# The role of presentation order and orientation on information search and evaluations: An eye-tracking study

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## Abstract

Previous research conducted by Bergus et al. (2002) identified that treatment evaluations are more negative when risks are presented last. Extending discussion of this order effect, the current studies investigate this effect in tabular style displays, manipulating both order and orientation; and using eye-tracking methodology, explores the effect of these variables on the information search process. Analysis from eye-tracking data revealed a tendency to read information sets sequentially (i.e. read all risk information before transitions to the other set), which is stronger for the vertical orientation where switching between information sets is less common. Further, while balanced search was observed when benefits presented first, when presented with the risks first, search becomes more risk-heavy. Eye-tracking measures did not strongly predict treatment evaluations, although, when holding other variables constant, time proportion spent on benefits positively predicted treatment evaluations.

**Key words: Eye-Tracking; Information Search; Order Effects; Information Design**

## Introduction

Previous research conducted by Bergus et al. (2002) investigated the role of order on judgements and decisions about a treatment. In their study, they investigated the effect that presenting either the risks last (benefits then risks presentation) or benefits last (risks then benefits presentation) had on favourability ratings of a treatment and choice about whether they would consent to a treatment. For their low risk Aspirin scenario, they found that when the last set of information read was about the risks (i.e. those presented with benefits then risks), ratings of favourability decreased (from pre-task favourability) compared to those who learned about the benefits last (i.e. presented with risks then benefits). Those presented with the risks last were also less likely to consent to a treatment.

Further evidence of this type of reliance or influence of the last piece of information processed (potentially because of its prevalence in one's memory) can be seen in a similar study by Ubel et al. (2010; who presented breast cancer patients with information about the benefits and risks of tamoxifen) and in other decision making tasks involving sequential information processing where individuals play an active role in searching out the information for themselves (Rakow, Denes & Newell, 2008; Ashby & Rakow, 2014).

When presented with this type of information in a medical setting or when people search for health information online, this information can often be presented using tabular-style displays (where risk and benefit information is separated into clear columns or rows either using a lined table or bullet point display). One such example, where this type of tabular style information format has been used is on the UK National Health Services (NHS) Choices website, where a fact sheet for prostate cancer screening (PSA) testing, which uses such separated, and bullet pointed display of the risks and benefits, is used (NHS Choices, 2016).

With such tabular displays (or any display allowing people to see the information simultaneously about the risks and benefits), the order in which people read the information is to some extent open to the individual. Research on information and picture search however reveals that people tend to examine information in an order consistent with their reading system, with those in western cultures starting in the top left and showing a bias to the left side of space and horizontal saccades made more frequently than vertical saccades (Foulsham et al., 2013; Foulsham, Kingstone & Underwood, 2008).

These differences in search lead to questions of how these differences may generalize to more specific differences in perceptions of health information. For example, how such a bias to reading the left side (or top) first may indicate that information read in this position is likely to be read first and thus make order important. Or, how, with horizontal saccades being more common than vertical saccades, a choice of orientation (whether blocks are presented side-by-side (i.e. horizontal arrangement) or above-and-below (i.e. vertical arrangement) may impact on search differences across information blocks.

### Current Study

Focusing on these types of tabular displays where information is presented simultaneously, the current research investigates whether such effects replicate across four low-risk (non-invasive) medicinal scenarios and whether orientation interacts with order.

Further, to understand the effect that such design choices of order and orientation have on pre-decisional information search strategies when presented with this information, eye-

tracking methodology was used to investigate information acquisition (search) processes. In particular, measures of looking order, proportion of time spent on the benefits number of transitions between reading the benefits and risks were calculated from the eye-fixation data.

Such measures allow a range of questions to be answered about people's search:

1) Is search consistent with the manipulated order or do people switch between searching between information sets frequently when given the choice?
2) How is search behavior affected by changes to the order and orientation?
3) Does this search behavior map onto subsequent treatment evaluations?

