

Exploring Annotation Strategies in Professional Visualizations: Insights from Prominent US News Portals

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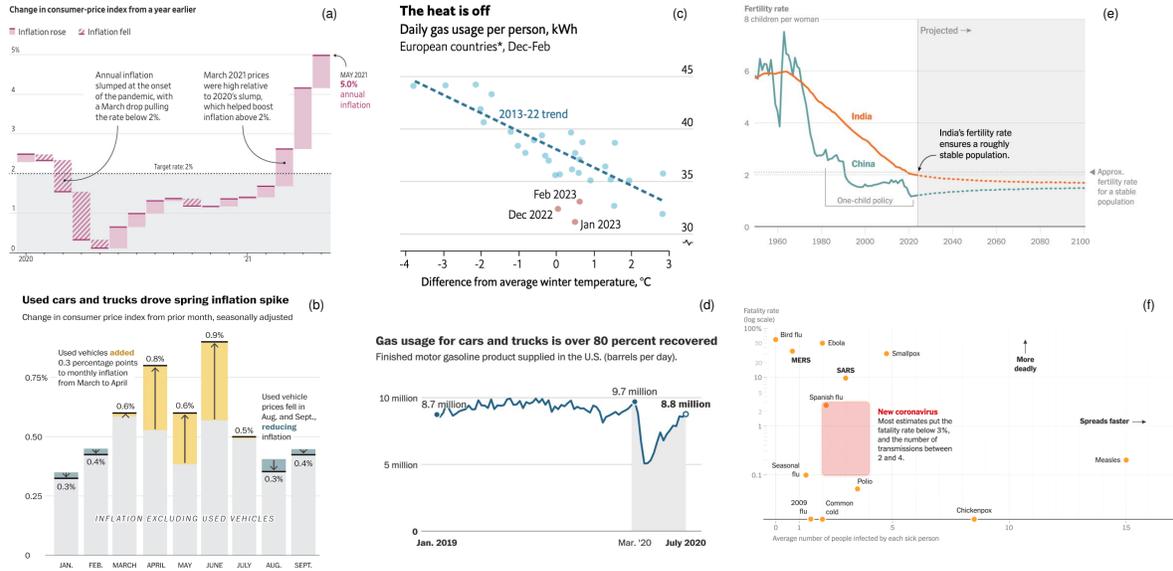


Fig. 1: Examples of annotated professional charts used in prominent US news portals, including (a) a waterfall chart (i.e., a variant of a bar chart) utilizing gray highlights, connectors, and text descriptions; (b) a bar chart with directional marks, value text, descriptions, and context-specific color highlighting; (c) a scatterplot featuring a trend line and text; (d) a line chart with context-specific highlighting and value text; (e) another line chart using text descriptions, connectors, enclosures, and context-specific highlighting; and (f) a scatterplot with context-specific highlighting, data point labels, and a text description.

Abstract— Annotations play a vital role in visualizations, providing valuable insights and focusing attention on critical visual elements. This study analyzes a curated corpus of 72 professionally designed static charts with annotations from prominent US news portals including *The New York Times*, *The Economists*, *The Wall Street Journal*, and *The Washington Post*. The analysis employed a qualitative approach involving identifying annotation types, assessing their frequency, exploring annotation combinations, categorizing text quantity, and examining the relationship between chart captions and annotations. The analysis reveals common patterns in annotation strategies used by professionals, including extensive use of annotations aligned with chart captions, targeted highlighting and descriptive text within charts, strategic utilization of multiple annotations as ensembles, and emphasis on article-related numerical values. These findings provide valuable guidance for improving annotation practices, tools, and methodologies, enhancing data comprehension and communication in visualizations.

Index Terms—Annotations, Visualization design, Visualization techniques, Professional practices

1 INTRODUCTION

Annotations are essential for better interpretation and understanding of data in visualizations. Studies demonstrated visualizations that contain annotations help viewers' mental organization [3]. Past studies have also identified annotation as one of the "critical tasks that enable iterative visual analysis" [11, 43].

