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The unintended consequences of argument dilution in direct-to-consumer drug advertisements

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Direct-to-consumer (DTC) advertising of pharmaceutical drugs is often cited as the culprit for inflated patient demand for advertised drugs. Further to this economic concern, we provide an evidence-based psychological account of another concern that warrants the re-examination of the merits of DTC advertising of prescription drugs. Across six experiments and a sample of 3,059 US participants, we find reliable evidence for the argument dilution effect. Specifically, when commercials list severe side effects along with those that are most frequent (which include both serious and minor side effects), as required by the Food and Drug Administration, it dilutes consumers' judgements of the overall severity of the side effects, compared with when only the serious side effects are listed. Furthermore, consumers' reduced judgement of severity leads to greater attraction to those drugs. In regulating pharmaceutical advertisements, the Food and Drug Administration appear to have paradoxically dampened consumers' judgements of overall severity and risk, and increased the marketability of these drugs.

Unique to only the United States and New Zealand, direct-to-consumer (DTC) advertising of pharmaceutical drugs is an industry worth US$4.5 billion a year[1]. The Food and Drug Administration (FDA), in promoting the interests of consumers (and patients), regulated and provided guidelines to pharmaceutical companies for both print and media advertising. The nexus of these guidelines stipulated a fair balance between information on benefits and risk— the space and airtime allotted to side effects by print and broadcast media, respectively, needed to sufficiently inform consumers of the various side effects and precautions, in addition to the standard marketing of the drug's benefits. The ubiquitous 60-second television commercial, where a significant portion of the last part of the advertisement is devoted to a laundry list of side effects, owes its impetus to the FDA regulations of 1997/1999[2–4]. Although the medical community, the general population and the media have expressed their annoyance and ridicule for these advertisements[5,6], we contend that there exists a meaningful concern and downstream negative consequences of these regulated advertisements. Specifically, we contend that, despite the FDA's good intentions to inform (vulnerable) consumers of the potential risk and side effects of pharmaceutical drugs, over the years these regulated advertisements might have produced the unintended outcome of dampening one's assessment of the side effects and in the process further promoted the benefits and attractiveness of the drugs.

From the decision-making literature, we know that individuals are plagued by a series of biases[7], resulting in suboptimal decisions and outcomes. One of these established biases is the argument dilution effect[8,9]. When making predictions about a target, a person evaluates an array of information (both diagnostic and non-diagnostic) in that evaluation. The dilution effect occurs whereby those who assess the mixed set of diagnostic and non-diagnostic information arrive at less extreme predictions in comparison with those who assessed only diagnostic information. That is, the non-diagnostic information—information of little value and consequence for outcome prediction—dilutes the value and importance of the diagnostic information in our prognostication. The dilution effect is evidenced in various social and non-social judgements, ranging from assessing intellectual ability[10], guilt of a suspect on trial[9], consumer brands[11] and lottery judgements[12].

The most robust psychological explanation is based on an averaging effect[13]. In this model, each point of information is afforded a weighted score, and adding weights to non-relevant information that are equal to those assigned to relevant information, dilutes people's overall judgement. Further, this model has been shown to predict both social and non-social judgements[13,14]. We therefore contend that the averaging effect and consequently the dilution of a category extends also to relevant but weak arguments, whereby a mixed set of information that contains both strong and weak relevant information dilutes people's overall judgement of the argument. Further to the existing work highlighting the cognitive and affective information that produce information distortion in DTC advertisements[15,16], we contend that the FDA, in regulating DTC advertisements to list side effects that range from the serious (such as stroke and thoughts of suicide) to those less serious (such as dry mouth and headache), have diluted consumers' judgements of the overall severity of the drug's side effects. Thus, the current practice of listing both severe and frequent but minor side effects, paradoxically plays down the risk factors in assessing the suitability of the drug, and in turn increases its attractiveness.

We conducted six experiments to test whether providing information on minor side effects along with major side effects reduces the overall perception of the severity of the side effects associated with the drug. In doing so, our research makes three important contributions. First, existing work on argument dilution has centred on the role of irrelevant (non-diagnostic) information in the dilution of attribute judgement. We extend this by demonstrating that relevant but weak diagnostic information also influences our calculus of argument strength. In addition, the dilution effect has primarily concentrated on positive information; we further the reach of the argument dilution effect by documenting it in the assessment of negative attributes. Finally, and most importantly, the applied results hold important policy implications in communicating risk to consumers of pharmaceutical drugs.

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Table 1 | Descriptive summary of results

	Study 1		Study 2a		Study 2b		Study 2c		Study 3		
	Full audio	Partial audio	Complete side effects	Major side effects	Complete side effects	Major side effects	Complete side effects	Major side effects	Complete side effects	Major side effects	Complete major-side-effects-emphasized
n	398	406	200	200	196	203	225	227	201	199	204
Severity of side effects	5.43 (1.08)	5.62 (1.15)	4.09 (1.27)	4.41 (1.27)	5.33 (1.22)	5.74 (0.98)	5.13 (1.16)	5.47 (1.10)	5.52 (1.12)	5.85 (0.88)	5.84 (0.88)

Each cell in the Severity of side effects row shows the mean value followed by the standard deviation in parentheses.

