

**Bachelor thesis 2021**

**From Relevance and Deceit to Understanding and  
Decision Making, what are the effects?**

**A study looking at the effects of Visual Representations and Topic  
Relevance on Understanding and Decision Making.**

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## **Abstract**

This study looked at the effect of Topic Relevance in a high and low condition, and Visual Representations in a controlled and distorted condition, on Understanding and Decision Making. Six hypotheses were created to test for effects. Leading to the main research question: **What are the effects of different Visual Representations and different levels of Topic Relevance on Understanding and Decision Making?**

This study conducted an experiment in the form of a questionnaire available to people living in the Netherlands. The questionnaire asked participants in a fictive setting to make a decision on whether the government should reopen non-essential stores in the Netherlands during the Covid-19 pandemic.

The results showed non-significant effects on all conditions. This study suggested that Topic Relevance is observed by people. Manipulation checks were used to find out if Topic Relevance made a difference to people and this was confirmed with a good Cronbach's Alpha. This study in its questionnaire failed to find significant results on this matter.

## Theoretical framework

“There is magic in graphs. The profile of a curve reveals in a flash a whole situation - the life history of an epidemic, a panic, or an era of prosperity. The curve informs the mind, awakens the imagination, convinces.” A quote from Henry D. Hubbard, creator of the Periodic Table of Elements, as an introduction to a book about graphic representation. This quote describes the visual representations and its purpose which also corresponds with a more scientific explanation where visualizations are external visual representations that are systematically related to the information that they represent (Bertin, 1983; Stenning & Oberlander, 1995). The information represented might be about objects, events, or more abstract information (Hegarty, 2011). Visualizations have many benefits over raw data or textual data. Some of these benefits are that visualizations can deliver data in the most efficient way possible (Analytik, 2020), or the usefulness for data cleaning, exploring data structure, detecting outliers and unusual groups, identifying trends and clusters, and presenting results (Unwin, 2020; Import.io, 2019). The studies show that Hubbard’s quote holds true. This shows the importance of visualizations and the impact they have on reading data.

There is not one almighty visual that is used to represent any type of data. Every type of visualization has its advantages and disadvantages for showing data. Studies have shown that using a different type of visualization for the same data can lead to different results in understanding the data (Spiller et al, 2020; Peebles & Ali, 2009; Pandey et al, 2015). Spiller et al. (2020) conducted a study where 100 participants were shown either a flow chart or a stock chart about the number of jobs during the Bush presidency and the Obama presidency. The participants were asked two sets of questions to determine their basic understanding of the graphs and their judgement about the charts. The results for basic understanding were the same for both stock- and flow chart when jobs were on the increase, but when jobs were on the decrease, differences appeared. The flow chart responses were more accurate in comparison to the stock chart. For judgement the study showed significant effects where the participants evaluated President Obama’s impact on the economy negatively when jobs data were presented as a stock. However, when jobs data were presented as a flow, participants evaluated President Obama’s impact on the economy positively.

Another study looking at the understanding of graphs by Peebles & Ali (2009) showed significant results as well. Peebles & Ali (2009) conducted an experiment with twenty-nine participants between the understanding of a line graph and a bar graph. The results showed that

9 people who were shown the line graph did not understand the line graph in any meaningful way. Every participant for the bar graph however, understood at least something about the graph. This concludes that people understood the bar graph better than the line graph even though the same information was shown.

A different study which uses the same type of graph (i.e. line graph) and shows the same data but with a distorted version and a controlled version also shows different results. Pandey et al. (2015) conducted a study where the purpose was to find out if participants would understand the presented data in the same amount if the visualization was distorted. The four most common type of distortion techniques according to Pandey et al. (2015) are; *Truncated Axis*, where on or more of the axes of a chart are altered by changing the minimum and maximum values presented on the scale. *Area as Quantity*, where quantitative data is encoded by size making a graph look bigger or smaller than it is supposed to look. *Aspect Ratio* primarily affects line-charts as it directly impacts the rate of increase or decrease of one quantity over another or the inclination/declination of the lines that are affected because of the changes in the aspect ratio. Lastly *Inverted Axis*, usually human beings relate directions with trends, such as: upwards – increase, downwards – decrease, right – front/progress, left – back/receding. The inverted axis does exactly this change-up. Results showed that all distortion techniques had a significant effect on the participants' responses and the Aspect Ratio technique had the biggest difference. So there is evidence that a different Visual Representation changes the Understanding of graphs.

The first dependent variable is Understanding, the second dependent variable will be the matter of Making Decisions. Spiller et al. (2020) discussed judgement in their study. Judgement is connected to decision making because interpreting data leads to decision making. In the setting of Spiller et al. (2020), the difference in judging a graph positively or negatively has great influence on decision making because they are opposite judgements. A study done by Nobarany et al. (n.d.) suggested that visualizations could increase the salience of the minority on decision making. The study tried to find an effect in the fact that the minority of a group would be more eager to speak up when visually shown that they are not the minority. This study did not show statistical significance but the study was in agreement in the hypotheses and suggested further studies to be more statistically powerful. Nobarany et al. suggest that visualizations in decision making scenarios can improve human performance. Depending on the situation, being it optimistic or pessimistic estimations or of current or near future situations may motivate users improve how they take advantage of their resources. The

lack of research on the effect of Visual Representation on Decision Making makes it difficult to give statements with credibility.

Visual Representation is not the only variable which has an effect on Understanding and Decision Making, the characteristics of the reader towards the visualization also plays an important role. Peck et al. (2019) wanted to find out if personal relation towards a visualization would affect Decision Making. The study let participants rank ten different visuals based on how useful those visuals were to the participant. The most recurring theme in the Peck et al. (2019) analysis were decisions framed or driven by personal experience. People that were impacted by the topic of the graph, gravitated towards those specific graphs.

