Frames and Slants in Titles of Visualizations on Controversial Topics

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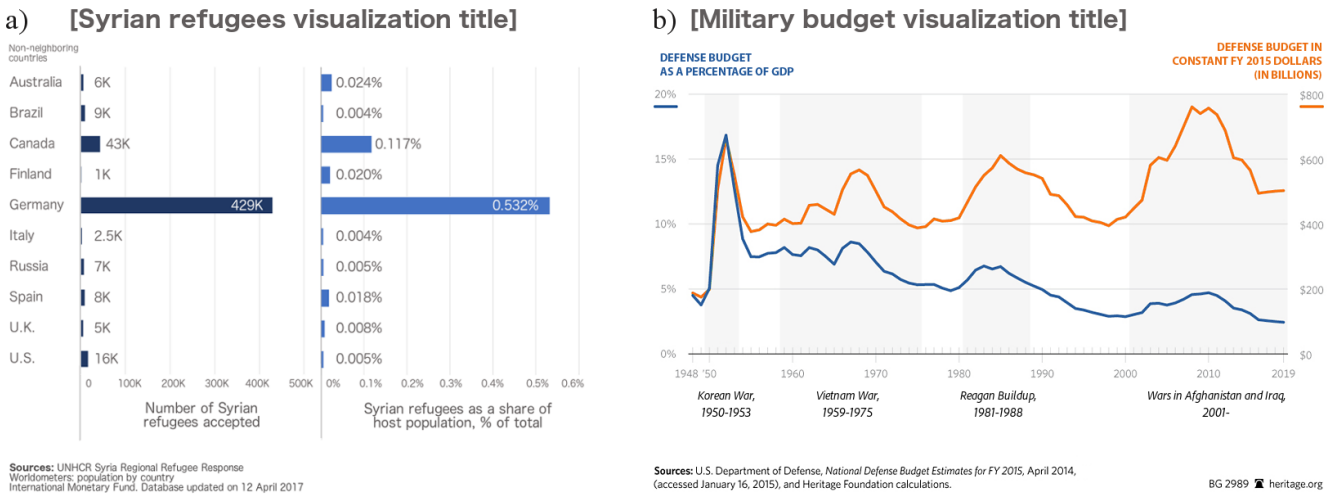

Figure 1: Two visualizations on popular foreign policies that show two variables supporting opposite sides of the policy.
a) shows the number of Syrian refugees accepted in each country and Syrian refugees as a share of host population
Policy: The United States should increase the number of Syrian refugees admitted.
Supporting title: U.S. has accepted a lower percentage of Syrian refugees than the U.K., Spain, Finland, and Australia
Non-supporting title: U.S. has accepted more Syrian refugees than the U.K., Italy, Russia, and Finland combined

b) shows the U.S. defense budget in the last 50 years in constant fiscal year 2015 dollars and as a percentage of GDP
Policy: The United States should increase its military budget to fight ISIS.
Supporting title: Defense budget on a steady decrease as a percentage of GDP over the past 50 years
Non-supporting title: Defense budget on an increase in constant dollars heading towards $500 billion by 2019

ABSTRACT
Slanted framing in news article titles induce bias and influence recall. While recent studies found that viewers focus extensively on titles when reading visualizations, the impact of titles on visualization interpretation remains underexplored. We study frames in visualization titles, and how the slanted framing of titles and the viewer's pre-existing attitude impact recall, perception of bias, and change of attitude. When asked to compose visualization titles in our first study, people used five existing news frames, an open-ended frame, and a statistics frame. In our second study, we found that the slant of the title influenced the perceived main message of a visualization, with viewers deriving opposing messages from the same visualization. The results did not show any significant effect on attitude change. We highlight the danger of subtle statistics frames and viewers' unwarranted conviction of the neutrality of visualizations. Finally, we present design implications for the generation and viewing of visualization titles.

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords
Frame; visualization title; bias; attitude change

INTRODUCTION
Titles of visualizations are comparable to headlines of news articles in their importance in the comprehension and recall of information [4]. Exaggerated news article headlines are prominent, and they are often slanted or less neutral than the accompanying articles, sometimes to the point of misrepresenting the article [1]. An extreme form of misleading titles, click-bait titles frame the most provocative material to grab attention. Frames are devices that highlight one aspect of information over another and may or may not be slanted. Similar to news article headlines, visualization titles may be slanted.

For example, both titles, “US accepts more Syrian refugees than most European countries” and “The world turns its back on refugees” introduce slants when used as a title for a Syrian Refugee visualization (Figure 1a). By framing and slanting in favor of different sides of the issue, each title prompts viewers to interpret the visualization from a different perspective.

Prior study has shown that slants and frames in news article titles bias readers to recall and infer information that aligns with the titles [13]. Less is known about how slants and frames in visualization titles affect visualization perception. In this work, we ask the question: "Do slants and frames in titles of visualizations influence recall and interpretation of the presented information?" We first compared known frames for news article titles to frames for visualization titles by conducting an online survey, in which we asked people to compose visualization titles with different slants. Through this survey, we aimed to identify potential frames in data visualization titles and to answer our research questions regarding people’s practices when constructing a title. The titles fell into five established news frames: conflict, economic, human interest, morality, and attribution of responsibility [31]. We further identified two additional frames that do not exist in news articles: the open-ended frame and the statistics frame.

Using the most frequently occurring frames, we then studied how the *slants* and *attitude-consistency* of the title influence: attitude change, the perceived main message, and the perceived bias in visualization for viewers. The notion of attitude-consistency is based on bias assimilation (i.e., people’s tendency to interpret new information in a way that maintains their initial beliefs [26]) and refers to the alignment between the viewer’s existing attitudes and slants of the titles.

We found that the slant of a title heavily influenced how people perceived the message of a visualization. Further, the majority of viewers had an unwarranted strong trust in data, believing that the information presented in data visualizations was always neutral. Although there was a substantial attitude shift after the study, title slant and attitude consistency of the title did not influence attitude change. We discuss how the subtlety of data frames and viewers’ conviction in the neutrality of visualizations can prevent them from detecting a slant in data visualization, and conclude with design implications for composing and viewing visualization titles.

