Hayeong Song
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VIS2025

Visualizing Trust: How Chart Embellishments Influence Perceptions of credibility

Hayeong Song, Aeree Cho, Cindy Xiong, and John Stasko

Georgia Institute of Technology

Design Challenge in Visualizations

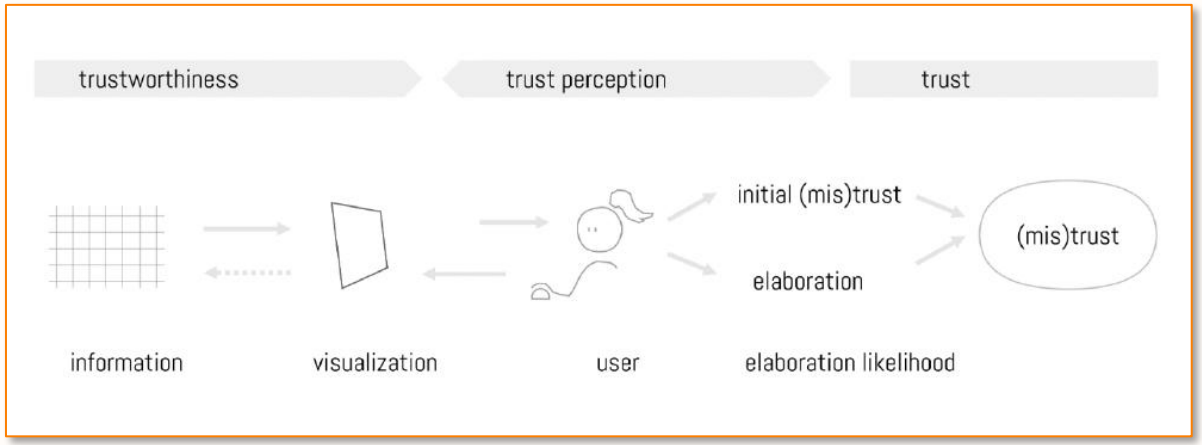
Trust Issues,

Design choices can erode credibility

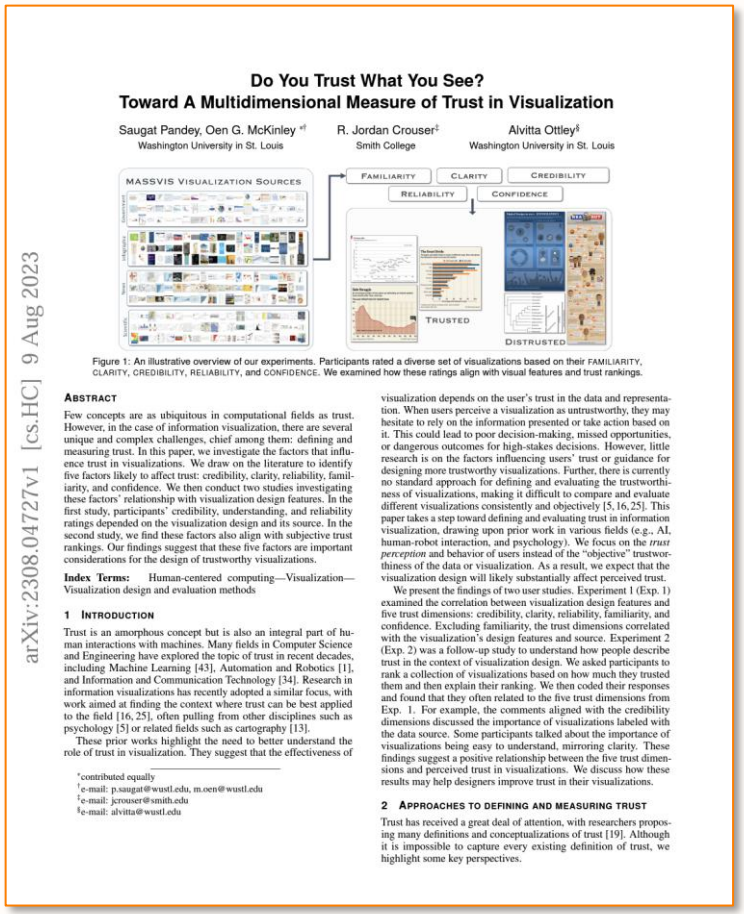
Limited empirical evidence

No clear evidence to refer to

Trust is multi-dimensional: we focus on evaluating it in visual design



A model for trust in information visualization
[Mayr et al. 2019]



Do You Trust What You See?
Toward A Multidimensional Measure of Trust in Visualization

Saugat Pandey, Oen G. McKinley *†
Washington University in St. Louis
R. Jordan Crouser‡
Smith College
Alvitta Ottley§
Washington University in St. Louis

Figure 1: An illustrative overview of our experiments. Participants rated a diverse set of visualizations based on their FAMILIARITY, CLARITY, CREDIBILITY, RELIABILITY, and CONFIDENCE. We examined how these ratings align with visual features and trust rankings.

arXiv:2308.04727v1 [cs.HC] 9 Aug 2023

ABSTRACT

Few concepts are as ubiquitous in computational fields as trust. However, in the case of information visualization, there are several unique and complex challenges, chief among them: defining and measuring trust. In this paper, we investigate the factors that influence trust in visualizations. We draw on the literature to identify five factors likely to affect trust: credibility, clarity, reliability, familiarity, and confidence. We then conduct two studies investigating these factors' relationship with visualization design features. In the first study, participants' credibility, understanding, and reliability ratings depended on the visualization design and its source. In the second study, we find these factors also align with subjective trust rankings. Our findings suggest that these five factors are important considerations for the design of trustworthy visualizations.

Index Terms: Human-centered computing—Visualization—Visualization design and evaluation methods

1 INTRODUCTION

Trust is an amorphous concept but is also an integral part of human interactions with machines. Many fields in Computer Science and Engineering have explored the topic of trust in recent decades, including Machine Learning [43], Automation and Robotics [1], and Information and Communication Technology [34]. Research in information visualizations has recently adopted a similar focus, with work aimed at finding the context where trust can be best applied to the field [16, 25], often pulling from other disciplines such as psychology [5] or related fields such as cartography [13].

These prior works highlight the need to better understand the role of trust in visualization. They suggest that the effectiveness of visualization depends on the user's trust in the data and representation. When users perceive a visualization as untrustworthy, they may hesitate to rely on the information presented or take action based on it. This could lead to poor decision-making, missed opportunities, or dangerous outcomes for high-stakes decisions. However, little research is on the factors influencing users' trust or guidance for designing more trustworthy visualizations. Further, there is currently no standard approach for defining and evaluating the trustworthiness of visualizations, making it difficult to compare and evaluate different visualizations consistently and objectively [5, 16, 25]. This paper takes a step toward defining and evaluating trust in information visualization, drawing upon prior work in various fields (e.g., AI, human-robot interaction, and psychology). We focus on the *trust perception* and behavior of users instead of the "objective" trustworthiness of the data or visualization. As a result, we expect that the visualization design will likely substantially affect perceived trust.

We present the findings of two user studies. Experiment 1 (Exp. 1) examined the correlation between visualization design features and five trust dimensions: credibility, clarity, reliability, familiarity, and confidence. Excluding familiarity, the trust dimensions correlated with the visualization's design features and source. Experiment 2 (Exp. 2) was a follow-up study to understand how people describe trust in the context of visualization design. We asked participants to rank a collection of visualizations based on how much they trusted them and then explain their ranking. We then coded their responses and found that they often related to the five trust dimensions from Exp. 1. For example, the comments aligned with the credibility dimensions discussed the importance of visualizations labeled with the data source. Some participants talked about the importance of visualizations being easy to understand, mirroring clarity. These findings suggest a positive relationship between the five trust dimensions and perceived trust in visualizations. We discuss how these results may help designers improve trust in their visualizations.

2 APPROACHES TO DEFINING AND MEASURING TRUST

Trust has received a great deal of attention, with researchers proposing many definitions and conceptualizations of trust [19]. Although it is impossible to capture every existing definition of trust, we highlight some key perspectives.

*contributed equally
†e-mail: p.saugat@wustl.edu, m.oen@wustl.edu
‡e-mail: jcrouser@smith.edu
§e-mail: alvitta@wustl.edu

Multi-dimensional nature of evaluating trust in visualizations
[Pandey et al. 2023]

There remains a gap in understanding how various design choices influence viewers' perceptions of credibility.

Research Question I

Does embellishment (design choices) erode message credibility ?

Research Question II

How do visualization elements (design factors) shape perception of credibility?