As an initial test of our hypothesis, in Study 1 we recruited 804 US participants from an online national database. Participants listened to a real drug commercial for Cymbalta—a drug used to treat depression and marketed DTC in the United States. Half of the participants listened to the entire 78 seconds of the audio commercial (full audio condition), whereas the other half listened to a slightly shorter, 75 seconds, version (partial audio condition) that lacked the mention of three minor side effects (stimulus material used for this and other studies is available at the open science framework link provided in the Data availability section). This manipulation constituted an omission of less than 4% of the advertisement's content. Following this, participants in both the full and partial audio conditions rated the severity of the drug's side effects and its attractiveness.

As hypothesized, participants who heard the commercial in its entirety rated the drug as containing less severe side effects than participants who heard the three-second-shorter commercial with no mention of minor side effects ($F(1,802)=5.52$, $P=0.019$, $d=0.17$), suggesting that the mention of the minor side effects diluted the perception of the overall severity of the side effects associated with Cymbalta (Tables 1 and 2). We did not find a significant effect of our manipulation on drug attractiveness but an indirect effect of dilution was observed, such that as participants evaluated the side effects to be less severe, the drug was rated as more attractive in the full audio condition compared with the partial audio condition ($b=0.06$, $P=0.019$, 95% CI [0.01, 0.11]). As demonstrated in past work, an indirect effect is sufficient to demonstrate mediation, as lack of a direct effect on the dependent variable can be an indication of other variables suppressing the effect of an independent variable[17,18]. To rule out lack of attention as an alternative explanation for our results, we asked participants to recall all major side effects that were reported in the audio commercial. Participants correctly remembered a higher number of major side effects in the full audio condition than in the partial audio condition ($M_{full}=3.18$, $M_{partial}=2.78$, $F(1,802)=51.12$, $P<0.001$).

If the psychological process of dilution is the underlying mechanism driving our results, then participants who recalled a higher number of side effects in the major side effects condition should report the side effects of the drug to be overall more severe compared with those who recalled a lower number of the major side effects. Accordingly, we tested for an interaction effect of the manipulation and recall of major side effects on the participants' perception of the overall severity of the drug's side effects. Analysis revealed a marginal main effect of the condition on the perception of drug side-effect severity ($F(1,800)=3.38$, $P=0.095$), along with a main effect of recall such that higher recall led to greater drug side-effect severity ($F(1,800)=15.94$, $P<0.001$). However, more importantly, a significant interaction between condition and recall was observed ($F(1,800)=7.03$, $P=0.008$). On decomposing the interaction (see Fig. 1), we find that the slope for participants in the partial (major side effects alone) condition was positive and significant ($b=0.33$, $P<0.001$), such that participants rated the drug's side effects to be more severe when they were able to recall a higher number of the side effects compared with when they recalled fewer side effects. The slope for participants in the full (major and minor side effects) condition was not significant ($b=0.07$, $P=0.371$), implying that recalling a higher number of side effects did not increase ratings of drug side-effect severity as their evaluations were ostensibly diluted by the presence of minor side effects. This analysis provides initial evidence of argument dilution as the underlying process driving the effect and, importantly, strong evidence ruling out attention as an alternative explanation for our results. Specifically, with better recall in the full advertisement condition, the presence of minor side effects significantly diluted participants' severity judgements. Finally, our results remain consistent when controlling for participants' symptoms of depression ($P=0.021$) and perceptions of trade-off ($P=0.063$). The results from Study 1 are important in documenting the presence of this phenomenon using a real-world DTC commercial with very minimal change in manipulation.

To establish the robustness of this effect and to further increase the ecological validity of our research, in Studies 2a–c we replicated the effects using a different medium (print) and also varied the architecture of these print advertisements. According to the FDA guidelines, print advertisement, apart from promoting the drug, should also highlight its various side effects, but this information is generally buried with other information in smaller text and is often in an inconspicuous location within the advertisement. We reasoned that changing a couple of side effects within a torrent of information would provide a more conservative test of our hypotheses. Accordingly, in Study 2a, participants were shown an actual print advertisement for the drug Lunesta, designed to treat sleep disorder. Randomly assigned participants read either the complete set of four side effects (two major and two minor; the complete side effects condition; $n=200$) or a subset of two major side effects (the major side effects condition; $n=200$). As hypothesized, a one-way analysis of variance (ANOVA) revealed that participants who read all four side effects evaluated the drug as containing less severe side effects than those who read just the two major side effects ($F(1,398)=6.43$, $P=0.012$, $d=0.25$, Table 1). As in Study 1, we did not observe a direct effect on drug attractiveness but an indirect effect of dilution was observed, such that as participants evaluated the side effects to be lower in severity, the drug was rated more attractive in the complete side effects (both major and minor) condition compared with the major side effects alone condition ($b=0.10$, $P=0.012$, 95% CI [0.02, 0.18]). Further, as expected, and as in Study 1, our results remain consistent when controlling for susceptibility to sleep disorder ($P=0.012$) and perceptions of trade-off ($P=0.053$).

