Structure and Empathy in Visual Data Storytelling: Evaluating their Influence on Attitude

Supplemental Material

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1 Qualtrics Questionnaire

1.1 Informed Consent

Storytelling in Visualisation
Informed Consent Form

Introduction
This study attempts to collect information about the use of storytelling in data visualisation. The survey is part of a doctoral research project at City, University of London (see contact at the bottom).

Procedures
This survey will take **20 minutes or less** and includes the following tasks:

1. Read through brief instructions and adjust your browser (we provide some help).
2. Answer questions about your personal characteristics.
3. Engage with an interactive visualisation.
4. Answer a second set of questions about the visualisation.
5. **Receive a completion code for prolific.**

Risks/Discomforts
There are no known risks for involvement in this study.

Benefits
Except for the financial compensation, there are no direct benefits for participating. However, it is hoped that through your participation, researchers will learn more about storytelling in data visualisation.

Confidentiality
All data obtained through your participation will only be stored and reported in an anonymised format.

Participation
Participation in this research study is **completely voluntary** and does not require any prior knowledge of the research topic. You have the right to **withdraw at any time**. If you desire to withdraw, please close your internet browser.

Compensation
When you successfully finish the survey you will be **financially compensated with £2.50** via prolific. Please be aware that you can only participate and be paid once.

Contact and Questions about the Research
If you have any questions regarding this study, you may contact the PhD research student Johannes Liem at johannes.liem@city.ac.uk (Supervisors: Professor Jo Wood, j.d.wood@city.ac.uk, Dr. Charles Perin, charles.perin@city.ac.uk).

Who has reviewed the study?
This study has been approved by the Computer Science Research Ethics Committee from City, University of London (ID: CSREC171212JL).

Consent
I have read and understood the above information. It is the desire of my own free will to participate in this study.

- Yes, I give consent and want to start the survey.
- No, I do not want to participate in the survey.

1.2 Instructions

Thank you for taking the survey.

Please complete the following tasks, which will take you 20 minutes or less:

1. Answer a few questions about your personal characteristics, for example, your age and gender.
2. Engage actively with an interactive map visualisation for several minutes.
3. Answer a set of detailed questions demonstrating that you understood and remembered what you have seen and learned while interacting with the visualisation.

Please maximise the browser window or switch to full-screen mode. Use the zoom function of your browser to enlarge or shrink the red, dashed frame. Adjust it so you can see the entire red frame on your screen. [Keyboard shortcuts: Cmd/Ctrl and +/-]

Please try to stay focused and in front of your computer during the survey. Please do not switch tabs or browser windows.

Click "Start the Survey" button when you are ready.

1.3 Demographic Questions

Please answer the following questions.

With which gender do you identify yourself?

- Male
- Female
- Prefer not to say

How old are you?

- 18 – 24
- 25 – 34
- 35 – 44
- 45 – 54
- 55 – 64
- 65 or older
- Prefer not to say

What is your highest level of education (if you education was outside the UK, pick the appropriate equivalent)?

- GCSE Level education (e.g., GCSE, O-Levels or Standards)
- A-Level education (e.g., A, AS, S-Levels, Highers)
- Degree or Graduate education (e.g., BSc, BA)
- Post-graduate education (e.g., PhD, MSc, MA)
- Vocational education (e.g., NVQ, HNC, HND)
- Non of the above
- Prefer not to say

How would you rate your religious belief on the following scale?

- *11 point scale:* not at all religious — very religious
- Prefer not to say

Can you live on the combined household income obtaining at present?

- Living comfortably on present income

- Coping on present income
- Finding it difficult on present income
- Finding it very difficult on present income
- Prefer not to say

Where would you place yourself on a political spectrum using the following scale?
- *11 point scale:* left — right
- Prefer not to say

1.4 Pre-Test: Immigration Attitudes *Experiment 1 Only*

Each question was displayed on a separate page.

In the next seven questions we ask you about people from other countries who come to live in the UK.

To what extent do you think the UK should allow people of the **same race or ethnic group** as most of the UK's people to come and live here?
UK's policy should be to ...
- Allow many to come and live here
- Allow some
- Allow a few
- Allow none
- Prefer not to say

The following questions have the same answer options as the question above.
- How about people of a **different race or ethnic group** from most people in the UK?
- How about people from the **poorer countries in Europe?**
- How about people from the **poorer countries outside Europe?**

Would you say it is generally bad or good for the UK's economy that people come to live here from other countries?
- *11 point scale:* Bad for the economy — Good for the economy
- Prefer not to say

Would you say that the UK's cultural life is generally undermined or enriched by people coming to live here from other countries?
- *11 point scale:* Cultural life undermined — Cultural life enriched
- Prefer not to say

Is the UK made a worse or a better place to live by people coming to live here from other countries?
- *11 point scale:* Worse place to live — Better place to live
- Prefer not to say

1.5 Stimulus Briefing

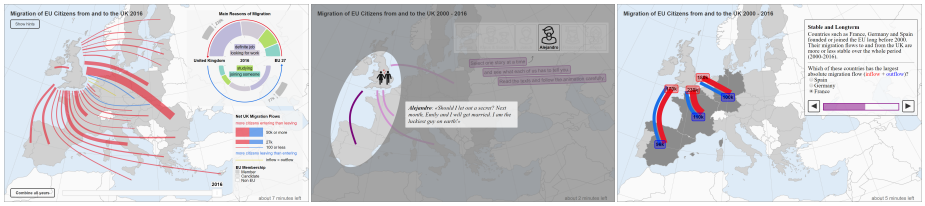
The next screen will show a visualisation of some data. You will have a few minutes to interact with it, after which a number of questions will be asked.

