

How visualization designers' assumptions can mislead in communicating with visualizations

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ABSTRACT

As the field of visualization continues to expand, understanding how visualization designers think and the kinds of assumptions they hold becomes crucial for creating and communicating clear, accurate, and impactful visualizations. In this exploratory study, we analyzed Twitter threads discussing visualization, aiming to uncover the beliefs and assumptions held by visualization designers. Utilizing 8 Twitter threads rich in discussion as case studies, we reveal the implicit assumptions that designers harbor while creating visualizations. If unaddressed, these assumptions often lead to confusion or misinterpretation. This paper discusses several strategies that designers can leverage to increase awareness about the assumptions they make. Though this study has limitations, given its reliance on inferred findings from self-reported Twitter data, it offers valuable insights for visualization design practitioners and proposes directions for future research. By addressing the issue of implicit assumptions by visualization designers, we can enhance the effectiveness and clarity of visualization communication.

Keywords: Framing, Visualization Communication, Design Cognition, Design Practice

1 INTRODUCTION

The widespread availability of data visualization tools and software has markedly increased the use of visualization as a communication medium for the general public. An increasing number of individuals, including those with limited expertise in visualization, are proactively creating, disseminating, and discussing data visualizations online. In the third week of July 2023 alone, over 15,000 tweets containing the words 'visualization,' 'datavis,' or 'dataviz' were shared, demonstrating the increased interest in this field. Furthermore, visualization conferences and workshops [1–3] now actively welcome individuals from non-traditional data visualization backgrounds such as journalists, artists, and data scientists. As this community grows, there has been a concentrated effort towards establishing guidelines, frameworks, and principles [6] to support visualization practitioners. Parsons and Shukla [17] argue that these recommendations should align with how practitioners design in real-world settings to better fit the reality of design practice. There have been efforts in understanding how practitioners work in real-world situations [4, 5, 15, 16, 21], yet much remains to be done, including understanding the tacit beliefs and assumptions that practitioners bear in mind while creating visualizations.

Assumptions frequently arise from the frames that individuals maintain. Researchers from various fields including Sociology [11], Communication [9], Economics [20], Cognitive Psychology [14], Linguistics [10], Design [13] [8], and Education [12] [18] have investigated frames, which pertain to the beliefs and assumptions (largely implicit) held by individuals. As per Lakoff [14] frames hold the

capacity to shape our thoughts and actions. Tversky and Kahneman [20] illustrated the impact of frames on our decision-making process. In the design literature, Donald Schon [19] introduced the concept of frame, emphasizing that they are largely implicit among practitioners. Dorst [7] perceives a frame as a unique viewpoint, and Kolko [13] refers to it as an "active perspective." Therefore, frames, embodied as implicit assumptions and beliefs, direct actions and behaviors, and ultimately influence the designs created by practitioners.

Given the increase in the number of practitioners in the field of data visualization, it becomes crucial to understand how designers' assumptions and beliefs influence the creation, communication, and discussion of visualizations. One of the starting points for such a study is open social media platforms such as Twitter, where visualizations are widely shared and the visualization community interacts and engages with them on a large scale. In this study, we aim to examine Twitter threads about visualization, highlighting how assumptions that designers hold can create obstacles in visualization communication. Additionally, we will explore strategies that visualization creators can employ to address such issues.

2 METHODOLOGY

For this paper, we utilized Twitter's advanced search functions to collect various threads in which data visualizations were posted and subsequently discussed by different members of the Twitter community. Our search was guided by the keywords 'datavis,' 'dataviz,' 'datavisualization,' and 'visualization,' including the hashtags for these terms, and required each tweet to have a minimum of 25 responses. This initial search yielded over 50 threads. We then filtered out irrelevant threads—those not pertaining to data visualization, lacking a specific visualization, or not in English—reducing our dataset to approximately 20 threads. We then analyzed this filtered set to identify instances of misinterpretation or miscommunication in the threads. We identified such instances if participants asked clarifying questions, offered suggestions, or questioned the insights from the original tweet. From this pool, we selected eight threads that particularly highlighted the assumptions made by the designer. While this method is not exhaustive and doesn't capture all potential discussions, it serves as a way to demonstrate how assumptions made by designers can impact visualization.

