It Is All About Perspective: An Exploration of Mitigating Selective Exposure with Aspect Indicators

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ABSTRACT
Selective exposure, the preferential seeking of confirmatory information, can potentially exacerbate fragmentation of online opinions and lead to biased decisions. We tested whether distinguishing information focusing on different issue aspects may encourage people to take different perspectives, thus moderate the negative influence of pre-existing beliefs on information seeking. Using an information aggregator that provides drug related comments, we conducted an experiment to study the impact of aspect indicators (indicating whether the comment is regarding effectiveness or side effects) on moderating selective exposure when seeking information for medical decision. We found that, when participants had preexisting biased beliefs in the effectiveness of medications (one medication is less effective than the other) treating high-risk diseases, they exhibited selective exposure, not only on effectiveness, but also on side effects, of the medications. Aspect indicators were able to reduce their selective exposure in seeking information on side effects, i.e., aspect where they did not have biased beliefs, which mitigated their overall decision bias. However, the effect of aspect indicator in reducing selective exposure was moderated by the decision contexts, including perceived risk of disease and whether the issue aspect was critical to the decision.

Author Keywords
Selective exposure; confirmation bias; information seeking; decision making; biases; health.

ACM Classification Keywords
H.5.4. Information Interfaces and Presentation: Hypertext/Hypermedia-User issues.

INTRODUCTION
Is the glass half full or half empty? This is a question often used to demonstrate that one's perception of reality may depend on one's perspective. Indeed, individuals often differ in their beliefs in certain aspects of a situation or an issue, and they may choose to pay more or less attention to different aspects (e.g., the water in the glass, or the empty part of the glass) as they make a judgment or decision.

Research shows that prior attitudes (e.g., pessimism) tend to induce preferential seeking of attitude-consistent information (e.g., half empty glass) and avoidance or ignorance of attitude-inconsistent information (e.g., water in the glass), a phenomenon called *selective exposure* to information [9, 16, 28]. Selective exposure may lead to biased judgment and decision, and, at a collective level, greater polarization and fragmentation in the society. As modern technologies make selection of information from preferred sources increasingly easy, their potential exacerbation of selective exposure has raised critics from many, calling attention to such problems as "echo chamber" [32] and "filter bubble" [30].

Meanwhile, researchers have recognized the benefits of enhancing exposure to diverse opinions could have on design of social information systems [17, 24, 25, 26, 27, 29]. These systems not only make different opinions more accessible (e.g., often in the form of information aggregators), but also, more importantly, leverage computational methods and design techniques to "nudge individuals in the direction of exposure to challenging information" [10]. The idea of "nudging", to induce behavioral change without invading individuals' freedom of choice, could be critical for exposing people to challenging information without incurring negative user experience with the system or denial of the information itself.

Our research is in line with this "nudging" approach. Noticing that controversial topics such as "Obamacare" often have many aspects, and people holding different attitudes may simply focus on different aspects, we see a design opportunity to improve their reception to diverse opinions by highlighting the difference in the perspectives that others take. Specifically, we are interested in testing the idea of mitigating selective exposure by distinguishing information on different aspects of a controversial topic, thus potentially reducing information seekers' resistance to arguments put forward by the other side, but on "non-conflicting aspects" of the topic where they do not have strong biased beliefs. To this end, we conducted an

experiment to explore how aspect indicators, i.e., interface features indicating the focused issue aspect of information, impact users' information seeking in a system providing diverse opinions.

We studied the effects of aspect indicator in the context of medical decision-making: a common situation where someone may have had or heard about negative opinions on a medication and consider switching to a different option by browsing other patients' comments online. Such decision is controversial if neither option has definite advantages but largely depending on individual's condition and preference.

The reasons we chose such a context were twofold. First of all, medical decisions naturally involve multiple aspects that are established, distinctive, and often consistently defined, e.g., effectiveness and side effects [13]. This allowed us to study aspect indicators without concerning the possible difference in the definition of aspects across topics and individuals. For example, imagine a patient is concerned about the slow *effectiveness* of a medication and intends to seek evidence for rejection, we are interested in whether he may show selective exposure, i.e., preferentially seeking of negative information on both *effectiveness* and *side effects* of the medication, and whether the presence of aspect indicators will make a difference.

Moreover, we expect to contribute to the emerging research area of studying biases in online health information seeking. Identified to be the most common cause of decision errors for clinical decisions [4], selective exposure could cause more harm to patients seeking information online as they are more likely to form incorrect beliefs, and selective exposure is found to increase their illusory confidence in them and result in inferior decisions [15, 16, 18, 33]. Our study sets to further understand this problem by exploring the presence of selective exposure in web technology supported medical decision-making,

Another key question is whether it makes a difference if the aspect where one has biased belief is a *critical* or *uncritical* aspect for the controversial topic. As theories in multi-attribute decision-making suggest, varying weights given to different attributes (i.e., aspects) may influence one's motivation to seek relevant information [37]. While we chose to study aspect indicators distinguishing effectiveness and side effects of treatments, we were aware that they might not be given equal consideration in different situations. Importantly, as [3] suggests, when choosing treatment for high-risk diseases, effectiveness is likely to be the critical aspect and given more consideration than side effects, while it may be the contrary for low-risk diseases. One may ask, e.g., if two patients with life-threatening diseases both have negative attitudes towards a medication, while one is concerned about its effectiveness that is vital to his life, the other is concerned about certain side effects that one can usually endure for a life-saving medication, would they exhibit differences in selective exposure tendency?