In Study 2b, we presented participants with an alternative and further conservative presentation of the merits and side effects of another actual prescription drug for the treatment of depression, Abilify, via a Drug Facts Box. The Drug Facts Box is a one-page summary that includes benefits and harmful effects of a drug, and it has

Table 2 | Separate one-way ANOVA for each of the four different items measuring the overall drug side-effect severity across the complete and major side effects condition

	How serious are drug's side effects			How harmful are drug's side effects		
	Complete side effects	Major side effects	Probability (difference in means)	Complete side effects	Major side effects	Probability (difference in means)
Study 1	5.49 (1.12)	5.66 (1.18)	0.039	5.37 (1.15)	5.57 (1.22)	0.016
Study 2a	4.25 (1.38)	4.59 (1.36)	0.012			
Study 2b	5.43 (1.27)	5.89 (1.01)	0.0001			
Study 2c	5.67 (1.29)	6.05 (1.06)	0.001			
Study 3	5.75 (1.16)	6.11 (0.87)	0.001			
	How would you assess the overall risk factor of using this drug?			**How safe would it be to consume this drug?**		
Study 1						
Study 2a	3.92 (1.34)	4.22 (1.34)	0.025			
Study 2b	5.23 (1.33)	5.60 (1.13)	0.003			
Study 2c	5.19 (1.34)	5.50 (1.30)	0.013	3.47 (1.5)	3.14 (1.46)	0.019
Study 3	5.29 (1.24)	5.60 (1.06)	0.001			

Each cell (except those under the Probability columns) denotes the mean value followed by the standard deviation in parentheses. Effects are significant and consistent for each of the items across all five studies.

been shown to improve consumer decision-making when choosing prescription drugs[19,20]. Participants were randomly assigned to a complete ($n=196$) or major side effects ($n=203$) information condition. In the complete information condition, participants read information regarding the benefits and both the major and minor side effects of the drug, whereas in the major side effects condition, information about the minor side effects was removed from the Drug Facts Box. Participants then responded to measures identical to those in Studies 1 and 2a. A one-way ANOVA revealed a significant difference across the two condition ($F(1,397)=13.90$, $P<0.001$, $d=0.37$), such that participants in the complete information condition rated the drug's side effects lower in severity ($M=5.33$, s.d. $=1.22$) compared with those in the major side effects alone condition ($M=5.74$, s.d. $=0.98$). As in Studies 1 and 2a, we also found an indirect effect of the manipulation on drug attractiveness, such that participants evaluated the drug as more attractive in the complete information condition compared with the major side effects alone condition due to their lower judgement of the severity of the drug's side effects ($b=0.14$, $P<0.001$, 95% CI [0.07, 0.22]).

In Study 2c, to further demonstrate the robustness of our effects, we employed another version of a drug commercial. Specifically, participants were presented with content for another actual DTC drug, Concerta—prescribed to treat attention deficit hyperactive disorder. We formatted the advertisement such that information about the side effects was sandwiched in between statements highlighting the benefits and merits of the drug. This followed the architecture of the audio commercial (Study 1), where side effects were presented among its benefits, but unlike Study 1, the side effects were more precisely and squarely sandwiched between the merits of the drug. Similar to the other studies, participants were randomly assigned to a complete side effects ($n=225$) or major side effects only condition ($n=227$). In addition, to rule out any potential measurement bias in participant's ratings of drug severity, in contrast to the previous studies, participants responded to an additional measure of drug severity—how safe it would be to consume that drug (reverse coded). In addition to being an extra measure, we also ensured the question was framed in a more positive direction focused on safety, rather than harm. Replicating our findings from before, a one-way ANOVA revealed a significant effect ($F(1,450)=10.25$, $P=0.002$, $d=0.30$) such that participants judged the drug less severe in the complete information condition ($M=5.13$, s.d. $=1.16$) compared with those in the major side effects only condition ($M=5.47$, s.d. $=1.10$). Bootstrap analysis revealed a significant indirect effect of our manipulation on drug attractiveness such that lower perception of the drug's severity in the complete information condition, as opposed to the major side effects only condition, made the drug appear more attractive ($b=0.14$, $P=0.001$, 95%CI [0.06, 0.23]). Our results also remained consistent when controlling for participant's susceptibility to the disease ($P=0.002$) and their perceptions of trade-off ($P=0.003$). Through the audio commercial in Study 1, the print advertisements of Studies 2a–c, and by utilizing different drugs, different architecture in presenting information, and different measures of severity ratings, we find strong and consistent support for dilution in DTC pharmaceutical commercials. Furthermore, we ran a separate study in which weak side effects were presented before (primacy) or after (recency) the strong side effects ($M_{before}=5.62$, $M_{after}=5.72$, $F(1,198)=0.50$, $P=0.48$), thereby ruling out a recency effect as an alternative explanation for our prior findings[21]. Thus, listing all frequent side effects, both major and minor, does not dampen the drug's attractiveness, but paradoxically increases it.