In the bottom right corner, you will see how much time you have.

Click Next when you are ready to continue.

1.6 Stimulus

Participants were randomly but equally allocated across the three conditions.
Find the interactive visualizations at: `https://flowstory.github.io/attitudes/`



Interactive flow map (non-narrative visualization) | Personal visual story designed to generate empathy | Structured visual narrative of aggregates of people

Figure 1: Three experimental conditions: exploratory (left), empathy (center), structure (right).

Below the visual stimulus we placed a reminder:
Remember: We will ask you to answer a set of detailed questions demonstrating that you understood and remembered what you have seen and learned while interacting with the visualisation. Use the available time to engage with the map.

1.7 Filter Questions

Please answer the following question: What colour was used in the visualisation to show migration inflow to the UK?

- green
- red
- yellow
- blue
- purple

Please answer the following question: From which EU country did the most people move to the UK between 2000 and 2016?

- Austria
- Bulgaria
- France
- Poland
- Denmark

Please answer the following question: What was the main reason for people from the EU to come to live in the UK?

- work
- study
- the health system
- retire
- join someone

1.8 Questionnaire Briefing

In the final section, we ask you to answer 28 questions. Please select the appropriate answer.

You always have the option to select "Prefer not to say". Please try to provide an answer and only use the option if you feel uncomfortable answering the question. Remember: all information you provide is anonymous.

Click Next when you are ready to continue.

1.9 Human Values Questions

Depending on the answer to the question of gender, the person descriptions were adapted to the corresponding gender. The following statement describes a person.

Thinking up new ideas and being creative is important to her. She likes to do things in her own original way.

Select how much the person is or is not like you.

- Very much like me
- Like me
- Somewhat like me
- A little like me
- Not like me
- Not like me at all
- Prefer not to say

The following questions had the same answer options as the question above.

- It is important to her to be rich. She wants to have a lot of money and expensive things.
- She thinks it is important that every person in the world should be treated equally. She believes everyone should have equal opportunities in life.
- It's important to her to show her abilities. She wants people to admire what she does.
- It is important to her to live in secure surroundings. She avoids anything that might endanger her safety.
- She likes surprises and is always looking for new things to do. She thinks it is important to do lots of different things in life.
- She believes that people should do what they're told. She thinks people should follow rules at all times, even when no-one is watching.
- It is important to her to listen to people who are different from her. Even when she disagrees with them, she still wants to understand them.
- It is important to her to be humble and modest. She tries not to draw attention to herself.
- Having a good time is important to her. She likes to "spoil" herself.
- It is important to her to make her own decisions about what she does. She likes to be free and not depend on others.
- It's very important to her to help the people around her. She wants to care for their well-being.
- Being very successful is important to her. She hopes people will recognise her achievements.
- It is important to her that the government ensures her safety against all threats. She wants the state to be strong so it can defend its citizens.
- She looks for adventures and likes to take risks. She wants to have an exciting life.

- It is important to her always to behave properly. She wants to avoid doing anything people would say is wrong.
- It is important to her to get respect from others. She wants people to do what she says.
- It is important to her to be loyal to her friends. She wants to devote herself to people close to her.
- She strongly believes that people should care for nature. Looking after the environment is important to her.
- Tradition is important to her. She tries to follow the customs handed down by her religion or her family.
- She seeks every chance she can to have fun. It is important to her to do things that give her pleasure.

1.10 Post-Test: Immigration Attitudes

In the remaining seven questions we ask you about people from other countries who come to live in the UK.
See the Section "Pre-Test: Immigration Attitudes".

1.11 Feedback and Survey End

Thank you for taking the time to do our survey!

Maybe you have the feeling that all these questions you just answered didn't really address the visualisation you engaged in.

You are right! The goal of the experiment is to see if different types of visualisations – you only saw one out of three – influence the outcome of all these questions you answered. To avoid priming your thoughts we didn't mention much of this at the beginning of the survey. But it is just fair to inform you about this now.

If you are interested in the research results, please note down flowstory.digitalcartography.org (Expect results in fall of 2018).

Thank you again for your valuable contribution, and feel free to leave any comments or thoughts you have:

Text box provided here.

2 Filtering

Before running any analysis, we discarded participants for the reasons described in Table 1.

Table 1: Filter descriptions and rationales for excluding participants.

