thus, the advertisement highlighted that each of the leaves for sale contained these antioxidants.

Participants reported the amount of wrinkle-reducing antioxidants they thought were in each leaf sold in this ad. Participants entered their responses on a seven-point scale (1 = Not many at all; 7 = A lot). Participants also indicated how much they thought a person's wrinkles would decrease from consuming the tea leaves sold from this ad. Participants entered their responses on a seven-point scale (1 = Not much at all; 7 = A lot). In addition, we assessed participants' behavioral intentions by asking them whether they would click on this ad if they had wrinkles that they wanted to decrease. Participants entered their responses on a seven-point scale (1 = Definitely not, 7 = Definitely yes).

Field Study. We launched the two pretested advertisements on a social media website. In order to maximize the likelihood that the advertisements reached consumers who

desired to manage their wrinkles, we distributed the advertisements to American females over 35 years old because research suggests that the majority of this population desires to reduce wrinkles (Bido 2017). The advertisements were shown 3,740 times, and we measured the number of times users clicked on the ads when they saw them as well as the number of times users chose not to click on the ads when they saw them. This allowed us to compute click rates (i.e., the number of clicks divided by the number of impressions).

Results and Discussion

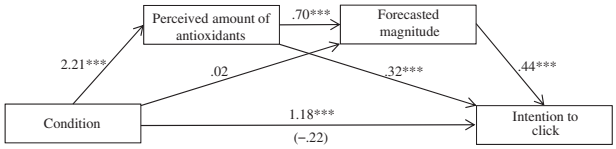
Pretest. As predicted, when the promoted leaves with wrinkle-reducing antioxidants had a larger (vs. smaller) prior probability of containing the wrinkle-reducing antioxidants, participants judged that each leaf sold from this ad had a larger number of wrinkle-reducing antioxidants ($M_{Larger} = 4.78$, $SD_{Larger} = 1.97$; $M_{Smaller} = 2.55$, $SD_{Smaller} = 1.76$; $t(200) = 8.47$, $p < .001$; Cohen's $d = 1.19$; 95% CI: .891 to 1.493), forecasted that this larger number of wrinkle-reducing antioxidants would more greatly reduce a user's wrinkles ($M_{Larger} = 4.05$, $SD_{Larger} = 1.85$; $M_{Smaller} = 2.48$, $SD_{Smaller} = 1.65$; $t(199) = 6.35$, $p < .001$; Cohen's $d = .893$; 95% CI: .602 to 1.184), and were more likely to click on the ad ($M_{Larger} = 4.27$, $SD_{Larger} = 2.12$; $M_{Smaller} = 3.07$, $SD_{Smaller} = 1.89$; $t(200) = 4.24$, $p < .001$; Cohen's $d = .597$; 95% CI: .313 to .880). Further consistent with our theorizing, mediation with bootstrapping revealed that participants in the larger (vs. smaller) probability condition reported that they would be more likely to click on the ad because they judged that each leaf sold from this ad had a larger number of wrinkle-reducing antioxidants, which in turn led them to forecast that the promoted tea would more greatly reduce wrinkles if it did reduce wrinkles (95% CI: .983 to 1.830; figure 5).

Field Study. Consistent with the pretest, the ad in the larger probability condition generated a greater click rate (1.06%) than the ad in the smaller probability condition (.40%), $\chi^2 = 5.64$, $p = .018$. Although the overall click rates appear low, they approximate rates observed in previous research (Kupor, Laurin, and Levav 2015; Tormala, Jia, and Norton 2012).

By conducting this study in a real advertising context, study 4B finds that the current bias has implications for real-world behavior. Indeed, the theorized phenomenon led to a 165% difference in consumers' likelihood of clicking on an advertisement that would enable them to purchase the promoted product. Of course, we suspect that the magnitude of the current phenomenon's impact on behavior likely varies as a function of numerous parameters (e.g., the product category and the perceived distance between the probabilities). We examine these possibilities in the General Discussion.

FIGURE 5

MEDIATION OF CONDITION ON INTENTIONS TO CLICK IN THE PRETEST OF STUDY 4B



NOTES.—The path coefficients are unstandardized betas. The value in parentheses indicates the effect of condition on the dependent variable after controlling for the mediators. $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$.