One aim of this research is to highlight the impact of assumptions made by visualization designers in causing confusion and misunderstandings in data visualization. This initial assessment investigates various issues raised by the Twitter community. Furthermore, guided by the insights from our preliminary analysis, we also propose a set of best practices. These recommendations aim to equip visualization designers with strategies to better reflect on their own assumptions while designing and communicating visualizations, thereby reducing instances of misinterpretation and miscommunication.

3 FINDINGS

3.1 Thread 1: 3D plots

In our analysis of the Thread 1 Fig. 1, we observed a case where the author stated: "*3D plots upset me so frequently that I made this teaching aid.*" It seems the author assumed the mode of presentation for such visualizations to be predominantly static.

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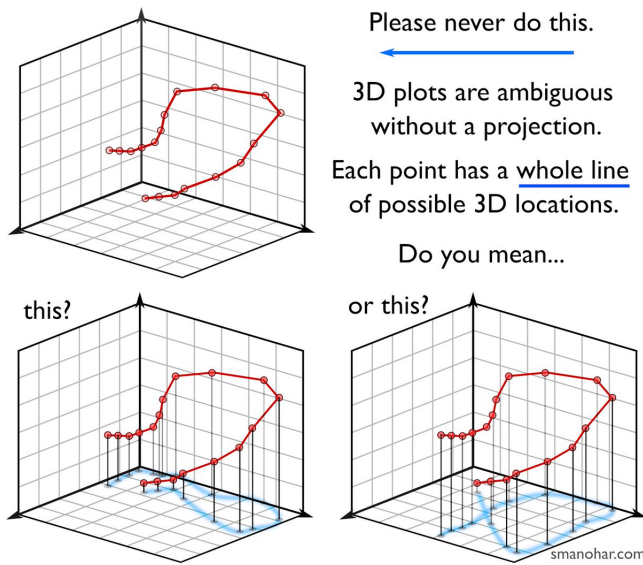


Figure 1: Visualization of 3D plots shared in Thread 1

However, this assertion was met with varying perspectives from the Twitter community. Some users suggested that the perceived ambiguity could be alleviated if the viewer had the option to manipulate the visualization, as reflected in responses like: “The main problem is that we continue to insist on supplying 3D plots as 2D projections so they can be printed out on dead trees. The ambiguity is easy to resolve if the viewer can rotate them. Even more so if they have VR/AR and can use their own depth perception”, and “I think no need for this if the graph is interactive.”

Another person underscored the utility of 3D modes in specific contexts, such as cosmography, where 3D mapping is vital, remarking, “we publish articles that provide interactive visualizations and videos, to better communicate the 3D structure.” Others sought further context for the application of 3D plots, questioning, “Ok I need context. What information or equation would you use these types of 3D plots for?”

Through this thread, it became apparent that the author made assumptions about both the mode of presentation and the potential use cases for 3D visualizations.

3.2 Thread 2: Tide visualization

Fig. 2 Thread 2 involved an author sharing a visualization with the intent to provide a “simple way to explain how high tides and low tides are caused by the moon”. However, certain users expressed that the visualization was misleading and could reinforce inaccurate assumptions, such as the belief that “... the tide only follows the moon”

Additional comments pointed out that the visualization overlooked other significant factors that influence tides, like the position of the sun, and did not mention phenomena like neap tides. Several individuals attributed these omissions to oversimplification, stating, “I believe over simplification has exaggerated things”.

In this case, the visualization designer may have unintentionally propagated a limited understanding of the causes of tides. This could be the result of adhering too strictly to a principle of simplicity, a lack of comprehensive knowledge in the field, or failing to clarify the specific purpose of the visualization.

3.3 Thread 3: Income share going to richest top 1%

Fig. 3 In the third thread, the author shared a graph depicting “how well the richest Top 1% have done across different countries over



Figure 2: Screen capture of tide visualization video in Thread 2

the past 200 years.” Here, the author appears to have made implicit assumptions about certain contextual factors, which resulted in an incomplete representation of the situation. Additionally, the author neither clearly stated the purpose of creating the visualization nor defined certain key terms, leading to confusion within the online community.

This lack of clarity prompted several users to seek further information. For instance, one comment asked, “This is only income not wealth, right? Or am I reading the chart wrong.” Others suggested that the graph might convey a misleading message, with one person suggesting, “Can you also make one for ‘share of wealth’ instead of ‘share of income’? May give a very different picture. The Netherlands, for example, has very low net income inequality. But among highest wealth inequality of any nation in the world.”