Filter	Experiment 1	Experiment 2
Filter questions		
Participants who failed to answer all three filter questions correctly. We believed these participants would not have engaged with the stimulus.	2	3
Timing		
Participants who answered more than seven questions about human values in less than two seconds each.	5	4
Participants who answered more than two questions about immigration in less than two seconds each.	pre: 0 / post: 15	2
Participants who answered all 21 human value questions in less than a minute overall ($21 questions \times 3 seconds = 63 seconds$).	4	4
Participants who answered all 7 immigration questions in less than 21 seconds overall ($7 questions \times 3 seconds = 21 seconds$).	pre: 0 / post: 14	5
Based on the pilot study and our own assessment, we determined that it is not possible to respond carefully to these questions in less than three seconds on average.		
Contradiction and 'prefer not to say'		
Participants who selected the same category for more than 16 questions of the human values. This would imply the participant provided contradictory answers.	2	1
Participants who selected 'prefer not to say' to more than five of the human values questions.	1	0
Participants who selected 'prefer not to say' to more than two of the four opposition to immigration questions.	pre: 4 / post: 2	3
Participants who selected that option to more than one of the three perceived immigration threat questions.	pre: 0 / post: 1	1
Averaging too few responses could distort the results. The thresholds we used are those recommended by the ESS.		
Number of occasions filters applied	50	23
Participants discarded by more than one rule	19	5
Overall filtered participants	**31**	**18**
Numbers of recruited participants	304	300
Numbers of selected participants for condition ...	**273**	**282**
... Empathy	91	91
... Structure	92	97
... Exploration	90	94

3 Results: Demographics

We visualize the results of the demographic questionnaire as additional material, to allow readers to get a better impression of the participants. Overall, the differences across conditions for each experiment are small. We provide the R scripts for processing and plotting the results on the GitHub repository `https://flowstory.github.io/attitudes/`. The Likert plots were created with [1].

3.1 Gender

In both experiments and across all three conditions the male to female ratio is around 4:6, which is similar to the ESS data.

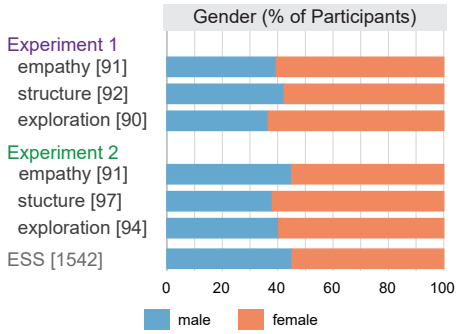


Figure 2: Distribution of "Gender" across experiments and conditions.

3.2 Age

The age distribution is comparable across conditions and experiments. In experiment 1 participants of the exploration group are slightly older in average. In experiment 2 participants of the empathy group are younger in average. Compared to the ESS data, our participants are in average more then 10 years younger.

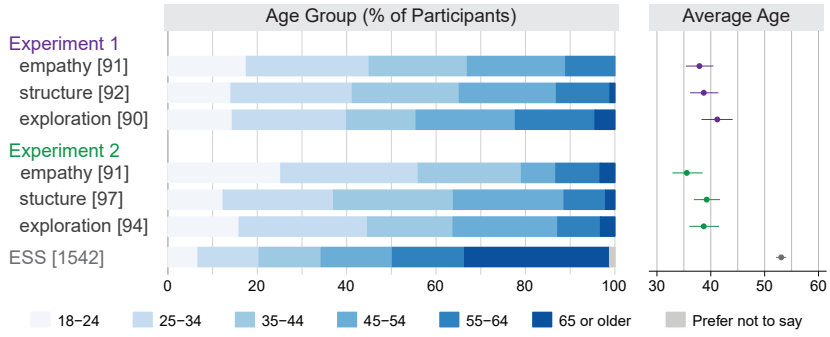


Figure 3: Left: Distribution of "Age Groups" across experiments and conditions. Right: Average age in years with 95% BCa confidence intervals (CIs).

3.3 Education

Compared to the ESS data, the participants of both experiments have a higher level of education in average, but are very similar across conditions for each experiment.

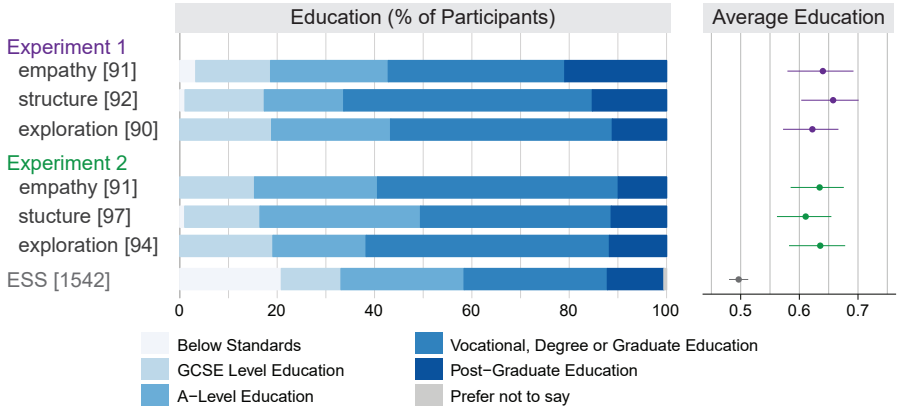


Figure 4: Left: Distribution of levels of "Education" across experiments and conditions. Right: Normalized [0..1], average education with 95% CIs.

3.4 Income

The majority of participants can cope or live comfortably on their current household income. More participants of the ESS tend to live comfortably on their present income than the participants of our experiments.