GENERAL DISCUSSION

Consumers often learn about the probability that products will yield various outcomes. Does this probability information influence consumers' judgments regarding those outcomes' magnitudes, and their purchase decisions as a result? We find that consumers expect product outcomes to be larger before they occur—and perceive them as larger after they occur—when those outcomes have larger (vs. smaller) prior probabilities. We further find that these probability-induced magnitude inferences can guide consumers' real behavior. These studies provide converging evidence across numerous different contexts that people perceive explicitly presented outcome information as larger in magnitude when those outcomes are associated with larger (vs. smaller) prior probabilities. Both mediation and moderation evidence suggests that this bias occurs because people assume that more probable outcomes originate from more powerful antecedents, and that more powerful antecedents produce larger outcomes.

These 10 studies further find that this phenomenon robustly emerges across six different judgment contexts that consumers frequently encounter, and generalizes across numerous different products (e.g., including products that are likely relatively familiar to consumers, such as tomatoes). Moreover, the effect size associated with this bias is relatively large: following the procedures outlined by McShane and Böckenholt (2017), we conducted a meta-analysis of all confirmatory studies that we conducted, and this meta-analysis estimated the overall effect size to be Cohen's $d = .82$ (95% CI [.715, .922]), suggesting that it may have significant real-world influence.

The current research is the first to document the nonnormative impact of probability information on consumer perceptions of product outcomes' magnitudes. Even when people have objective information about products' outcomes (e.g., the precise numerical quantification of their impact, or pictorial depictions of their impact), information about that outcome's prior probability of occurring in the

first place systematically distorts judgments of those outcomes' magnitudes. Importantly, this phenomenon is irrational—for example, if a product causes a consumer's eosinophil count to increase from 397 per microliter to 435 per microliter, whether or not that product had a larger (vs. smaller) prior probability of increasing eosinophils provides no objective insight into the amount by which that individual consumer's eosinophil count has now increased. Nevertheless, we find that such objectively irrelevant information regularly biases judgments of the magnitude of a product's consequences, which in turn biases consumers' decisions about whether to purchase that product.

Theoretical Contributions

Contributions to the Probability Perception Literature. Prior research has documented a phenomenon opposite to the one we advance here: people perceive as *less* probable monetary events with larger magnitudes (Dai et al. 2008; Epstein 1982). The current research advances beyond these prior findings by examining instead the effect of probability on magnitude judgments, and finds that people perceive a positive, rather than a negative, association between these variables.

Outside the realm of economic forces, other work finds that motivated thinking causes the magnitudes of self-relevant events to influence perceptions of their probability (Bonnefon and Villejoubert 2006; Krizan and Windschitl 2007). This literature suggests a relationship in the direction we posit—albeit with magnitude causing probability, not, as we predict, vice versa. Of note, one article speculated about, but did not test, a possibility consistent with the first part of our hypothesis: Keren and Teigen (2001) theorized that larger outcome magnitudes signal more powerful and more probable antecedents.

Our findings advance beyond this literature in numerous significant ways. First, the effect we document is in the reverse causal direction to the one uncovered in this existing literature: we predict and find that consumers assume that more probable events will be larger in magnitude. Second, we are the first to find that an event's probability influences not only people's forecasts of its magnitude, but also their very perceptions of its magnitude after it unfolds. This possibility not only has important theoretical implications, but also has substantial practical implications because it suggests that the phenomenon shapes a wide array of consumer decisions (Slovic 1964). Third, the current research is also the first to document the fact that consumers have a lay belief that the same causal force (i.e., the same "active ingredient" in an antecedent) produces both an outcome's probability and magnitude, and that this lay belief undergirds people's probability-based magnitude judgments. Further, we also find that people project this lay belief systematically to all manner of events regardless of their self-relevance. We unpack these contributions below.

Contributions to the Causal Perception Literature. Because the phenomenon we document is in the reverse causal direction to the one implied by some prior literature (Bonnefon and Villejoubert 2006; Keren and Teigen 2001; Krizan and Windschitl 2007), the current research provides novel insight into the architecture of consumers' underlying causal schemas. Consumers are often inconsistent in their application of causal schemas—for example, consumers' judgments of a product's quality from its price do not translate into their judgments of a product's price from its quality (Mishra and Nayakankuppam 2006). Our research provides novel insight into whether consumers display such an inconsistency in their judgments regarding the relationship between probability and magnitude by examining whether consumers infer an outcome's magnitude from its probability in a manner consistent with the way in which they infer an outcome's probability from its magnitude.