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There has been, however, limited study of what strategies are employed by visualization professionals when designing and annotating charts to optimize clarity and effectiveness. This knowledge holds significant importance for several reasons. First, visualization professionals possess specialized knowledge and expertise about effectively communicating data. By thoroughly examining their strategies and techniques, we can derive best practices that potentially enhance the clarity and effectiveness of visualizations using annotation. Secondly, gaining insight into professionals' annotation practices contributes to enhancing the user experience by informing the design of intuitive and informative annotations that facilitate users' interpretation and interaction with the data, including the selection of relevant annotation types, the use of explanatory labels, and the thoughtful sequencing of annotations to guide the viewer's attention. Understanding and applying these practices enable us to harness the storytelling and narrative potential of annotations and further enhance the interpretability and communicative power of visualizations.

In light of the numerous insights associated with understanding how professionals annotate visualizations, this paper focuses on investigating the various techniques employed by visualization professionals to enhance the communicative and expressive nature of their visualizations through annotations. To accomplish this, we assembled a corpus of professional charts from four prominent US news portals, encompassing diverse chart types. These charts were systematically coded using the design space framework proposed by Rahman et al. [28]. By systematically analyzing the corpus of professional charts, we aim to uncover common patterns, gaining valuable insights that inform the development of effective annotation practices for creating impactful and informative visualizations.

This paper contributes a comprehensive analysis and insights learned from professional annotation practices. Our findings showed that professionals extensively employ annotations in their charts, utilizing context-specific highlighting with colors to emphasize areas of interest. They also incorporate relevant details from related articles to enhance clarity. Additionally, there is a consistent relationship between the annotations and chart captions and a tendency to emphasize article-related numbers within the charts, facilitating easy comprehension of numerical values. These insights offer valuable guidance for developing annotation practices that enhance the effectiveness and clarity of visualizations, empowering practitioners to create compelling charts that effectively communicate information to their audience.

2 RELATED WORK

Annotations draw attention to critical parts of a visualization to help externalize and explore data [19, 26, 36, 37] and facilitate collaborative data analysis [4, 5, 16, 26, 33].

Annotation Techniques Annotations in visualizations are external cues that use various visual marks to highlight focal points. Kong et al. introduced graphical overlays, such as reference structures, highlights, redundant encodings, summary statistics, and annotations, which aid readers in tasks and can be applied to existing charts [20, 22]. Chen et al. presented TouchtoAnnotate, a technique and prototype for creating annotations in a multi-touch interface with minimal human effort [6]. Free-form ink annotations, including circles, lines, arrows, and text, effectively highlight visually salient features during asynchronous collaborations [21]. Other studies have explored annotations in visualization design, including contextual linking of text and interactive graphics [24], expressing chart construction errors to a lay audience [13], and optimizing bar chart layout using annotations on trends in bar heights and text values [31]. Moreover, Rahman et al. conducted a study on visualization students' annotation practices with grouped bar charts, where they identified five main annotation types – enclosure, connector, text, mark, and color used in response to high-level chart-related questions [29, 30].

Externalization, Communication, and Collaboration Annotations serve as a crucial component of visual data analysis, highlighting significant data facts [19, 43]. They aid in externalizing analysts' thought processes, supporting meta-analysis and data exploration, and are particularly valuable in generating insight reports, such as the VisInReport tool, which utilizes annotations to clarify events in different views [36]. Captions and annotated text have proven effective in communicating visual information [1], with readers often preferring a combination of text and charts. However, users tend to rely primarily on text and struggle to integrate information across visualizations [27]. In terms of collaboration, annotations play a role in externalizing thoughts, facilitating discussions, and enhancing exploratory data analysis [4, 26, 33, 42]. Tools like Click2Annotate enable the creation of rich annotations, while sketching tools and systems like CAV and UberTagger support collaborative data analysis by allowing annotation and communication among team members [2, 5, 7, 9, 38]. The selection and placement of annotations significantly impact comprehension and interpretation [40].

Applications Utilizing Annotation Annotations are widely incorporated into applications to support analysis documentation and

promote social interaction. Jigsaw facilitates annotations during investigative analysis [18, 39], while CzSaw supports decision-making documentation [17]. Sense.us employs graphical annotations for collaborative data analysis [12], and Many Eyes allows association of textual and graphical annotations in interactive visualizations [41]. Annotations play a crucial role in data-driven storytelling, guiding viewers to relevant data [14, 23, 25, 34, 35]. ChartAccent enables creating data-driven stories [32], while Contextifier adds context messages to annotated line graphs [15]. Perception tests by Chun et al. analyze the impact of annotation forms in news visualizations [8]. Additionally, annotations have been applied for detecting deception in line charts [10].