Further, a suggestion to create a comparative chart to increase its relevance was also shared: “I think the following graph which compares the income of the top 1% with the bottom 50% during the last is more informative.” One individual highlighted the importance of articulating the goal of a visualization, stating, “We have to be extremely careful when choosing the main goal, and what to measure. The main goal, IMHO, should: - NOT be to minimize the % that goes to the top 1%. - be to maximize, consistently the life improvement of the bottom 50%”

The analysis of this thread emphasizes the importance of providing a comprehensive context, clearly defining terms, and articulating the purpose of a visualization to ensure effective communication and avoid misinterpretation.

3.4 Thread 4: Percentage of people with university degree or higher

Fig. 4 In the fourth Twitter thread, the author shared a graph depicting the percentage of people holding a university degree or higher. However, community members sought more information to bolster the trustworthiness of the visualized data. A primary concern was the authenticity of the data source, leading one participant to ask, “where can I find the data you used for the map?” Another participant offered a potential clarification for perceived discrepancies in the data, stating, “Looking at Switzerland, for this to be correct, I think it must include all ‘tertiary education’, including apprenticeships not just university.”

Questions were also raised about the definition of ‘university degree’, with one person querying, “A PhD is a University degree.”

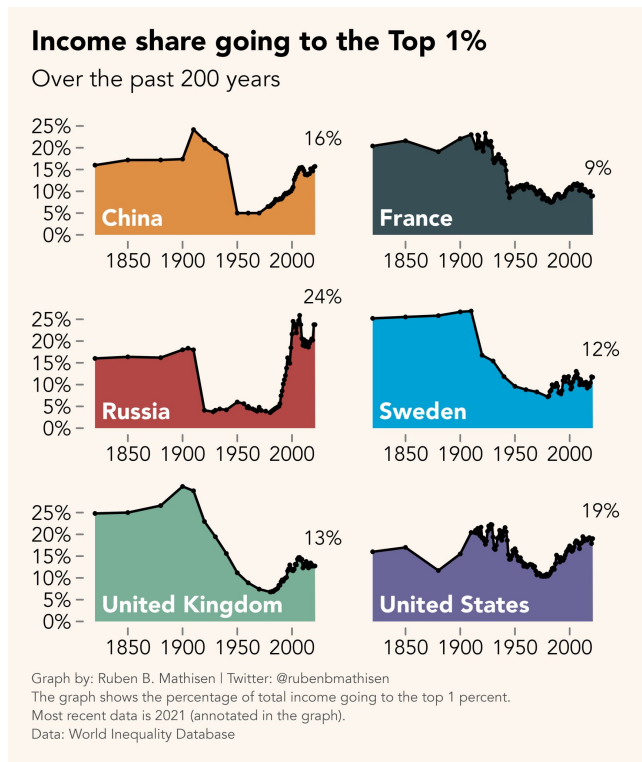


Figure 3: Visualization showing income share of top 1% over time in Thread 3

What's higher?" Another user questioned the demographic parameters of the data, remarking, *"This does not make sense if you don't indicate the age window you are referring to. If it is all the population, all values are way too high."* To this, the author responded with additional detail, specifying, *"The map shows % of adults (25-64 years) with bachelor's degree or higher"*.

From this thread, it is apparent that the author may have implicitly assumed that viewers were primarily interested in the visualization, not accounting for their desire to understand the data behind it. Moreover, the author did not initially clarify key demographic details or define certain terms, such as 'university degree', demonstrating the impact of implicit framing on the way visualization designer can create and communicate visual data.

3.5 Thread 5: Island visualized

Fig. 5 In the fifth Twitter thread, the author shared a visualization depicting the world's largest islands. However, several people questioned both the data sources and the assumed definition of 'island' applied in the visualization. One user queried, *"if Australia is being treated as an island, where is Antarctica?"* Another added, *"The island 'Eurasia' is a little bigger than both Antarctica and Australia together. So please include definitions in your maps"* This sentiment was echoed by another participant who asked, *"So the America-Asia-Europe-Africa landmass isn't an island?"*.