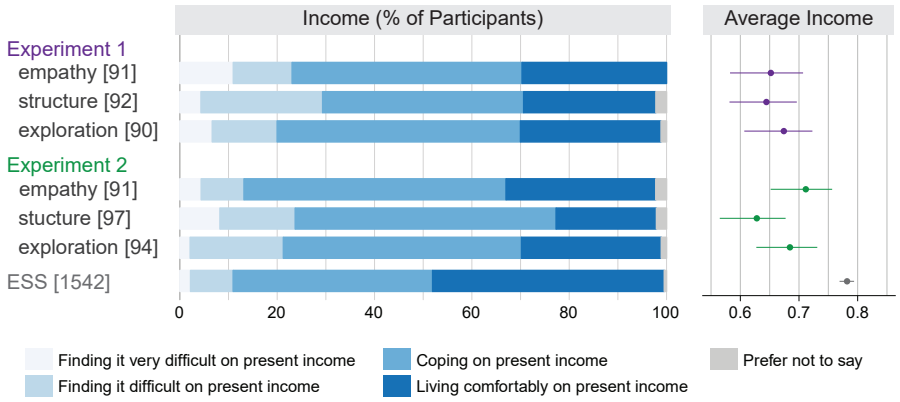


Figure 5: Left: Distribution of how participants can live on their current household "Income" across experiments and conditions. Right: Normalized [0..1], average income with 95% CIs.

3.5 Religion

Overall participants of both experiments are not very religious. In experiment 2 participants of the structure conditions are more religious than participants of the other conditions (mean difference of around 15%).

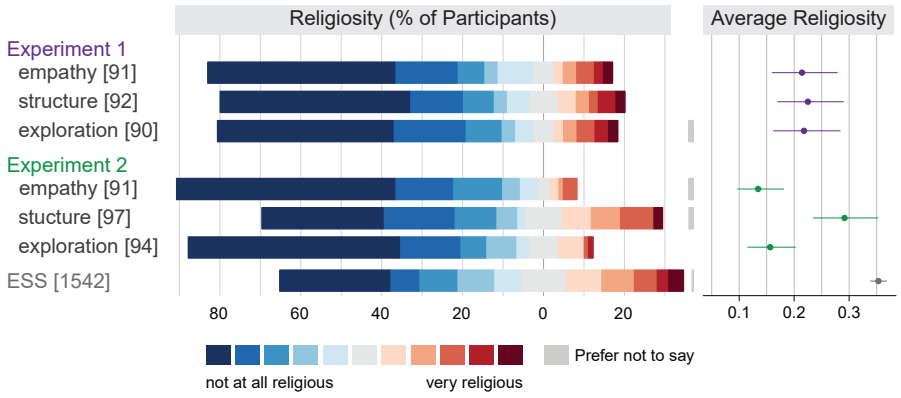


Figure 6: Left: Distribution of the degree of "Religiosity" across experiments and conditions. Right: Normalized [0..1], average religiosity with 95% CIs.

3.6 Politics

In average participants placed themselves on the center-left side of the political spectrum. Participants of the exploration condition of experiment 2 are slightly more left.

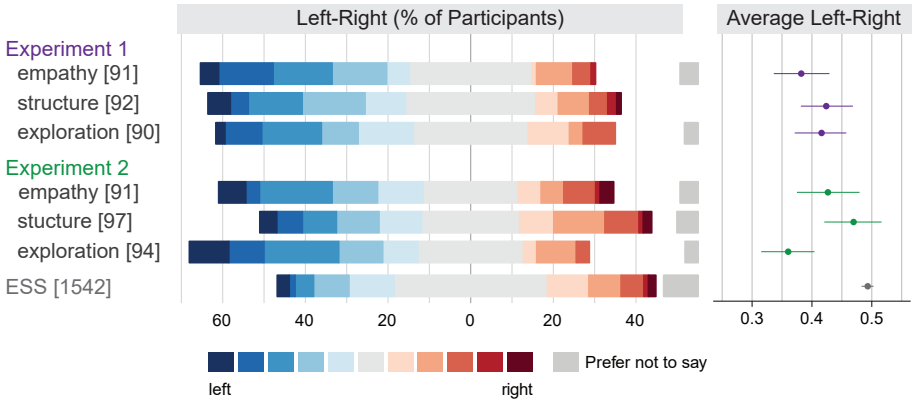


Figure 7: Left: Distribution of political position on a scale ranging from "Left to Right" across experiments and conditions. Right: Normalized [0..1], average political position with 95% CIs.

4 Results: Human Values

The four higher-order values are similar across conditions for both experiments and are in a similar range as the ESS data. The plots show that the differences across conditions within an experimental run of the human values are 5% or less, and therefore comparable.