RELATED WORK

The importance and the role of news article titles have been studied extensively by researchers in media and communication [7, 12, 34, 36]. Titles of visualization are gaining researchers’ attention. Hullman et al. discussed the potential of text annotation as a rhetoric device in visualization [21], and Borkin et al. revealed the viewers’ extensive focus on titles [4]. These results arose from general research on visualization, and we extend the work by specifically focusing on the issues of slants and frames in visualization titles. We examine visualization titles’ impact on viewer’s recall, perception of bias and change of attitude. We next summarize prior work on headlines and visualization titles that motivated our work, and review research on slants and frames in news article titles.

Titles and Headlines

Claude Hopkins wrote in his seminal work “Scientific Advertising” that “the identical ad run with various headlines differs tremendously in its returns. It is not uncommon for a change in headlines to multiply returns from five or ten times over” [19]. Recognizing the importance of headlines, copywriters and journalists embed sensationalism or stylistic and narrative devices in headlines to persuade people to read the rest of the advertisement or article [3]. Research has repeatedly demonstrated the impact of headlines on news interpretation since 1950s [34], including their impact on people’s perception on social issues such as racism [36] and genetic-determinism [7]. In this study, we study how visualization titles impact people’s attitude on the topic addressed in the visualization.

Although the significance of titles in news articles and advertisements has been studied in depth, research exclusively focusing on visualization titles has been limited. Visualization research has explored various factors that influence comprehension and judgment, such as social information [20] and affect [5, 8, 18]. However, studies on the impact of titles on visualization have been scarce despite the integral role titles play in visualizations. Borkin et al.’s eye-tracking study on visualizations revealed that people spend the most amount of time on the text, especially the title [4]. Moreover, a visualization with a title conveying its main message was more likely to be recalled correctly compared to visualizations with generic titles [4]. In their paper on visualization rhetoric, Hullman and Diakopoulos called attention to textual annotations that are often neglected in InfoVis evaluation [21]. As one of the four editorial layers in visualization, textual annotation guide the viewer’s attention to a specific part of a graph and thus play an integral part of visual rhetoric by framing the narrative. We focus on this framing nature of visualization titles in our study and the effects of slants in visualization titles.

Cognitive Biases

Previous work has explored cognitive biases related to visualizations such as priming and anchoring, availability bias, and framing [2, 35, 11]. Bedek et al. present eight key cognitive biases for visual analytics of which four were highly relevant to our study: framing, selective perception, confirmation bias, and anchoring. In his work on media framing and biases, Entman describes that "frames introduce or raise the salience or apparent importance of certain ideas, activating schemas that encourage target audiences to think, feel, and decide in a particular way" [14]. He presents two meanings of bias in media: decision-making bias and content bias. Decision-making bias arises from the inevitable influence of journalists’ motivations and attitudes on their articles and titles. But Entman emphasizes in his works [14, 15] that decision bias is not the sole

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cause of news slant, which involves many other factors such as current events, the skills of news managers, public opinion indicators, and perceived facts. Experiment 1 of our study examines (1) whether people show any decision-making bias when instructed to write a title for a visualization and (2) the frames they use when composing visualization titles.

Content bias occurs when the media favors one side of a controversial issue instead of presenting both sides equivocally. Entman distinguishes bias from news slant, which occurs on the article level where a single editorial uses framing that favors one side. When the slant is systematic and persists across time and media outlets, it leads to bias where the promoted side is empowered through the slanted framing. Ecker et al.'s study on news article headlines compared the effects of headlines with different slants on people's recall and interpretation [13]. They found that a misleading headline framing impaired the reader's memory for factual articles and their inferential reasoning for opinion based articles. Experiment 2 of our work focuses on slants in visualization titles and their influence on the perception and interpretation of the visualizations.

Selective perception and confirmation bias both deal with people's tendency to choose information that is more relevant or supportive of their existing beliefs[10, 28]. Closely related to confirmation bias, biased assimilation refers to people's tendency to interpret new information in a way that maintains their initial beliefs [26]. In a landmark study on bias assimilation by Lord et al.[26], proponents and opponents of capital punishment read fictitious research findings for and against the death penalty. Participants assimilated evidence in a biased way, discounting the methodology when the result disconfirmed their existing attitudes even though the study was counterbalanced so both fictitious studies involved the same methodologies. More interestingly, exposure to mixed evidence led participants to become more convinced of their initial attitudes (i.e., attitude polarization) rather than more moderate in their opinions. In light of this phenomenon, our study examines how the attitude-consistency of the title influences the perception of bias and attitude change.

While we studied the effects of cognitive biases such as framing effect and confirmation bias, we endeavored to mitigate unintended cognitive biases, such as anchoring effects, from influencing the results. Anchoring effect is the tendency to rely on the first piece of information when making a decision. More details are provided in the method section.

EXPERIMENT 1: FRAMES IN TITLE COMPOSITION

Building upon prior research on news article titles and framing, we studied frames and slants in visualization titles. In Experiment 1, we collected 888 titles with different frames through an online survey. The survey asked people to compose titles for visualizations on two popular policy issues. We chose two policy-related visualizations that contained two contrasting sides that could be emphasized through the title. Then, we coded and analyzed the resulting collection of titles to answer the following research questions regarding people's practices when constructing titles.

RQ1. When asked to create a title that frames a visualization:
a) What frames do people use?
b) How do the frames of slanted titles differ from the frames of neutral titles?
c) How do people's pre-existing attitudes on the topic influence the slant of the titles they compose?

Methods

To answer RQ1, we considered collecting and analyzing existing visualization titles. However, this approach does not allow us to compare titles since each visualization has only one title (and hence one frame). We chose crowdsourcing to create multiple titles and frames for analysis. This title collection provided baselines for the contrasting titles in Experiment 2.

Participants

We conducted two independent experiments on Qualtrics. We chose Qualtrics as our platform to obtain a representative sample of the U.S. population in age, gender, household income, education, and ethnicity. All the studies were anonymous and survey responses were unidentifiable. We began by recruiting 100 participants; 11 participants were added to meet the goal of a nationally representative sample. We discarded responses that failed an attention check question or contained gibberish titles. Each experiment took approximately 15 minutes, and the participants were paid $6 for their participation.