In addition, several users pointed out perceived omissions in the data. For instance, one person questioned, *"Why is Japan not listed? I must be missing something."* while another queried, *"Where's Sri Lanka?"*

It appears that the visualization designer in this case made assumptions about the authenticity of the data source. Moreover, the designer seems to have been guided by a colloquial understanding of 'island' rather than explicitly defining the term for the purposes of the visualization. This case emphasizes the importance of clear defi-

Population with university degree or higher in 2021*

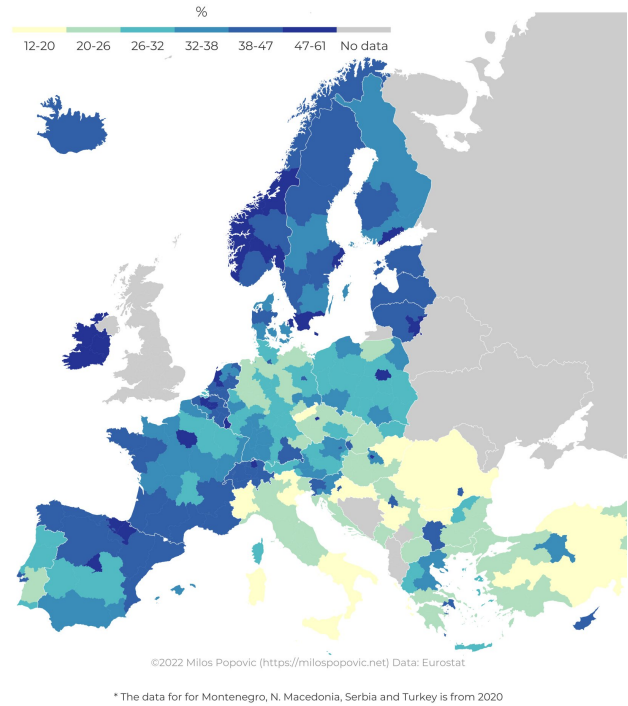


Figure 4: Visualization showing percentage of people with university degree or higher in Thread 4

nitions and thorough data vetting in ensuring accurate and effective visual communication.

3.6 Thread 6: Smartphone at work

Fig. 6 In the sixth thread, the author utilized data on phone presence at 'places of work' to illustrate when people typically go on vacation. The author noted, *"Google measures when our phones are at 'places of work', and in France, Germany, Italy and Sweden (for example) you can see a clear dip in July and August, when people go on vacation. No such dip is visible in the United States or Japan"*.

Nevertheless, numerous participants spotlighted potential limitations and biases within the data. One user remarked, *"But don't we want some way to take into account hrs/wk at the workplace, not just the decrease from normal? Have I missed this? Maybe in the US they just don't go to the work?"* Another user pointed out the recent trend of remote-working vacations, suggesting it might exaggerate the seasonal dips.

Further, some users critiqued potential biases in data selection, with one stating, *"I find this unconvincing, because you're cherry picking the 'summer holiday' period to favor France. In the US, you see very dramatic dips around July 4 and Labor Day, which fall at the periphery of what you're calling 'summer holiday' in Europe."*

This discussion underlines that the biases of visualization designers can influence data selection and thus potentially skew the narrative. Moreover, it showcases how failing to articulate potential limitations of the data can lead to miscommunication.

3.7 Thread 7: Work hour of rich vs poor

Fig. 7 In the seventh thread, the creator shared a visualization illustrating the difference in working hours between the wealthiest



Figure 5: Visualization showing the world's largest islands in Thread 5

1% and the poorest 1%, stating, “Turns out the difference in working hours between the Top 1% and Bottom 1% is only 3.4 hours per week”. However, many users questioned the dataset and the assumptions made in the visualization.

A participant asked for clarification on whether the dataset truly reflected the top 1% of the population or just the top 1% of those surveyed. Another user noted potential misleading tendencies, stating, “It seems pretty misleading to condition on working more than 35hr/week to begin with”

Moreover, numerous users criticized the title’s representation, arguing that it did not accurately reflect the data presented. One user commented, “A comparison of the working hours between fully employed rich and poor people $\neq$ a comparison of the working hours between rich and poor people. Your initial tweet and title of the graph make it sound like the latter” Another added, “Again, not wrong, but I don’t think the graph represents what the title indicates to a sufficient extent.”