To the best of our knowledge, such questions have not yet been well explored in the selective exposure literature. Specific to medical decision, it is unclear whether concerns on a critical aspect of the decision may motivate people to deliberatively seek accurate information, and as a result, reduce selective exposure [12], or whether it may incur a higher level of anxiety when making possibly irreversible decisions, hence increase selective exposure [9, 25]. To study this, we examined the effects of aspect where one has biased belief (side effects/effectiveness) and perceived risk of the disease (high/low) in the experiment.

In the current paper, we define:

- *attitude* as one's pre-existing preference between treatment options to be compared.
- *attitude-consistent* (*inconsistent*) information as information that supports (opposes) the attitude.
- *belief* as the detailed, aspect specific existing opinions, e.g., one treatment may cause bad side effects.
- *biased aspect* as the aspect (effectiveness/side effect) where one has pre-existing biased belief; and *unbiased aspect* as where one does not.
- *critical aspect* as the aspect that is critical to the decision; and *uncritical aspect* if otherwise.

To summarize, in this paper, we are interested in understanding how aspect indicator in a system providing diverse opinions influences the information seeking and decision making of users with pre-existing biased beliefs. We also examined whether the differences in which aspect the user has biased beliefs in, or whether it is a critical or uncritical aspect for the decision, have effects. We explored the research questions in a medical decision-making context, and chose treatments' effectiveness and side effects to be the two studied aspects. Specifically, we ask the following research questions:

RQ1: How do aspect indicators influence selection of comments on effectiveness or side effects for users having pre-existing biased beliefs in one or the other of the two aspects?

RQ2: How do aspect indicators influence selection of comments on effectiveness or side effects when making decision regarding high versus low risk diseases?

RQ3: How do aspect indicators influence the decision outcomes for users having pre-existing biased beliefs in effectiveness or side effects, and for decision regarding high versus low risk diseases?

RQ4: How do disease risk and biased aspect influence selective exposure tendency in seeking medical information online? How does the selective exposure, if any, impact the decision outcomes? How do aspect indicators impact the process?

RELATED WORK

Selective exposure has been mainly studied based on Festinger's cognitive dissonance theory [8, 79]. According

to the theory, when committed to a belief or decision, people are driven to seek supportive information and avoid or ignore unsupportive information in order to eliminate the negative state of cognitive dissonance. Therefore, to mitigate selective exposure, the key lies in reducing the cognitive dissonance one experiences when processing attitude-inconsistent information [9, 10, 32].

Given that many controversial topics involve multiple aspects or dimensions, narrowing down information seeker's perceived conflicts to only a subset of them could potentially reduce the overall cognitive dissonance. Consistent with this idea, previous research found that people are more likely to interact with others holding dissimilar attitudes if they share common ground on some aspects of the topic [1, 11, 24]. Similarly, a strategy adopted by decision-making support systems (DSS) to "de-bias" users with strongly held biases is to first partially acknowledge or endorse certain aspects of their positions before bringing in attitude-challenging information on other aspects [21]. These results suggest that, selective exposure could potentially be reduced by explicitly showing that attitude-challenging information focuses on aspects where the information seeker does not have conflicting beliefs. We are interested in testing the idea in this paper.

Interfaces that present information by aspects are pervasive. Many algorithms have been developed to extract and classify aspects of information in various domains [14, 20, 35, 36]. Relevant to our study, tools have been developed to show how information sources with different biases (e.g. media, politicians) focus on different aspects of controversial issues [1, 29] to assist users in sense making and deliberation. While a number of previous studies examined users' navigation of such interfaces, e.g., tag-based [36] or multi-facet [20] ones, to the best of our knowledge, we are among the first to study how presenting information by aspects influences seeking of attitude consistent versus attitude inconsistent information.

While online selective exposure has been frequently studied in the political domain [10, 11, 17, 26, 27] due to the deep concern of polarized society. A few recent studies drew attention to the problem in online health information seeking. In particular, research on "Cyberchondria" [19, 33, 34], a term referring to people's escalation of medical concerns after performing online information search, suggests that Internet may potentially reinforce selective exposure. For instance, search engine, the most popular tool for seeking medical information online, often uses algorithms favoring satisfying searchers rather than accuracy, hence tend to provide confirmatory information that strengthens users' pre-existing beliefs. Consistent with findings from psychological research [8], this line of research also indicates that anxiety associated with medical decisions may exacerbate online selective exposure by drawing attention to alarming terminologies [33].