Study material

To select the visualizations for our study, we began by exploring Borkin et al.'s visualization collection [4] and visualizations on news websites. We coded titles of 200 visualizations from four major news sites[1] for different factors including sentiment, subjectivity, and misleading slant. We found that over 20 percent of the titles contained an evaluative/framing statement. This led us to focus our study on frames in titles. We also noticed a series of visualizations that presented information with two possible interpretations. Of these, we tested multiple visualizations and topics through an in-lab pilot study with five participants. In the pilot, we considered less political topics such as screen time for children as well as more politicized topics. We decided to focus on political issues because: 1) people have stronger prior attitudes on these issues, making them more appropriate for answering RQ1c and RQ2b based on prior studies on the effect of attitude on the perception of new information [26]; 2) the pilot participants were more engaged in the study and provided more extensive feedback for these topics. We chose two visualizations that highlighted recent foreign policy issues (See Figure 1). The visualizations covered Syrian refugees and military spending, two of the most popular foreign policy issues in 2017 [23]. One visualization presented registered Syrian refugees in non-neighboring countries (hereafter referred as the "refugee visualization" and the associated title as the "refugee title," see Figure 1a). The second visualization tracked the U.S. military budget over the years with annotated war periods (hereafter referred as the "budget visualization" and the associated title as the "budget title," see Figure 1b). The refugee visualization appeared in the Atlantic under the title of "Give Me Your Tired, Your Poor"

[1]The Economist, The Wall Street Journal, National Post, and Fortune

Generic	Issue-specific/ Subcategory	Example	Syrian refugees d	pro	con	n	Military budget d	pro	con	n	Total
Conflict	risk	Letting in potential killers?	3	1	27	7	0	0	0	1	40
	imperative	Keep them out	2	0	14	0	1	14	2	1	34
	priority	We can't feed our own	1	1	11	2	2	0	13	3	31
Economic	economic	U.S. can't afford to house refugees	0	2	5	0	9	21	27	12	76
	imperative	No more increase for war	0	0	0	0	0	2	6	1	9
Human interest	human	Syrians need homes too	5	17	2	7	0	1	1	1	34
	safety	Safety against terrorism	0	0	0	0	0	18	3	2	23
Morality	morality	We need to do our share	0	4	0	6	0	10	0	0	20
	US identity	We must remember lady liberty	0	7	1	1	0	0	0	0	9
Responsibility	responsibility	Other countries need to do more for Syrian refugees than US	0	2	11	3	0	1	5	1	23
Statistics	variable	Comparison of defense budget to GDP	6	2	1	7	7	2	0	6	31
	trend	Decrease in defense spending	1	37	24	6	8	40	34	14	164
	value	16K Syrian Refugees in the US	11	2	4	9	0	0	0	0	26
	balanced	Defense budget in billions of dollars and as a percentage of GDP	8	0	0	5	7	0	0	2	22
Open-ended	topic	Syrian refugee acceptance	73	4	4	42	74	4	6	49	256
	undecided	Syrian refugees, what to do	0	0	0	10	0	1	1	8	20

Table 1: Generic and issue-specific/subcategory frames in the visualization titles composed by the respondents. "d" refers to default titles and "n" refers to neutral titles.

[16]. The budget visualization was created by the Heritage Foundation and appeared in several online news articles[30].

We chose a bar chart and a line graph because they are the most frequently used chart types in news outlets after choropleth maps [25]. The refugee visualization is a bar graph consisting of two sections. The left side shows the number of accepted Syrian refugees in each country; the right side represents accepted Syrian refugees as a percentage of the host population. The source visualization was a single bar graph with an overlaid dot graph presenting both the number of refugees and refugees as a share of host population, which pilot participants found difficult to interpret. We made three modifications to the visualization that maintained the information and improved interpretability. First, we separated the information into two sections with each section capturing the number of refugees and refugees as a share of host population, respectively, to simply the chart. Next, the original visualization used data from a 2014-15 source. We updated the data to a 2017 dataset. Finally, we presented a subset of the countries (the non-neighboring countries) instead of all of them. Some neighboring countries accepted over a million refugees while non-neighboring countries accepted thousands or hundreds. Due to this disparity, the numbers of refugees accepted among non-neighboring countries was indistinguishable in the original graph. Since we wanted to show how many refugees the U.S. (a non-neighboring country) was accepting compared to other countries, we chose to focus on non-neighboring countries. We changed the line colors in the budget visualization from blue and green to blue and orange after observing some confusion in the pilot study. The blue line shows the military budget as a percentage of GDP, and the orange line shows the budget in constant FY 2015 dollars.

Each visualization offered different messages based on whether the viewer focused on the percentage or the absolute number. The U.S. ranked third in the number of Syrian refugees accepted, but accepted the fewest as a percentage of host population. The military budget has declined as a percentage of GDP since the Korean War, but has fluctuated upward in constant dollars. After modifying the visualizations, we tested the study materials and the procedure through two online pilot studies on Reddit and Amazon Mechanical Turk (AMT). In the next section, we present the survey procedure and how we modified the questions based on the pilot studies.

Survey Procedure

Experiment 1 consisted of five stages. In Stage 1, participants filled a demographic survey on their gender, age, and education level. Next, they indicated their current attitudes on six popular policy issues, including two topics covered by the chosen visualizations. The participant answered the extent they agree with the statements, "The United States should increase the number of Syrian refugees admitted." and "The United States should increase its military budget to fight ISIS." Their attitudes were measured on a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." After reporting pre-experiment attitudes, the participants were presented with one of the two visualizations and were asked to compose a title that best represented the content in Stage 2. We refer to these titles as "default" titles from here on. This step was repeated for the second visualization. We balanced the order of the visualizations to prevent order effects.

In Stage 3, we asked participants to compose three titles: two slanted framing titles (supporting/not supporting a policy) and a neutral title. For the supporting title of the refugee visualization portion, participants were instructed: "Regardless

of your personal opinion, imagine you are a journalist working for a liberal newspaper company. Help them draft a title that supports the U.S. accepting more Syrian refugees." To compose the title opposing the policy, the words "liberal" and "supports" were replaced with "conservative" and "opposes", respectively in the instructions. Similar questions were asked for the military budget visualization.