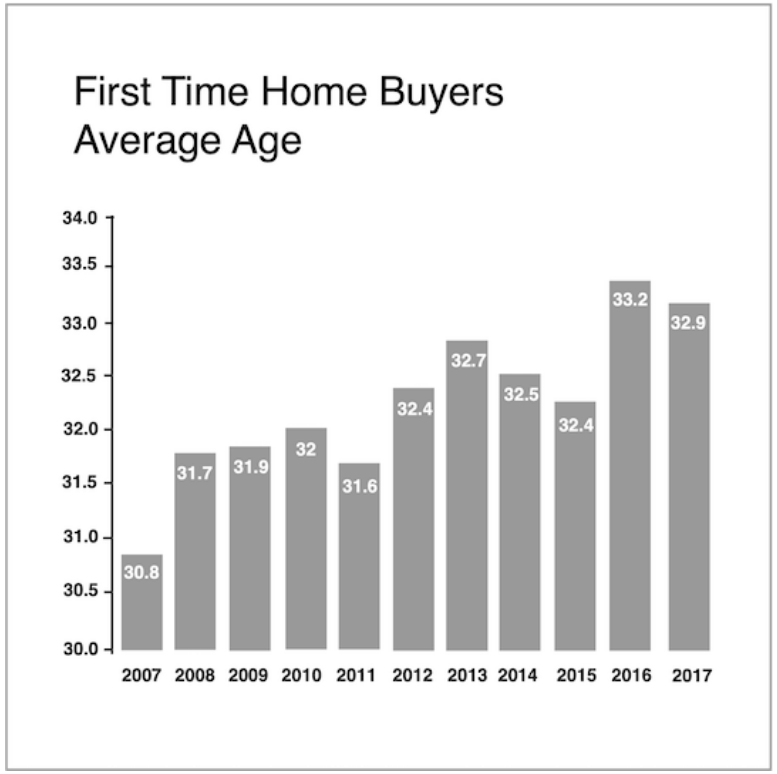
PART I

Visualization

Message

Visual genre

Embellishment vs Plain



Which one is more credible?

Study Design

Tasks

Single ratings

Option selections

Demographic survey

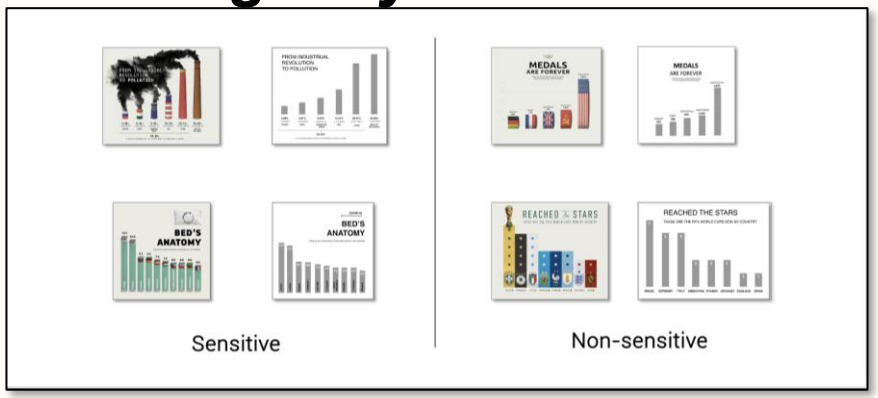
148 Participants

2 Embellishment styles

Cartoon-style vs Plain

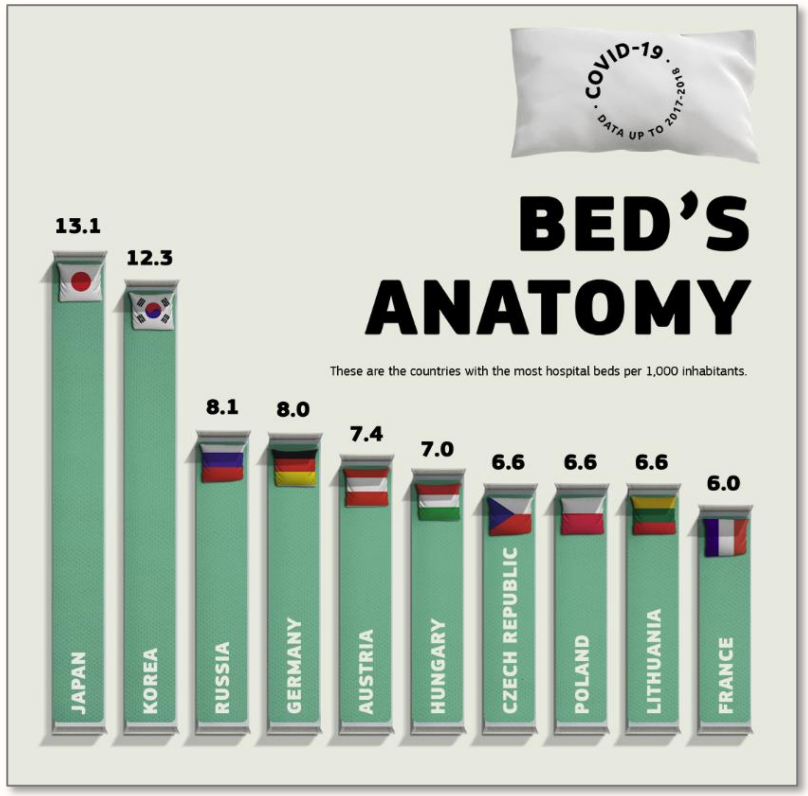
(74 Participants)

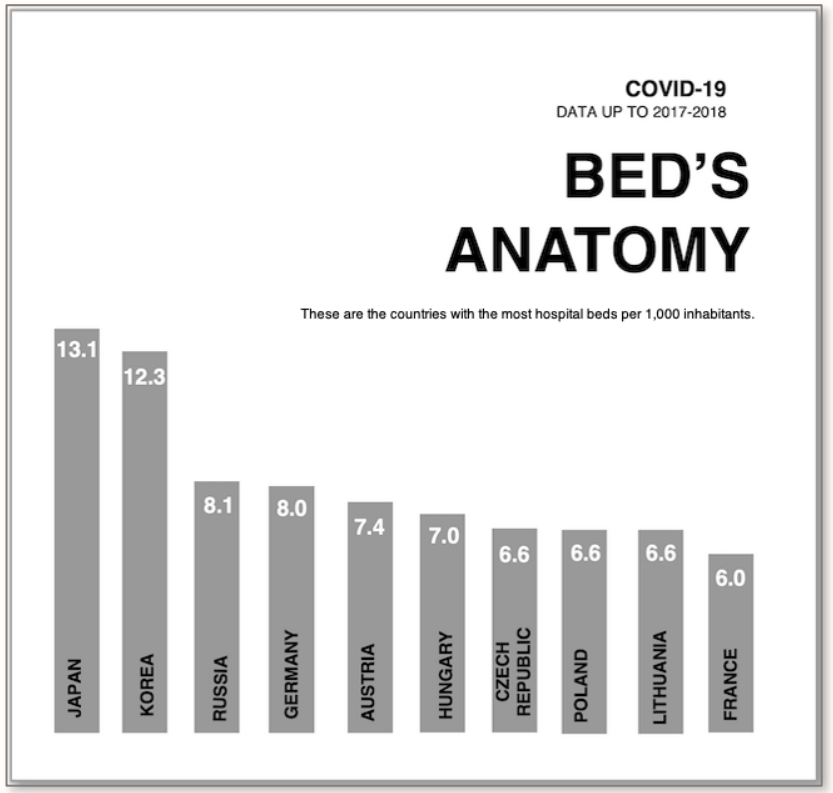
Image style vs Plain



(74 Participants)

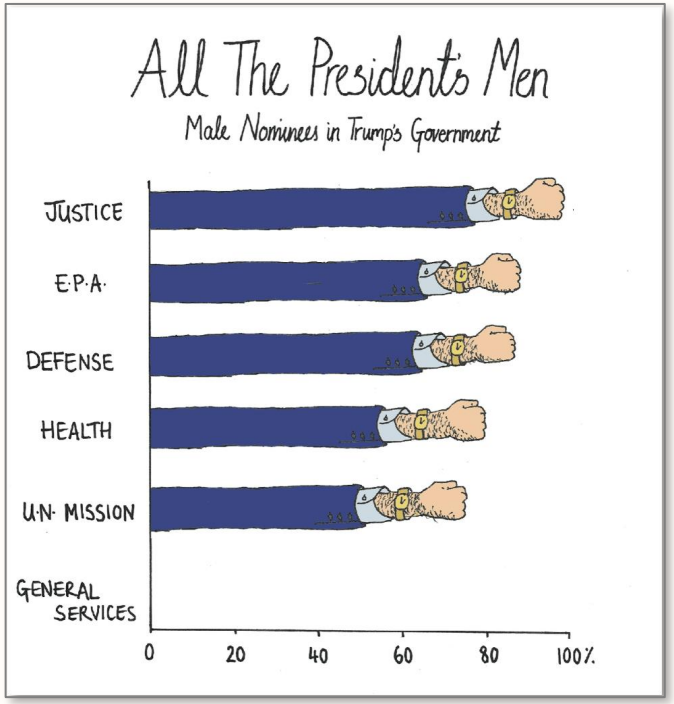
Image-style vs Plain

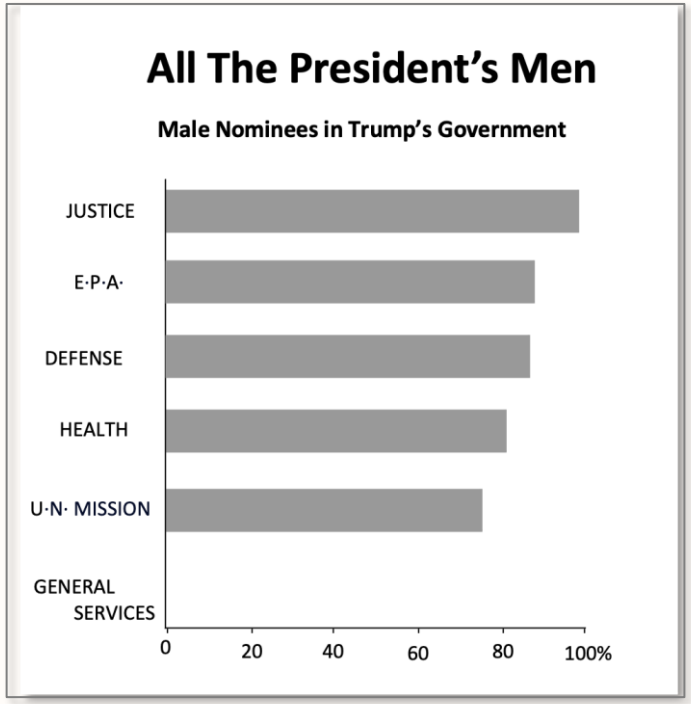




Which one is more credible?