*Predictions:* Three main predictions were made, based on the literature presented above:

- Based on Bergus et al (2002), a recency effect is predicted. Thus, people should be more influenced by the information presented last.
- Despite simultaneous presentation, people will read information according to the manipulated order (i.e. in the order consistent with reading patterns).
- From findings that horizontal saccades occur more frequently than vertical saccades (Foulsham et al., 2008), reduced switching in the vertical orientation is predicted, which may lead to a stronger order manipulation in this orientation.

## Methods

### Participants
One hundred and fifty two students (108 in Study 1; 44 in study 2) from the University of Essex participated for course credit or payment.

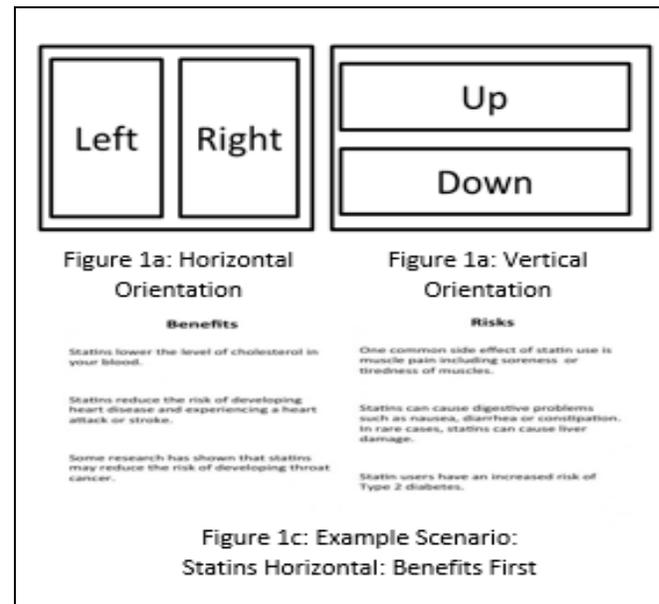### Materials and Procedure

#### Evaluation Task
In both experiments, participants were presented with four hypothetical situations:
- Aspirin therapy treatment for mild carotid stenosis
- Statins for high cholesterol
- ACE (angiotensin converting enzyme) inhibitors for high blood pressure
- Anticoagulant medicine for deep vein thrombosis

Each scenario began with an introductory page, explaining the situation which led to the hypothetical medical diagnosis, the medical diagnosis is (and means) and what one of the recommended treatments is.

Next, participants were presented with three risk and three benefit statements for that treatment scenario (which were closely matched for characters/word length). These were presented in one of four orientation X order presentations, such that either the risk information or benefit information is presented first (either on the left or top) and with either information presented in a vertical (figure 1a: up/down) or horizontal (figure 1b: left/right) orientation.



Figure 1a: Horizontal Orientation

Figure 1a: Vertical Orientation

**Benefits**

Statins lower the level of cholesterol in your blood.

Statins reduce the risk of developing heart disease and experiencing a heart attack or stroke.

Some research has shown that statins may reduce the risk of developing throat cancer.

**Risks**

One common side effect of statin use is muscle pain including soreness or tiredness of muscles.

Statins can cause digestive problems such as nausea, diarrhea or constipation. In rare cases, statins can cause liver damage.

Statin users have an increased risk of Type 2 diabetes.

Figure 1c: Example Scenario: Statins Horizontal: Benefits First

Irrespective of presentation order (orientation) after each risk (benefit) presentation, participants were presented with six treatment evaluation questions (3 positive & 3 negative):

- *P1:* How favourable would you rate the treatment?
- *P2:* Would you choose the treatment?
- *P3:* Would you recommend this treatment?
- *N1:* How concerned would you be about the side effects?
- *N2:* Would you avoid this treatment?
- *N3:* If you were to choose this treatment, how likely do you think it is that you would experience one of its side effects?

For each of these questions, rating responses were made on a 7-point scale. For the analysis, because of a high Cronbach's alphas (α-range .87-.92 in study 1; α-range .85-.92 in study 2), responses from across these six questions (after reverse coding the scores for the three negative questions) were combined for each participant to form an overall treatment evaluation rating.