Stage 4 measured participants' post-experiment attitude by asking for their attitude on the two issues covered in the visualizations and the reason for their answers. We calculated attitude change by taking the difference between the post-survey attitude and the pre-survey attitude (e.g., no attitude change = 0, changing from "Strongly Agree" to "Somewhat Disagree" = -4). We further asked whether they were now more or less inclined to support the policy after seeing the information provided and the reason for the change. We used this reported attitude change to confirm the calculated attitude change. Participants indicated the change in inclination on a 5-point Likert scale ranging from "Less" to "Same as before" to "More." Finally, in Stage 5, we showed the visualizations with three factual questions (ex. "How many Syrian refugees were accepted in Spain?" and "What is the estimated defense budget for 2019 in constant collars?" The full list of factual questions is available in the Supplementary Materials.) for each visualization. We asked factual questions to assess the participants' visualization literacy levels and whether they understood different components of the visualization. To avoid influencing participants' title compositions via priming or anchoring effects, we asked these factual questions after the title composition portion of the study.

Identifying frames and slants in visualization titles

Frames influence how people interpret information. One of our goals was to compare news article title frames with visualization title frames. Based on previous studies on news frames, de Vreese proposed two approaches for identifying frames: deductive coding with pre-defined generic frames and inductive coding for issue-specific frames [9]. Generic frames appear in diverse topics and "transcend thematic limitations" while issue-specific frames are only pertinent to certain topics [9]. We first used inductive coding to identify issue-specific frames for visualization titles since existing news frames may not cover all potential frames for visualization titles.

Two researchers read the titles together and defined 25 issue-specific frames for the refugee titles and 30 issue-specific frames for the budget titles. They also coded the slant of each title as supporting, non-supporting, and neutral. They independently coded 160 titles for frames and slants and established agreement ($\kappa = .71$ [95% CI, .642 to .778], $p < .001$). After discussing, reconciling the coding discrepancies, and collapsing frames, one of the coders continued to code the rest of the titles with 14 frames for the refugee titles and a different set of 14 frames for the budget titles. Then, we categorized each issue-specific frame into five pre-established generic frames [31] and grouped the remaining issue-specific frames into new generic frames: the open-ended frame and the statistics frame. The list of frames is presented in Table 1. We coded the slant of a title as *attitude-consistent* if the title aligned with the participant's attitude, *attitude-inconsistent* if it did not align with the participant's attitude, and *attitude-irrelevant* if the participant indicated a neutral stance on the topic.

Results

RQ1a. Frames in visualization titles

The five existing news frames are conflict, economic, human interest, morality, and attribution of responsibility [31]. The conflict frame sets the situation as "us vs them" through displaying conflict and disagreement between entities. In the titles composed for Experiment 1, the conflict frame (N=105, 13%) sets the U.S. citizens as "us" and Syrian refugees or ISIS (Islamic State of Iraq and Syria) as "them." The imperative category simply demands action (e.g., stopping refugees from entering the U.S. or fighting ISIS) while the risk category points out potential negative consequences. Other titles prioritize "us" over "them" in terms of deserving aid or attention. The economic frame (N=85, 10%) emphasizes the consequential loss or gain and occurred more frequently for the budget visualization since it closely related to the topic of the visualization. The human interest frame (N=57, 7%) emphasizes people who are impacted by the situation and presents the information using an emotional angle. Using this frame, refugee titles present Syrian refugees as individuals who need housing and support, and budget titles present the U.S. citizens as individuals seeking safety. The morality frame (N=29, 4%) examines the issue from a moral standard, urging people to embrace refugees and thwart harm. Lastly, the responsibility frame (N=23, 3%), originally introduced as the "powerlessness" frame [27], attributes responsibility of the cause or solution to an entity. People mostly used the responsibility frame in refugee titles to pass the responsibility of accepting refugees to other countries. Table 1 contains example titles for each of these frames.

While coding for frames in visualization titles, we identified two frames in addition to the five preexisting news frames [31]. The first frame is the open-ended frame, which gives a broad overview by stating the topic or the issue. We present this most frequently used frame (N=276, 34%) in more detail as we answer RQ1b. The second is the statistics frame (N=243, 30%). A statistics frame can refer to three levels of data – variable, trend, and value. *Variable* represents the highest level of data that can be emphasized in the title. The title "Comparison of defense budget to GDP" refers to the variable "budget as a percentage of GDP" without mentioning the other variable in the visualization (i.e., "budget in constant FY 2015 dollars"). The second level of statistics frame presents a *trend* in the visualization. Refugee titles often involved a comparative trend (e.g., "US falls short in comparison to other countries"), and budget titles stated a time trend (e.g., "Current defense budget lower than anytime in past years"). The most confining statistics frame focused on a single *data value*. The value could be an outlier as in the title, "Germany shows the way" for the refugee visualization. Germany accepted far more refugees than any other country making it an appropriate value for emphasis that could serve as a point of comparison. Otherwise, the value could be related to the subject of interest (e.g. "US allowing 16K Syrian refugess [sic] into the country"). Both types of data value reflect the current state of the issue and can

be used in an argument to support or oppose a policy. Another subcategory in the statistics frame is *balanced*; balanced titles represent both sides of the argument. They could simply name both variables (e.g., "Defense budget in billions of dollars and as a percentage of GDP") or contrast the trends (e.g., "Reduction in defense budget as percentage of GDP versus increase in defence spending"). It is worth noting that the six frames in the two new generic frames support multiple issues.

RQ1b. Open-ended frames in default and neutral titles

The dominance of open-ended frames in the default titles and neutral titles marked the primary difference between default titles, neutral titles, and slanted (supporting/non-supporting) titles. Whereas only 5% of slanted titles used open-ended frames, 66% of default titles and 60% of neutral titles used open-ended frames. Although the prominence of open-ended frames in neutral titles was expected, it is interesting that a higher percentage of default titles than neutral titles used open-ended frames. A possible explanation is provided as we answer RQ1c below.