Cartoon-style vs Plain

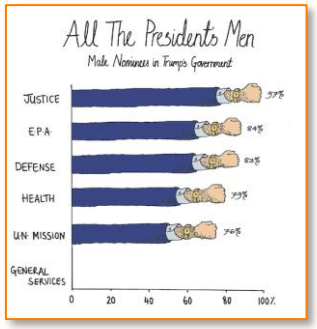


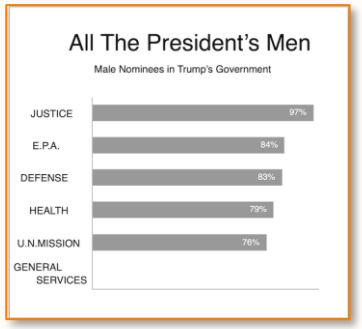


Which one is more credible?

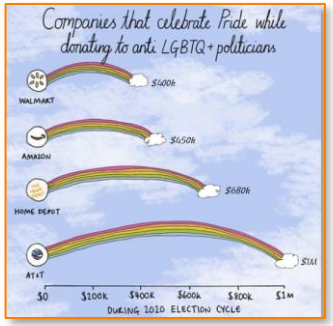
Cartoon-style vs Plain

More belief-triggering



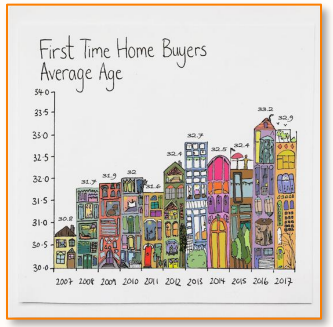


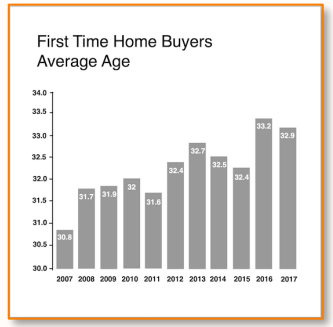
Gender ratios



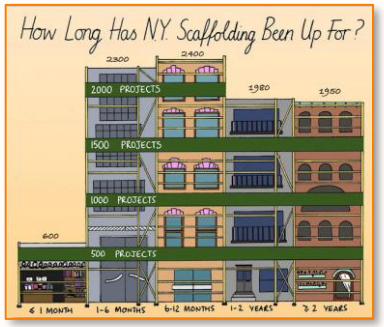
LGBT

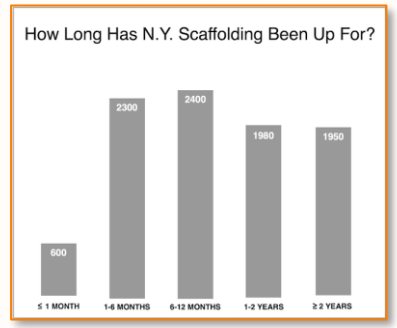
Less belief-triggering





Home buyer's age





Construction duration

Hypotheses

H1: Plain > Cartoon-Style

H2: Plain > Image-style

H3: Belief-triggering topics (more likely): Plain> Embellished

Task & Measure

Quantitative:

Credibility Likert Scale (1 - low, 7 - high)

Option selection:

Professional presentation, social media post (credibility proxy)

Qualitative:

Open-ended questions

Statistical Analysis

Quantitative:

Single ratings: Two-way ANOVA,

Tukey's HSD post-hoc ($\alpha = .05$)

A/B options selection: Odds ratio analysis

Qualitative:

Open-ended questions (open coding)

Results

H1 (true) : Plain > Cartoon-style

H2 (partially true): Plain >= Image-style

H3 (did not find support): Belief triggering topics (more likely): Plain > Embellished

Study 1: Key takeaways

Does embellishment erode message credibility of visualization?	It depends. Image-style: no, cartoon-style: yes
What are the key factors that erode credibility of charts? (qualitative)	Fonts, color usage, and style of bars

Research Question I

Does embellishment (design choices) erode message credibility ?

Research Question II

How do visualization elements (design factors) shape perception of credibility?