This concept of relevance is also supported by Padilla et al. (2018) and their model. Padilla et al. (2018) created a cognitive framework, a dual-processing model. The first type of processing is for fast, easy and computationally light decisions with visualization. The second type allowed for slower, more contemplative, and effortful decisions with visualizations. Looking closely, the mind can either process things fast without much thought, or slow with great thought. This idea can be linked to Topic Relevance in the following manner. If a topic is irrelevant to a person, then the first type of processing will most likely occur (fast and easy processing) because not much thought will be given to the topic. However with a highly relevant topic, the second type of processing will most likely occur (slow and contemplative) because the topic is of high importance to the person. These findings suggest that the Topic Relevance has an effect on Decision making.

The same Padilla et al. (2018) model can be applied to Understanding. When a topic is relevant to a person, the second type of processing will occur, which is slow and with more thought to better wanting to understand the situation. When a topic is irrelevant to a person, it can be argued that not much need for understanding is present and therefore the first type of processing, fast and east, occurs more frequent. No studies have been found which showcase clear results of the effect of Topic Relevance on Understanding.

**Research Question: What are the effects of different Visual Representations and different levels of Topic Relevance on Understanding and Decision Making?**

This research will look at how Visual Representations in a normal (unaltered) version versus a distorted version will have an effect on a person's Understanding of the Visual Representation and also on a person's Decision Making. Furthermore this research will look at

the effect of high and low Topic Relevance of a person on Understanding and Decision Making. This study had six hypotheses.

**H1: Topic Relevance has a positive effect on Decision Making.**

If the topic is more relevant to the participant, then the decision will be taken with more thought as predicted with the dual processing model from Padilla et al. (2018). The participant will not blindly agree to a statement, the participant will think more about it. If the Topic Relevance is high, more participants will want to reopen stores by choosing a higher point on the 7-point Likert scale with the decision than when the Topic Relevance is low.

**H2: Topic Relevance will have a positive effect on Understanding.**

If the Topic Relevance is high, meaning the topic is really relevant for a person, this person will put more effort into understanding the visualization. This will be reflected by the total amount of correct answers a participant gives to the understanding questions in the questionnaire. If the Topic Relevance is low, this means the topic is less relevant for a person and therefore will not put as much effort into understanding the visualization. This will be reflected with the total amount of incorrect answers a participant gives.

**H3: Visual Representation will have a positive effect on Decision Making.**

Participants will want the stores to stay closed more when the distorted visual is shown compared to the control visual. Participants will select a lower point on the 7-point Likert scale to keep the stores closed in the questionnaire because the axis distortion makes the situation look worse for the situation. The control visual will make participants want to reopen the stores and therefore choosing a higher point on the 7-point Likert scale.

**H4: Visual Representation has a negative effect on Understanding.**

Visual distortion will negatively affect the understanding of the graph. Participants will either overestimate or underestimate as concluded in Pandey et al, 2015. Therefore participants will answer incorrectly more often in the questionnaire when they see a distorted version of the graph. The Understanding questions in the controlled version of the graph will be answered more correctly.

**H5: Topic Relevance will increase the Decision Making ratio in both Visual Representations.**

In both Visual Representation scenarios, Topic Relevance will increase the Decision Making scale ratio, making the number higher meaning that participants want the store to reopen in a higher degree. The more relevant the topic is for a participant, the more attention is given to the situation. If the Topic Relevance is high in the controlled graph, participants will want the stores to reopen, because the situation seems good. As hypothesis 3 stated, visual representation will have a different effect on decision making if the topic is highly relevant to a person. For high Topic Relevance in the distorted graph, more participants will want to keep the stores closed.

**H6: Topic Relevance will increase the Understanding in both Visual Representations.**

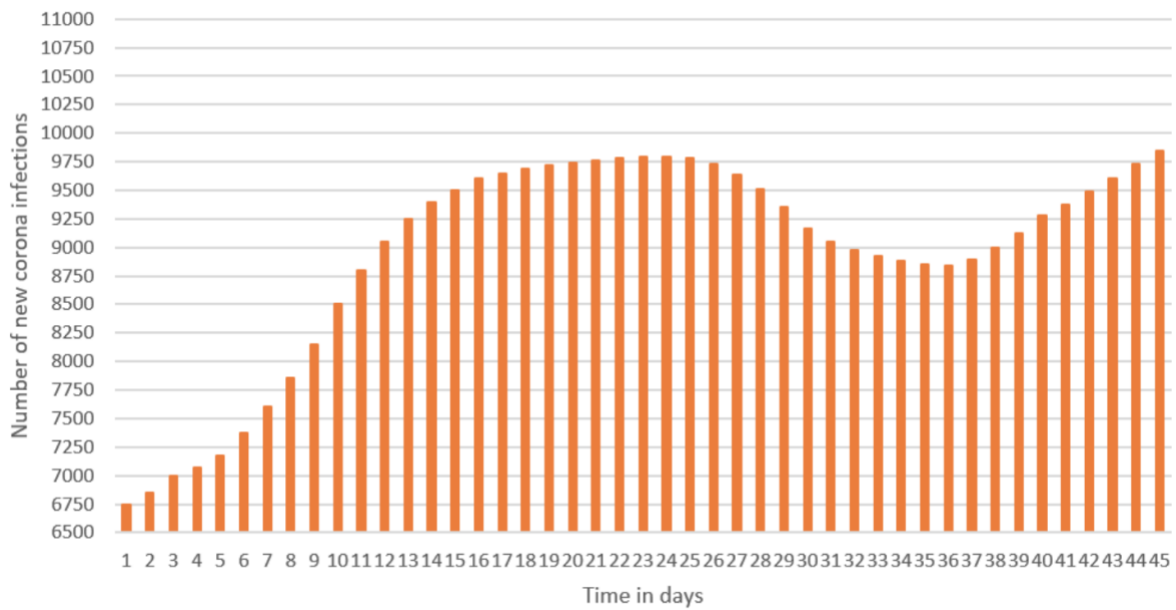
If a topic is more relevant to a person, a person will think more about the subject and enable their more effortful processing capacities. Hypothesis 4 states that the visual distortion will have a negative effect on Understanding by having people wrongly answer the Understanding question more in comparison to the controlled version of the graph. Having a highly relevant topic will increase the total amount of correct answers in Understanding in both Visual Representations.