Simply stating the topic was the most objective and the most frequently used frame (N=256). The level of detail ranged from the simplest form (e.g.,"National Defense Budget") to specifying the data range (e.g.,"Defense Budget 1948-2019") or the key points (e.g.,"Defense Budget for Major US Conflicts"). Undecided titles refer to the ambiguity of the situation or pose the topic as a question to be answered (e.g., "Uncertainty of Increasing Refugees From Syria" and "Syrian Refugees Need A Place To Go ... Are We That Place?"). Undecided titles differ from the topic titles as they encourage readers to take a stance without suggesting which one. The presentation of an ambiguous problem accompanied by a data visualization uses the visualization as evidence for a stance.

RQ1c. Influence of attitude in "neutral" title composition

The influence of pre-existing attitudes on title composition appeared in "neutral" titles composed for the instruction "Provide a **neutral** title for this visualization." Only 70% (N=151) of the responses for neutral titles were truly neutral, and the remaining 30% (N=62) contained a slant although instruction emphasized the term "neutral" in bold. Out of these 72 slanted titles, there were 26 attitude-consistent, 18 attitude-inconsistent, and 18 attitude-irrelevant titles. The presence of slants in "neutral" titles is interesting considering that more titles (N=177) composed for the "no instruction" condition at the beginning of the study were neutral. We speculate that bias-assimilation occurred while composing slanted titles for a visualization, where they retained the title that reinforced their prior attitude [26]. This retained frame, in turn, might have influenced the last title (i.e., "neutral" title) they composed.

At other times, the slant became ambiguous as participants mixed in their attitude into the titles while trying to follow the instructions. For example, when asked to write a title that supports increasing the number of Syrian refugees accepted, a respondent wrote "Refugees from terorist [sic] countries need our help." Although the phrase "need our help" uses the frame "human impact" and gives it a supporting slant, the phrase "terrorist countries" implies a risk and gives it a non-supporting slant. The slanted "neutral" titles and ambiguous titles inform us that people's attitudes could influence the slant of the title regardless of the author's intention.

Title slant	**Recalled main message slant**		
	Supporting	Non-supporting	Neutral
Supporting	**52**	13	48
Non-supporting	11	**25**	49

Table 2: The number of participants who wrote supporting /non-supporting/neutral main messages in the recall phase given the slant of the visualization title seen. The slant of the perceived main message often matched the slant of the title that the participant had seen as indicated by bold values.

In summary, 1) people used the statistics frame, the open-ended frame, and five existing news frames to compose visualization titles; 2) although people generally used neutral open-ended frames when asked to compose neutral titles, some of the "neutral" titles contained slants that reflected the writer's prior attitude. In the next section, we will show how the statistics frame and the presence of slants in titles can have a significant, and sometimes misleading, impact on visualization interpretation without people's awareness. More specifically, the presence of slant in a visualization title can bias people's interpretation of the visualization, while the use of the statistics frame establishes a false impression of impartiality.

EXPERIMENT 2: INFLUENCE OF SLANTS IN TITLES

Using the titles derived from Experiment 1, we conducted a second experiment with a different set of participants to examine whether the slant of the title influenced viewer's recall, perception of bias, and their opinion change. Specifically, we seek to answer the following research questions:

RQ2. When viewing a visualization with titles that frame different sides of the issue addressed in the visualization:
a) How does the slant of the title influence the perceived main message of the visualization?
b) How does the degree of consistency between the title and the viewer's attitude influence the perceived bias?
c) How are the slant and the attitude-consistency of the title associated with attitude change?

Each participant saw one visualization with an attitude-consistent title and one visualization with an attitude-inconsistent title. If the participant's attitude was neutral for a given topic, the participant was randomly assigned to a condition. The order of visualizations and the assignment to attitude-consistent/inconsistent title conditions were counterbalanced across participants. Because we assigned the participants to title conditions based on attitude-consistency, the number of participants assigned to supporting and non-supporting titles varied (refugee supporting: 51, refugee non-supporting: 51, military supporting: 66, military non-supporting: 38).

Methods

Participants

Participants were recruited in a similar manner to Experiment 1. After collecting survey responses from 100 participants, we gathered 4 additional survey responses so that the demographic

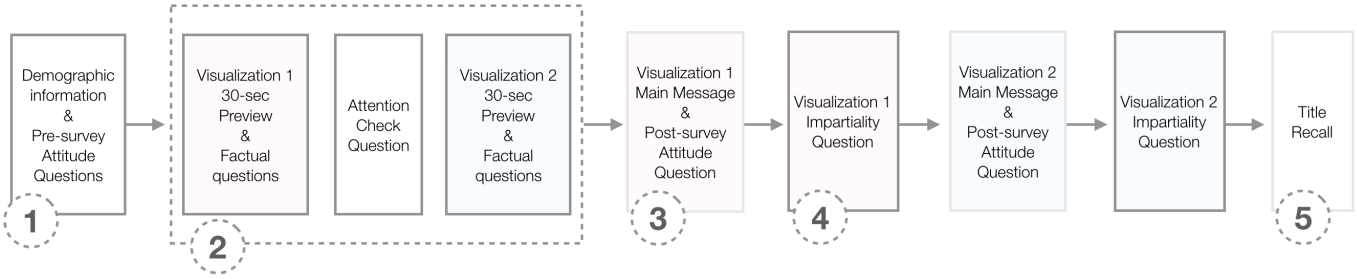

Figure 2: The study procedure for Experiment 2 with numbered stages. The first visualization sections are colored in pink and the second visualization sections in blue. Stages where the visualization was not shown on the page are indicated by a lighter gray border. Stages 3 and 4 are repeated for the second visualization.

makeup of the participants matched that of the U.S. population, resulting in 104 survey responses in total. We discarded all survey responses that failed the attention check question or failed to answer any visualization literacy question correctly.