Annotations are a crucial component of visual data analysis, facilitating data exploration, collaborative analysis, and effective communication. While there have been several studies examining various facets of annotations, there is still a need for a systematic investigation into how professionals annotate charts. Understanding professionals' annotation practices is essential for identifying effective techniques and guidelines to enhance data comprehension and improve visual representations. By closing this gap in knowledge, we can advance annotation techniques and ultimately improve the quality and impact of visualizations.

3 BACKGROUND OF THE METHODOLOGY

In our previous research, where we developed a taxonomy and design framework that encompasses common annotation practices in various chart types [28], we defined *annotations* as “*supplementary elements, such as graphical shapes, text, or color, added to a visualization to provide additional context beyond the basic data presented, and to draw attention to specific portions or elements of the data, thereby enhancing the understandability and expressiveness of the visualization*”. We began by conducting a focused pilot study on grouped bar charts, which allowed us to establish a taxonomy of annotations. Building upon this foundation, we extensively investigated diverse chart types to gain deeper insights into the annotation techniques used by individuals. Through this thorough investigation, we identified a design space demonstrating the widespread application of annotations across different chart types. In our analysis, we utilize two main aspects of the design space, namely the annotation types and annotation ensembles.

Annotation Type Within our proposed design space, we have identified and categorized seven distinct annotation types: *Enclosure*, *Connector*, *Text*, *Mark*, *Color*, *Trend*, and *Geometric*.

- The *Enclosure* annotation employs partially or fully closed boundaries, e.g., ellipses, brackets, and rectangles.
- The *Connector* annotation utilizes lines, including solid, dotted, and directional lines (i.e., arrows).
- The *Text* annotation involves using words or sentences to convey information about the data. Text annotations usually are used on the charts to provide additional context to clarify things.
- The *Mark* annotation utilizes symbols or shapes to identify specific objects or categories within the data. It plays a role in visually distinguishing elements such as counties or dates.
- *Color* annotations leverage color properties, predominantly hue, to convey data-related information. They mainly highlight a certain area of interest or visual elements.
- The *Trend* annotation denotes various trends present in the data, such as correlations in scatterplots or changes in values over time or across different categories on a bar chart.
- The *Geometric* annotation encompasses geometric operations, including the enlargement of specific areas or segments within charts. For instance, this annotation type can be applied to highlight a specific segment of a pie chart or enlarge a portion of a chart to emphasize its significance.

Annotation Ensembles In the same research, we introduced the concept of an ensemble of annotations. We observed that individuals relied on combining multiple annotations when a single annotation type proved inadequate to convey the intended information effectively.

Our current research analyzes professional charts to identify common patterns and techniques experts use. Specifically, we examine the annotation types identified in our previous research and investigate how

professionals use them in chart designs. This investigation allows us to gain insights into the potentially effective techniques commonly used by professionals when utilizing annotations in their visualizations.

4 METHODOLOGY & STUDY

Our study aimed to understand how visualization professionals annotate charts when they design visualizations. To do this, we collected and analyzed a corpus of professional charts from different sources. We then performed qualitative analysis on that corpus of professional visualizations.

4.1 Chart Collection

We gathered charts from four popular US news portals – *The New York Times*, *The Economist*, *The Wall Street Journal*, and *The Washington Post*. These charts were collected manually within the past five years, excluding those from 2017 or earlier. Our selection process entailed thoroughly evaluating the graphic sections within the selected news portals, enabling us to identify articles featuring charts relevant to our study. Using our annotation design space as a guide, we ultimately chose 118 charts that exhibited some form of annotation. We observed that most of the charts belonged to one of three main categories: bar charts, line charts, or scatterplots, and there were very few charts that fell outside of these categories. Consequently, we focused our analysis exclusively on these chart types and removed any charts that did not fit into these categories from our chart corpus. Furthermore, we excluded charts with dynamic components, as our study focused on static charts. As a result, we obtained a set of 72 professionally designed static charts with annotations.

4.2 Analysis

We conducted a qualitative analysis of the collected corpus of professional charts in order to gain comprehensive insights.