Meanwhile, patients' selective seeking and avoidance of medical information has been broadly explored in more general (offline) contexts (e.g., [22]). Avoidance of new, challenging information was found to be a common coping strategy used by patients to manage fear and uncertainty, especially among those with serious, life-threatening diseases such as cancer [5, 6].

A few studies have explored designs that integrate de-biasing strategies in health information search interfaces to mitigate the negative impact of biased beliefs. For example, [18] employed an anchor de-biasing intervention that asks users to assemble evidence for and against a proposition before they commit to a decision. [31] used a social tagging interface that presented popular terms supporting different positions of controversial health topics, and found it to raise awareness of different perspectives and reduce users' selective exposure. In this paper, we conducted an experiment based on this general idea by testing how information seekers select diverse drug related comments with labeled aspects.

METHODOLOGY

Platform and Task

We created CompareMed, a system supporting comparative medical decision by aggregating patients' comments from social media. To help a user compare two treatments, the system presents comments on each treatment side by side. For each treatment, it presents a list of comment snippets (with usernames), which one can click to read the whole message. Each snippet is shown with a star rating, which reflects how negative or positive the comment is, using a 1 (negative) to 5 (positive) scale. In the experimental conditions (Figure 1(a)), the system presents *aspect indicators*- star signs that not only show comment sentiment, but also, by the labels ("side effects" and "NO side effects", or "ineffective" and "effective"), indicate whether the comment focuses on discussing the effectiveness or side effects of the treatment. Different color schemes were also used to further differentiate the two kinds of comments. In the control condition, only one kind of star signs was used, with generic labels ("bad" and "good")(Figure 1(b)). This format, including the star signs, and separate ratings given to effectiveness or side effects of a medication, is commonly seen on drug-review websites.

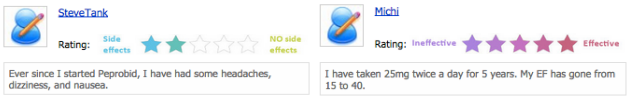

Figure 1(a). Snippets of side effects comment (left) and effectiveness comment (right) for experimental conditions

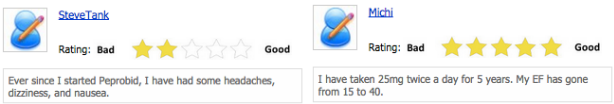

Figure 1(b). Snippets for control conditions

To introduce "pre-existing biased beliefs" in the experiment, for each task, participants were given a scenario to imagine that a close friend was having negative experience with a treatment they just initiated, and facing the decision of switching to an alternative treatment, which the friend had heard might work better. The participant was asked to use CompareMed to learn about the two options and provide suggestions. We expected that it would introduce biased beliefs favoring one treatment (*alternative*) to the other (*current*).

Participants were asked to freely browse the system until they were ready to give suggestions. Then they proceeded to the survey page, where they rated their preference between the current and alternative treatment, and wrote down their suggestions for the friend. Each participant was asked to complete 6 such tasks for different diseases.

Experimental Design

The experiment included two between-subjects variables: biased aspect (effectiveness/side effects), presence of aspect indicator (presence/absent); and one within-subject variable: disease risk (high/low). In other words, participants were randomly assigned to one of four conditions: having biased beliefs in effectiveness/side effects and with or without aspect indicators. Each participants were given 6 decision-making tasks, half of which were about high-risk diseases that could be potentially life-threatening and needed to be cautiously controlled: congestive heart failure (CHF), deep venous thrombosis (DVT) and acute asthma attack; the other three were low-risk minor diseases that were commonly seen and could be treated or controlled by over-the-counter medicines: diarrhea, back pain and heartburn (acid reflux).

Material

Comments

For each disease, we chose two medicines that had similar user ratings on WebMD as candidate treatments to be compared in the experiment. Their names and other identifying information were replaced to avoid recognition.

For each medication, we collected 50-60 comments from the "user comments" section of popular drug information websites (e.g., WebMD.com, rxlist.com), and medical discussion forums, e.g., medhelp.org. We were conscious about having a balanced number of positive and negative comments, and comments regarding effectiveness and side effects. We intentionally excluded comments that did not have a clear focus on either aspect.

Two researchers independently rated all comments for their sentiment (positive/negative) and focused aspects (effectiveness/side effects). We then excluded comments that they disagreed on and ended up with a collection of 32 comments for each medicine, with *evenly* distributed sentiment and aspects to create a "controversial" decision where the information does not significantly favor one option over the other. Table 1 presents examples of each type of comment.

Scenario

An important step in the experiment was to introduce biased beliefs by giving participants a scenario of a disfavored current treatment and a potentially better alternative. To manipulate the biased aspect, two versions of scenario were created for each of the 12 medicines (2 medicines for 6 tasks): one mentioning lack of effectiveness, and the other complaining about side effects of the current medication. To make it coherent, the scenario mentioned side effects that also appeared in some of the negative comments.