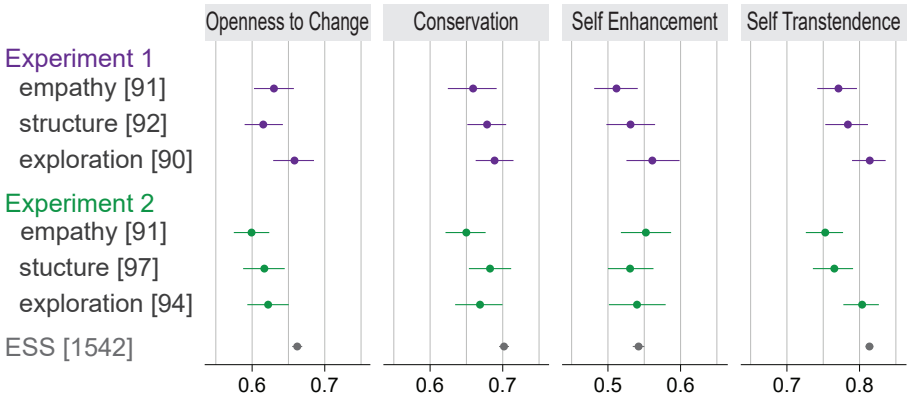


Figure 8: Normalized [0..1] higher-order values "Openness to Change", "Conservation", "Self Enhancement", and "Self Transtendence" by conditions and experiments.

5 Results: Immigration Attitudes by Items

The Figures 9 and 10 show the distribution of participants responses for each of the seven questions of opposition to migration and perceived immigration threat, respectively. Results are grouped by condition showing the results of the pre test of experiment 1 and the post tests of both experiments.

5.1 Opposition to Immigration

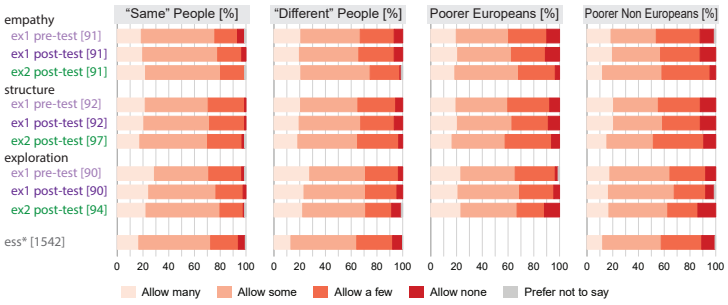


Figure 9: Distributions of participant responses in percent for *opposition to immigration* by item, condition, and experiment On an 4 point scale, participants were asked how many migrants the UK should allow to come if they are from the *same* or *different* ethnicity as the UK's majority; and if they are from *poorer* countries *inside EU* or *outside EU*. The values on the right show the total numbers of responses. (*) Item was dropped in the most recent ESS round.

5.2 Perceived Immigration Threat

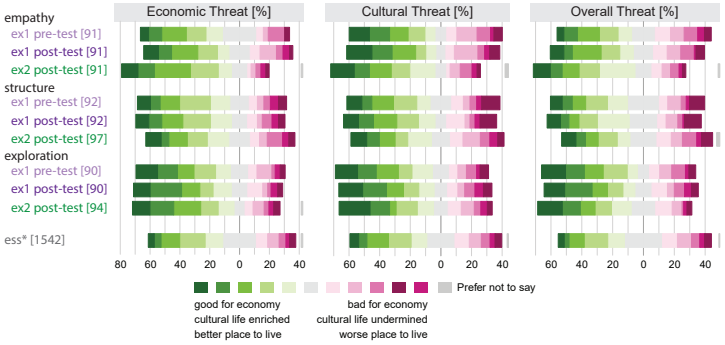


Figure 10: Distributions of participant responses in percent for *perceived immigration threat* by item, condition and experiment. On an 11 point scale, participants were asked whether immigration is good or bad for *economy*, whether immigration enriches or undermines *cultural* life, and whether *overall* immigration makes UK a better or a worse place to live. The values on the right show the total numbers of responses.

6 Numeric Results: Immigration Attitudes

To complement the visual results in the manuscript we provide numerical results and comparisons. The first row of a cell in the following tables shows the unstandardized effect size and its BCa 95% confidence interval, while the second row shows the standardized effect size measure Hedges g (as described in Kirby and Gerlanc [2]). Hedges g is part of the Cohen's d-type effect size measures family. To calculate Cohen's d-type effect sizes, the unstandardized effect size is divided by an unbiased estimate of the population standard deviation, expressing the effect (i.e., the difference between the contrasted groups or tests) in standard deviation units [2]. Find more information on the interpretation of Hedges g in [2, 3].

6.1 Experiment 1: Pre vs. Post

Table 2: Contrasting means for *opposition* and *perceived threat* between the pre and the post test of experiment 1 by condition.

	Opposition	Perceived Threat
empathy	-0.005 [-0.024, 0.015] -0.051 [-0.252, 0.161]	-0.020 [-0.036, -0.007] -0.281 [-0.461, -0.076]
structure	-0.004 [-0.018, 0.010] -0.054 [-0.248, 0.152]	-0.012 [-0.025, -0.001] -0.204 [-0.381, -0.000]
exploration	0.004 [-0.014, 0.023] 0.041 [-0.173, 0.233]	-0.001 [-0.014, 0.011] -0.023 [-0.231, 0.185]

6.2 Contrasting Opposition by Condition

Table 3: Contrasting means for *opposition* between the three conditions for the pre test of experiment 1 and the post tests of both experiments.