Also as previously noted, our research is the first to document that consumers have a lay belief that the same causal force produces both an outcome's probability and its magnitude. In this way, we provide novel insight into the architecture of consumers' underlying causal schemas. Although there may be cases in which this belief is accurate, there are many cases in which it is not (Butt et al. 1988; Cundy and Mackay 2011; Gardiner 2009; Lee et al. 2007; Ngan Kee and Lee 2013; Schwartz 2005). Nevertheless, we find not only that consumers have this lay belief, but also that it persists even when people view objective magnitude information. By illuminating previously undocumented scaffolding undergirding causal judgments, this research may have numerous further implications: for example, this lay belief may lead consumers to assume that interventions that decrease an event's probability will also decrease its magnitude. Similarly, this lay belief may increase the burden of proof required to persuade consumers that an outcome's probability and magnitude emanate from different sources.

Documenting this lay belief further advances the causal perception literature by illuminating the manner in which consumers' struggles in interpreting probability information extend far beyond those that have been previously documented (Denes-Raj and Epstein 1994; Loewenstein et al. 2001); we find that consumers' misunderstanding of probability information leads them to incorrectly assume that probability information contains insight into attributes beyond an event's probability, which biases a much wider range of inferences than has been previously documented.

Contributions to the Consequence-Cause Matching Literature. This research also provides the first evidence that consumers' perceptions of an antecedent's power lead them to match the size of its outcomes' probabilities and magnitudes. Illuminating this process advances the consequence-cause matching literature, which has

previously examined contexts in which consumers observe either the magnitude of an outcome or the magnitude of its cause, and then utilize this information to infer the magnitude of its corresponding cause or outcome, respectively (Johnson et al. 1994; LeBoeuf and Norton 2012). Because we find that consumers make spontaneous inferences about the antecedent of an outcome's magnitude from its probability, our research is the first to reveal that this matching process can occur across causes and outcomes that are both unknown yet spontaneously inferred.

Contributions to the Response Expectancy Literature. Moreover, we are also the first to argue that consumers not only assume outcomes will be larger if they learn that those outcomes are likelier, but also actually *see* outcomes that were a priori more probable as being larger after the occurrence of those outcomes. Advancing past research, we build on the idea that strongly held beliefs can color perceptions of outcomes (Levin and Gaeth 1988). In a similar vein, we find that people not only expect more probable outcomes to be larger, but also in fact *perceive* them as larger once they take place. This finding has important practical implications: the current phenomenon's influence on both consumers' expectations of future outcomes and their very perception of those outcomes suggests that it may shape a wide array of consumer decisions (Slovic 1964).

Alternative Explanations

Although we provided evidence consistent with the proposed mechanism behind this phenomenon, it is important to consider alternative processes that might have played an additional role.

Anchoring and Adjustment. First, could an anchoring and adjustment process underlie the phenomenon? We conducted numerous studies to investigate this possibility. First, we engineered study 1E's response measure to provide insight into this alternative: whereas a process of anchoring and adjustment predicts that larger (vs. smaller) probabilities lead participants to uniformly estimate larger magnitudes regardless of the queried magnitude, study 1E found the opposite when smaller magnitude estimates were consistent with the theorized mechanism.

Study 2 provides further converging evidence inconsistent with this alternative: because anchoring effects occur even when anchors are perceived to be irrelevant to a judgment (Ariely, Loewenstein, and Prelec 2003), this account would predict probability-based magnitude judgments in all of study 2's conditions (as well as in all of the conditions employed in the supplemental studies detailed in web appendixes I–J); conversely, and consistent with our theorizing, these studies found that probability information influences magnitude judgments only when an outcome's probability and magnitude are perceived to derive from the same antecedent. Further inconsistent with an anchoring and adjustment alternative, study 3 also found that the current phenomenon emerges even when there is no objective numerical difference between the probability information present in the larger (vs. smaller) probability context.

Also important, literature reveals that numerical anchors do not influence responses reported on scales anchored with units that deviate from those characterizing the numerical anchor (Frederick and Mochon 2012). For example, whereas anchoring and adjustment lead a giraffe's weight in pounds to influence the number of pounds that people report in response to unrelated questions, a giraffe's weight in pounds does not influence the numbers people generate when the units of those numbers are not pounds (Frederick and Mochon 2012). Inconsistent with an anchoring and adjustment mechanism, the current research finds that the proposed bias emerges when participants report the outcome magnitude in units other than the units employed in the manipulation (e.g., study 1F). Together, the current research provides substantial evidence inconsistent with an anchoring and adjustment alternative.