To strengthen the negatively biased attitude on the current option, we included an image with each scenario, picturing a patient suffering from the particular disease (for biased belief in effectiveness) or side effects mentioned (for biased belief in side effects). Pictures were consistently chosen to be simple, with no excessive information but portrait of a single patient.

To strengthen the difference in the perceived risk level of the diseases, for the high-risk disease, the scenario mentioned the disease could be life threatening and needed to be attended very cautiously, while for the low-risk diseases it mentioned it was not a serious problem.

For randomization purpose, in each experiment session, the two medicines of each task were randomly chosen to be the current or the alternative option by randomly loading one of the two created scenarios. On the screen, the current option and alternative option were randomly placed on the left or right side, with the current option labeled as "currently taking" on the heading. The order of the six disease tasks was also randomized.

Measurement

Aspect	Sentiment	Example
Effective-ness	Positive	Dosage currently 25mg of Peprobid twice a day and I am feeling pretty great. My EF is up to 50-55% from 20%. And my BP is 130/85, which is a great improvement from 208/182. My heart doctor and my PCP both told me that this will be a miracle medicine and they were right
	Negative	Diagnosed with Congestive Heart Failure, It was hoped this would reduce my BP and help me avoid worse conditions up ahead. Now I have been taking Peprobid for the last 3 months, I really can not say it has made me feel one bit better.
Side effects	Positive	After being on Atenolol for 5 years, switching to Peprobid was a vast improvement. I used to jitter and feel exhausted all the time with the other meds. No side effects so far with Peprobid.
	Negative	I am only on 12.5 mg of Peprobid but I sleep all night & day, if I am not sleeping I am so exhausted I can not move with out becoming so short of breath I have to stop and sit not moving for at least 15-29 min. The side effects are dragging me down.

Table 1. Example of comments for the medicine "Peprobid" treating congestive heart failure

We are interested in participants' information selection (i.e., comments that were clicked to read) and their decision outcomes. The experimental platform recorded participants' clicks on comments, and we used them to analyze the number of selections for each type of comment.

To measure decision outcomes, after each browsing session participants were asked to rate two statements: 1) The alternative is a better option; and 2) I would like to switch to the alternative; based on a 1 (disagree) to 5 (agree) Likert scale. The ratings were averaged to create *decision index*, which reflects participants' preference for the alternative over the current option.

Participants

We recruited 67 participants from a university town in the Midwest of United States by using online job boards and a campus-wide mailing list for faculties and university staff. Participants' average age is 26.58 (SD=11.58), including 21 male and 13 with post-graduate degree. There was no significant difference in age, gender and education of participants assigned to the four experimental groups. We measured participants' experience with online health information seeking by asking them rate how often they look online for: 1) information about medicines; 2) disease related information; 3) healthy lifestyle related information; and 4) health related social media. We also measured their self-rated knowledge for all the diseases used in the experiment. We did not observe significant difference of the two measurements among the experimental groups.

RESULTS

To report on the results, we will first test whether aspect indicators influenced the selection of comments on effectiveness or side effects for participants who had biased beliefs in one or the other aspects (R1). Then we will examine whether aspect indicators influenced information selection differently for participants concerned about high versus low-risk diseases (R2). In the last part, we will explore how these factors - disease risk, biased aspect and aspect indicators - impacted participants' decision outcomes (R3), and if so, attempt to understand the causes by examining the presence of selective exposure (R4).

Biased Aspects on Selection of Comments on Different Aspects

To test whether the aspect indicators impacted the selection of comments on effectiveness or side effects, we started by calculating the selection percentage of effectiveness/side effects related comments (divided by the total number of selected comments) for each task, by each participant.

We ran a mixed effect linear regression model on the selection percentage of comments, by including comment aspect (effectiveness/side effects), participant's biased aspect (effectiveness/side effects), and presence of aspect indicators (present/absent) as fixed-effect independent variables[1]. We found a significant three-way interaction among all the fixed-effect variables ($\beta=0.13$, $t(64)=2.43$, $p=0.02$). We illustrate the interactive effect by plotting the average selection percentages of effectiveness and side effects related comments in Figure 2.