**Methodology**

*Materials*

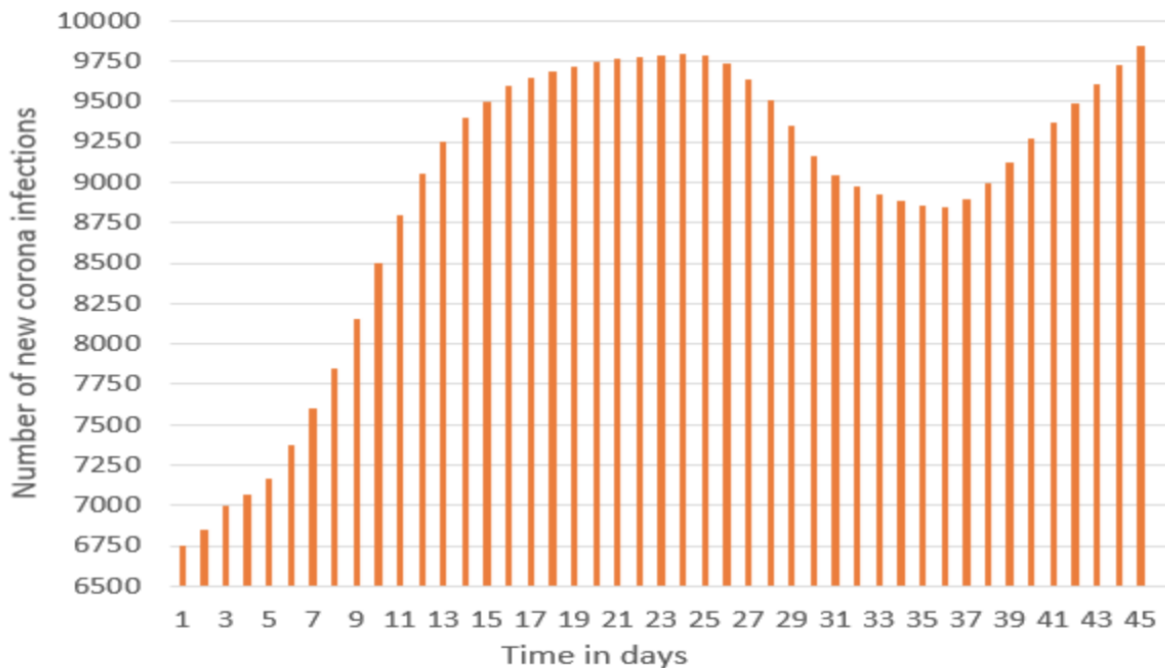
The independent variables for this experimental study are topic relevance and visual representation. The variable topic relevance is divided into two levels, low and high. The two chosen levels are distinct in such a way that a low level of topic relevance is distant from the participant. A high level of topic relevance is extremely relevant to the participant. In the case of high relevance, participants (who live in the Netherlands) have to make a decision about a regulation in the Netherlands which would directly affect them. For the low topic relevance, the same population set (citizens of the Netherlands) is asked to make a decision about a similar regulation but in a far away country, namely Zambia, Africa. This does not directly affect the participant in any matter because Zambia is physically and mentally far away from the Netherlands and will therefore be low in topic relevance. The second independent variable is visual representation. Two different types of visual representations are looked at in the present study. The first type is a stock graph. The stock graph is the control graph where information is shown in a graphic according to standard rules for creating a visual. The data is fictive and shown in an ‘honest’ visual representation, see figure 1.

Figure 1: Controlled (stock graph) Visual Representation



The second type is a distorted stock graph. The distorted version is a graph where the visual is changed in such a way that information is exaggerated, see figure 2.

Figure 2: Distorted (deceptive stock graph) Visual Representation



The questionnaire scenarios will look as follows as shown in table 1.

Table 1

*Questionnaire scenarios for High and Low Topic Relevance*



| High Topic Relevance   | Low Topic Relevance   |
|--|---|
| “The following graph depicts <b>fictional</b> data about the <i>change in growth</i> of new corona infections relative to the day before each day in the Netherlands.” | “The following graph depicts <b>fictional</b> data about the <i>change in growth</i> of new corona infections relative to the day before each day in Zambia.” |

### *Participants*

This research is part of a bigger research which is further explained in Appendix 2. This part of the research had 170 participants (141 (82.9%) Dutch speakers, mean age = 28.05, sd = 12.99). The most frequent education level was Bachelor University (N = 59), 34.7%. Followed by University of Applied Sciences (N = 39), 22.9%. Then thirdly came Master University (N = 32), 18.8%. Fourthly, High school (N= 29), 17.1%. Fifthly, Trade school (N = 9), 5.3% and lastly the least frequent education level was PhD (N = 2), 1.2%). Due to the convenience sampling method, the Netherlands is chosen as the population because all six researchers are situated in the Netherlands and for convenience of finding participants and keeping the independent variable ‘topic relevance’ as accurate as possible; one country is chosen for all participants.