#### Eye tracking
In Study 2, eye-tracking was conducted during the risk and benefit presentation phase of the study using the EyeLink 1000. The study was conducted within the associated Experiment Builder software application. Interest areas were defined around the six statements (3 risks, 3 benefits) and the two titles (Benefits, Risks).

From the eye-tracking data that was recorded, three main measures were calculated: SMRD order scores, time proportion (on Benefits) and number of transitions, and are explain below:

**SMRD Order:** This was chosen as a way of measuring whether actual looking order is consistent with the "manipulated order" (i.e. that when the risks are presented first according to our design, people look at the risks first). To create our measure of looking order, the formula used by Johnson, Häubl and Keinan (2007) was adapted[1]. While they used it to examine the order of thoughts (which they had people write down), we adapted it to examining looking order by replacing thoughts with fixations in the formula.

To calculate this, the formula below (Figure 2) was used (where MR represent median rank):

$$\frac{2(MR_{Benefit} - MR_{Risk})}{\text{Number of Fixations}}$$

Figure 2: SMRD Order Formula

To allow this calculation of ranks to be conducted, fixations were coded for order. For example, the first fixation coded as "1", the second as "2" and so forth until all fixations included. Taking an example, looking mainly at the risk first lead to a positive SMRD score, and mainly benefits first a negative SMRD score.

**Time Proportion:** Another potentially relevant variable in determining people's subsequent choices is the proportion of time spent looking at the different types of information (i.e. risk and benefits), which helps to represent a measure of attention (i.e. amount of attention paid to each type of information).

Using the interest areas that were preset into the eye-link analysis software, this measure calculated the time spent looking in each interest area. This was then transformed into a proportion of time by dividing the time spent in the interest area by total time spent. From this, the proportion of time spent on the benefits was calculated by summing the proportion of time spent on the four relevant interest areas (i.e. the three benefits and benefit title for time spent on the benefits). Thus, at the end, a percentage score out of 100 was calculated and represented the balance of time spent on the benefits (versus the risks).

**No of Transitions:** This also represented a measure of attention, but this measured how people switched their attention between information sets. This was chosen to investigate the findings from the search literature of a tendency to make horizontal rather than vertical saccades (see introduction and prediction 3 for details).

For our purposes, this measured the number of times people switched between reading the risk information block to reading the benefit information block. A transition was

coded every time two adjacent fixations in the time-ordered fixation sequence were from different information blocks (i.e. one was from the risk block, while the other was from the benefits block).

## Results

### Eye-tracking Information Search Analysis

Each analysis was conducted collapsing the four scenarios[2] and using a generalized estimating equations (GEE) model[3] (with exchangeable correlation matrix, robust standard errors and Gaussian identity matrix).

### Order SMRD Score

As can be seen from the graph in figure 3 (note: scores of 1 denote reading all risks before all benefits, while -1 denotes reading all benefits before all risks), our manipulation of order was successful (B=0.80, Z=24.44, p<.001), with those presented with the risks first (i.e. on top or on the left hand side) reading the risks first (and therefore having a positive SMRD scores) and those shown the benefits first showing a negative SMRD order score.
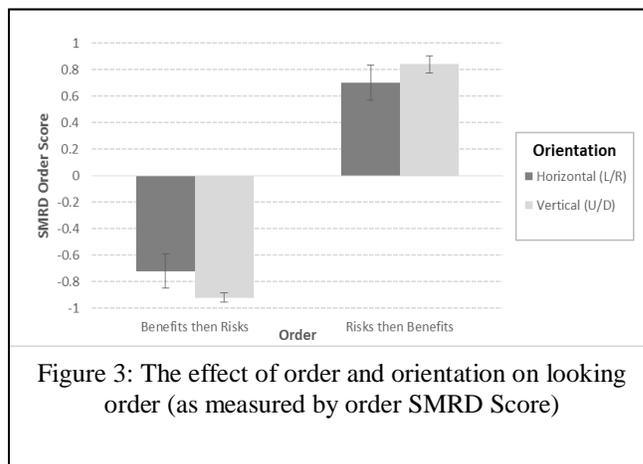


Figure 3: The effect of order and orientation on looking order (as measured by order SMRD Score)

Although no significant main effect of orientation was found, a significant interaction between order and orientation was identified (B=0.08, Z=2.59, p=.009). As this shows, what is happening is that SMRD scores are closer to 0 in the horizontal orientation. As such, supporting our third prediction that the effect of order would be stronger in the vertical orientation (i.e. SMRD scores closer to extremes of +1 and -1).