Gricean Norms. Another alternative that is worth considering is whether Gricean norms contribute to the phenomenon. Study 1A provides evidence inconsistent with this possibility: even in the context of a validated intervention that deactivates Gricean norms, consumers continued to judge more probable outcomes as larger in magnitude.

Interpretation Ambiguity. Alternatively, is it possible that participants in the current research represented the probability of a continuous outcome's occurrence on a probability distribution (i.e., containing a unique probability for each possible outcome magnitude), and thus perceived information about a single probability as meaningless or ambiguous? We suspect that this possibility is unlikely—people frequently adopt simplified (and incorrect) heuristics to avoid contending with the complex reality of probability distributions, and thus often do not incorporate entire distributions into their decision making (Bar-Hillel 1980; March and Shapira 1987; Tversky and Kahneman 1974). Moreover, the frequency with which consumers encounter websites, ads, and other sources that highlight the probability information that we investigated (i.e., a single probability that a continuous outcome will unfold; web appendixes A–F) further suggests that consumers are accustomed to interpreting such information. Moreover, it is not clear why potential interpretation ambiguity would lead people to perceive outcomes with a higher prior probability as larger in magnitude. Nevertheless, we investigated this possibility in two supplemental studies detailed in web appendixes I–J. Both studies replicated the current phenomenon when consumers viewed complete information about an outcome's probability distribution: in these studies, participants read that the focal antecedent had a binary outcome (i.e., either it

had no effect or it had a precise probability of producing a single outcome magnitude). Both studies replicated the current effect in the context of this complete information about an outcome's probability distribution.

Impact Bias. Alternatively, could the impact bias contribute to the current phenomenon? The impact bias literature finds that forecasters overestimate the extent to which high specification values (i.e., factors that forecasters expect will increase an event's hedonic impact) intensify an event's hedonic impact, and that forecasters also overestimate the extent to which low specification values (i.e., factors that forecasters expect will decrease an event's hedonic impact) will reduce an event's hedonic impact (Buechel et al. 2014; Buechel, Zhang, and Morewedge 2017). There are three reasons why we suspect that the impact bias does not account for the present results. First, because a low probability is a high specification value, the impact bias leads forecasters to *over*estimate the hedonic impact of *smaller*-probability outcomes and *under*estimate the hedonic impact of *larger*-probability outcomes (Buechel et al. 2017). By contrast, we find the opposite pattern of forecasts (e.g., studies 1A–1C).

Also inconsistent with the possibility that the impact bias underlies our results, prior research indicates that the impact bias emerges when people believe they can influence an event, but not when they cannot—as a result, for example, people who are forecasting their affective reaction to a successful die roll exhibit an impact bias prior to rolling the die (i.e., when they perceive they can still influence the die's outcome), but not after rolling the die prior to viewing its outcome (i.e., when they perceive they have less influence over the die's outcome; Morewedge and Buechel 2013). In the current research, we find robust evidence that the current phenomenon emerges after an outcome has already unfolded, and thus when participants could not influence it. These data thus provide further evidence inconsistent with the possibility that an impact bias underlies the current phenomenon.

Further inconsistent with this possibility, the impact bias is eliminated when an outcome is affect-rich during forecasting (Buechel et al. 2014). Because study 1E found that our results persist when people view photographs of an event's outcome, and because prior research reveals that the presence of photographs generates an affect-rich judgment context (Hsee and Rottenstreich 2004), these findings provide further converging evidence inconsistent with the possibility that the impact bias underlies our findings.

Future Directions

Future research could examine whether there are contexts in which probability-based magnitude judgments generate a contrast effect rather than the assimilation effect documented in the current research. Literature reveals that expectations are most likely to generate contrast effects in unambiguous situations that substantially deviate from people's expectations (Bohner et al. 2002; Herr et al. 1983; Hovland et al. 1957). Drawing on this literature, we speculate that probability-based magnitude expectations are similarly more likely to generate contrast effects under those same conditions. We encourage future research to investigate that possibility.

Future research could also profit from examining whether there are particular probability thresholds within which the current phenomenon emerges most strongly. Across studies, we intentionally varied the probability distance between our conditions in order to examine the bias's robustness. These studies provide converging evidence that the theorized phenomenon is robust to relatively small (e.g., study 1C), and even nonexistent (study 3), objective probability differences. Nevertheless, it seems likely that there is some minimum difference beyond which people perceive no substantive difference between two probabilities. This threshold might vary across different product categories, different types of magnitude judgments (e.g., visual perceptions, numeric perceptions, or arithmetic perceptions), as well as different absolute probabilities (e.g., the difference between a 1% probability and a 20% probability might seem larger than the difference between a 61% probability and an 80% probability, and thus yield stronger effects).