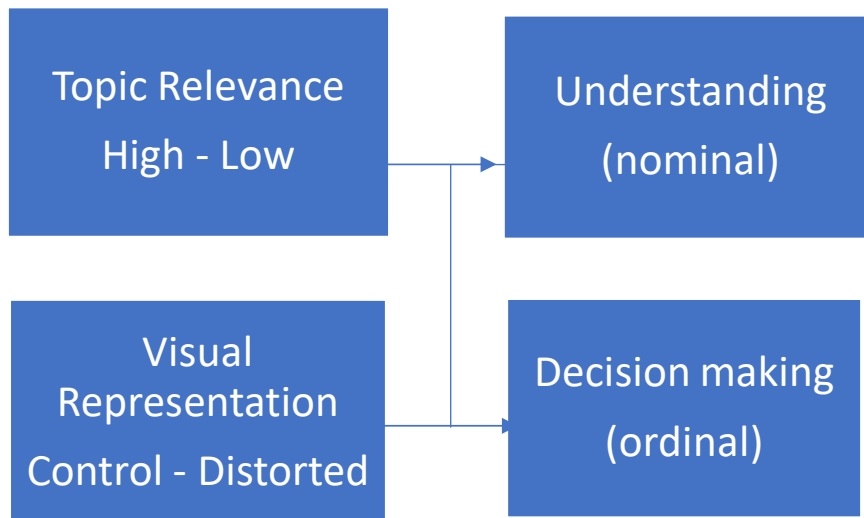
### *Design*

The study is a 2x2 between-subjects design with Topic Relevance and Visual Representation being the independent variables and Understanding and Decision Making being the dependent variables. This results in the 2x2 design as shown in figure 1. Participants are exposed to one level of an independent variable and then answer questions influencing the dependent variables.

Figure 3: Analytical model of present research

**Independent variables**

**Dependent variables**



### *Instruments*

The dependent variables for this study are Understanding and Decision making. Understanding is the variable which finds out whether participants know how to read the graph they are presented with. The study conducted by Pandey et al, used the dependent variable *response accuracy* where a user signals how much graph Y is bigger than X. The answer to this shows the user’s understanding, namely if the user understood both graphs, or the user did not. The current study is a between-between subject design, so participants only saw one graph.

The first dependent variable, decision making, is being measured by using a 7 point-Likert-scale. This shows a participant’s conviction when making a choice. The topic for the questionnaire was the reopening of shops in the Netherlands during the Covid pandemic. The question for Decision Making will look as shown in table 2.

Table 2

#### *Questionnaire question for the dependent variable Decision Making*

| #                 | Question  | Answer  |
|-------------------|---|---|
| <b>Question 4</b> | The authorities of the Netherlands are supposed to make a decision about whether they should reopen the non-essential shops or whether they should prolong the closing of non-essential shops for another 14 days.<br>Based on the graph you are seeing, what would your advice be? | scale of 1 to 7 (1 = definitely stay closed, 7 = definitely reopen) |

The second dependent variable, Understanding, is being measured by asking the participants five questions to see if they are able to understand the graphs that are shown and

are able to deduce the important information from them. For the statistical analysis, the correctly answered questions were added up for each participant to see the total amount of correctly answered Understanding questions. The worst outcome would be zero correct answers, the best outcome would be five correct answers. The questions for Understanding will look as shown in table 3

Table 3

*Questionnaire questions for the dependent variable Understanding*

| #                 | Question  | Answer                      |
|-------------------|---|-----------------------------|
| <b>Question 1</b> | How many new covid cases were registered on <b>day 3</b> ?  | 7000                        |
| <b>Question 2</b> | Look at <b>day 3</b> and <b>day 4</b> . Which day shows the biggest increase in new infections compared to the day before?            | Day 3                       |
| <b>Question 3</b> | Compare the <u>period</u> from day 1 to day 10 to the period from day 11 to day 20. Which period shows a stronger rise in infections? | Period from day 1 to day 10 |
| <b>Question 4</b> | What is the difference in the number of new infections between <b>day 12</b> and <b>day 13</b> ?                                      | 200                         |
| <b>Question 5</b> | On which day did the <u>decrease</u> of covid-19 infections start to <u>slow down</u> ?   | Day 31                      |

There were three manipulation check questions to find out if Topic Relevance mattered to participants. These questions were taken from previous research conducted by Frewer et al. (1996). In the Netherlands condition of the survey the Topic Relevance was aimed towards the Netherlands, and in the Zambia condition of the survey the Topic Relevance was aimed towards Zambia. The manipulation check question was implemented to find out if participants found graphs about the Netherlands more important than graphs about Zambia. This was indeed the case, the reliability of ‘manipulation checks’ comprising three items was acceptable:  $\alpha = .798$ . The three manipulation questions are presented in table 4. Consequently, the mean of all four items was used to calculate the compound variable ‘Manipulation checks’, which was used in the further analyses.

Table 4

### *Manipulation check questions of the questionnaire*

| <b>#</b>          | <b>Question</b>   | <b>Answer</b>   |
|-------------------|---|---|
| <b>Question 1</b> | The graph I saw is very relevant to me personally.  | Scale of 1 to 7 (1 = strongly disagree, 7 = strongly agree) |
| <b>Question 2</b> | The positive COVID-19 tests in (The Netherlands / Zambia) are very relevant to me personally. | Scale of 1 to 7 (1 = strongly disagree, 7 = strongly agree) |
| <b>Question 3</b> | The COVID-19 regulations in (The Netherlands / Zambia) are very relevant to me personally.    | Scale of 1 to 7 (1 = strongly disagree, 7 = strongly agree) |

### *Procedure*

In order to participate in this experiment, participants were asked to open a Qualtrics invitational link to answer the survey either on a computer or a mobile phone. The first step was to ask the participant if they wanted to have the survey in the Dutch language or the English language followed by a consent form where approval was required to continue the survey. Then the requirement for participants to tell where they currently live was asked. Only participants living in the Netherlands were allowed to continue the survey. After these requirements, basic information was collected such as age, gender and current / last completed educational level. Then the survey started with the Decision Making question. The participant was told that the data is fictional accompanied with one graph of three possible conditions (distorted, stock and flow) and one of the two levels of relevance (the Netherlands being high and Zambia being low). After answering the Decision Making question, the participant was shown the next page. The participant is reminded that the graph they are seeing is the exact same graph as in the previous question but now accompanied with five Understanding questions. Next are the three manipulation check questions. This is the end for the usage of this current research but the survey continued with questions about other subjects. Because the info gained from those answers are not used in any way in this research, explaining the procedure is unnecessary. At the end the participant was thanked for their participation and could close the survey.