Experiment 1: PRE Opposition	structure	exploration
empathy	-0.002 [-0.079, 0.072] -0.008 [-0.304, 0.282]	-0.039 [-0.115, 0.036] -0.149 [-0.443, 0.142]
structure		-0.037 [-0.112, 0.039] -0.140 [-0.427, 0.148]
Experiment 1: POST Opposition	structure	exploration
empathy	-0.001 [-0.077, 0.074] -0.003 [-0.293, 0.286]	-0.030 [-0.104, 0.046] -0.117 [-0.408, 0.175]
structure		-0.029 [-0.105, 0.043] -0.114 [-0.407, 0.174]
Experiment 2: POST Opposition	structure	exploration
empathy	0.046 [-0.020, 0.111] 0.199 [-0.081, 0.495]	0.014 [-0.054, 0.083] 0.057 [-0.236, 0.340]
structure		-0.032 [-0.103, 0.039] -0.127 [-0.413, 0.156]

6.3 Contrasting Perceived Threat by Condition

Table 4: Contrasting means for *perceived threat* between the three conditions for the pre test of experiment 1 and the post tests of both experiments.

Experiment 1: PRE Perceived Threat	structure	exploration
empathy	0.011 [-0.064, 0.085] 0.043 [-0.246, 0.332]	-0.054 [-0.131, 0.021] -0.203 [-0.501, 0.094]
structure		-0.065 [-0.142, 0.013] -0.241 [-0.542, 0.050]
Experiment 1: POST Perceived Threat	structure	exploration
empathy	0.020 [-0.061, 0.097] 0.073 [-0.218, 0.367]	-0.035 [-0.115, 0.047] -0.126 [-0.419, 0.157]
structure		-0.055 [-0.135, 0.026] -0.198 [-0.493, 0.094]
Experiment 2: POST Perceived Threat	structure	exploration
empathy	0.091 [0.020, 0.160] 0.365 [0.069, 0.652]	0.004 [-0.067, 0.074] 0.016 [-0.271, 0.305]
structure		-0.088 [-0.161, -0.016] -0.338 [-0.628, -0.053]

7 Exploratory Results

To inform our discussion and provide more context to the confirmatory analysis we conducted further exploratory analysis. Specifically, we add perspective to **result 1** and **result 2** by looking at demographics and human values. In the paper we just present the conditions and variables relevant to these results. Here we provide the results of the exploratory analysis for all conditions and variables.

7.1 Immigration Attitudes by Demographics

7.1.1 Immigration Attitudes by Gender

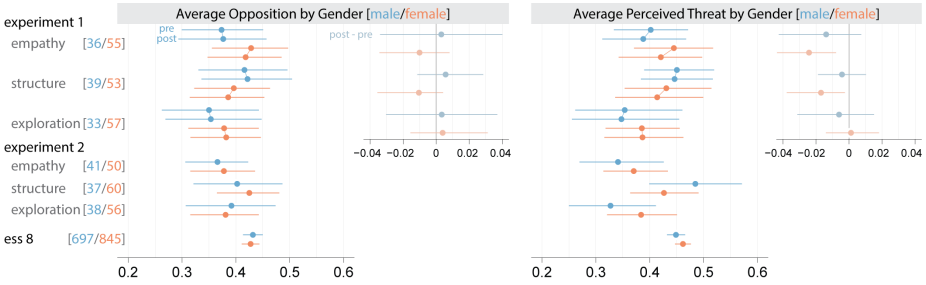


Figure 11: Exploratory results of average opposition and average perceived threat by **Gender**. The plots compare ***male*** and ***female*** participants (none answered 'prefer not to say').

7.1.2 Immigration Attitudes by Age

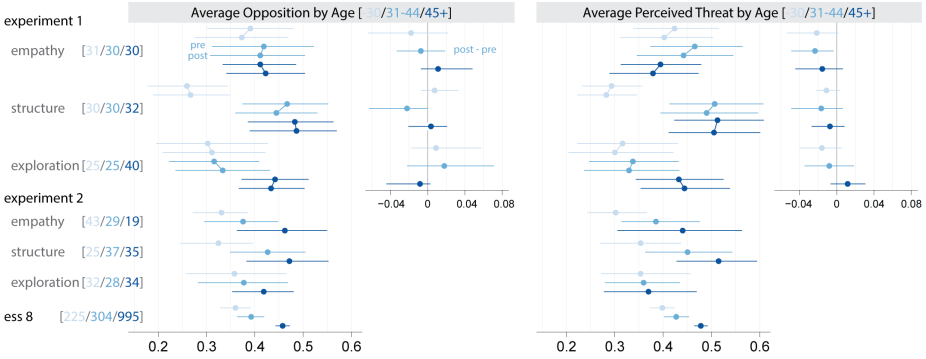


Figure 12: Exploratory results of average opposition and average perceived threat by **Age**. The participants are grouped by thirds.