Having demonstrated the phenomenon using an audio commercial and replicated the effects with multiple print advertisements, in Study 3 we set out to further establish the robustness of this phenomenon by experimentally attenuating[22] the cognitive process of dilution (that is, an averaging effect)—the psychological process that we argue is the engine behind our observed set of results. If dilution is the result of averaging all side effects listed, it is plausible that the process is dampened if participants can cognitively isolate major and minor side effects, by assigning greater emphasis/weight to major and less emphasis/weight to minor side effects when evaluating the overall severity of side effects. Accordingly, we added a third condition—the complete major-side-effects-emphasized condition—wherein all side effects were presented, but major side effects were presented in bold 14-point red text and minor side effects were presented in regular 12-point black text. Placing greater emphasis on major side effects should result in mental separation and the assignment of greater weights to the major side effects when cognitively computing the overall severity of side effects.

A one-way ANOVA with severity of side effects as the dependent variable resulted in a significant main effect across the three experimental conditions ($F(2,601)=7.56$, $P<.001$). As predicted,

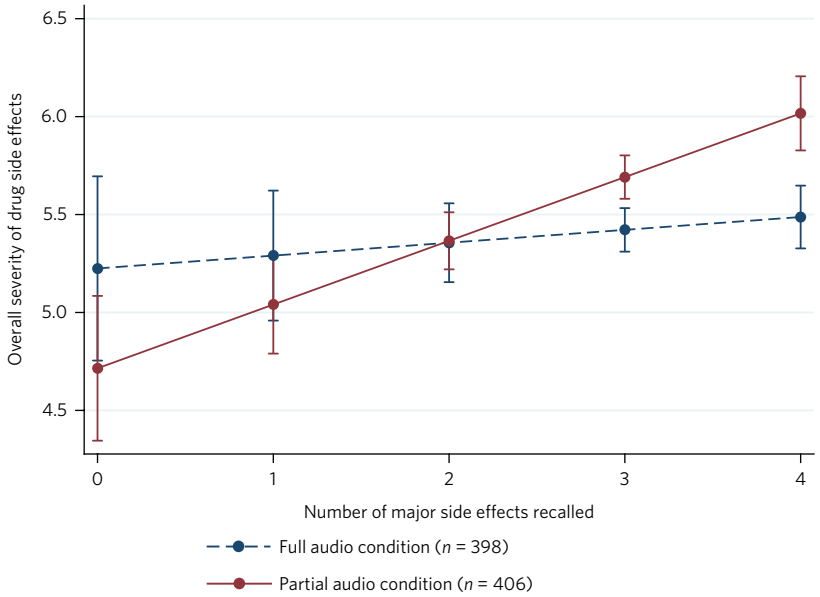

Fig. 1 | The interaction effect of the two audio conditions and participants' recall of major side effects on the perception of the drug's overall side-effect severity ($n = 804$). Only the slope for the partial audio condition is significant ($P < 0.05$). The error bars indicate 95% confidence interval.

there was no difference in means between the major side effects condition and the complete major-side-effects-emphasized condition ($t(401) = 0.11$, $P = 0.91$, Table 1). Consistent with Studies 1 and 2a–c, participants in the complete side effects condition perceived the drug's side effects to be less severe than did those participants assigned to the major side effects condition ($t(398) = 3.28$, $P = 0.001$, $d = 0.33$, Table 1). However, more importantly we also found that participants rated side effects to be significantly more severe in the complete major-side-effects-emphasized condition than in the complete side effects condition ($t(403) = 3.20$, $P = 0.002$, $d = 0.32$, Table 1). Thus, by experimentally moderating the cognitive process of averaging, we further provide evidence of argument dilution as the psychological process driving the varied assessment of severity. Finally, as in previous studies, we did not observe a direct effect on drug attractiveness, but controlling for the complete side effects condition, a significant negative indirect effect was observed for the major side effects condition ($b = -0.11$, $P = 0.001$, 95% CI [−0.18, −0.05]) and the complete major-side-effects-emphasized condition ($b = -0.11$, $P = 0.002$, 95% CI [−0.17, −0.04]) on drug attractiveness via severity perceptions. Specifically, as participants in the complete side effects condition rated the side effects to be lower in severity, they found it to be more attractive compared with those participants in the major side effects condition and the complete major-side-effects-emphasized condition. Finally, our results remain identical when controlling for symptoms of sleep disorder ($P = 0.001$) and perceptions of trade-off ($P = 0.001$).

Thus, by experimentally moderating the psychological process, Study 3 not only replicates the findings of Studies 1 and 2a–c, but also, more importantly, further extends our results by experimentally demonstrating the psychological process underlying the phenomenon of the argument dilution effect. Furthermore, Study 3 provides a practical avenue through which dilution can be tempered in DTC advertising. Specifically, by listing both major and minor side effects, but nudging consumers' attention and weight allocated to the major side effects, consumers appear less susceptible to the argument dilution bias.

Finally, to empirically demonstrate the robustness of our effect, we conducted a meta-analysis of the above five studies and also Study S1 in the Supplementary Information ($n = 2{,}855$). The complete major-side-effects-emphasized condition in Study 3 was not included in the meta-analysis, as that was used to test the psychological process via moderation. However, the other two conditions were included in the meta-analysis. Using random effects analysis we find the effect to be significant with 95% confidence intervals not containing zero ($d = 0.285$, 95% CI [0.203, 0.366]). Thus, paradoxically, listing both major and minor side effects appears to help the marketability of the drug.