### *Statistical treatment*

This research presented empirical data and used two, Two-Way ANOVA analysis to try and find an effect of Topic Relevance on Understanding and on Decision making, and an effect of Visual Representation on Understanding and Decision Making. This study will also

find out if there is interaction between Topic Relevance and Visual Representation and that effect on Understanding and Decision Making.

**Ethical checklist**

This research will undergo the ethical checklist review according to Radboud University Nijmegen standards by the latest updated version of 11 January 2021.

## Results

The statistical tests used to test the three hypotheses, hypothesis 1, 3 and 5, investigating Decision Making all showed insignificant results. Table 4 shows the means for either of the graphs (stock or deception) and the according level of Topic Relevance (high or low). The 7 point Likert scale showed that the mean for the Stock graph was 2.17 and the mean for the Deception graph was 2.21. A two-way analysis of variance with Visual Representation (Representation) and level of Topic Relevance (Relevance) as factors showed a non-significant main effect of Visual Representation on Decision Making ( $F(1, 166) = .009, p = .923$ ). The level of Topic Relevance was also not found to have a significant main effect on Decision Making ( $F(1, 166) = .515, p = .474$ ). The interaction effect between Visual Representation and Topic Relevance was not statistically significant ( $F(1, 166) 1.056$ ) as shown in table 5. Figure 2 shows a graph to visualize the insignificance of Topic Relevance on Decision making in this study. The graph has seven points on the Y-axis representing each level of decision participants could choose. The X-axis shows the relevance condition. The line is almost straight, so this supports the statistical test. Figure 3 has the same approach to reading the graph but the X-axis changes to visual representation.

Table 5

Means and standard deviations for Decision Making in High and Low Topic Relevance with two types of Visual Representations (1 = definitely stay closed, 7 = definitely reopen)

| <b>Relevance</b> | <b>Representation</b> | <b>M</b> | <b>SD</b> | <b>N</b> |
|------------------|-----------------------|----------|-----------|----------|
| High             | Stock graph           | 2.40     | 1.676     | 40       |
|                  | Deception graph       | 2.17     | 1.678     | 40       |
|                  | Total                 | 2.29     | 1.670     | 80       |
| Low              | Stock graph           | 1.98     | 1.468     | 46       |
|                  | Deception graph       | 2.25     | 1.480     | 44       |
|                  | Total                 | 2.11     | 1.472     | 90       |
| Total            | Stock graph           | 2.17     | 1.573     | 86       |
|                  | Deception graph       | 2.21     | 1.568     | 84       |
|                  | Total                 | 2.19     | 1.566     | 170      |

Figure 4: Visual result of the effect of Topic Relevance on Decision Making

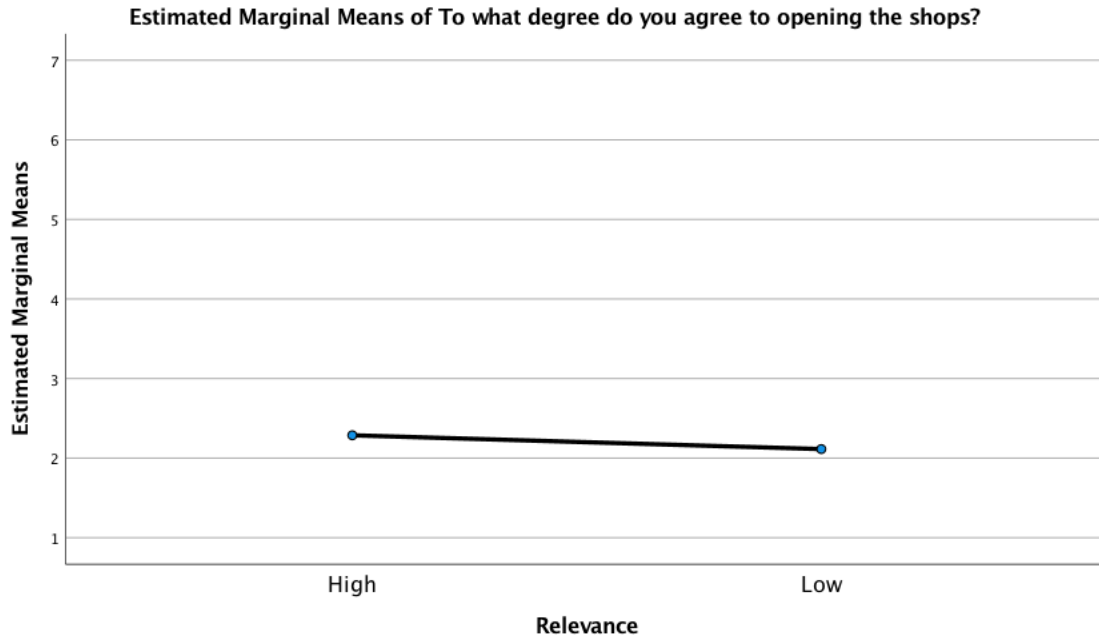
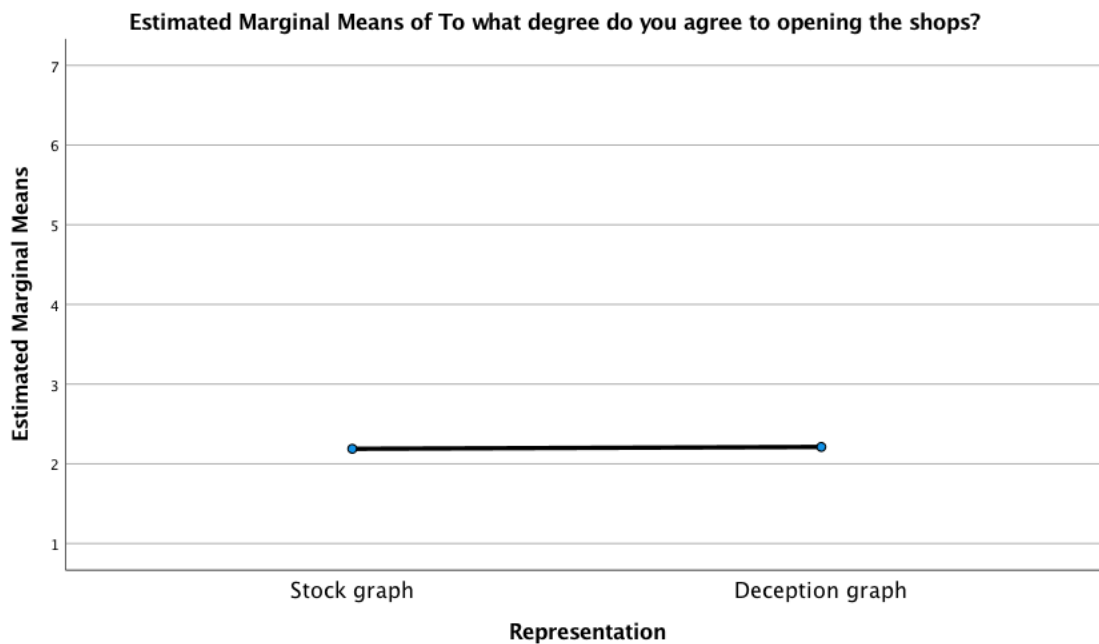