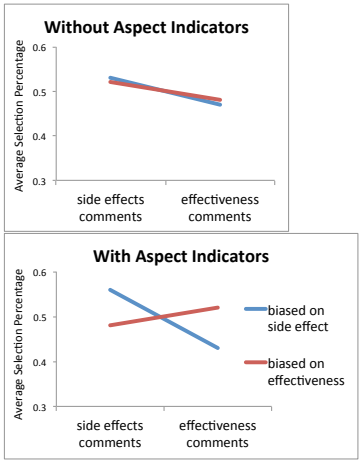

Figure 2. Selection percentages of side effects/effectiveness comments for participants with different biased aspects

The figures show that, the aspect indicators led participants' preferential selection of comments on the aspect where they had biased beliefs. In the control condition where there was no aspect indicator, thus harder to identify the focused aspect of comment (whereas not impossible, given the snippets), they did not discriminate the selection between the two types of comment. To confirm the conclusion, we tested the interactive effect between biased aspect and comment aspect in the condition with or without aspect indicators separately. As expected, we found it to be significant in the conditions with aspect indicators ($\beta=0.16$, $t(32)=3.98$, $p<0.01$), but not in the control conditions ($\beta=0.04$, $t(31)=1.12$, $p=0.26$).

This result suggested that aspect indicators led participants to explore more about the aspect they were concerned about in their pre-existing beliefs. It could also be seen as a validation of our manipulation to introduce biased beliefs in different aspects of the topic, as participants in the two experimental conditions (biased on side effect or effectiveness) responded differently in their information seeking on the two aspects.

Disease Risk on Selection of Comments on Different Aspects

Given that previous research [3] suggests that people tend to put more weight on effectiveness related information for high-risk diseases, but side effects for low-risk diseases, we were interested in testing whether the aspect indicators would facilitate this tendency.

[1] For all the mixed-effect regression analyses in this paper, participant was included as random-effect.

We ran a mixed-effect linear regression on the selection percentage of side effect/effectiveness comments by including comment aspect, disease risk (high/low), and presence of aspect indicators as fixed-effect independent variables. We found a significant three-way interaction among them (*ß=0.21, t(64)=3.93, p<0.01*). In Figure 3, we illustrate this three-way interaction by plotting the average selection percentages of each type of comment.

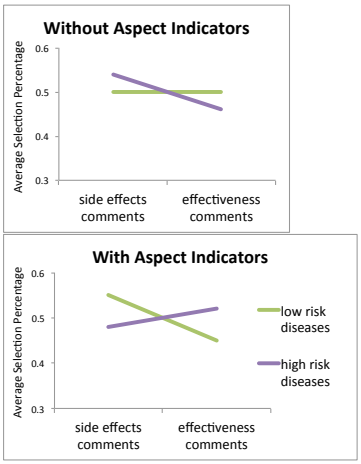

Figure 3. Selection percentages of side effects/effectiveness comments for treating high versus low risk diseases

Figure 3 suggests that, with the assistance of aspect indicators, participants were more interested in seeking effectiveness related information for high-risk diseases, but side effects for low-risk diseases. The conclusion is confirmed by the significant two-way interaction between comment aspect and disease risk found in the conditions with aspect indicators (*ß=0.10, t(32)=2.35, p=0.02*).

The tendency is consistent with what was found in [3], suggesting that effectiveness, rather than side effects, is the *critical aspect* when considering treatment options for high-risk disease; although this tendency tends to be reduced, or even reversed for low-risk diseases.

In short, aspect indicators facilitated participants to seek more effectiveness related comments for treating high-risk diseases, but more side effects related comments for treating low-risk diseases.

Decision Outcome

As discussed earlier, we measured decision outcome in the post-task survey by two 5-point Likert-scale items: "the alternative is better than current treatment", and "I would like to switch to the alternative". We created the *decision index* by averaging the ratings of the two. The value reflects the preference for the alternative over the current option, with larger value indicating higher preference. For quality control reason, we excluded 10% of the results where the ratings to the two questions differed by larger than 2.

We ran a mixed effect linear regression model on the decision index, by including disease risk, biased aspect and presence of aspect indicators as fixed-effect independent variables. We found a significant three-way interaction among all of them (*ß=-1.32, t(64)=-2.06, p=0.04*), and a two-way interaction between disease risk and biased aspect (*ß=0.91, t (64)=2.00, p=0.05*).

The results suggested that whether participants had pre-existing biased belief on effectiveness or side effects had different impact on decision bias for high versus low risk diseases. The presence of aspect indicator, however, seemed to moderate such difference. To further understand the effects, we tested the interactive effect between disease risk and biased aspect separately for the control and experimental conditions. As expected, we found it to be significant when there was no aspect indicators (*ß=-0.94, t(62)=2.12,p=0.03*), but not when aspect indicators were presented (*ß=-0.40, t(65)=-0.86, p=0.40*). To illustrate, we plot the average decision index for in Figure 4.