To begin with, we examined the different types of annotations employed by professionals in the charts (i.e., text, connectors, enclosures, marks, colors, etc.) and the frequency of their presence in the charts. Additionally, we explored the frequency of distinct annotations used in each chart. Next, we delved into the professionals’ usage of different combinations of annotations, which we refer to as ensembles of annotations. We also observed the variety of distinct ensembles of annotations employed in the charts.

We then analyzed the quantity of text present when professionals utilized text annotations in various forms within the charts. We categorized the amount of text as either low, medium, or high, with low denoting individual words, medium representing phrases, and high indicating complete sentences. In addition, we closely examined the relationship between the captions and annotations used in the charts. To achieve this, we thoroughly read the associated article and caption to identify the intended message. Subsequently, we carefully investigated the connection between the article’s caption and the annotations used in each chart. We also documented qualitative observations that shed light on how the annotations and ensembles of annotations were employed in the charts, providing further clarification on the role of these annotations within the chart’s context.

This comprehensive examination allowed us to assess how the annotations complemented and reinforced the intended message, establishing a coherent narrative between the visual and textual components. Additionally, it provided valuable insights into the intricate details of annotation usage in professional charts. All the charts and data are available here: <https://osf.io/spmv8/>

5 EVALUATION

In this section, we explore the annotation strategies utilized by visualization professionals, such as ensemble annotations, context-specific highlighting, article-specific descriptions within charts, the relationship between annotations and captions, and the emphasis on significant numerical information. These insights provide valuable perspectives on design choices that enhance a visualizations’ clarity and effectiveness, offering the possibility of more effective communication through well-crafted annotations.

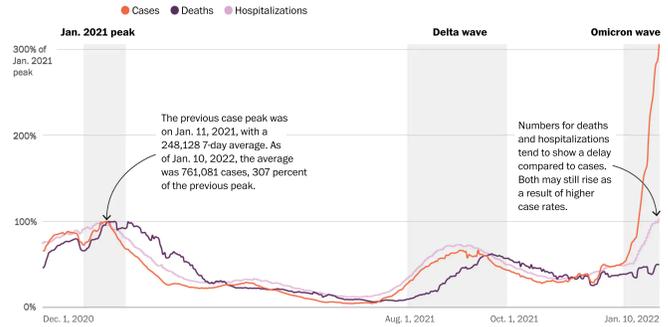


Fig. 2: The figure illustrates a line chart where context-specific gray highlighting is applied, providing visual cues for specific area of interest. Also, descriptive text and connectors are employed as annotation ensembles to enhance the comprehensibility of the chart.

5.1 Abundant Use of Ensembles

The analysis of charts reveals a prevalent and significant utilization of ensemble annotations. For instance, in *Figure 1a*, connectors such as lines and arrows are employed in conjunction with text descriptions to establish connections between points of interest on the chart and their corresponding textual explanations. Similarly, *Figure 1b* demonstrates the use of color (i.e., highlighting) to emphasize points of interest while accompanying text provides further context regarding the highlighted area of the chart. In *Figure 2*, a similar approach is observed, where gray highlighting is utilized to highlight areas of interest, and text descriptions, along with connectors in the form of arrows, are employed to convey pertinent details related to the article. This combination of connectors and text descriptions is also evident in *Figure 4*. In *Figure 3*, a distinct approach is observed, where a line is employed to delineate visual elements on the bar chart, while the associated text is used to describe the contextual aspects of the separation. It is worth noting that instances where only a single annotation is used, are exceedingly rare; most cases involve the utilization of annotations in ensembles.

Design Implications The prevalent use of ensembles of annotations in professional charts suggests their potential value in clarifying and enhancing communication. Professionals utilize these ensembles to combine multiple annotation types, which may help to clarify complex information and improve the overall understanding of the visualizations. While the exact effectiveness of ensembles of annotations is not directly assessed in our research, their widespread usage by professionals indicates their potential utility in facilitating more precise and effective communication.