Figure 5: Visual result of the effect of Visual Representation on Decision Making



The statistical tests for the three remaining hypotheses, hypothesis 2, 4 and 6, investigating Understanding also showed insignificant results. Table 6 shows the means for either of the graphs (Stock and Deception) and the according level of Topic Relevance (High or Low). The Understanding score was evaluated by adding up the correctly answered survey question. A total of five Understanding question were asked, so a score of 5 would be perfect. The mean Understanding score for the Stock graph was 4.15 and the mean for the Deception graph was

4.10. A two-way analysis of variance with Visual Representation (Representation) and Level of Topic Relevance (Relevance) as factors shows a non-significant main effect of Visual Representation on Understanding ( $F(1, 166) = .151, p = .698$ ). The level of Topic Relevance was also not found to have a significant main effect on Understanding ( $F(1, 166) = .202, p = .654$ ). The interaction effect between Visual Representation and Topic Relevance was not statistically significant ( $F(1, 166) < 1$ ) as is shown in table 6. Figure 4 shows a graph to visualize the insignificance of Topic Relevance on Understanding in this study. The graph has five points on the Y-axis representing each level of understanding question answered correctly by participants. The X-axis shows the relevance condition. The line is almost straight, so this supports the statistical test. Figure 5 has the same approach to reading the graph but the X-axis changes to visual representation.

Table 6

Means and standard deviations for the Understanding of Visual Representations and Topic Relevance (5 questions true or false)

| <b>Relevance</b> | <b>Representation</b> | <b>M</b> | <b>SD</b> | <b>N</b> |
|------------------|-----------------------|----------|-----------|----------|
| High             | Stock graph           | 4.15     | 1.03      | 40       |
|                  | Deception graph       | 4.03     | .95       | 40       |
|                  | Total                 | 4.09     | .98       | 80       |
| Low              | Stock graph           | 4.15     | .97       | 46       |
|                  | Deception graph       | 4.16     | 1.01      | 44       |
|                  | Total                 | 4.16     | .98       | 90       |
| Total            | Stock graph           | 4.15     | .99       | 86       |
|                  | Deception graph       | 4.10     | .98       | 84       |
|                  | Total                 | 4.12     | .98       | 170      |