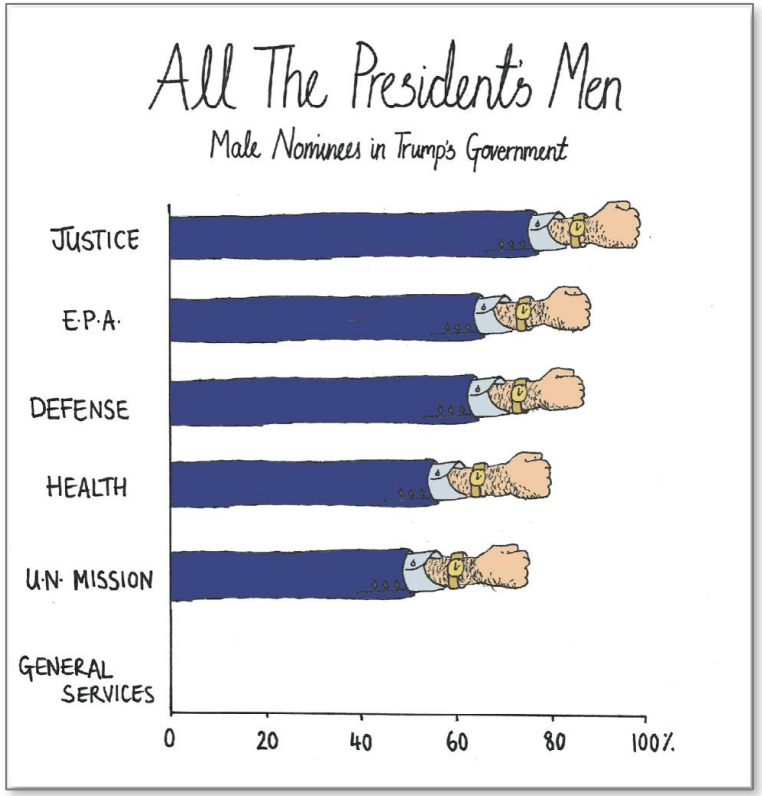
PART II

Communication

Message

Visualization elements

Fonts, bars, and color



Rank the following visualizations in order of credibility

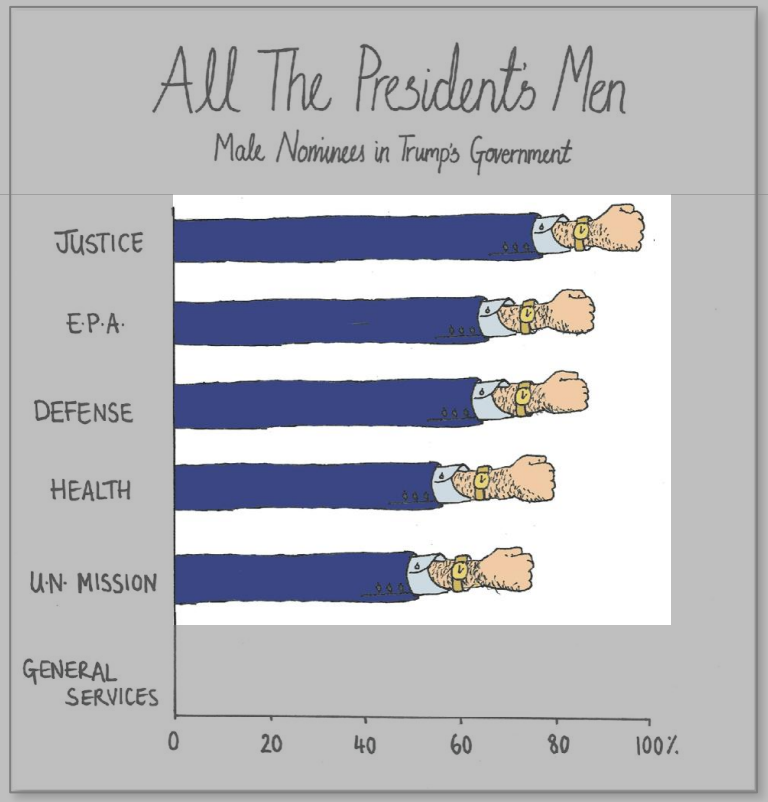
PART II

Communication

Message

Visualization elements

Fonts, bars, and color



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PART II

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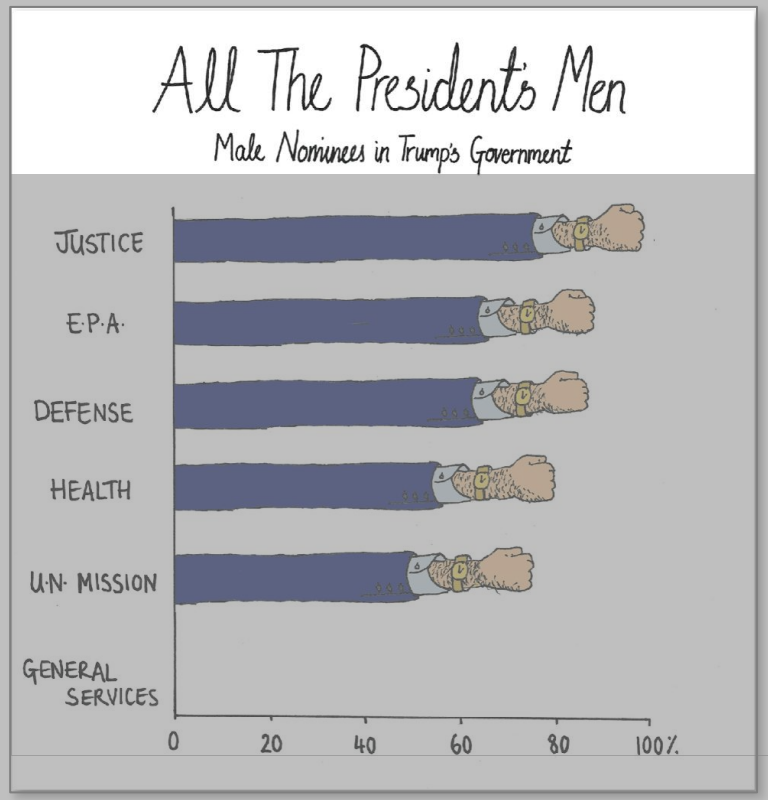
Visualization elements

Fonts, bars, and color



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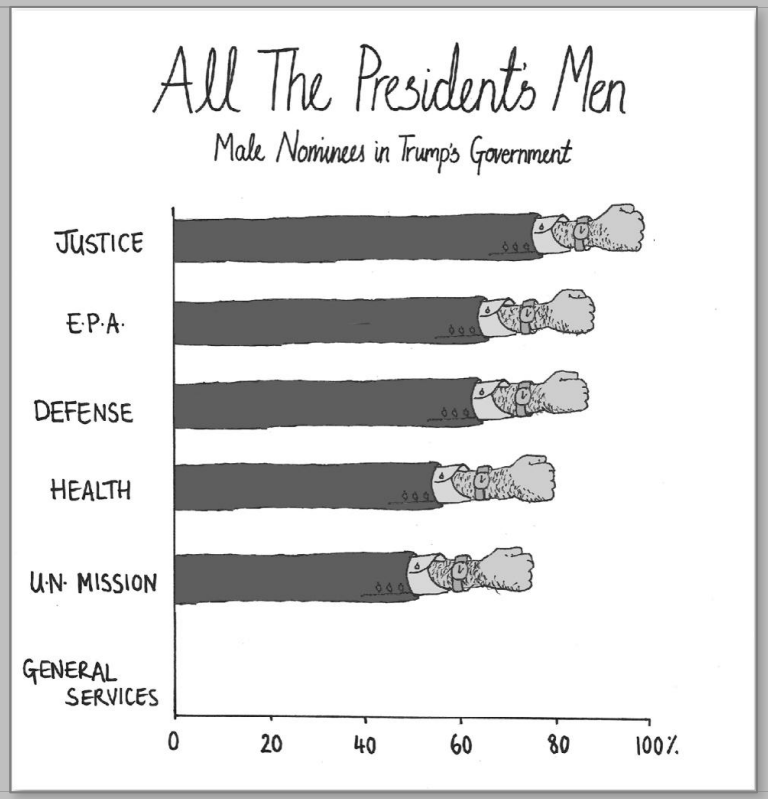
PART II

Communication

Message

Visualization elements

Fonts, bars, and color



Rank the following visualizations in order of credibility

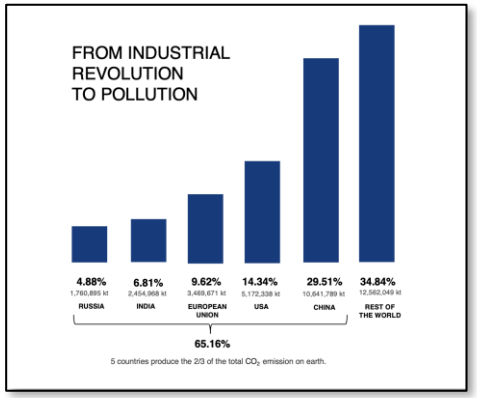
PART II

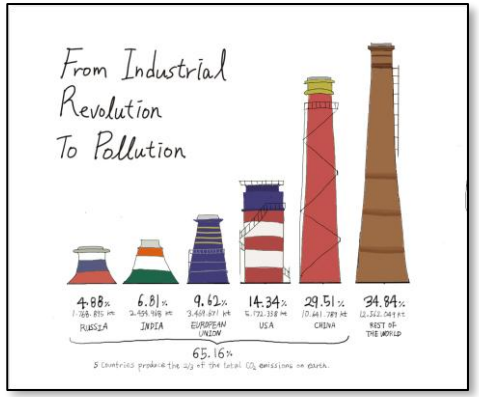
Communication

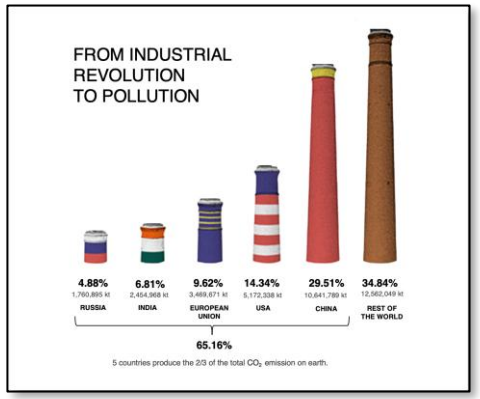
Message

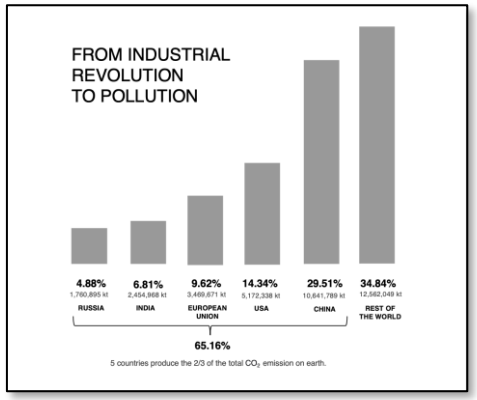
Visualization elements

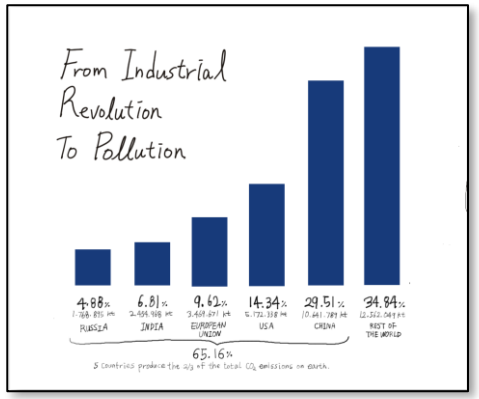
Fonts, bars, and colors











Rank the following visualizations in order of credibility

Hypotheses

H1 (Color) : **Color usage** will degrade the perception of the credibility of charts compared to **grayscale**.

H2 (Font) : Usage of **hand-drawn fonts** will degrade the perception of the credibility of charts compared to **common fonts**.

H3a (style of bars) : **Cartoon-style bars** will degrade the perception of the credibility of charts compared to **plain bars.**

H3b (style of bars) : **Image bars** will degrade the perception of the credibility of charts compared to **plain bars.**