Recently, the American Medical Association's House of Delegates called for a ban on DTC advertising in the United States[23], citing that these advertisements produce an inflated demand for drugs. In addition to the theoretical contribution of demonstrating the psychological process of dilution among negatively valenced arguments, importantly we provide an evidence-based psychologically grounded account of a more serious concern that warrants the re-examination of the merits of DTC advertising of prescription drugs. Specifically, across a sample of 3,059 US participants, the target audience for these commercials, we find strong support for the psychological dilution of severity in judgements of side effects when both major and minor side effects are presented. Further, because of these diluted severity judgements, drug advertisements containing all side effects are judged to be more attractive. More broadly, this raises an ethical dilemma—a conflict between what could be viewed as a moral imperative to provide complete information to the patient versus a form of paternalism that attempts to influence the patient's decisions in a manner that makes them better off[24]. The choice of information architecture employed in Study 3, which affords consumers the ability to compartmentalize and assign appropriate weights to major versus minor side effects, presents one possible avenue by which pharmaceutical companies and regulators may look to attenuate the argument dilution effect while maintaining transparency. Whichever nudge is implemented to combat this bias, it is clear that our results underscore the unintended consequences of current advertisements, and the need for the FDA to reassess the prescriptive policy requirement for pharmaceuticals companies to list the full range of side effects in DTC drug commercials.

Methods

Study 1. *Participants*. Eight hundred and four participants from the Unites States — the target audience of DTC advertisements — were recruited through Amazon

Mechanical Turk (AMT) (M_{age} = 35.72; 48.26% female; response rate 87.7%). Given the subtle manipulation, we collected a large sample (≈400 per cell) to detect smaller effects while ensuring we minimized the probability of type-1 error.

Design and procedure. Participants were instructed to listen to an actual drug commercial for Cymbalta—a drug used to treat depression and marketed DTC in the United States. Participants were randomly assigned to either a full 78-second condition (full audio condition), in which they listened to the complete advertisement for Cymbalta, or to a partial, 75-second, condition (partial audio condition) that did not include the mention of three minor side effects (nausea, dry mouth and constipation). This manipulation constituted an omission of less than 4% of the advertisement's content. Following this, participants in both the full and partial audio conditions rated the severity of the drug's side effects on a Likert scale, from 1 (definitely not serious/harmful) to 7 (definitely serious/harmful) by answering two questions: (1) "How serious are Cymbalta's side effects; and (2) "How harmful are Cymbalta's side effects. Participants also judged attractiveness of the drug on a seven- point Likert scale by answering: (1) "If you were in the market for a depression drug, how likely would you purchase Cymbalta"; (2) "How effective would Cymbalta be in curing depression"; and (3) "At what percentage price, above or below, the average market price of other depression drugs should Cymbalta be priced, on a slider scale ranging from −50 to + 50". The composite was created by combining *z* scores for the three measures (α = 0.70).

We controlled for participants suffering from depression or similar symptoms, as these participants could be motivated to ignore or play down the severity of the drug's side effects. Participants thus responded to one item measure on a seven-point scale: "Please indicate how often you suffer from depression or symptoms similar to depression". Furthermore, we also wanted to control for the participant's prior beliefs around the trade-off between greater effectiveness and increased severity of side effects. Trade-off was measured with the item: "FDA's GmbH medical index provides effectiveness rating of the drug on a 0 to 100 scale, with 100 being most effective. If a drug is ranked as 100 percent effective on this index, what would be your estimate of the extent to which this drug would have serious side-effects". It is important to note that although increased side effects with dose-related increases in efficacy (benefits) can sometimes occur for a specific medicine, in many cases there is no clear link between the likelihood of benefit and harm.

Study 2a. *Participants*. Four hundred US participants, the typical audience for DTC advertisements, were recruited using AMT (M_{age} = 35.69; 45.75% female; response rate 93.7%). As print advertisements are lower on media richness[25], we felt a smaller sample size would suffice, but still recruited a large enough sample (≈200 per cell) to avoid any possibility of type-1 error. Study 1 participants were excluded from taking part in Study 2a.

Design and procedure. Participants were shown an actual print advertisement for the drug Lunesta, designed to treat sleep disorder. Randomly assigned participants either read the complete set of four side effects (two major and two minor) (complete side effects condition; n = 200) or a subset of two major side effects (major side effects condition; n = 200). The two major side effects were uncontrollable shaking of a body part and mental problems with attention. The two minor side effects included in the complete side effects condition were dry mouth and headache. Participants then rated the severity of side effects and attractiveness of Lunesta, similar to Study 1. Participants also rated their perceptions of tradeoff and their own susceptibility to sleep disorder, using the identical items from Study 1.

Study 2b. *Participants*. As in Study 2a, we set out to recruit approximately 200 participants per cell. Our final sample consisted of 399 participants from AMT (M_{age} = 38.48; 55.64% female; response rate 92.58%). Participants from prior studies were excluded from taking part in this study.

Design and procedure. Participants were shown a Drug Facts Box for the drug Abilify, manufactured to treat depression. The Drug Facts Box employed was identical to the one used and prescribed in ref. [19]. Randomly assigned participants read either the complete information about the drug (the complete side effects condition; n = 196) or the complete information excluding a few minor side effects (the major side effects condition; n = 203). Participants then rated the severity of the side effects of Abilify and its attractiveness, in the same way as in the above studies.