Figure 6: Visual result of the effect of Topic Relevance on Understanding



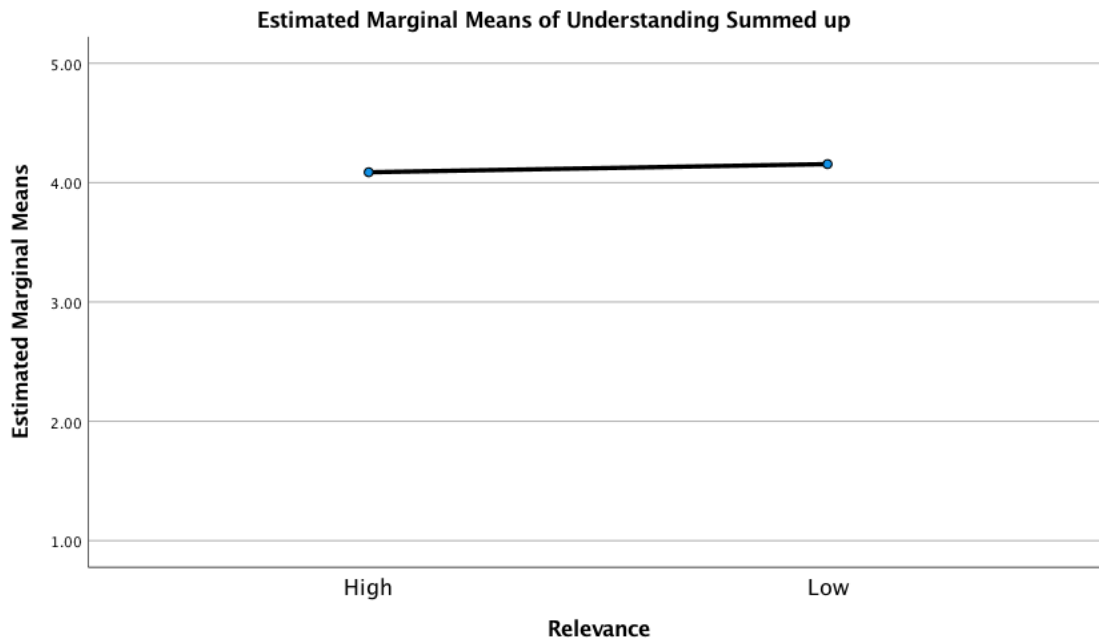
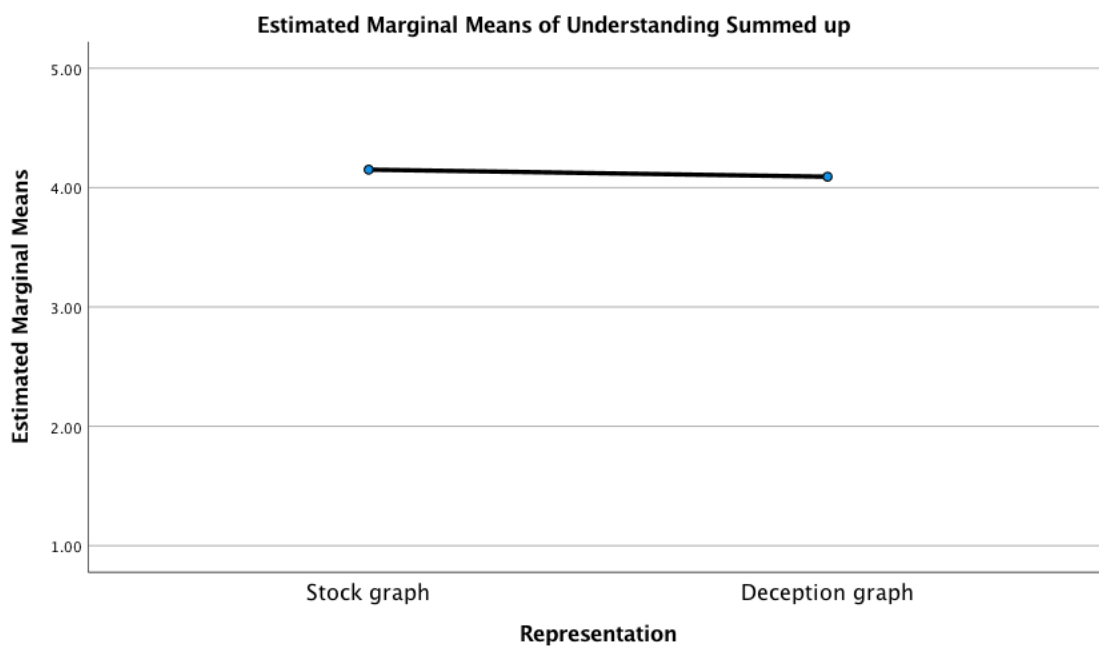


Figure 7: Visual result of the effect of Visual Representation on Understanding



Although the statistical tests show insignificant results for the difference in High and Low Topic Relevance, the manipulation check does seem to imply that participants show a difference in High and Low Topic Relevance. The manipulation check shows a good Cronbach's Alpha so the Topic Relevance difference is clear to participants.

## Discussion

The main goal of this study was to investigate what the effects were of different Visual Representations on Understanding and Decision Making and different levels of Topic Relevance on Understanding and Decision Making. The study also tried to find out if Topic Relevance would increase the Decision Making ratio in different Visual Representations and if Topic Relevance would increase Understanding in both Visual Representations.

The results showed insignificant effects for the effects of different Visual Representations and different levels of Topic Relevance on Understanding and Decision Making. The results also showed that Topic Relevance could not increase the ratio of Decision Making or the increase in Understanding.

A focus of this study was the deceptive version of the graph which was based on the research of Pandey et al, 2015 which showed significant results. The distortion technique of the deceptive graph in this study was taken from Pandey et al, 2015. Pandey et al, 2015 made use of the *Aspect Ratio* distortion which primarily affects line-charts. In this study however, the Aspect Ratio distortion was used for a stock graph. This study limited the aspect ratio to the x-axis. If the y-axis was changed, the distortion look more extreme in such a way that the bars in the graph looked to increase faster and decrease faster. This could change the Decision Making ratio for the Deception Graph in the study.

Another reason why this study did not show significant results for the Understanding variable is because the average correctly answered questions was high. The Understanding questions were answered correctly with a high average in all conditions (an average of at least 4.09 out the 5 questions were answered correctly). There was an error in the fifth Understanding question for the English version in the Deceptive condition. The information that was left out was that participants did not see that they should look after day 45 in the graph. The question states that participants should look beyond the graph, this could have lead to misunderstandings in answering the question because participants did not know where to look. A statistical test however shows that there was no significant difference ( $p = 0.671$ ) between the Dutch and English version of the fifth Understanding question in the Deceptive condition. This suggests that the Understanding questions were answered correctly too often and therefore making it difficult to show significant differences.

While this study did not show any significant results, the study did show acceptable manipulation checks about Topic Relevance. This suggests that people think differently for topics which are more relevant to themselves. The manipulation check worked, but the survey questions did not show differences in Topic Relevance. This study hypothesized that decision making in relevant situation would take more thought and consideration in comparison to situation which are not or less relevant to us. Perhaps if a study is conducted with an even more clearer distinction in Topic Relevance, there will be significant results.