The conversation here underscores the potential unconscious assumptions designers may harbor regarding their choice of dataset. Additionally, it emphasizes the crucial role of introspection on one’s own assumptions and biases while crafting key elements of a visualization, such as the title.

3.8 Thread 8: Tsunami wave caused by the asteroid

Fig. 8 In the eighth thread, the author posted a visualization displaying the impact of the Tsunami wave caused by the asteroid that hit Earth 66 million years ago. However, the visualization raised several questions from the audience, calling for additional information for better comprehension.

Some users questioned the time elapsed in the simulation and the speed of the asteroid when it hit. One participant asked for data sources that contributed to the visualization, querying, “what was in the “Geological Record” used a the data referenced in the article for this simulation?”. Numerous others expressed confusion about the visualization. Questions such as “What does the counter stand for? Time, measured in mm:ss?” and “How long would it take for that type of wave to subside?”.

Some participants pointed out further complexities and variables that could affect the visualization, with one remarking, “Am I right in saying speed and depth of water would also play a part...” Others addressed potential limitations of the visualization, like the absence of inshore wave activity, as one person mentioned, “the waves didn’t stop at the shore, but moved inland quite a distance. this sim shows none of that.”

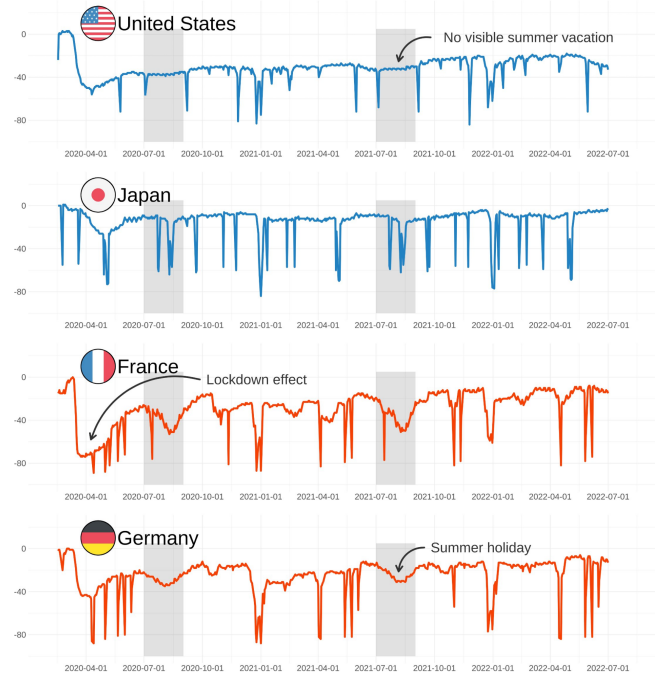


Figure 6: Visualization showing ‘smartphone at work’ in Thread 6

The dialogue underscores the necessity of sharing comprehensive details about the chosen dataset, its sources, and measurement units and actively explicating the implicit assumptions that designers might have during creating and presenting the visualization. Additionally, it emphasizes the importance of considering various interpretations and perspectives while designing visualizations and communicating effectively to foster better understanding.

4 DISCUSSION

The examination of eight Twitter threads provides a preliminary and indirect insight into the assumptions harbored by visualization designers. This analysis also highlights how such assumptions and beliefs can result in misinterpretations and misunderstandings during the interpretation of visualizations. The subsequent section details some of the assumptions held by designers that have surfaced through this study:

4.1 Assumptions held by visualization designers

4.1.1 Assumption around Definition

As highlighted in threads 4, 5, and 7, assumptions about the definition of terms used in the visualization led to miscommunication and confusion among the community. For example, participants had discussions about the lack of clarity around what ‘university degree’ means or how ‘island’ is defined.

4.1.2 Assumptions about Data

In visualization, data is critical and transparency regarding the data used is paramount. Findings from threads 2, 3, 4, 5, 6, 7, and 8 discuss assumptions regarding the nature of data. Several instances of data assumption were observed.

In thread 2, the assumption of simplicity led to an oversimplification of the relationship between the moon and tides, thereby leading to an inaccurate representation.