Study 2c. *Participants*. Given the similar medium of print to that in Studies 2a and b, we once again aimed to recruit approximately 200 participants per cell. Our final sample consisted of 452 participants from AMT (M_{age} = 37.63; 56.42% female; response rate 90.6%). As before, participants who took part in prior studies were excluded from taking part in this study.

Design and procedure. Participants were presented with the text from an advertisement for the drug Concerta for the treatment of attention deficit hyperactive disorder (ADHD), in which the drug's side effects were sandwiched in between its benefits and merits. This manipulation squarely mirrored the architecture employed by several drug commercials, whereby both the beginning and conclusion of the advertisement are devoted to highlighting various strengths or benefits associated with the drug, with the side effects inserted in between. Randomly assigned participants read either the complete side effects of the drug including both major and minor side effects (the complete side effects condition; n = 225) or all major side effects barring the minor side effects (the major side effects condition; n = 227). Participants then rated the severity of the side effects of Abilify and its attractiveness, in a similar way as in the above studies. In previous studies, drug side-effect severity was measured using items evaluating the seriousness, harm or risk associated with the drug. However, in this study we included an additional item employing a different frame. Specifically, participants responded to the item 'how safe would it be to consume Concerta' (α = 0.81). Finally, participants reported whether they were suffering from ADHD, and their perceptions of trade-off.

Study 3. *Participants*. Consistent with our rationale for sample size and as in Studies 2a–c using a text-based stimuli, we recruited roughly 200 US participants per cell (n = 604; M_{age} = 34.97; 45.70% female; response rate 92.4%). As before, participants who took part in prior studies were excluded from taking part in this study.

Design and procedure. To strip away the extraneous information typically found in actual drug commercials that may crowd out viewer's attention to side effects, Study 3 provided participants only with information about side effects. Participants read about Xylopinol, a hypothetical drug that treats sleep disorder. This was a three-condition between-subject design, whereby participants were randomly assigned to a major, a complete or a complete major-side-effects-emphasized condition. In the major side effects condition, they were informed of only four major side effects of the hypothetical drug Xylopinol, designed to aid insomnia, whereas in the complete side effects condition they were alerted to both four major and two minor side effects. In the complete major-side-effects-emphasized condition, participants read about both major and minor side effects, with major side effects more emphasized compared with the minor ones. Participants read that several pharmaceutical companies were actively working to develop drugs that could be effective in treating these sleep disorders. Following this, participants were informed of the four major side effects (memory loss, depression, severe liver issues and suicidal thoughts), both the four major and two minor side effects (headache and dry mouth) or the complete major-side-effects-emphasized condition. Specifically, they read:

> "One such company, Astrazin Pharmaceutical Ltd., has developed a drug, Xylopinol that treats sleep disorders. US Food and Drug Administration (FDA) has found the drug to be effective and have approved the drug for sale in the United States.
>
> However, as is the case with most drugs, Xylopinol may result in some unwanted side effects such as memory loss, depression, severe liver issues and suicidal thoughts (headache and dry mouth)."

After reading the scenario, all participants responded to a set of questions identical to those in Studies 2a and b aimed at assessing the severity of side effects and drug attractiveness. As in Studies 1 and 2a–c, participants also rated their perception of quality, prior belief of trade-off and their own susceptibility to sleep disorder.

Statistical analysis. All analyses were performed using the statistical software Stata. Data across conditions were analysed using a one-way analysis of variance with post hoc analysis of means. Testing of indirect effects was carried out using a bootstrap procedure with 5,000 iterations. Significance was assumed for P values less than 0.05.

Data availability. The authors declare that all data supporting the findings, study protocols and stimulus materials are available at https://osf.io/yw47v/.

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Author contributions

N.S. developed the research idea. N.S. and H.K. designed the experiments; H.K. analysed the data; and N.S. and H.K. wrote the paper.

Ethics statement

The ethics approval for this project was provided by London Business School as per the school's guidelines. In line with ethical guidelines, all participants provided informed consent before taking part in the studies.

Competing interests

The authors declare no competing interests.

Additional information

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Experimental design

1. Sample size

   Describe how sample size was determined.

   We set out to collect a large sample (≈200 per cell) across all our studies to ensure we could detect smaller effects, while ensuring we minimized the probability of Type-1 error. For Study 1, given the very subtle manipulation, we set out to collect larger sample than the other 5 studies.

2. Data exclusions

   Describe any data exclusions.

   Across all studies, all participants who completed the survey were included in our analyses. Thus, none of the participants were excluded from our analyses. Participants who had participated in one of the previous studies were excluded from participating again in other studies.

3. Replication

   Describe whether the experimental findings were reliably reproduced.

   All attempts of replication were successful, and reported within the manuscript.

4. Randomization

   Describe how samples/organisms/participants were allocated into experimental groups.

   Participants were randomly assigned across the experimetnal/treatment groups and any control groups through Qualtrics, an online data collection software that enables researchers to collect data from participants.

5. Blinding

   Describe whether the investigators were blinded to group allocation during data collection and/or analysis.

   Investigators were blind to group allocation, as this was done automatically by the Qualtrics software, as described above.