Study Design

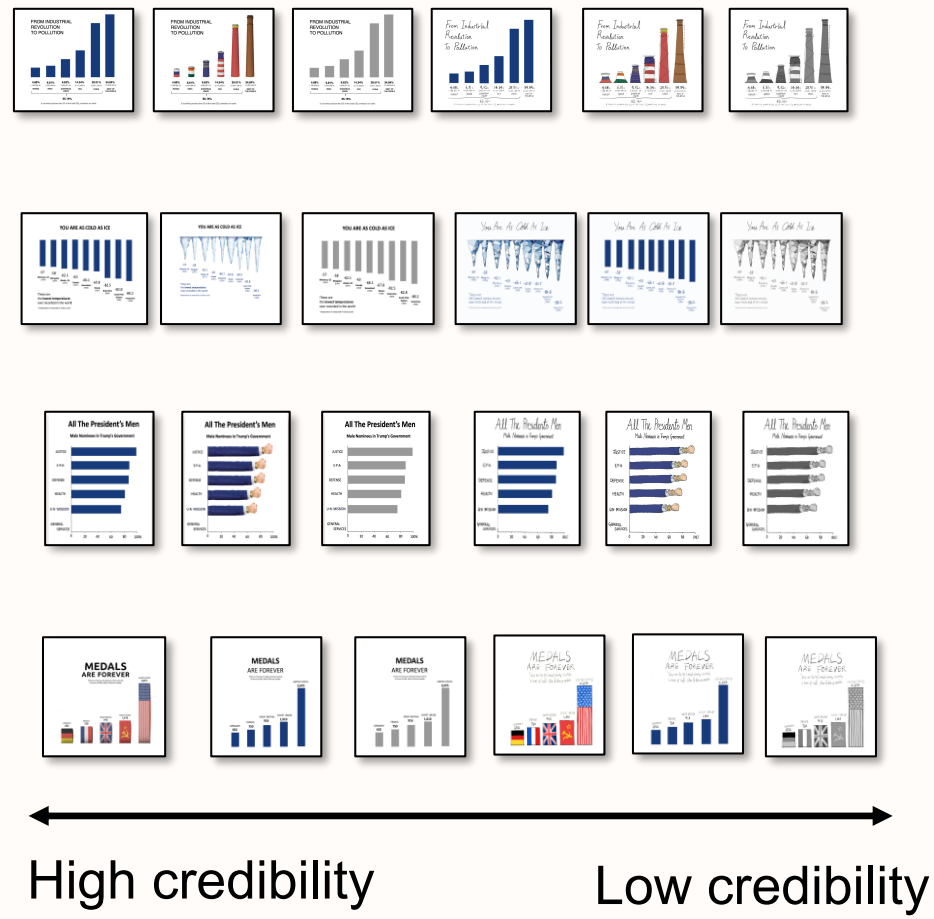
Tasks

Ranking

Demographic survey

160 Participants

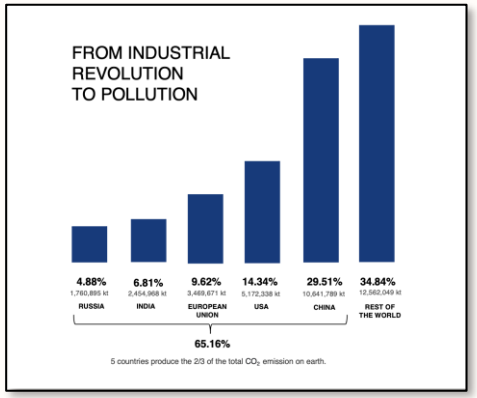
4 Topics

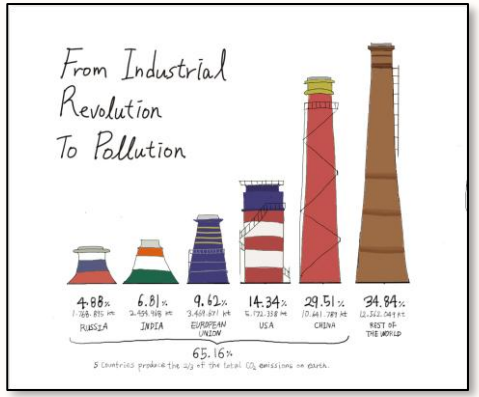


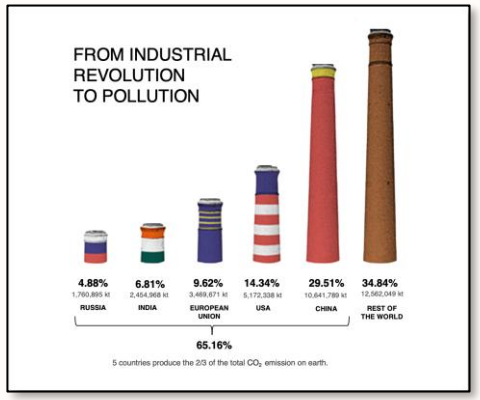
High credibility

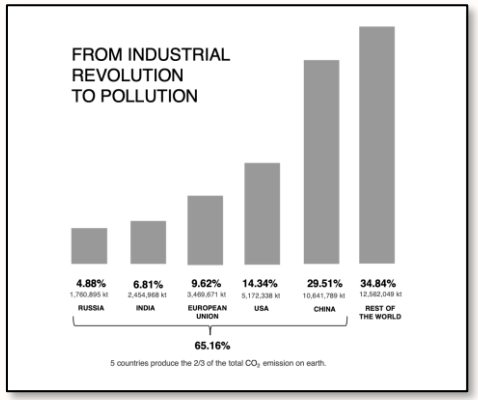
Low credibility

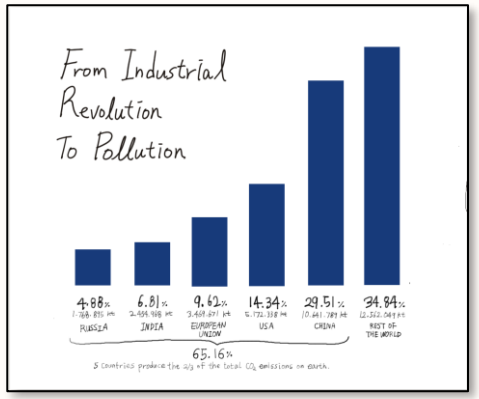
Visualization stimuli





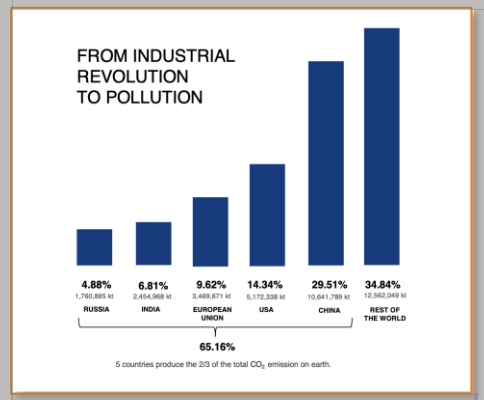


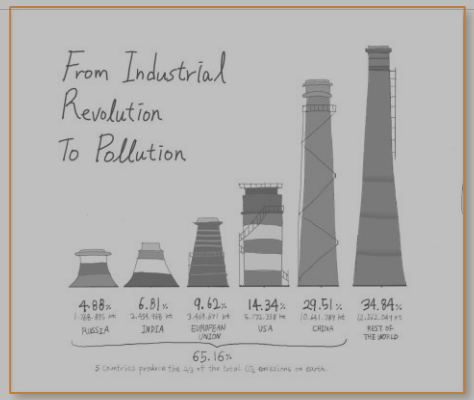


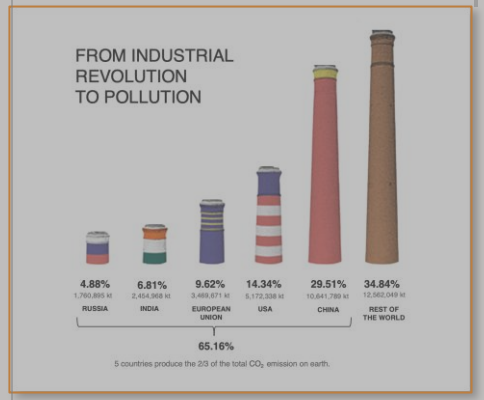


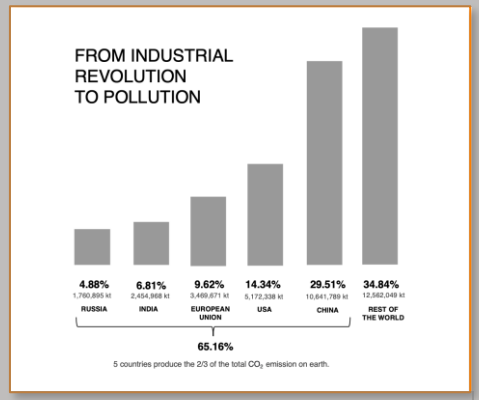
Visualization stimuli

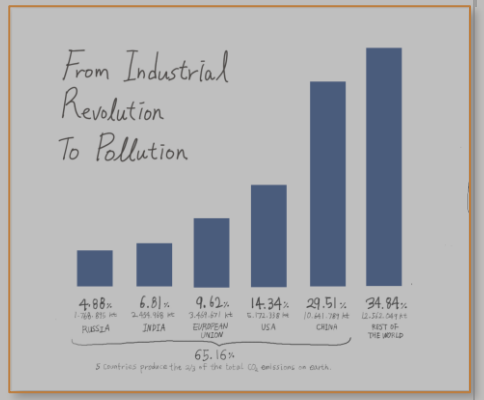
Part a: Effect of color





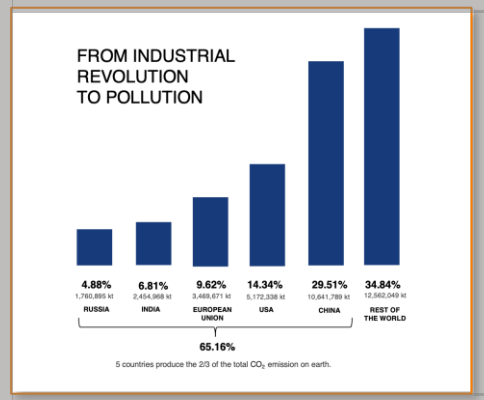


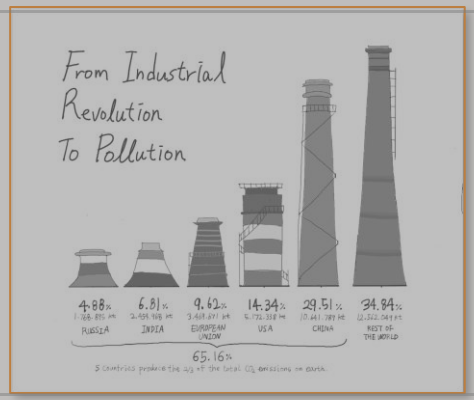