### Time Proportion Spent on Benefits

As can be seen from the graph in figure 4, only small differences are seen between the different orientations. One

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[1] This formula has been adapted across a range of studies, such as in political psychology research (Hardisty, Johnson & Weber, 2010).

[2] In each analysis 175 responses were analyzed (4 responses for each participant, one for each scenario, apart from one participant whose responses were not recorded for the final scenario due to an eye-tracking malfunction).

[3] GEE model was chosen as it represents a flexible approach to handling correlated data structures. A full discussion of this method can be found in Honish Edwards, Elden & Leonard (2010).

would predict that people would look evenly at the information and, as figure 2 shows, this is the case when the benefits are presented first (Horizontal: t(40)=1.09, p=.283. Vertical: t(46)= -0.79, p=.43)[4]. However when risks are presented first, the time spent on the benefits drops and search becomes risk heavy (Horizontal: t(32)=-5.17 p<.001; Vertical: t(54)= 5.65, p=.001).
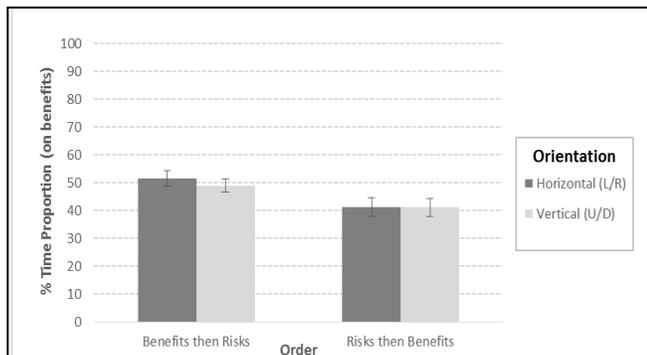


Figure 4: The effect of order and orientation on time proportion spent searching the benefits information

**No of Transitions**

As Figure 5 below demonstrates, while order (whether risks or benefits first) played little role in how many times participants transitioned between risk and benefit information, orientation made a big different to how many time people switched between reading the different information sets (B=-0.85, Z=-4.09, p<.001). When participants were presented with the information side by side (the horizontal orientation), participants were more likely to switch between reading information about the risks and reading information about the benefits. For the vertical orientation (where information was presented above and below), switching occurred less commonly.
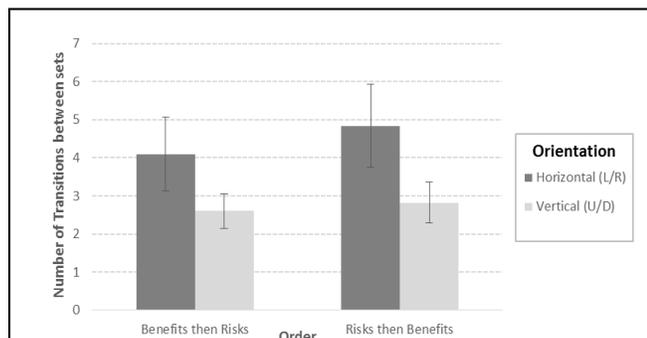


Figure 5: The effect of order and orientation on number of transitions between information sets

**Effect on Overall Treatment Evaluations**

*"Manipulated Order" Analysis:* As figure 3 reveals, people look in the manipulated order (i.e. generally looked

at the benefits before the risks in the benefits then risks conditions), as such it is appropriate to investigate the effect of these different order X orientation conditions on treatment evaluations. Across both experiment 1 and 2, only in 1 of the 8 scenarios did an effect of order reach significance (ACE Study 1, F(1,102)=7.90, p=.006, $\eta^2$=.072) all others F<1.30, p>.275). No main effects of orientation (all F<2.27, p>.135) or interaction between order and orientation (all F<1.96, p>.170) were found.[5] Thus, in most cases, the treatment evaluation ratings across these four conditions were similar, often sitting close to the middle of the scale.