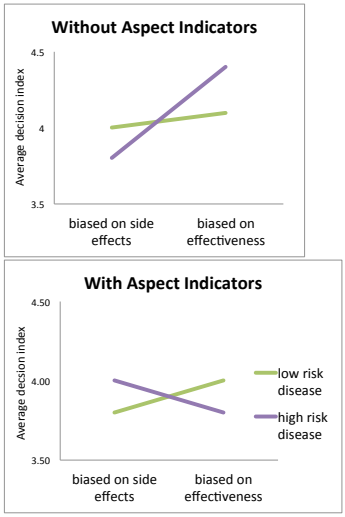

Figure 4. Decision Index for participants with biased beliefs on side effects versus effectiveness

Figure 4 suggests that, in the control conditions, when making decisions for high-risk diseases, participants who had biased beliefs in the effectiveness of treatment options were most likely to make biased decision consistent with pre-existing beliefs after performing information seeking in the system. This tendency, however, was moderated by the presence of aspect indicators, leading to no statistically significant difference among all conditions with different biased aspects and disease risk. We will attempt to uncover the potential causes of such differences in decision outcomes in the next section by examining participants' selective exposure tendency.

Selective Exposure

For the rest of the paper, we are interested in understanding selective exposure, i.e., the preferential selection of attitude consistent over inconsistent information, in the context of online medical information seeking. In particular, we will focus on exploring the potential causes of the difference in decision outcomes we observed in the previous section.

To start with, we coded *attitude consistency* for each comment as an independent variable. Given the introduced bias of "a disfavored current treatment and a potentially better alternative", we coded negative comments on the current and positive on the alternative treatment to be *attitude consistent*. We coded positive comments on the current treatment and negative on the alternative to be *attitude inconsistent*. Therefore, for each task, there are four types of comment: attitude consistent/inconsistent comments on effectiveness or side effects.

To verify that participants' decision outcomes were influenced by their selective exposure, we started by testing the effect of selective exposure on decision outcomes. We calculated *selective exposure index*, by the number of attitude consistent comments minus that of attitude inconsistent comments selected by each participant for each task, and tested its main effect on the decision index. As expected, we found a significant positive effect of selective exposure on the decision outcomes ($\beta=1.06$, $t(66)=4.62$, $p<0.01$), i.e., the preference for the alternative option. It confirmed that participants' biased decisions were associated with selective exposure in their information seeking process.

Given that we have identified the interactive effects of biased aspect, disease risk and presence of aspect indicators on the decision outcomes, we focused on exploring their effects on participants' selective exposure tendency. We first calculated the selection percentage of different types of comment (attitude consistent/inconsistent, on side effects/effectiveness) among all comments selected. We ran a mixed-effect linear regression model on the selection percentage, by including comment attitude consistency, comment aspect, participants' biased aspect, disease risk and presence of aspect indicators as fixed-effect independent variables.

We found a significant three-way interaction among attitude consistency, biased aspect and disease risk ($\beta=0.07$, $t(63)=2.10$, $p=0.04$), and a significant four-way interaction among attitude consistency, comment aspect, presence of aspect indicator and disease risk ($\beta=0.14$, $t(63)=2.22$, $p=0.03$)[2]. In the following section, we will focus on interpreting these interactive effects to unfold how these variables impacted participants' selective exposure.

Effects of Biased Aspect and Disease Risk on Selective Exposure

The three-way interaction among attitude consistency, biased aspect and disease risk suggests that biased aspect affected selective exposure tendency differently for seeking information for high-risk versus low-risk diseases. To illustrate the interaction, we plot the average selection percentages of each type of comment for low-risk and high-risk diseases in Figure 5.

The figures show that, when participants had biased beliefs in the effectiveness of medications treating high-risk diseases, they exhibited significant selective exposure tendency, by seeking more attitude consistent comments than inconsistent ones. They did not show such bias when making decision for treating low-risk diseases, nor when they were only concerned about side effects of medicines treating high-risk diseases. The conclusion is confirmed by the significant interaction between biased aspect and comment consistency for high-risk diseases ($\beta=0.06$, $t(65)=2.28$, $p=0.02$), but not for low-risk diseases ($\beta=-0.01$, $t(65)=-0.50$, $p=0.62$).

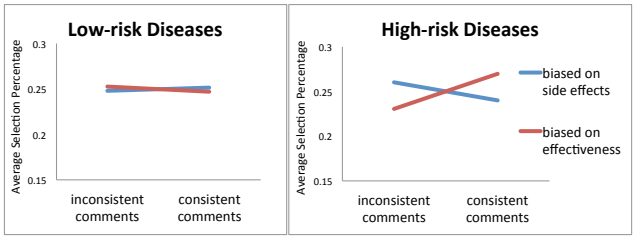

Figure 5. Selection percentages of different comments for participants with biased beliefs on side effects or effectiveness

This result suggests that, information seekers with biased beliefs in the effectiveness of medications treating high-risk diseases are more likely subject to selective exposure. It can be understood from the fact that they may be especially prone to anxiety when seeking information regarding a critical aspect of a potentially irreversible, life-concerning decision. Comparatively, concerns on side effects of a life-saving drug, or treatment choice for a low-risk minor disease, are likely less vital situations and thus may not induce the same level of selective exposure tendency.

The results may shed some light on the finding in previous section that, in the control condition, participants tended to make biased decision when they had biased beliefs in the effectiveness aspect for high-risk diseases- because such bias led to more prominent selective exposure. However, to understand why this decision bias was moderated by the presence of aspect indicator, we may need to examine how they impacted participants' selective exposure tendency on different aspects, which we will discuss in the next section.