Note: all studies involving animals and/or human research participants must disclose whether blinding and randomization were used.

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For all figures and tables that use statistical methods, confirm that the following items are present in relevant figure legends (or in the Methods section if additional space is needed).

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement (animals, litters, cultures, etc.)
☐	☒ A description of how samples were collected, noting whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
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☐	☒ A description of any assumptions or corrections, such as an adjustment for multiple comparisons
☐	☒ The test results (e.g. *P* values) given as exact values whenever possible and with confidence intervals noted
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Software

Policy information about availability of computer code

7. Software

Describe the software used to analyze the data in this study.	All analyses were performed using the statistical software Stata (v. 14).

For manuscripts utilizing custom algorithms or software that are central to the paper but not yet described in the published literature, software must be made available to editors and reviewers upon request. We strongly encourage code deposition in a community repository (e.g. GitHub). *Nature Methods* guidance for providing algorithms and software for publication provides further information on this topic.

Materials and reagents

Policy information about availability of materials

8. Materials availability

Indicate whether there are restrictions on availability of unique materials or if these materials are only available for distribution by a for-profit company.	All stimulus materials, study protocols and data are available on Open Science Framework. Direct link to these can be found at: https://osf.io/yw47v/

9. Antibodies

Describe the antibodies used and how they were validated for use in the system under study (i.e. assay and species).	N/A

10. Eukaryotic cell lines

a. State the source of each eukaryotic cell line used.	N/A
b. Describe the method of cell line authentication used.	N/A
c. Report whether the cell lines were tested for mycoplasma contamination.	N/A
d. If any of the cell lines used are listed in the database of commonly misidentified cell lines maintained by ICLAC, provide a scientific rationale for their use.	N/A

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11. Description of research animals

Provide details on animals and/or animal-derived materials used in the study.	N/A

Policy information about studies involving human research participants

12. Description of human research participants

Describe the covariate-relevant population characteristics of the human research participants.	All participants were sampled via Amazon Mechanical Turk (AMT), ensuring they resided in the US - a relevant target for DTC advertisements.

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SUPPLEMENTARY INFORMATION

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In the format provided by the authors and unedited.

The unintended consequences of argument dilution in direct-to-consumer drug advertisements

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SUPPLEMENTARY INFORMATION

Supplementary Study 1

The objective of this study was to replicate our findings for overall severity of drug's side effects by demonstrating that identical results are obtained even when measurement items are framed in a positive direction. Specifically, instead of asking participants to report how serious are the drug's side effects, participants responded to an additional item judging the safety of consuming the drug. We also employed a different pharmaceutical drug to examine the reliability of the measure across different contexts.

Supplementary Methods 1

Participants. A total of four hundred US participants were recruited using Amazon Mechanical Turk (M_{age}=37.02; 55.00% female; response rate 95.69%). Similar to Studies 2-4, we recruited a large sample (≈200 per cell) to avoid any possibility of Type 1 error. Participants from other studies were excluded from partaking in this study.

Design and Procedure. Participants were randomly assigned to a major or a complete side effects information condition. In the *major side effects condition*, they were informed of only four major side effects of a hypothetical drug, Xylopinol, designed to aid insomnia, whereas in the *complete side effects condition*, they were alerted to both four major and two minor side effects. Participants read that sleep disorder continued to be a major concern in the developed world; and as a result, several pharmaceutical companies were actively working to develop drugs that could be effective in treating these sleep disorders. Following this, participants were either informed of the four major side effects (memory loss, depression, severe liver issues and suicidal thoughts) or both the four major and two minor side effects (headache and dry mouth). Specifically, they read:

One such company, Astrazin Pharmaceutical Ltd., has developed a drug, Xylopinol that treats sleep disorders. US Food and Drug Administration (FDA) has found the drug to be effective and have approved the drug for sale in the United States. However, as is the case with most drugs, Xylopinol may result in some unwanted side effects such as ***memory loss, depression, severe liver issues and suicidal thoughts (, headache and dry mouth).***

After reading about Xylopinol's side effects, participants were asked to rate the severity of side effects associated with the drug by answering three question on a 7-point Likert scale – *1) how safe would it be consume Xylopinol 2) how serious are Xylopinol's side effects, 3) how would you assess the overall risk factor of using this drug?*(α=.81). Similar to other studies, participants also rated their perception of drug attractiveness, tradeoff and their own symptoms/susceptibility to sleep disorder.

Results. We replicated our overall finding. It was found that participants assigned to the complete side effects condition, evaluated the drug as overall low on severity compared to those in the major side effects only condition ($F(1,398)=12.92$, $p=.0004$, $M_{Complete}=5.12$, $M_{Major}=5.49$, $d=.36$). However, more importantly we found similar effects for each of the items measuring the drug's severity, such that participants reported the drug to be significantly more safe ($F(1,398)=4.71$, $p=.03$, $M_{Complete}=3.40$, $M_{Major}=3.10$), containing less serious side effects ($F(1,398)=27.46$, $p<.001$, $M_{Complete}=5.54$, $M_{Major}=6.10$), and overall low in assessment of risk ($F(1,398)=4.69$, $p=.03$, $M_{Complete}=5.21$, $M_{Major}=5.47$) in the complete side effects condition compared to participants in the major side effects only condition. Consistent with other studies, we also found a significant indirect effect ($b = .12$, $p<.001$, *95% CI* [.06, .19]) of our manipulation on drug attractiveness via severity such that participants in the complete information condition evaluated the severity of the side effects to be lower, and thus found the drug to be more attractive compared to participants in the major

side effects condition. Further our effects remain consistent after controlling for trade-off (p<.001) and participants susceptibility to sleep disorder (p<.001). Overall, the study demonstrated that argument dilution effects are independent of the question and framing used to measure the drug's overall severity.