Also relevant to the expanse of contexts in which probability information distorts magnitude judgments, the current research documented probability information's impact on magnitude judgments across a wide range of judgment contexts, including those that were likely familiar to participants. In fact, many of the examined product contexts include the most frequently consumed foods in the United States (e.g., oranges; Casselbury 2018; Drewnowski and Hann 1999; Paulin 1998), many of our studies investigated nutrients in these products that are frequently discussed in popular culture (e.g., iron; Enos 2014; Seidenberg 2017; Szabo 2018; Spritzler 2018), and many of our studies investigated outcomes with which people are quite familiar (e.g., teeth whitening and hair growth). However, because particularly high expertise can attenuate judgment errors (Englich and Soder 2009; Schwarz and Clore 2007), future research could profit from investigating whether particularly high levels of expertise or familiarity with a focal product moderate the current phenomenon. For example, one dimension of familiarity that the current studies did not investigate is familiarity with probabilities. In other words, we did not investigate contexts in which people are likely familiar with the probability that a particular antecedent causes a particular outcome. It is possible that the current bias would attenuate among consumers who are highly familiar with such information.

Also relevant to future research, study 2 and the studies described in web appendixes I–J revealed that probability

information no longer guides magnitude judgments when people perceive that independent antecedents determine an outcome's probability and magnitude. The current research largely examined cases in which people spontaneously assumed that the same antecedent produced an outcome's probability and magnitude. But there are likely cases (beyond the contexts documented in the current research) where people do not make this assumption. In such cases, the effects we documented should not hold.

Practical Implications

Magnitude forecasts and perceptions are a primary driver of consumers' behavior (Dahlbäck 1990; Kupor et al. 2019; Slovic 1964; Yates and Stone 1992). For example, consumers are more likely to try weight loss methods that they believe produce greater weight loss (Paxton et al. 1991), and patients are less willing to take medications that they judge cause more severe side effects (Berry et al. 2003; Khan and Kupor 2016). The current research reveals that these magnitude judgments are systematically biased by the outcomes' prior probability, which in turn shapes consumers' behavior. For example, consumers infer that a product that has a larger (vs. smaller) probability of increasing bone density will increase their bone density by a larger magnitude if it does impact their bone density, and these probability-based magnitude perceptions increase consumers' likelihood of consuming and recommending the product (study 3). Similarly, these probability-based magnitude perceptions influence consumers' real incentive-compatible behavior (studies 4A and 4B).

Perhaps because a primary input into consumers' purchase decisions is the perceived magnitude of utility that products yield (Hartmann and Apaolaza-Ibáñez 2012; Kupor, Flynn, and Norton 2017; Kupor et al. 2019; Kupor, Reich, and Laurin 2018; Li et al. 2012; Magnusson et al. 2003; Ming-Sung Cheng et al. 2009), marketers often strive to convince consumers that their products yield large beneficial outcomes. The current research suggests that marketers can magnify consumers' perceptions of the magnitude of their products' impact—and thus increase sales—if they highlight their products' high probability of having any impact at all.

In a similar vein, consumers' perceptions of a harm's magnitude are a dominant driver of their decisions about whether to incur a cost to remedy that harm and protect themselves from that harm in the future (Chen 2011; Kupor et al. 2019; Leonard and VanLandingham 2001; Sjoberg 1999). Perhaps as a result, marketers and public health officials often attempt to persuade consumers to protect against potential harms (e.g., dangerous inclement weather and infectious diseases) by highlighting the magnitude of damage that can result from those harms (Aptiom 2018; CDC 2018; MedlinePlus 2018). The current research suggests that these marketing appeals may have greater persuasive impact if marketers highlight these harms' high probability of having any impact at all.

In sum, this research illuminates a previously undocumented phenomenon—in which probability information systematically biases people's magnitude judgments—and uncovers the conditions in which this bias is most likely to occur. In so doing, it provides novel insight into the inferences people draw from probabilities, the perceived architecture of causal forces, and a primary input into consumers' purchase decisions.

DATA COLLECTION INFORMATION

The first author managed the collection of data for studies 1B–4A using Amazon Mechanical Turk in 2018–2019. These data were analyzed by the first author. The first author supervised the collection of data for study 1A by research assistants at Boston University in 2019. The first author managed the collection of data for study 4B on a social media website. The first author analyzed these data.

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