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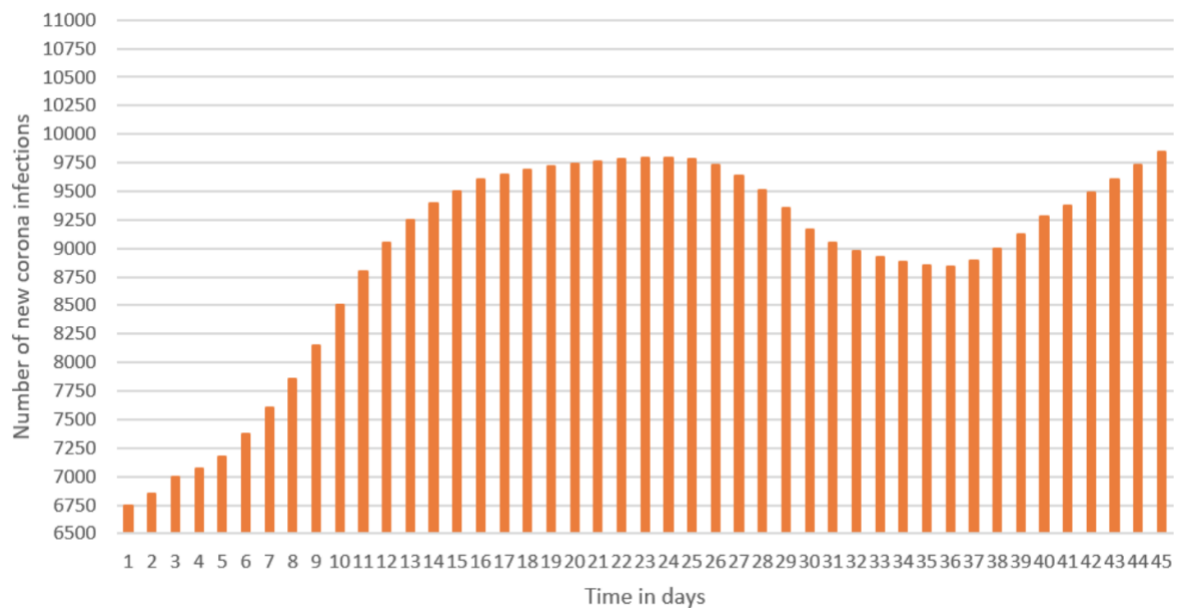
Zürcher et al. BMC Medical Ethics (2019) 20:31 <https://doi.org/10.1186/s12910-019-0371-0>

## Appendix 1

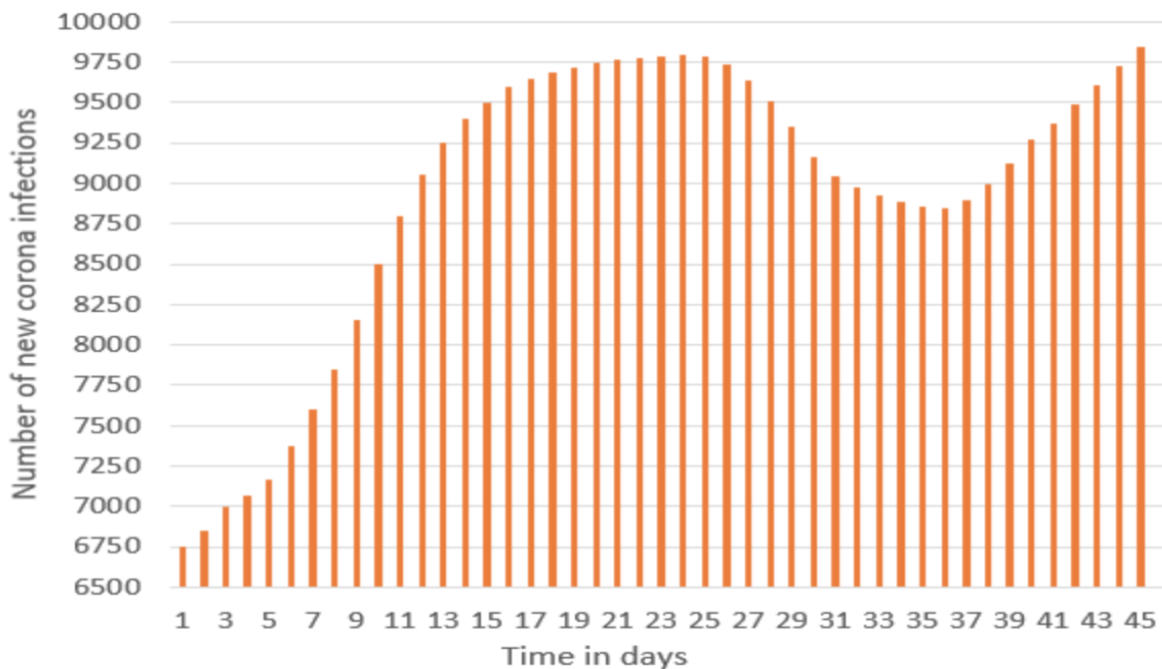
Graph visualizations used for the questionnaire.

Figure 1 shows the controlled version of the questionnaire setup, whereas figure 2 shows the distorted version of the questionnaire setup. The identical graphs were used both for The Netherlands and Zambia. Both graphs were available in languages English and Dutch depending which language the participant selected.

**Figure 1: Visual Representation Controlled**



**Figure 2: Visual Representation Distorted**



## **Appendix 2**

### Full data set information

The current research was part of a larger experiment. The original experiment was a 3x2 design with three visual representations being the Distorted graph, the Stock graph and the Flow graph. A total of 261 participants (211 in the Dutch language 80.8%, mean age = 26.98, SD = 12.17). The educational level with the highest frequency was Bachelor university (N = 94), 36% followed by University of Applied sciences (N = 57), 21.8%. Thirdly is High school (N = 40), 14.9%. Fourthly is Master University (N = 39), 14.9%. The last two educational levels, Trade school(N = 14), 5.4% and PhD (N = 3) 11%.

### Appendix 3

Statement of own work

Sign this Statement of own work form and add it as the last appendix in the final version of the Bachelor's thesis that is submitted as to the first supervisor.

Student name: Tom Lüer

Student number: 1063722

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- b. I also declare that I have only submitted text written in my own words
- c. I certify that this thesis is my own work and that I have acknowledged all material and sources used in its preparation, whether they be books, articles, reports, lecture notes, and any other kind of document, electronic or personal communication.

Signature: \_\_\_\_\_

A handwritten signature in black ink that reads "Lüer". The signature is written in a cursive style with a large, sweeping initial 'L'.

Place and date: Venlo, 7<sup>th</sup> of June 2021