Study material

Experiment 2 used the two visualizations from Experiment 1. Two titles were selected for each visualization based on the most frequent issue-specific frames from Experiment 1: one in favor of (i.e., supporting title) and one against (i.e., non-supporting title) the policy issue addressed in the visualization. If titles in the most frequent frame emphasized facts not mentioned in the chart, we selected the next most frequent frame. For example, "risk" was the most frequently appearing frame that opposed accepting more refugees (i.e., non-supporting refugee titles), but the titles mentioned risks and problems that were not mentioned in the visualization. Thus, we selected the next most frequent frame, which was "trend."

After we chose a frequent and appropriate frame for both sides of the issue (e.g., trend), we chose one title with the frame from the title collection (e.g.,"U.S. has accepted more Syrian refugees than the U.K., Italy, Russia, and Finland combined") and parallelized it for the other side (e.g., "U.S. has accepted a lower percentage of Syrian refugees than the U.K., Spain, Finland, and Australia"). Captions in Figure 1 list the four titles. More specifically, we chose a supporting title for the budget visualization and parallelized the non-supporting title; we selected a non-supporting title for the refugee visualization and parallelized the supporting title. Thus, each of the titles framed the visualization to emphasize an aspect of the visualization that would support or oppose the policy.

Procedure

Experiment 2 started out with the same procedure as Experiment 1 for demographic and pre-experiment attitude surveys (Stage 1). Instead of showing a visualization without a title and asking for one in Stage 2, we showed each visualization with a title based on the participant's current attitude on the topic (one attitude-consistent, one inconsistent).

In an early pilot, we found that some participants could not recall any information because they did not look at the visualization for a sufficient time. To encourage participants to familiarize themselves with the visualizations, Stage 2 began with a preview page where the participants were instructed to look at a visualization for a few minutes before moving to the next page to answer some questions on the visualization. The next button appeared after 30 seconds so participants could not proceed until that time elapsed. The next page showed the same visualization with three factual questions on its content, as in Stage 5 of Experiment 1, to measure their visualization literacy. These questions asked the participants about facts not covered in the titles to check for potential priming or anchoring effects. After showing the first visualization, we included an attention check question that asked for the topic of the visualization. Then, we showed a preview of the second visualization followed by factual questions. Factual questions were included in this stage again to assess visualization literacy and as a distractor task before Stage 3, the recall stage.

Stage 3 contained two open-ended recall questions for each visualization; we asked participants to write down the main message of the information provided on the topic, and anything else they learned in detail. Stage 3 also included post-experiment attitude questions on the topic covered in the visualization, where we asked participants to indicate their agreement with a statement as we did for Stage 1, and to indicate whether they were more/less likely to support the policy. The visualizations reappeared in Stage 4, this time with questions "Is the information presented above consistent with your knowledge on this issue?" and "How neutral (impartial) is the information presented above?" We referred to the "information" instead of "visualization" so that the participants could consider the visualization *and* the title as a whole. Each question was followed by an open-ended question that asked for the reason for their answers. We asked these questions after the recall questions to avoid influencing their answers. Stages 3 and 4 were repeated for the second visualization. Lastly, we asked the participants to write the visualization titles to the best of their recollection in Stage 5.

Results

RQ2a. Slants in titles influence the perceived main message

The analysis of the perceived main messages revealed that 65% of the answers (N=136) reflected the material covered in the titles. 31% of the answers (N=65) only stated the general topic, and others stated facts that were not mentioned in the title. The factual questions did not influence the messages. We categorized the slants of the perceived main messages as supporting, non-supporting, and neutral. Neutral messages

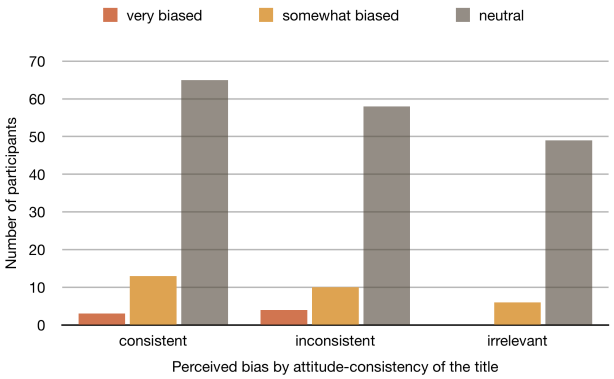

Figure 3: The number of participants who perceived a visualization as very biased/somewhat biased/neutral when the visualization was accompanied by an attitude-consistent/inconsistent/irrelevant title.

mentioned the topic or contained both supporting and non-supporting messages. Out of 101 titles that contained a slanted message, 77 matched the visualization the viewer had seen. Table 2 shows the slant of the perceived messages for supporting and non-supporting titles. The total counts for supporting and non-supporting titles are different because we assigned participants based on their pre-survey attitudes to see one attitude-consistent title and one attitude-inconsistent title. The slant of visualization titles resulted in a significant difference in the perceived main message ($\chi^2 = 27.06$, df = 2, $p < 0.001$).

The influence of titles on the perceived main message conforms with the results of Borkin et al.'s work on visualization recognition and recall [4]. Viewers did not only derive the topic of the visualization through the title, but also the specific message or slant of the visualization from the title. However, when asked to recall the visualization title, 33% of the participants (N=34) stated that they did not remember any of the titles and 9% (N=9) stated that they did not remember one of the two titles. Interestingly, many of them had already written the content of the title as the main message of the visualization. R48 responded "the title was not important enough to save to memory. graph more important." However, s/he had replicated the exact message of the title when s/he wrote that U.S. accepted more refugees than most countries, even combined, as the main message of the visualization.

RQ2b. Trust in data and perception of impartiality

Regarding the question "How neutral (impartial) is the information presented above?", a majority of the participants reported the information as being neutral. Similar ratios of participants answered that the information was neutral whether they saw an attitude-consistent (80%), attitude-inconsistent(80%), or attitude-irrelevant (89%) visualization (See Figure 3). The attitude-consistency of the title had no influence on the perceived level of bias ($\chi^2 = 3.896$, df = 4, $p = 0.42$).