In short, the results suggest that information seekers exhibited significant selective exposure tendency when they had biased beliefs in the effectiveness of medications for treating high-risk diseases.

Effects of Disease Risk and Aspect Indicator on Selective Exposure to Information of Different Aspects

The four-way interaction among attitude consistency, comment aspect, presence of aspect indicators and disease risk suggests that the aspect indicators had different impact on participants' selective exposure when seeking information on effectiveness or side effects, and it differed

[2] The three-way interaction among biased aspect, comment aspect and presence of aspect indicator is still significant.

for high versus low risk diseases. To unpack the four-way interaction, we tested the three-way interaction among attitude consistency, comment aspect and presence of aspect indicators for high-risk and low-risk diseases separately.

When seeking information to make treatment decisions for high-risk diseases, we found the above mentioned three-way interaction to be significant (β *=0.12, t(64)=2.51, p=0.01*). We illustrate it in Figure 6 by plotting the average selection percentages of different types of comment.

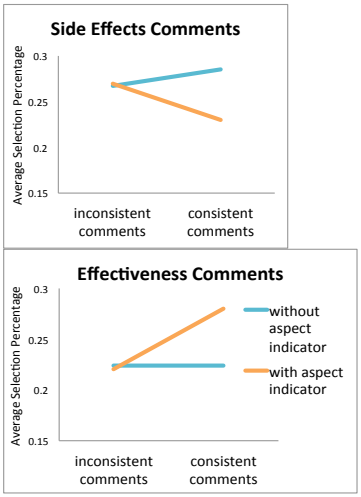

Figure 6. Selection percentage of different types of comment for treating high-risk diseases

The figures suggest that, when seeking information for treatment of high-risk diseases, the presence of aspect indicators increased the preferential selection of attitude consistent comments, i.e., selective exposure tendency, for seeking effectiveness related information, but decreased it for seeking side effects related information. To verify, we tested the interactive effect between presence of aspect indicators and comment consistency for selecting side effects or effectiveness related comments separately. Indeed, we found a significant interaction for selection of effectiveness related comments (β *=0.06, t(65)=2.00, p=0.04*) and a reverse marginal one for side effects (β *=-0.06, t(65)=-1.57, p=0.10*).

We did not find either the similar three-way interaction (β *=-0.02, t(64)=-0.53, p=0.59*), or other significant effects for information seeking tasks regarding low risk diseases, suggesting that the aspect indicators did not significantly impact the selective exposure tendency when participants were only concerned about low-risk diseases.

The above results seem to suggest that, by distinguishing the focused aspect of information, it may increase selective exposure for seeking information related to effectiveness, the *critical aspect*, for treating high-risk diseases, and decrease it for side effect-the *uncritical aspect* in this case.

Now we can revisit the difference that the aspect indicators made on the decision outcomes- the fact that it reduced the decision bias for participants who had biased beliefs on effectiveness of medications treating high-risk diseases. We plot the average selection percentages of different comments in the particular situation (biased on effectiveness, for high-risk diseases) in the control and experimental conditions separately in Figure 7.

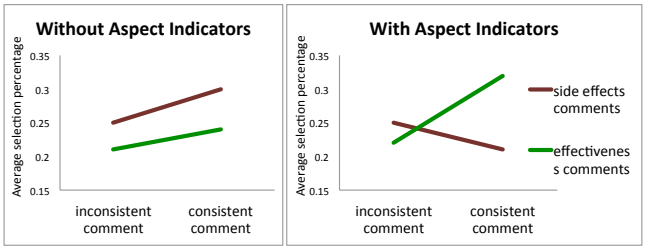

Figure 7. Selection percentage of different comments in the situation of "biased on effectiveness, high-risk diseases"

The figure suggests that, in the control condition where participants could not easily discriminate the focused aspects of comments, they exhibited selective exposure for seeking both effectiveness and side effects related comments, even though they only had biased beliefs in the effectiveness aspect. In the experimental condition, the aspect indicators helped participants to distinguish the two kinds of comment at the selection stage, and hence "nudged" them to only show selective exposure on the effectiveness aspect but not the side effect aspect, which could potentially have caused the moderated decision bias we observed. To verify that selective exposure in seeking side effects related comments was decreased, we tested the interactive effect of attitude consistency and presence of aspect indicators on the selection percentage of side-effects related comments, and found it to be marginally significant (β*= -0.07, t(32)=-2.02, p=0.08*).

This is an encouraging finding by suggesting that, as we have hypothesized, highlighting the focused issue aspect may encourage people to consciously seek information from different perspectives, and potentially alleviate their perceived conflicts on aspect where they do not have strong biases, at least when it is an *uncritical aspect* to the decision. Imagine someone has negative biases on the effectiveness of a treatment, if s/he indiscriminately seeks biased information for both aspects, s/he may conclude that the treatment is both ineffective and causes bad side effects. This could be especially problematic in medical decisions as they often involve trade-offs made between different aspects [13].