*Eye-tracking Analysis:* Holding all other eye-tracking variables constant (i.e. SMRD order and orientation), time proportion on benefits positively predicted treatment evaluations (B=0.02 Z=2.28, p=.023).

## Discussion

Considering the original study by Bergus et al. (1992), they found a recency order effect with the most recent information having the biggest effect on subsequent perceptions of a treatment. Unlike those researchers, our results did not support such a recency order effect, finding instead no consistent pattern of recency or primacy. The search data discussed later however does hint at a primacy advantage for negative information as a more likely possibility. Three suggestions are made to explain why such a disparity in results may have been found.

First, returning to Bergus et al.'s (2002) aspirin scenario, it is not clear that the list lengths (i.e. lists of risks and benefits) were matched for either word or character length. In particular, the risk list length appeared longer[6]. Such differences may have enhanced any order effects.
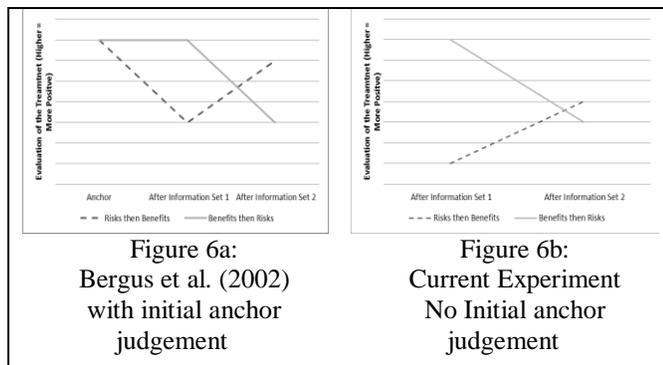
Second, such difficulties in finding consistency in order effects has been discussed by Hogarth and Einhorn (1992). One factor that they highlight of particular relevance for comparing this study to the previous study is the role of evaluation task (or response mode) differences, particularly in short information scenarios. These researchers have argued that differences in the response mode can change the way people evaluate information and what information is used as an anchor. Considering this anchor in particular, while Bergus et al (1992) had an initial evaluation question which provides people with an initial anchor, our study use only an end of sequence response, with no initial anchor specified. With no anchor provided, it is the first piece of information which provides the anchor value. Figure 6a provides an illustration of how these differences in anchor and processing strategy may predict the different pattern of results found in these studies. In particular, as Figure 6

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[4] Analysis conducted via a one-sample t-test with test value of 50.

[5] Degrees of freedom for each study scenario:
*Study 1 df's:* between (1, 101-104)  *Study 2 df's:* (1,39-40)

[6] Indeed, in our study, as the one risk introduced four different side effects, we used information about three of the four of these as our three separate risks.

shows, while a clear recency order effect is seen for Bergus et al. (2002), for our study, by using the first piece of information as an anchor, very little difference between final evaluation scores is predicted.

Figure 6a:
Bergus et al. (2002)
with initial anchor
judgement

Figure 6b:
Current Experiment
No Initial anchor
judgement

Third, in particular, it is worth noting that in keeping our scenarios simple and thereby short, this may have attenuated the size of any potential overall order effects on treatment evaluations. This may have occurred since with such short scenarios, it is not unreasonable to think that people could keep all 6 pieces of information (i.e. 3 risks and 3 benefits) in their memory at once, at least once the items' "gist" meaning had been processed (Miller, 1955; Reyna, 2008). Further, such differences in response mode appear to become less important as the scenario length increases and primacy becomes the predicted order effect irrespective of response mode.

Despite these factors, which may affect people's processing of the information in order to make a decision, the search data responses should be relatively unaffected by the strategy choice variable (which should affect starting position and information integration rather than search). Further, at longer scenario lengths, differences would be predicted to be more pronounced with the effect of the response mode diminished.