When asked for the reason for reporting the information as neutral, nearly half of the respondents (44 out of 104) answered for at least one visualization that it simply presented statistics and thus was neutral. Some explicitly mentioned that no opinion had been present (e.g., "it is statistics not someones opinion") and that "facts teach their own lesson, not a lesson we try to make them teach" (R34). Participants frequently cited sources of the visualization as another reason for partiality and impartiality. The same source was seen as biased (e.g., "I trust the numbers a little less because the Department of Defense itself conducted the study, so perhaps more reassured if it was conducted by a neutral third party.") or neutral (e.g., "I would assume it to be correct since it came from the defense department.") depending on their attitude towards the source.

Experiment 1	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
refugee	0	0	2	9	69	26	3	1	0	0
budget	1	1	2	13	75	11	5	3	0	0
Experiment 2 (slant of titles)	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
refugee-pro	0	0	1	2	30	9	5	2	2	0
refugee-con	0	1	4	5	28	9	3	1	0	0
budget-pro	1	1	3	13	32	12	3	1	0	0
budget-con	0	0	2	9	21	2	2	0	1	1

Table 3: The number of participants who indicated an attitude change for each topic and title slant. Attitude change is measured by the difference between the post-survey attitude and the pre-survey attitude. Each attitude is on a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Expected directions of change are marked in pale blue.

Fifteen respondents (14%) brought up the possibility or the presence of a bias in the information on the refugee visualization. R8 elaborated that "It points out that the US has done more than a carefully selected group of countries, including some that are much smaller and Russia, who wouldn't be as likely to provide aid. It also ignores that the US has done much less than even Germany." We can infer that s/he was referring to the message in the title since it emphasized the U.K., Italy, Russia and Finland, but did not mention Germany. Out of 15 respondents who detected bias, nine had seen an attitude-inconsistent title, two an attitude-irrelevant title, and four an attitude-consistent title. Interestingly, fewer than half (N=6) of these participants mentioned a spin for the budget visualization, "The numbers are the numbers, but comparing spending to the GPD is a calculated move" (R89). The heightened awareness of the slant for refugee visualization might be due to the human interest factor embedded in the issue resulting in a guilt-trip, "Because it sort of shames those of us that don't believe that Syrians should be brought into the country into thinking we aren't doing our part" (R17).

RQ2c. Limited change in attitude

The summary of attitude changes in Experiment 1 and 2 are shown in Table 3. First, we checked whether viewing visualizations and composing titles had any impact on attitudes towards the topic. We removed one outlier response from the analysis where the absolute difference between pre-survey and post-survey attitudes greatly contradicted the self-reported attitude change (-5 vs 0). We performed a simple linear regression on pre-survey and post-survey attitudes with the expected cor-

relation set to 1 (i.e., no change in attitude). The coefficient for pre-survey attitude for Syrian refugees was -0.098 ($p = 0.02$) and the coefficient for defense budget was 1.26 ($p < 0.001$), showing a substantial deviation from a perfect correlation between pre-survey and post-survey attitudes. The mean attitude change in Experiment 1 was 0.44 for the refugee visualization, and 0.49 for the budget visualization. Next, we compared the attitude changes in Experiment 1 to attitude changes in Experiment 2. The mean attitude change in Experiment 2 was 0.70 for the refugee visualization, and 0.72 for the budget visualization showing a slight increase in attitude change. However, we found no statistically significant difference for the refugee visualization ($\chi^2 = 9.93$, df = 7, $p = 0.19$) nor for the budget visualization ($\chi^2 = 10.52$, df = 9, $p = 0.31$).

We performed a multinomial logistic regression on attitude changes using demographic information (e.g., age, gender, education), visualization literacy, and the slant and the attitude-consistency of the title as predictors. Visualization literacy was defined by the number of factual questions the participant answered correctly. A test of the full model against a constant only model show no statistical significance, indicating that the set of predictors could not reliably distinguish between positive, negative, and no attitude change ($\chi^2 = 12.76$, df = 16, $p = 0.55$). We speculate that the lack of an observed effect of demographic and title related factors on attitude change is due to the dominance of participants who indicated the same attitude in the pre-survey and post-survey attitude sections. The limited change of attitude is not too surprising as we had predicted the difficulty of changing an existing attitude with a single visualization. Due to the highly skewed distribution, we also report the actual counts of attitude change in Tables 3. Despite the absence of significant difference in attitude change for supporting titles and non-supporting titles ($\chi^2 = 3.6146$, df = 8, $p = 0.46$), Table 3 suggests a slight inclination to follow the slant in the title for refugee supporting and military non-supporting titles.

Next, we look at the polarity of attitude change by examining whether the viewers' attitudes became less or more neutral after the survey. Since we used a Likert scale for measuring attitude, we were able to look at subtle attitudes shifts (more/less polarized attitude) in addition to attitude switches (e.g., supporting to non-supporting). We categorized attitudes that move away from the neutral point as "'more" polarized and those that move towards neutral as "less" polarized. We categorized attitude as "switched" if it had switched from supporting to non-supporting or vice versa. We additionally accounted for participants who could not indicate attitude polarization because they had already checked the end points (i.e., 1 or 7) as their pre-survey attitude. Half of the responses indicated the same attitude polarity (i.e., no change in attitude), 19% of participants indicated less attitude polarization after seeing the visualization, 21% indicated more attitude polarization, and 6% indicated a switch in attitude.

In summary, we found that 1) while people self-reported that a visualization was not biased (83%), our coded interpretations of their recalled main message of the visualization revealed a bias (for 50% of the participants). Furthermore, of the messages coded as slanted 77% matched the slant of the title; 2) viewing visualizations with slanted titles did not result in a statistically significant attitude change overall, however 40% of the participants showed a moderate attitude shift and 6% showed an attitude switch. Thus, a visualization title holds the power to sway people's interpretation of the visualization, and thereby their attitude, even without their awareness.

DISCUSSION

In this section, we discuss how the subtlety of statistics frames and viewers' belief in the impartiality of visualizations can prevent them from detecting slants in data visualization. We propose design implications for composing and viewing visualization titles to address potential slants in data visualizations.

The subtlety of slants in the statistics frame

Although titles using a statistics frame all refer to the data in the visualization, the level of data that is emphasized can change the subtlety of the slant in the title. For example, titles using the broadest statistic frame that mentioned a variable (e.g., "Syrian refugee acceptance by countries as a percentage of their population") generally have no explicit slant in themselves. However, because each visualization involved two variables, one for and one against a policy, only mentioning one variable prompts the viewers to focus on a section of the visualization that supports one side of the policy.