However, when we looked at the effect of aspect indicators on moderating selective exposure in seeking information on *unbiased aspect* in another situation- when participants had biased beliefs in side effects of treatments for high-risk diseases- we did not find the same interactive effect between aspect indicators and attitude consistency on

selection of effectiveness related comments ($\beta = 0.02$, $t(31) = 0.42$, $p = 0.68$). It suggests that aspect indicators should still be used with caution. They may not be as effective in reducing selective exposure on *unbiased aspect* if it happens to be the *critical aspect* to the decision, as it could be overridden by the tendency to seek confirmatory information on the critical aspects of decisions.

In short, we found that, for participants who had biased beliefs about the medication in one aspect- the effectiveness-in treating a high-risk disease, the aspect indicators assisted them to differentiate comments on the other aspect- its side effects, where they did not have biased beliefs, and reduced their selective exposure on seeking the latter. By assisting participants to assess different aspects of the decision more accurately, aspect indicators hence helped their decision bias.

CONCLUSION AND DISCUSSION

To summarize, we conducted an experiment to study how aspect indicators- interface features that distinguish between comments on effectiveness and side effects of medicines- influenced users' interaction with a medical-decision support tool that aggregates online drug reviews. Particularly, we were interested in testing whether aspect indicator could assist users with pre-existing biased beliefs in one aspect of the medicine to differentiate information on other aspects where they do not have biased beliefs, and moderate their selective exposure tendency on them. We found that:1) aspect indicators can help users seek information on aspects that they are more concerned about, such as the aspect where they had biased beliefs, and the critical aspect of the decision, e.g., effectiveness of medicines for treating high-risk diseases; 2)in the context of medical decision, people who have biased beliefs in the effectiveness of medicines treating high-risk diseases are more likely subject to selective exposure, which may result in biased decisions. 3) aspect indicators can mitigate the above-mentioned problem, by assisting users to distinguish between information on different aspects, and reduce their selective exposure in aspect that they do not have biased beliefs. The moderation of selective exposure was found to be associated with mitigation of bias in the decision outcomes.

Most importantly, we interpret the results as evidence supporting that interface cues showing focused aspects of information can be a feature that "nudges" users towards diversity-seeking, as it can potentially narrow down information seekers' existing biased beliefs to a subset of issue aspects. Therefore it may reduce their resistance to attitude-inconsistent information on other aspects and encourage them to see the issue from different perspectives.

However, the aspect indicator should still be used with caution, as its effectiveness may be dependent on the criticality of the aspect. In the context of medical decision-making, it seems to be more effective when the unbiased aspect is an uncritical aspect than a critical aspect of the issue for the user. We should point out, however, that more research is needed to test whether this conclusion may be generalizable to other contexts. While we didn't observe its effectiveness in reducing selective exposure in *unbiased aspect* when it is a *critical aspect* (in the situation with biased beliefs in side effects of medicine treating high-risk diseases), the reason could be that it was offset by the tightened anxiety associated with seeking effective treatment for high-risk diseases, and we do not know whether it applies to other contexts, e.g., political debate. Moreover, the selective exposure tendency in this situation, where one is only concerned about side effects of a life-saving drug, seems to be low in general, and that could also lead to the absence of the additional effects of aspect indicators.

With the same goal of highlighting arguments put forward by the opposite side but focusing on non-conflicting aspects, a variation of the ides is to highlight the aspects where a user and an attitude or ideology dissimilar source may agree on. For example, on a political forum, a function that enables users to see "topics you agree on" of another member, could potentially reduce the barriers of interactions between people with different political leaning. Another similar idea is to reconstruct messages that support a different position by aspects, and bring forward the non-contradicting aspects before introducing more challenging ones.

To achieve these goals, a diversity-enhancing or "de-biasing" system should ideally be able to identify on which aspects of a controversial issue the user may have strong biased beliefs. Existing techniques can be applied to solve the problem [1, 14]. Our study also suggests that techniques that partition a topic into aspects and infer the varying weight of aspects for the individual could also be useful for developing fine-grained systems that gradually nudge users to take different perspectives.

Our study also contributes to the literature on biases in online health information seeking. We found that, in anxiety prone situation such as when a user is seeking information for treating high-risk diseases, information seekers tend to seek more confirmatory information. Therefore, de-biasing techniques should be considered when designing medical decision-support systems. Our study also suggests that, while medical decision is a typical multi-attribute decision, information seekers may not explicitly seek to accurately assess all the different attributes. Aspect indicators, or other kind of design features that encourage users to seek diverse information and assess different attributes could facilitate informed decision-making. In a more advanced setting, the varying weights given to different attributes, based on the decision context and/or user profile, should also be taken into consideration.

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