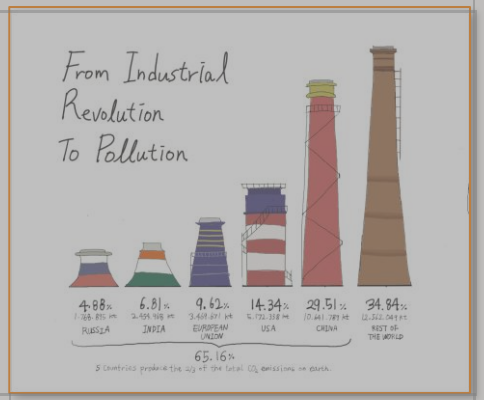


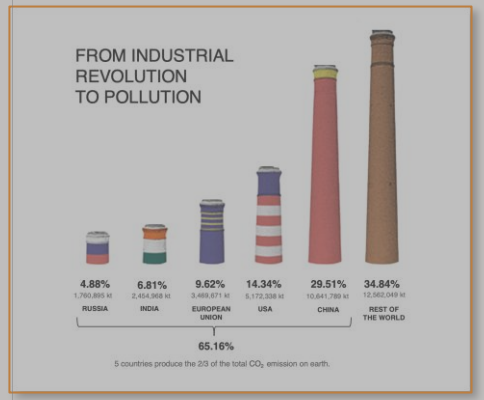
Visualization stimuli

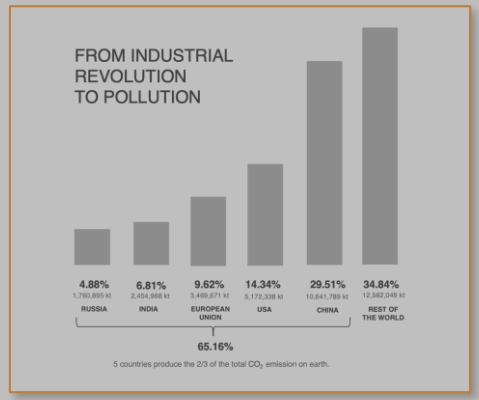
Part b: Effect of font style

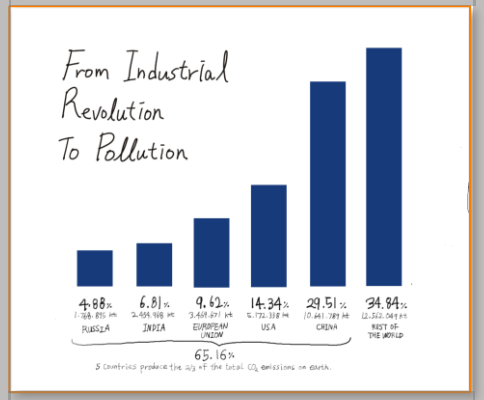






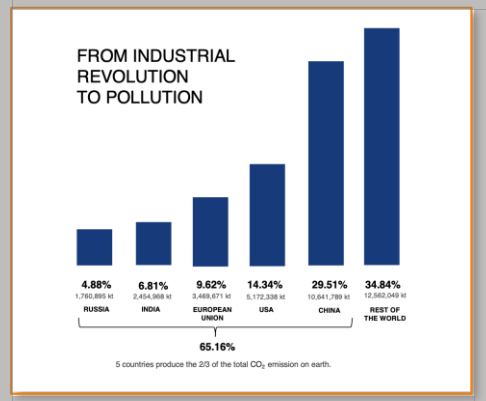


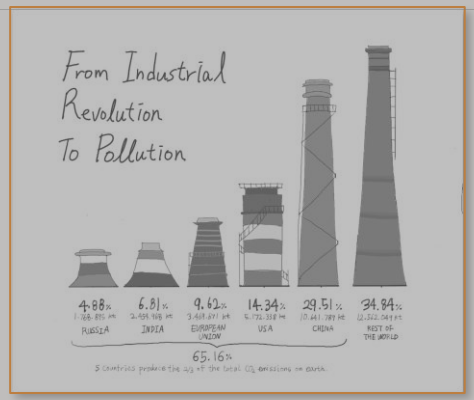


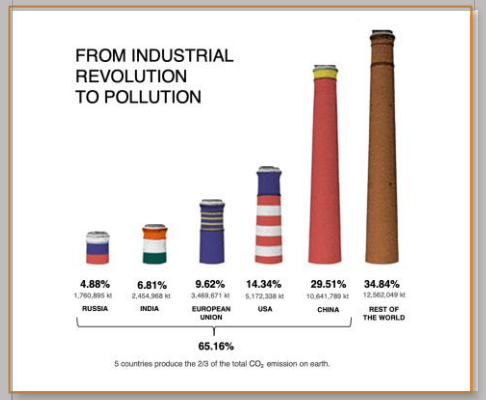


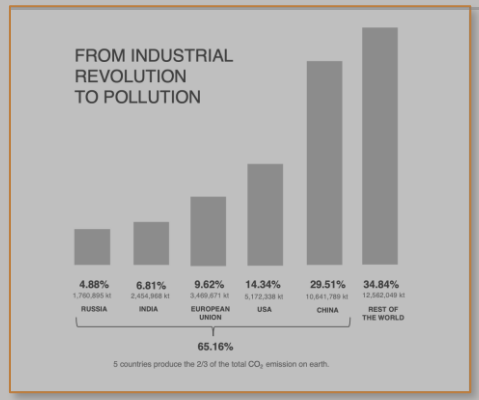
Visualization stimuli

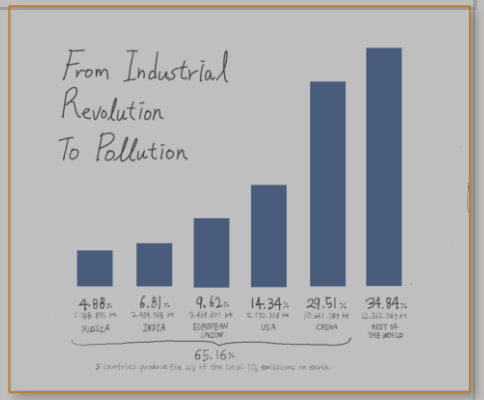
Part c: Effect of bar style



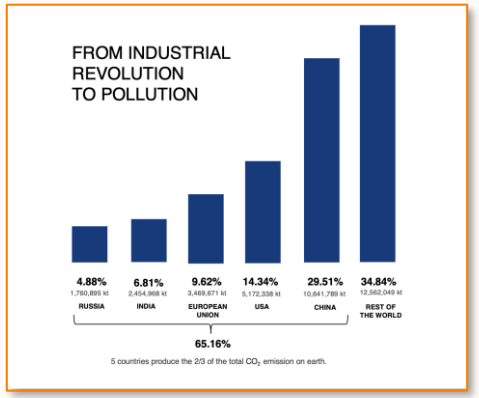


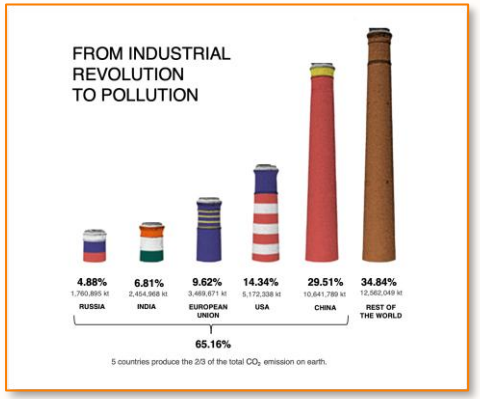


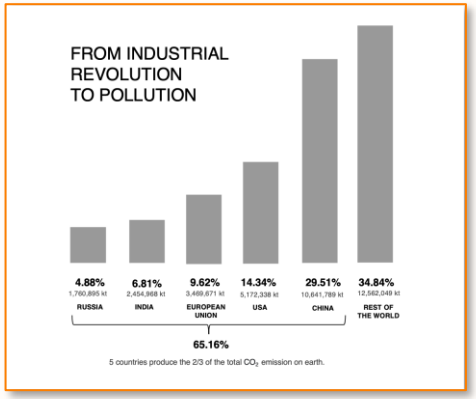


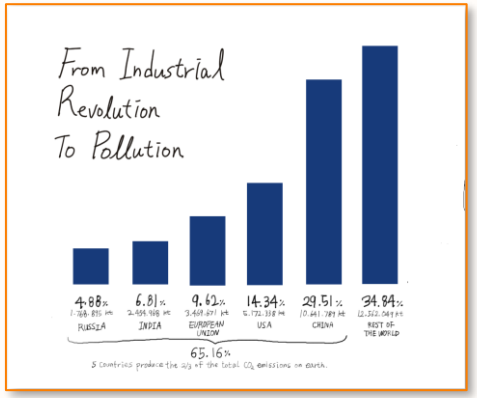


Task (Rank)









Please rank the following visualizations
in order of increasing credibility from low to high