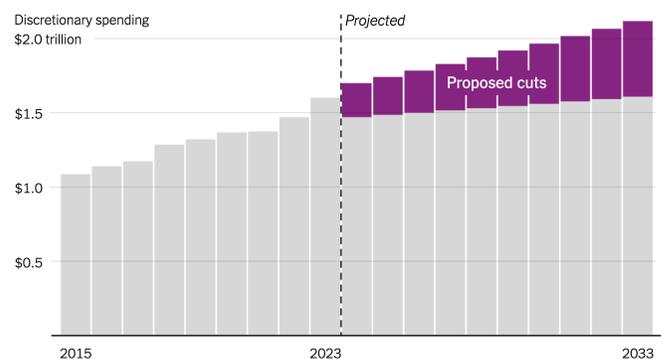


Fig. 3: The figure presents a bar chart in which a dotted line connector and textual elements are utilized to differentiate visual components within the chart. Additionally, colored highlighting is employed to emphasize relevant visual elements corresponding to the focus of the associated article.

5.2 Context-Specific Highlighting

We consistently observed the application of context-specific highlighting within the charts we analyzed. The most common highlighting technique involved the use of shades of different colors or the use of different shapes to draw viewers' attention to article-related details within the charts. For instance, in [Figure 2](#), which represents data on different variants of Covid-19, the chart was accompanied by an article from *The Washington Post* discussing the reduced number of deaths and hospitalizations attributed to the Omicron variant, despite a significant increase in Omicron cases compared to other variants. To enhance the reader's comprehension of the article, specific portions of the line chart were highlighted using lighter shades, particularly light gray, to draw attention to the peaks of various waves. This visual emphasis facilitated a direct connection between the article's content and the chart, enabling readers to grasp the information more effectively. Similarly, in [Figure 3](#), a bar chart was presented alongside an article from *The New York Times* discussing a bill passed by House Republicans. The bill aimed to curtail federal spending by implementing spending caps on discretionary programs. The article highlighted that defense, veterans' health care, Medicare, and Social Security were protected from cuts. To provide readers with a clearer understanding of the bill's impact, the chart employed violet highlighting to indicate the amount of reduction in different years. This visual aid served to augment readers' comprehension of the article, assisting in the assimilation of the information regarding the bill and its projected impact on federal spending over the next ten years, starting from 2023.

Design Implications The inclusion of context-specific highlighting in professional charts underscores its potential importance in improving understanding and conveying information effectively. Professionals strategically utilize shades of different colors to emphasize key details, aiming to facilitate a deeper understanding of the accompanying articles or narratives. While our research does not directly assess the effectiveness of context-specific highlighting, its widespread adoption suggests its potential to enhance information assimilation and overall chart comprehension. By employing color to draw attention to specific areas or data points, professionals establish a stronger connection between the chart and its associated content, enabling readers to grasp the information more effectively. Thus, the prevalent use of context-specific highlighting highlights its potential value in enhancing clarity and facilitating effective communication in professional charts.

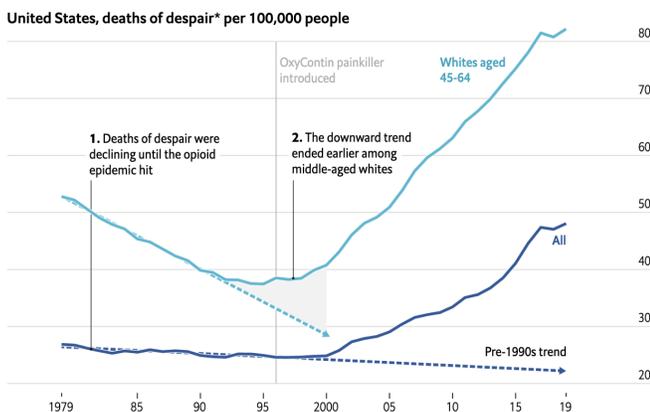


Fig. 4: The figure illustrates a line chart featuring connector-text ensembles that incorporate descriptions of important article-related facts and highlight a specific event at a designated point in time. Gray highlighting is used to convey context-specific information related to the article.