Threads 4 and 5 highlighted assumptions about the authenticity and completeness of data. For example, in thread 5, people ques-

Rich and Poor Work Similar Hours

Working hours are self-reported and reflect how much respondents 'actually' work in a week, including second/third jobs and overtime. Data from the United States for 8,234 respondents in the Current Population Survey (May 2022) working full-time (>35 hours/week).

Graph by: @rubenbmthisen (Twitter)

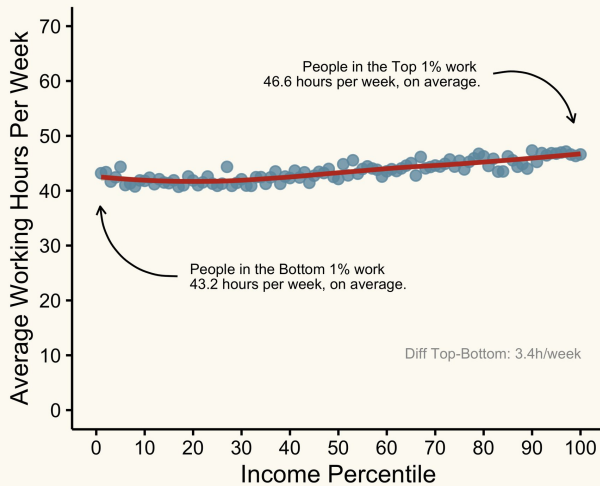


Figure 7: Visualization depicting work hour of rich vs poor in Thread 7

tioned the data as various prominent island nations like Japan and Sri Lanka were missing from the visualization.

Thread 6 highlighted assumptions around potential biases while picking up the data. For example, one of the participants in thread 6 accused the designer of “cherry-picking the ‘summer holiday’ period to favor France.”

4.1.3 Assumptions in Communication

The analysis of the threads unveiled certain assumptions that designers made while communicating the visualizations. Thread 1 spotlighted the author’s assumption about the platform of display, critiquing the use of 3D plots. However, participants in the discussion suggested that if employed in an interactive way or on an AR/VR platform, 3D plots could significantly improve comprehension.

Thread 7 also brings forward the author’s assumptions regarding the interpretation of a visualization that compared the working hours of the top 1% and the bottom 1% of earners. In practice, viewers understood it differently, eliciting a variety of responses that questioned the underlying data and the misleading nature of the title.

4.2 Impact of assumptions on visualization communication

Unexplicated implicit assumptions can significantly affect visualization communication, potentially leading to misinterpretations, misrepresentations of information, and eroding trust.

4.2.1 Misinterpretation

Implicit frames can guide designs based on the designer’s assumptions, which may in turn lead to confusion and misinterpretation of the visualization. For example, in Thread 7, the author’s assumption about the definition of ‘working hours’ for the top 1% and bottom 1% earners caused significant misunderstanding. Participants interpreted the visualization differently than the author intended, leading to confusion and questions about both the data and the visualization’s

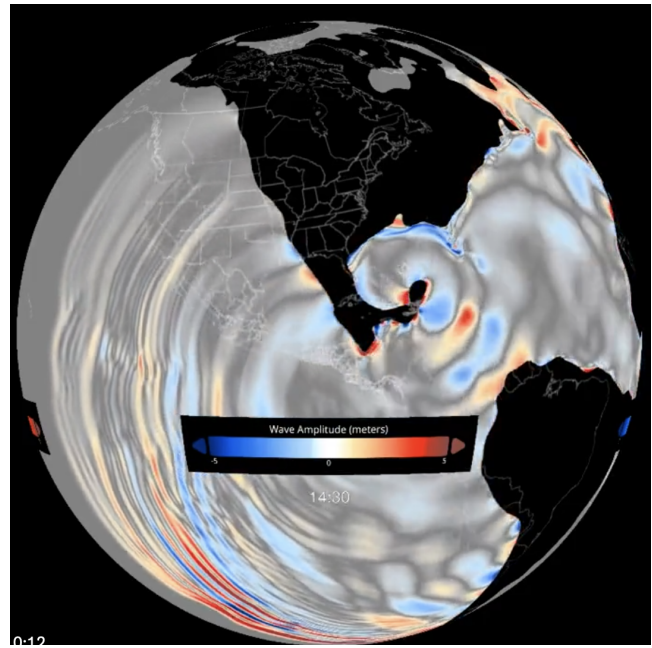


Figure 8: Visualization of Tsunami wave caused by the asteroid in Thread 8

title. A similar issue arose in Thread 4, where the term ‘university degree’ lacked clarity.