Measure & Analysis

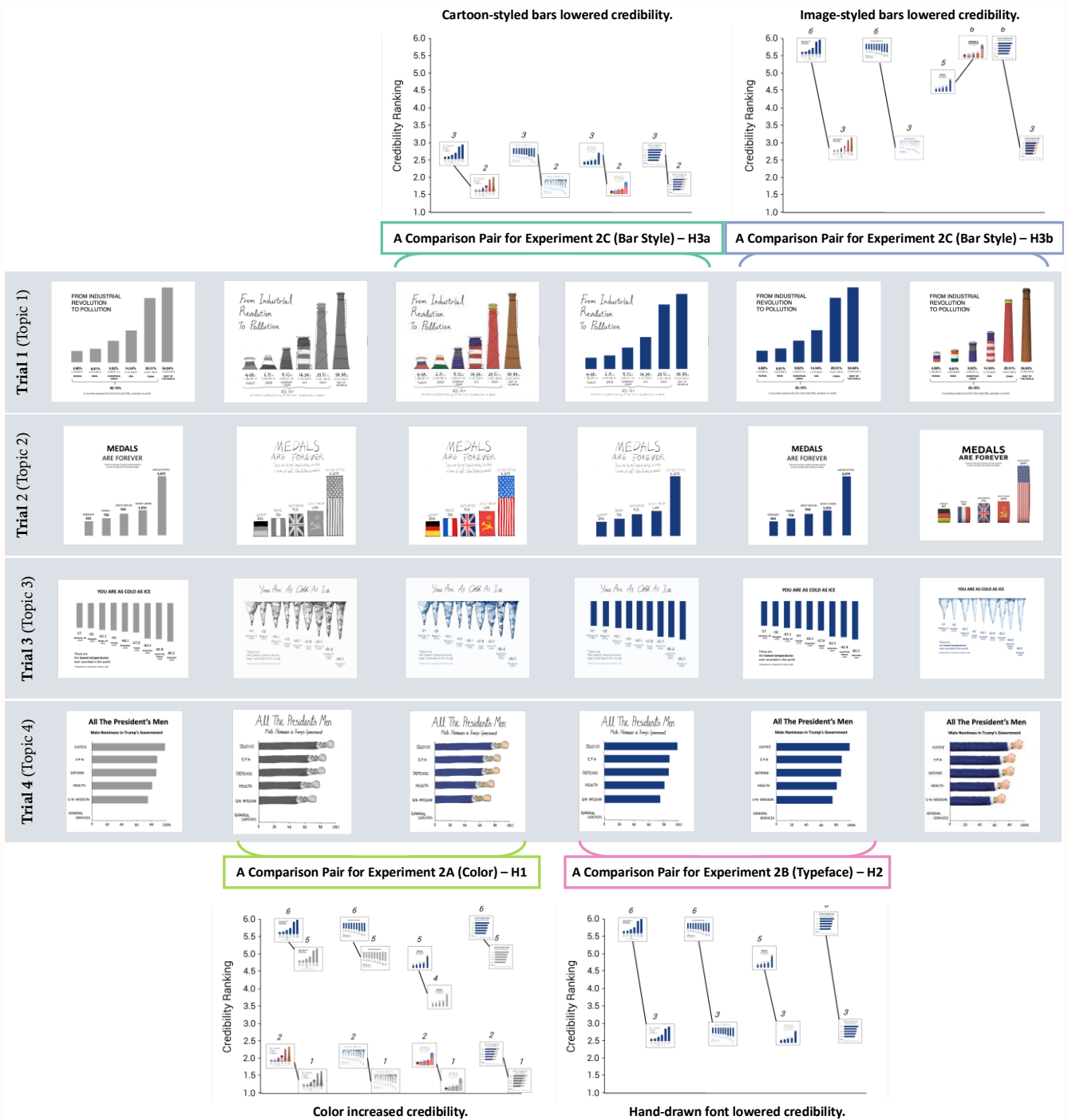
Rank order (credibility) :

Kruskal – Wallis test for rank order analysis

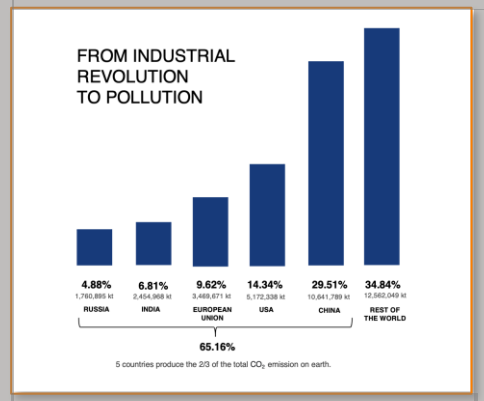
Multiple choice option :

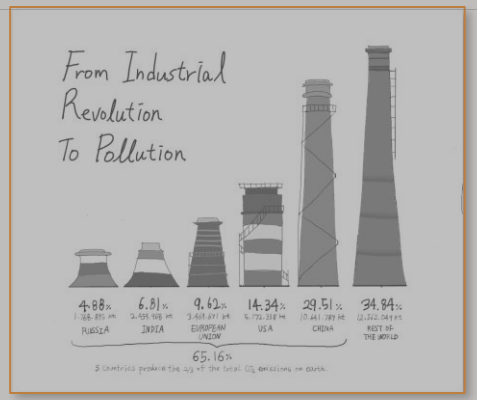
Percentage & number of respondents

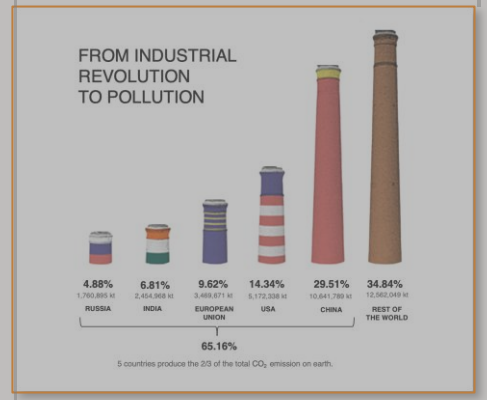
Results

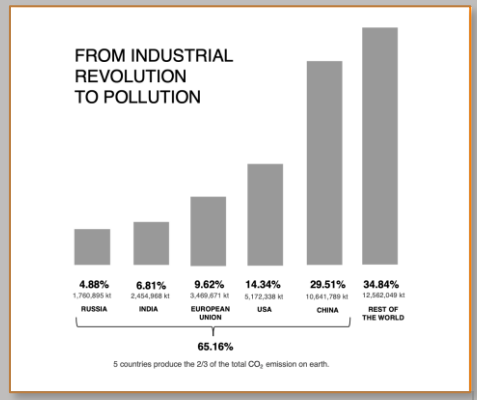

Cartoon-styled bars lowered credibility.
Image-styled bars lowered credibility.
Credibility Ranking
A Comparison Pair for Experiment 2C (Bar Style) – H3a
A Comparison Pair for Experiment 2C (Bar Style) – H3b
Trial 1 (Topic 1)
Trial 2 (Topic 2)
Trial 3 (Topic 3)
Trial 4 (Topic 4)
A Comparison Pair for Experiment 2A (Color) – H1
A Comparison Pair for Experiment 2B (Typeface) – H2
Color increased credibility.
Hand-drawn font lowered credibility.