5.3 Article-Specific Descriptions

In addition to incorporating context-specific highlighting, we have observed a considerable inclusion of article-specific details within charts using text. Chart designers have strategically integrated descriptions of key points from the articles into the charts, either to reinforce the main

arguments presented in the articles or to emphasize specific points of interest. For instance, in [Figure 1a](#) sourced from *The Wall Street Journal*, a portion of the corresponding article discusses the significance of the base effect, specifically focusing on how the Covid-19 pandemic resulted in a temporary decrease in inflation below a certain threshold, followed by a subsequent increase in inflation the following year. This portrayal illustrates the impact of an economic anomaly. To elucidate this concept, the waterfall chart, a specialized variant of a bar chart, incorporates text descriptions directly related to the aforementioned article content. By doing so, the chart facilitates a clear connection for readers, allowing them to relate back to the content of the article easily. Similarly, in [Figure 2](#) obtained from *The Washington Post*, the text descriptions accompanying the line chart at various peaks of the Covid-19 pandemic provide information on total cases, deaths, and hospitalizations. This data explains how the omicron variant resulted in comparatively fewer deaths and hospitalizations compared to previous peaks, taking into account the total number of Covid-19 cases. These text descriptions further establish a link to the corresponding article's content. Furthermore, [Figure 4](#) sourced from *The Economist* employs text descriptions within the chart to expound on the number of deaths of despair per 100,000 people in the United States over the years, commencing from 1979. The chart provides a comprehensive visualization that complements the related article's depiction by incorporating these text descriptions.

Design Implications The integration of article-specific descriptions within charts is vital in enhancing the effectiveness of professional visualizations. The widespread utilization of article-specific descriptions signifies their potential value in providing additional context and facilitating a deeper understanding of the article's content. These descriptions within charts contribute to a more comprehensive visualization, enabling readers to establish stronger connections between the textual narrative and the visual representation. Thus, the significant inclusion of article-specific descriptions in charts emphasizes their importance in facilitating communication and reinforcing critical points conveyed by professional visualizations.

5.4 Relation Between Captions and Annotations

We have observed a consistent pattern in professional visualizations with captions. Typically, the captions are closely related to the annotations used in the visualizations, and the annotations used in the charts support the general message of the captions. This trend was evident across most of the charts we examined. For example, in the bar chart in [Figure 1a](#) from *The Wall Street Journal*, the caption provides a hint about the change in consumer-price index compared to the previous year. The annotations in the chart clearly depict the fluctuations in inflation for 2020 and 2021, aligning with the caption's message. The gray highlighted area emphasizes the target rate of change, while the text with connectors describes whether the inflation rate is below or above 2%. Similarly, in the bar chart in [Figure 1b](#) from *The Washington Post*, the caption states that used car and truck prices have significantly contributed to the overall increase in inflation this year. The annotations in the chart support this message by explaining the impact of these prices on inflation. The arrow-like marks illustrate changes in the consumer price index, reinforcing the caption's main point. Additionally, in the line chart in [Figure 1d](#) from *The Washington Post*, the caption describes the recovery of gas usage for cars and trucks without specifying a timeframe. The annotations in the chart strongly support this narrative. The gray highlighting filters out the area of interest, while the text displays different values related to gas usage, making the changes in gas consumption evident.

Design Implications The consistent pattern observed in professional visualizations, where the captions are closely related to the annotations used in the charts, holds significant importance. This finding underscores the deliberate alignment between the textual and visual components of the charts, emphasizing a coherent and reinforcing narrative. By closely examining the relationship between captions and annotations, we gain valuable insights into how professionals craft visualizations to convey the intended message effectively. This alignment enhances the overall comprehension and impact of the visualizations,

ensuring that viewers can readily grasp the key messages conveyed by the charts. As such, this finding highlights the critical role of aligning captions and annotations in creating visually engaging and informative charts.

5.5 Emphasizing Numbers

We have observed a consistent tendency to emphasize significant numerical information about articles in our investigation. This is evident through explicit mentions of numbers within the charts, which clarify specific facts and reinforce the article's narrative. An illustrative example is depicted in Figure 2, a line chart sourced from *The Washington Post*, presenting data on Covid-19 cases for different variants. The chart includes textual descriptions that explicitly highlight numbers, such as the 7-day average of various peaks and their comparative changes, directly supporting the article's storyline. Such annotations are prevalent throughout our collected chart corpus. Furthermore, we noticed instances where numbers are explicitly provided within the charts, even when a clear axis is available for numerical reference. This deliberate inclusion serves to reinforce the significance of these numbers in comprehending the article's narrative. For instance, Figure 1d displays a line chart from *The Washington Post*, illustrating the pattern of gas usage for cars and trucks from January 2019 to July 2020. Despite the availability of circular marks on the line and the accompanying left axis, the chart includes explicit numerical values for different points within the given time frame.