Supplementary Study 2

The objective of Study S2 was to demonstrate the impact of argument dilution primarily on a behavioral measure - participants' willingness to pay (WTP) for the drug. We hypothesized that participants will be willing to pay more for drugs they perceive to have less serious side effects. Second, in all our prior studies, complete side effects condition contained greater number of side effects compared to major side effects only condition, thus an alternate mechanism driving our results could be information overload. To rule out information overload as an alternate psychological mechanism, we included a third condition where we provided information of only minor side effects equivalent in number to that of the major side effects condition. If information overload is the mechanism then one should see no difference between the major and minor side effects conditions, however, if argument dilution is the psychological process driving the effect, participants should express greater willingness to pay in the minor and complete side effects condition compared to the major side effects condition. Finally, by examining the effect of our manipulation on a downstream behavioral variable (WTP), this study demonstrates that argument dilution directly influences the attractiveness of the drug, which in previous studies might have been suppressed by asking participant the drug's overall severity and attractiveness simultaneously.

Supplementary Methods 2

Participants. Consistent with our rationale for sample size, and similar to Studies 2a-c and Study 3 using a text based stimuli, we aimed to recruit roughly 200 US participants per cell (N= 585; M_{age}=36.06; 45.81% female; response rate 94.4%).

Design and Procedure. Similar to Study 3, participants read about a hypothetical drug, Xylopinol, which treats sleep disorder. This was a 3-condition between-subject design, whereby participants were randomly assigned to either a *major*, a *complete* or a *minor side effects* condition. In the *major side effects condition*, they were informed of four major side effects, whereas in the *complete side effects condition*, they were alerted to both four major and four minor side effects. In the *minor side effects* condition, participants read about four minor side effects. After reading the scenario, all participants responded to two questions assessing their WTP. Participants were informed, among other things the price of a drug depends on severity of side effect, such that drugs with minimal side effects are priced higher compared to drugs higher in severity of side effects. Participants then responded to two items. First, participants were asked *what percentage price above or below, the average market price should Astrazin Pharmaceutical price Xylopinol*? Second, in order to get a dollar value for WTP, participants were informed drugs with minimal or no side effects costs about $8, drugs with strong side effects costs about $2 and those in the middle are priced around $5. With that as reference, participants were asked, *assuming you are in the market for a sleep drug, how much would you be willing to pay for Xylopinol between $2-$8*. The two measures were combined to create a composite willingness to pay after zscore transformation (α=.53). Identical to prior studies, participants also rated their perceptions of tradeoff and their own susceptibility to sleep disorder.

Results. A one-way ANOVA with willingness to pay as the dependent variable resulted in a significant main effect across the three experimental conditions ($F(2,582)=7.93$, $p<.001$; *see Supplementary Table 1*). As predicted, participants were willing to pay more in the complete side effects condition than major side effects condition ($t(394)=1.98$, $p=.047$, $d=.20$). However, more importantly we also found that participants willingness to pay was significantly higher in the minor side effects condition than in the major side effects

condition ($t(386)=4.02$, $p<.001$, $d=.41$). This provides further evidence of argument dilution as the cognitive process driving the varied assessment of severity in willingness to pay, as opposed to information overload account. Further, complete side effects condition was also significantly different from minor side effects condition ($t(384)=2.00$, $p=.047$, $d=.20$) such that participants expressed greater willingness to pay in the later condition, providing further support for an averaging account for dilution. Finally, our results remain identical when controlling for symptoms of sleep disorder and trade-off ($p<.05$). Despite these results, an important note of caution is to note that one of our WTP item, by presenting a tradeoff between side-effects and pricing, could have biased participant's responses, producing inflated differences between conditions. This is a valid concern for the differences between the *major* and *minor* side effects condition. However, this potential flaw is unable to account for the difference between the *complete* and *major* side effects condition. Further, our results hold if we analyze the data only using the average percentage price item (i.e., no reference to tradeoff) instead of the composite. However, we acknowledge the above limitation and suggest that results of this study be interpreted with this limitation in mind. Taken together, this study not only helps to rule out another alternate account, but further demonstrates the downstream impact of argument dilution on WTP, an important behavioral measure for consumers and producers of pharmaceutical drugs.

Supplementary Table 1: Descriptive summary of results from Supplementary Study 2 with means and standard deviation in parentheses.

	Supplementary Study 2		
	Complete side effects	*Major side effects*	*Minor side effects*
N	197	199	189
Willingness to pay	.01 (.83)	-.16 (.87)	.17 (.74)

Note. Each cell in the row denoted by willingness to pay represents mean value followed by standard deviation in parentheses.