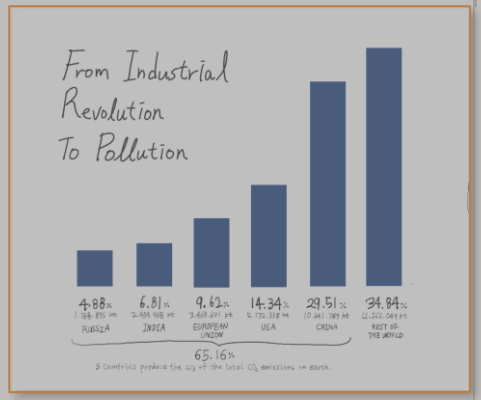
Color increased credibility



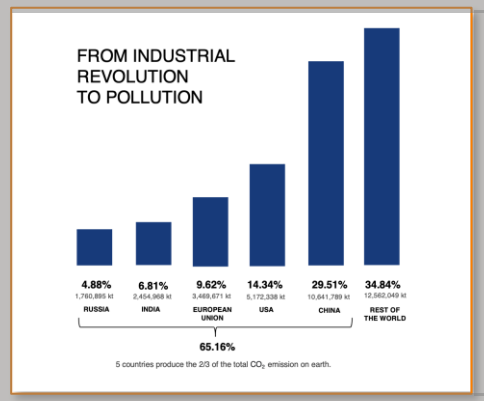


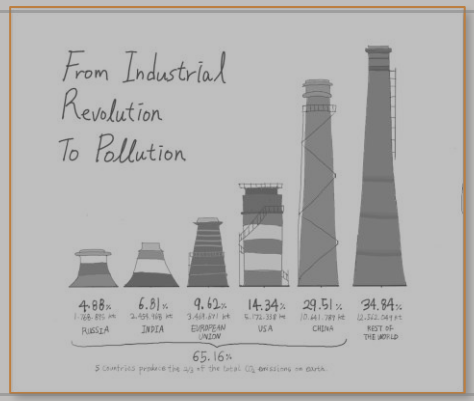


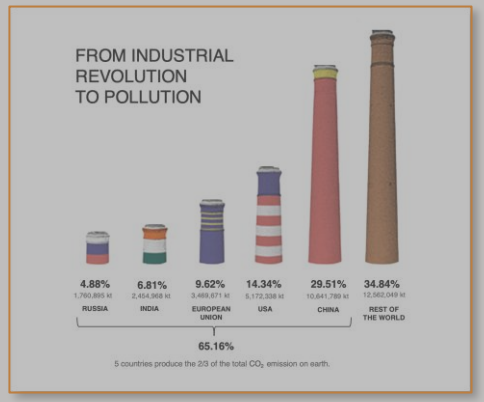


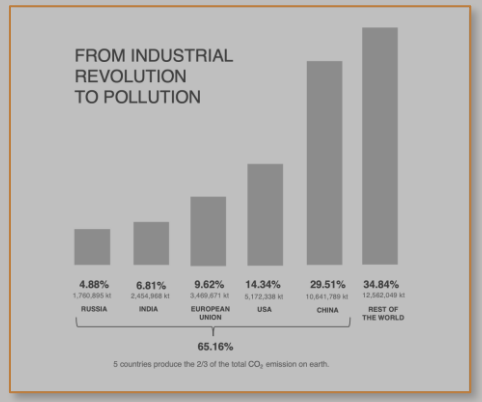


Hand-drawn font lowered credibility









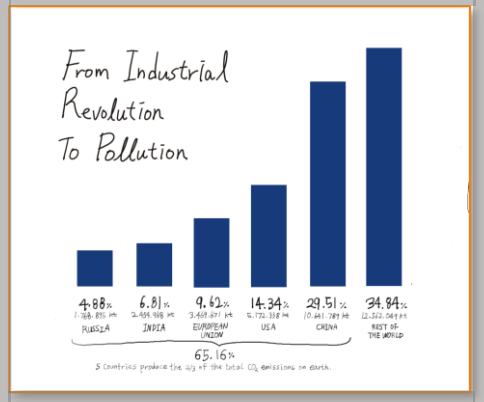
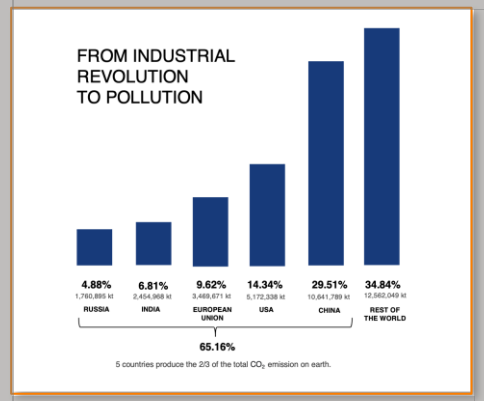
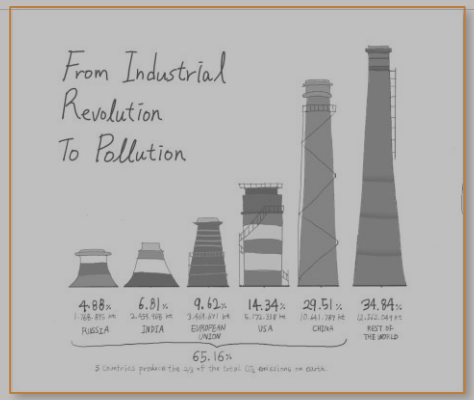
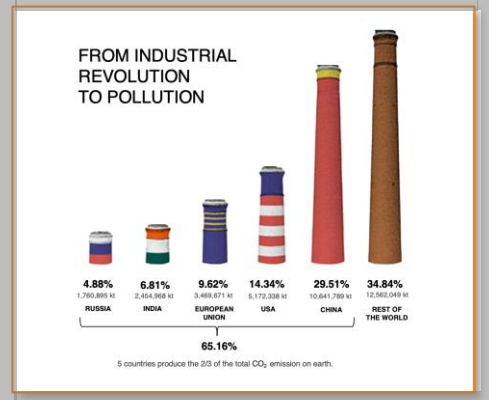
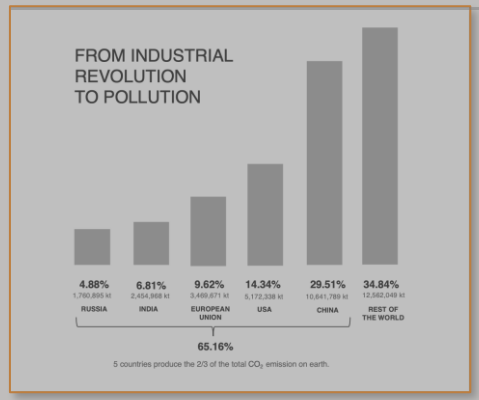


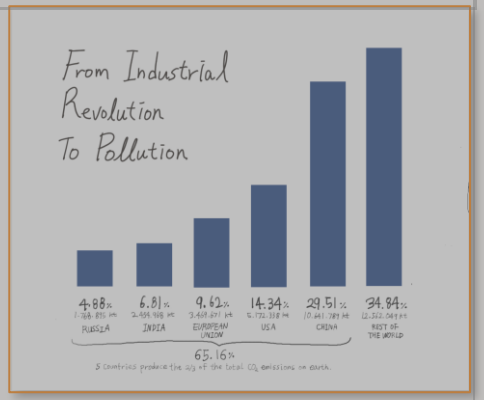
Image style bars lowered credibility.



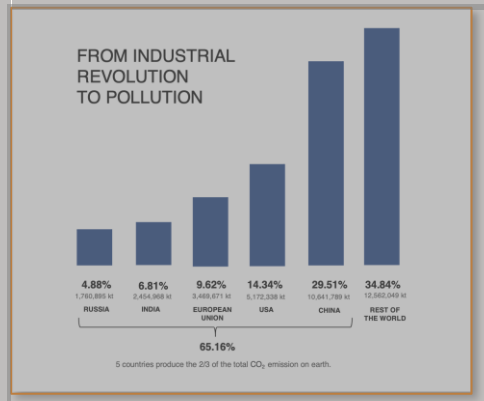


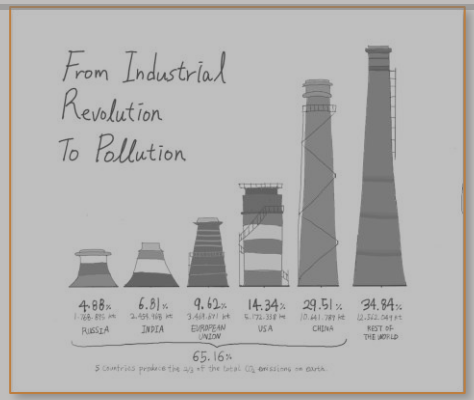


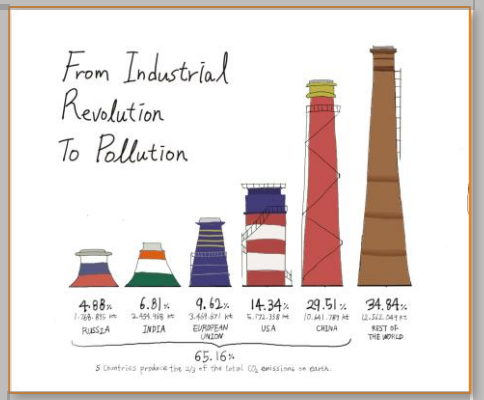


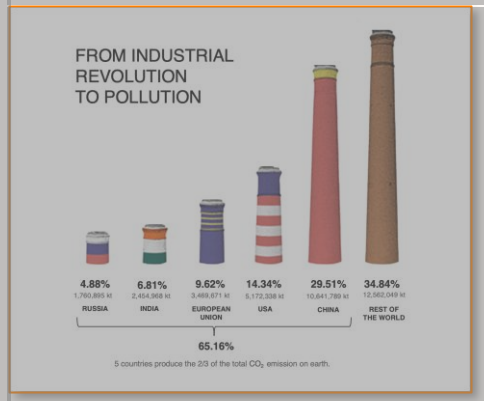


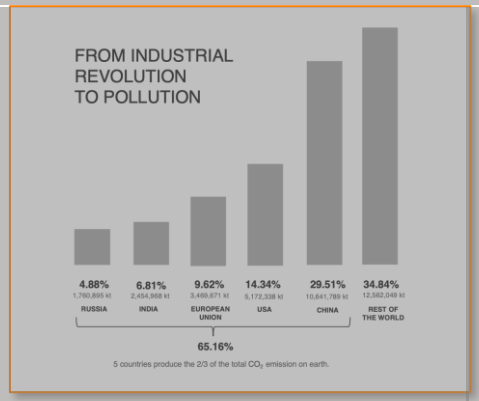
Cartoon bars style lowered credibility

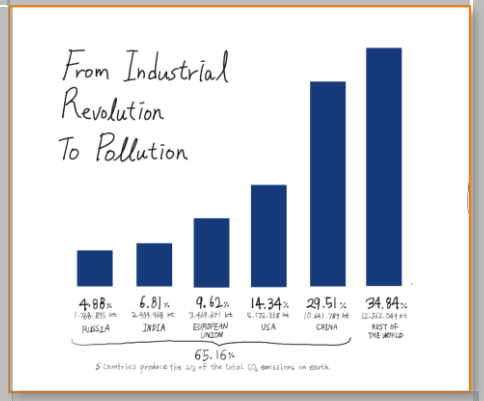












Implications

Embellishment can be incorporate without sacrificing credibility

Image-like visualizations maintained credibility comparable to **plain** charts.

Among the design elements we studied, font style and color had an impact on credibility

Hand-drawn style lowered credibility: perceived as subjective

Colors compared to grayscale enhance credibility

Implications

Audience and context should guide design

Scientific charts: minimize embellishments; avoid hand-drawn fonts and cartoon styles.

Public-facing charts: use image bars and color thoughtfully to communicate without compromising credibility.

Thanks!