Design Implications The consistent emphasis on significant numerical information within charts by visualization professionals holds paramount importance. By strategically highlighting these numerical values within the charts, professionals effectively enhance readers' comprehension and underscore the significance of the numerical information concerning the overarching storyline. This prevalent use of annotations is a testament to professionals' unwavering commitment to providing numerical clarity, even in the presence of readily available reference axes. These findings underscore the professionals' meticulous efforts in conveying the article's narrative by deliberately utilizing explicit numerical values within their visualizations.

6 DISCUSSION

Balancing Complexity We observed that visualization professionals are committed to the principle of simplifying complex information without oversimplifying, aligning with Einstein's famous quote – "Everything should be made as simple as possible, but not simpler". Through strategic annotation techniques, professionals simplify complex information while maintaining accuracy.

Visualization professionals demonstrated a balanced approach to simplifying complex charts while avoiding excessive simplification. When a specific portion of a chart was deemed necessary based on the corresponding article, professionals used highlighting techniques to draw attention to that particular area. By selectively highlighting the most relevant portions related to the article's message, they simplified chart comprehension without going overboard with unnecessary highlighting. Similarly, when incorporating text descriptions in their charts, professionals focused on the article's central idea. They did not overload the charts with excessive details but included only the pertinent information necessary to convey the article's central message. This approach ensured that they did not oversimplify the content while still achieving the goal of making it understandable and straightforward for their audience.

Although our research did not directly evaluate the intentions of visualization professionals, their approach suggests a mindful consideration of cognitive load. By carefully selecting and incorporating annotations, professionals create visualizations that prioritize key information, minimize distractions, and streamline comprehension. The observed patterns indicate a deliberate effort to balance simplification and complexity, reducing the cognitive burden and enhancing the clarity and effectiveness of visual communication.

Implications for Effective Visualization Design The findings of our investigation have significant implications for effective visualization design.

- The prevalent use of ensemble annotations, such as connectors, color highlighting, and text descriptions, demonstrates the effectiveness of combining multiple annotation types to simplify complex information and improve understanding.
- Context-specific highlighting techniques draw attention to article-related details within the charts, enhancing information assimilation.
- The integration of article-specific descriptions reinforces key arguments and facilitates a deeper understanding of the content.
- By aligning captions with annotations and considering cognitive load, professionals can optimize information assimilation and deliver meaningful insights.
- Emphasizing numerical information through explicit mentions and inclusion of numerical values enhances clarity and reinforces the narrative.

These findings highlight the importance of thoughtful annotation strategies in creating clear and impactful visualizations. Incorporating these findings into visualization design enables professionals to effectively communicate complex data, engage audiences, and facilitate better understanding.

Limitations Our findings are limited to static visualizations, and further investigation is needed to explore the application of these strategies in interactive or dynamic visualizations. Additionally, it is crucial to note that our study did not directly assess the effectiveness of the identified strategies in different contexts. While our research provides valuable insights into the strategies employed by visualization professionals, their effectiveness may vary depending on the specific scenario or audience. It is also important to acknowledge that we did not have direct input from professionals in our study.

7 FUTURE WORK AND CONCLUSION

Future Work Looking forward, a crucial step is evaluating identified annotation strategies across diverse scenarios through rigorous user experiments. This approach can reveal how various annotation techniques impact distinct audiences and chart types, enhancing data comprehension and communication. Further, conducting in-depth interviews with visualization professionals offers insights into their rationale for specific annotation strategies. This qualitative strategy will uncover decision-making processes, reinforcing the strategies' significance. A final promising avenue is exploring annotation integration within dynamic visualizations and across chart types. Investigating how annotations adapt to evolving data and interact with diverse visualization formats enhances their flexibility and relevance. Additionally, delving into how annotation strategies resonate with different user groups, including those with varying familiarity with visualization techniques, provides a comprehensive understanding of their universality and potential customization.

Conclusion Our study provides valuable insights into optimizing chart annotations, leading to enhanced data communication and comprehension. By analyzing a curated corpus of professional charts, we have gained an understanding of the strategies employed by visualization professionals to utilize annotations effectively. This research is important as annotations can play a role in bridging the gap between raw data and meaningful interpretations, potentially facilitating understanding, insight generation, and enhancing the user experience.

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