7.1.3 Immigration Attitudes by Education

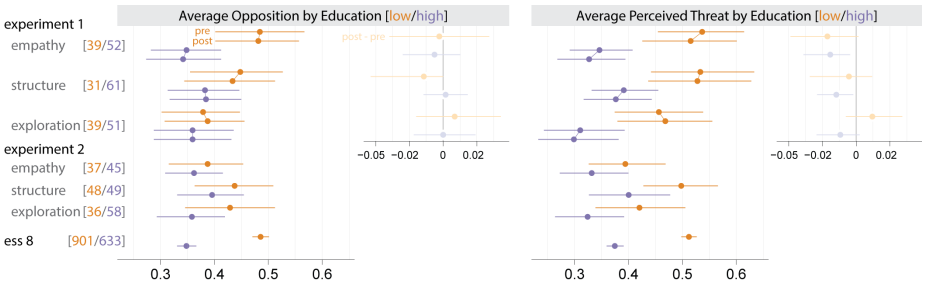


Figure 13: Exploratory results of average opposition and average perceived threat by **Education**. The answer options *Below Standards*, *GCSE Level Education*, and *A-Level Education* are binned into ***low***, and *Degree or Graduate Education* and *Post-Graduate Education* into ***high***.

7.1.4 Immigration Attitudes by Income

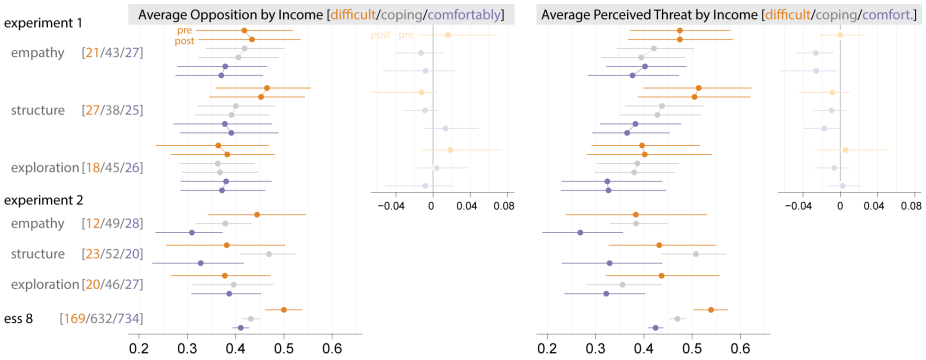


Figure 14: Exploratory results of average opposition and average perceived threat by **Income**. We group participants finding it *very difficult* or *difficult* to live on present income into ***difficult***, and use the other two original groups ***coping*** and living ***comfortably*** on income.

7.1.5 Immigration Attitudes by Religion

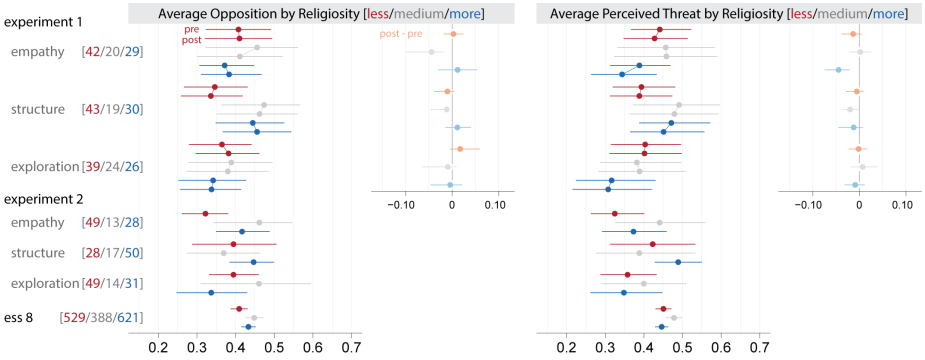


Figure 15: Exploratory results of average opposition and average perceived threat by **Religion**. Due to unbalanced distribution is the binning of this topic relative, we created three bins of equal size (as good as possible): ***less religious***, ***medium religious*** and ***more religious***.

7.1.6 Immigration Attitudes by Politics

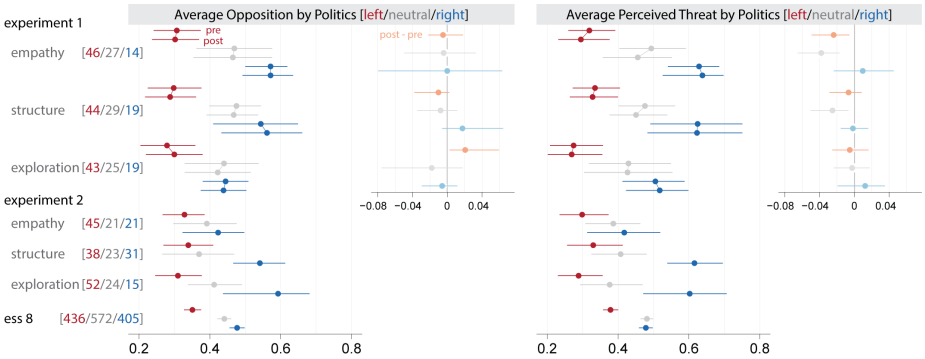


Figure 16: Exploratory results of average opposition and average perceived threat by **Politics**. The binning separates participants orientation on the ***left*** and the ***right*** spectrum, and all participants who selected the ***center/neutral*** option.