Looking at this search data reveals that changes in order and orientation do appear to change how people search the information presented. First, providing support that our external manipulation of order was successful, actual search order (as measured by the order SMRD) mapped onto the manipulated order that the scenario was assigned to. When participants were presented with the benefits "first" (at top or left side), they generally read the benefit information first, therefore having a negative SMRD value. When risks were shown "first", risk information was read first and participants had a positive SMRD value.

Thus, even with simultaneous presentation of information (and therefore no external constraints on order of search), people are still affected by a decision aid designer choice of where to place the information in a table. Rather than switching between reading the risks and benefits, participants generally chose to read each information set sequentially. Such effects suggest that typical reading

patterns (i.e. the tendency to start reading at the top left) in some way constrains how people will read information even when presented simultaneously (Foulsham et al., 2013). Thus, suggesting that use of simultaneous presentation format do not automatically remove presentation order effects from consideration.

Of note within this effect of order, the addition of orientation as a variable in our study highlights a further dimension to consider with this effect. In particular, orientation appears to affect the strength of the search order effect, with a stronger order effect seen in the vertical orientation than the horizontal orientation. Thus, a clearer sequential processing strategy - following the manipulated order (thereby reading all risks then all benefits, or vice versa) - is seen in this vertical orientation. When risks and benefits are presented side-by-side however in the horizontal orientation, this is weakened and switching between information sets (i.e. between risk and benefit information) becomes more common. Such results support our third prediction of a stronger order effect in the vertical orientation, based on previous search evidence by Foulsham et al. (2008) which found that in picture search horizontal movements are more common than vertical movements. Such an effect is further supported in the analysis of transitions between information sets where, switching between sets is significantly higher in the horizontal orientation than the vertical orientation.

Considering our final attention-based search measure taken, time proportion spent reading the benefits, this revealed that while an equal proportion of time is spent (approximately 50%) on the risks and benefits when benefits are presented first, when risks are presented first, the time spent on the benefits drops and search becomes risk heavy (closer to a 60/40 split). This asymmetric difference may suggest that risk information is particularly attention "grabbing" and difficult to engage from, thereby sustaining attention for longer and reducing the time left to spend reading the benefits. Support for such a finding can be seen in the negativity bias literature, where a propensity to attend to, learn from and use negative information more than positive information has been found, Vaish, Grossmann, & Woodward, 2008).

Further, such a finding would predict a primacy advantage for the risk information rather than a recency effect, since the extra attention placed on this information as the negativity literature suggests, should lead people to "learn" and "use" this negative information to a greater extent. Thus, leading to more negative treatment evaluations. Such an effect is supported by analysis of the effect of the eye-tracking variables, where only time-proportion was a significant predictor of treatment evaluations when holding the other variables constant.

**Future Directions**
In future research looking at more complex scenarios, we predict that the search order and orientation differences

would become more pronounced as the amount of information presented is increased and aggregating information in a sequential fashion becomes essential.

Given more complex risk and benefit presentation scenarios, we predict that with such scenarios should lead to a primacy rather than a recency advantage. Such is predicted from our finding of a risky heavy search when risks are presented first (a primacy advantage), evidence that longer scenarios force toward a primacy advantage (Hogarth and Einhorn, 1992) and a reduced role of response mode in these longer scenarios.

For a second type of more complex scenario, multi-attribute (multi-option) choice, the role of orientation on search may be of particular importance. We predict that such orientation changes may change whether a more within-option search or between option-search processing strategy is taken. Such differences in search tend to lead to the adoption of different choice strategies, which may ultimately affect which option is preferred (Hills & Hertwig, 2010).

## Conclusion

These results highlight the role that seemingly arbitrary choices about the design of a decision aid, informational leaflet or website, such as order or orientation of the information can affect how information is searched. In certain situations, these search differences may subsequently affect judgements and choices made using such information as a basis for knowledge about a choice scenario.

## Acknowledgments

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