4.2.2 Misrepresentation of information

Designs that are built on unspoken assumptions about the data can result in distortions. For instance, in Thread 2, an oversimplified portrayal of the moon-tide relationship led to a flawed representation of reality. Likewise, Thread 6 drew attention to a perceived bias in selecting data, described as “cherry-picking data favorable to France,” calling into question the credibility and reliability of the visualization.

4.2.3 Undermine trust

Implicit assumptions can also undermine the viewer’s trust in the visualization. When the data source is not explicitly stated or when the data appears incomplete or biased (as in Threads 4, 5, and 6), the audience may question the visualization’s credibility. For instance, in Thread 5, the omission of prominent islands from the visualization led to questions about the completeness of the data, thereby undermining the audience’s trust in the visualization.

4.3 Strategies to become aware of implicit assumptions

The analysis of the threads above underscores the crucial role of recognizing implicit assumptions and beliefs in bringing clarity and efficacy to visualizations. We’re presenting some of the strategies that can aid visualization designers in enhancing this awareness:

4.3.1 Maintaining Transparency

One of the key strategies involve fostering transparency about the data source, any biases, domain expertise, and the level of knowledge on the topic being visualized. Instances from threads 4, 5, and 6 where participants questioned the authenticity and completeness of data suggest that transparency about the data source could foster greater trust in the visualization.

4.3.2 Practicing active reflection

Developing the habit of being reflective can help identify any inherent biases and promote a more holistic understanding of the various ways in which a visualization may be interpreted or misinterpreted. For instance, in thread 6, accusations of bias in data selection could have been mitigated through more reflective practices.

4.3.3 Communicating with intent

Defining and conveying the purpose of creating a visualization is another strategy that can help expose potential assumptions of designers. For example, in thread 7, misinterpretation arose because of unclear purpose, suggesting that the visualization intended to compare working hours among fully employed rich and poor people, not all rich and poor people.

4.3.4 Providing ample information

Offering sufficient information can dispel ambiguity. This was evident in thread 4, where confusion arose due to an unclear definition of 'university degree.' In numerous threads, including 6, 7, and 8, further details shared by the author helped dispel confusion surrounding the visualization.

4.3.5 Engaging in iteration and feedback

Actively engaging with the audience, seeking their feedback, and integrating it into the visualization can help reveal the designer's implicit assumptions and beliefs. This was evident in Threads 7 and 8, where the authors directly engaged with audience questions and concerns. Such engagement enabled the authors to scrutinize and question their own assumptions, thus enhancing the communication surrounding the visualization.

5 CONCLUSION

Our preliminary analysis of eight Twitter threads has demonstrated that interpretation of data visualizations can be negatively influenced by the implicit assumption, beliefs, and perspectives held by designers, that may lead to miscommunication and misunderstanding. Our findings underscore the importance of transparency and reflection by designers in the visualization process. Sharing data sources explicitly, defining terms, acknowledging limitations, and engaging in active reflection can help uncover and mitigate these implicit assumptions. Equally crucial is the practice of actively engaging with the audience, gathering their feedback, and being open to iterating the visualization based on their insights. This participatory approach can lead to richer, more nuanced visualizations that effectively communicate their intended message. By shedding light on these implicit assumptions, this study aims to encourage visualization designers to delve deeper into their own perspectives and biases. Understanding these nuances can aid in creating more effective, accessible, and accurate visual representations, fostering improved communication.

This study does possess several limitations. Firstly, it is reliant on self-reported data from Twitter, which does not allow for a direct examination of the implicit frames and assumptions that reside within the mind of a data visualization designer. The deductions about these frames and assumptions are largely subjective, depending heavily on the researchers' interpretation. In the future, a more comprehensive understanding of these implicit assumptions could be obtained by studying design practice using various methodological approaches. These could include 'think-aloud' protocol studies, direct observations, interviews, or diary studies, providing a deeper insight into the mindset of data visualization practitioners. Such future research endeavors would undoubtedly prove valuable in illuminating assumptions and implicit frames. By increasing our awareness and addressing these unspoken assumptions, we can take a meaningful stride towards improving the efficacy and transparency of data visualization and its communication.

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