7.2 Immigration Attitudes by Human Values

7.2.1 Immigration Attitudes by Conservation vs. Openness to Change

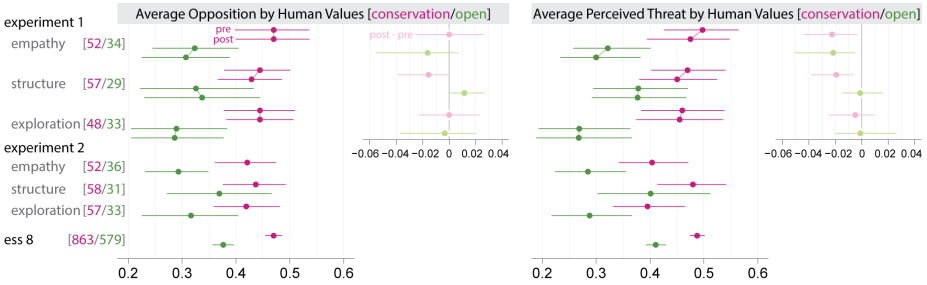


Figure 17: Exploratory results for confirmatory results by **higher-order human values**. The dimension contrasts ***conservative*** participants with people ***open to change***.

7.2.2 Immigration Attitudes by Self-Enhancement vs. Self-Transtendence

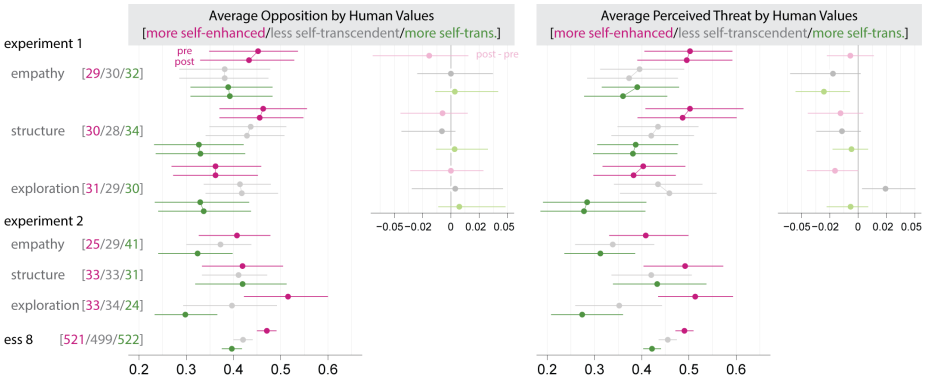


Figure 18: Exploratory results for confirmatory results by **higher-order human values**. The dimension, contrasting self-enhancement and self-transcendence, is a relative comparison due to unbalanced distribution. The participants are grouped in three bins: ***more self-enhanced***, ***less self-transcendent***, and ***more self-transcendent***.

7.3 Immigration Attitudes by Time

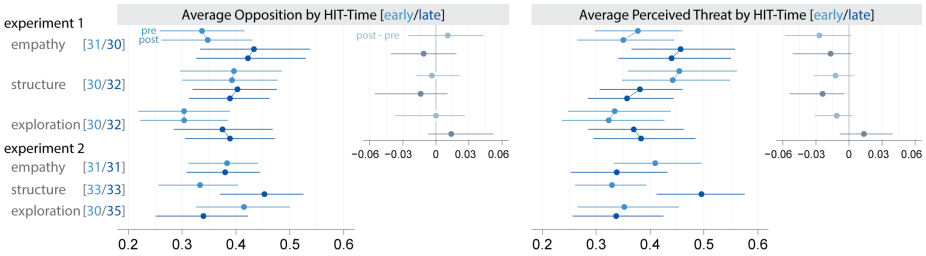


Figure 19: Comparing the first third of submissions and the last third.

8 Terminology for Visual Data Storytelling

We use **visual data storytelling** as an umbrella term, describing the overall research field of storytelling in data visualization. Visual data storytelling is also used by others (e.g., [4, 5]). Equivalent terms are narrative visualization (e.g., [6], [7]), data-driven storytelling (e.g., [8, 9]), or storytelling with data (e.g., [10]).

Our terminology follows modern, cognitive narrative theory ([11, 12]), where a **narrative** is a combination of two concepts: **story and discourse**. A story is a narrative's mental representation, a cognitive construct in a reader's mind. The **discourse** part deals with the ability of materialized representations (e.g., a text or a visualization) to constitute or evoke a **story**. For creating mental representations (stories) of a narrative, narrative techniques are used in storytelling, or **visual-narrative techniques** in visual data storytelling. Visual-narrative techniques combine visualization techniques and narrative techniques.

For the experiment we created two **visual narratives** (a) and (b) with a **visual-narrative design** and one visualization (c) with a **baseline design**. While the designs of (a) and (b) implement **visual-narrative techniques**, the design of (c) only uses common **visualization techniques**. The visual-narrative design of (a) implements visual-narrative techniques that are believed to evoke empathy (short: empathy design). Six individuals report why they came to the UK. Hence, we call them **personal visual narratives**. The visual-narrative design of (b) uses visual-narrative techniques that mainly provide structure (short: structure design), presenting facts in a thematic, temporal, and spatial order. Hence, we call it a **structured visual narrative**.

The designs are tested using three conditions. While the visual-narrative designs of (a) and (b) are both used in the **storytelling conditions**, namely the **empathy condition** and the **structure condition**, the baseline design of (c) is used in the **exploratory condition**.

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