Titles addressing a *trend* present a more explicit slant. These titles can be misleading if they do not specify the variable that they are referring to. For example, after seeing the title "Current defense budget lower than anytime in past years," a viewer might misconceive that the defense budget is decreasing in constant dollars while in fact, the budget is only decreasing as a percentage of GDP. Titles that mention the associated data variable present a more accurate trend (e.g., "Defense budget as a percentage of GDP on a steady decrease over the past 50 years"). Thus, titles using different statistics frames can have different levels of slants ranging from more explicit slants to the more subtle slants.

Subtle slants can be more powerful than explicit slants. In her article on fake news online, danah boyd wrote, *"It's subtle content that is factually accurate, biased in presentation and framing, and encouraging folks to make dangerous conclusions that are not explicitly spelled out in the content itself. That's the beauty of provocative speech: It makes people think not simply by shoving an idea down their throats, but inviting them to connect the dots"* [6]. Rather than making a strong biased statement that might be attitude-inconsistent and trigger a backlash, using a subtle slant can successfully convey "statistical facts" that may influence the viewers' future decisions. In the case of data visualization titles, a slanted title only mentioning a data variable may be the most dangerous as it appears to be most neutral but cues the viewers to connect the dots and infer the trends.

"Numbers do not lie, the graph is what it is."

The trust in the impartiality of statistics led people to be unaware of the possible framing of the visualization, questioning "It's fact. How can it be biased?" (R16). This aligns with the results from a prior study by Tal and Wansink showing that

the presence of a trivial graph can increase the persuasiveness of information [33]. They proposed that the belief in graphs may be based on an inferential process that links graphs to scientific basis and scientific bases to truth. Our study results endorse this inference pattern, as some participants linked visualization with statistics–and statistics as representing the truth. This supports Pandey et al.'s finding that not only graphical appearance but also the presence of statistics influences people's attitudes [29].

The unawareness of potential bias in visualization can lead to misconception of information. In prior work on misleading titles in news articles, researchers found that readers were able to detect slants in the titles when there was an obvious mismatch with the title [13]. The mismatch triggered strategy monitoring and memory updating processes by which the readers were able to correct initial misconceptions. However, the misconception continued for opinion articles with less perceived inconsistency between the title and the article. In the case of visualization titles, the viewer's trust in data, combined with subtle data frames in titles, blinded people from the potential bias that might lead them to infer conclusions that they would not have given a neutral title.

Design Implications

Based on our results, we propose one design implication for the generation of visualization titles and one design implication for the viewing of titles. Researchers have worked on automatically generating visualizations and different components of visualizations [32, 17, 22]. Our results can expand on this work by guiding the automatic generation of titles for these visualizations. Based on the frames identified in the study, we envision using statistics frames in automatic generation of visualization titles. For instance, NewsViews automatically generates interactive geovisualizations based on relevant articles and databases [17]. NewsViews and similar visualization automation systems could evaluate potential titles for the generated visualizations based on the level of data emphasized in the title and become aware of the level of slant in visualizations with multiple variables.

Our results showed the influence of titles on the perceived main message of the visualization and the potential risk of slanted titles. The misleading influence of visualization titles can be alleviated through designs that prompt viewers to interact with the titles. For example, a platform could offer passive engagement with titles by allowing the viewers to toggle off the titles or displaying titles after a 5 to 10 seconds delay. This provides the viewers the time to process information and interpret the visualization before being influenced by the title. An active engagement with titles involves prompting the viewers to compose their own titles. Kim et al. showed that predicting a graph before seeing the real data increased recall and comprehension [24]. Given the results that simply viewing and composing titles for a visualization can lead to some attitude change, we can envision the benefit of a platform where the viewers compose a title for the visualization and compare their titles with titles composed by others. Seeing a variety of titles on a single visualization can inform the viewers, as well as the creators of the visualizations, of other potential interpretations of the visualization. Title composition could further benefit the viewers by prompting them "to interact with their internal representations to deepen their understanding of data" [24]. After collecting a sufficient number of titles, the system could set the desired balance in the title as the default title while providing viewers access to the whole collection of titles.

LIMITATIONS

Although we tried to account for cognitive biases by testing the survey procedure through three pilot studies, it is possible that we were not able to eliminate all cognitive biases. For example, even with multiple iterations of our questions, our prompt for composing titles may have influenced the titles created by our participants. Also, the titles that we studied were crowdsourced and thus may differ in nature from visualization titles found in existing news articles. Furthermore, our study involved two visualizations, and the results should not be extrapolated to other visualization types. We hypothesize that people may rely more on textual information for visualization types that are more complicated and harder to interpret. The topic of the study was limited to controversial issues, and thus the results may differ if less political and controversial topics had been studied. For example, greater attitude changes may be observed for less controversial topics as people's prior opinions may not be as strong. Future work is needed to generalize the results to less controversial topics.

CONCLUSION

In this study, we identified general frames for visualization title and studied the influence of titles on the recall, perception of bias, and attitude change. Visualization title frames matched pre-established news frames with an addition of open-ended frames and statistic frames. Statistic frames referred to variables, trends, and values, and occurred most frequently in slanted titles. The results showed that the slanted frames in titles influenced the perceived main message of a visualization without impacting the perceived bias. Informed by bias assimilation, we further examined how people's pre-existing attitudes effect the composition and interpretation of visualization titles. We observed that many participants wrote slanted titles that matched their attitude even when explicitly instructed to write neutral titles. The results did not show a significant effect of attitude-consistency or the slant of the title on the perception of bias nor on attitude change, mainly because people viewed the information as impartial and indicated little attitude change.

Our findings suggest the influence of titles on visualization interpretation and reveal the lack of awareness on the potential bias introduced by the title. We conclude by suggesting how the frames can be used in automated generation of visualizations and how people could interact with visualization titles for improved comprehension of the data. Our results are directly applicable to social media sites such as Twitter, Imgur, and Reddit where visualizations are currently being shared as a standalone material. It is uncertain whether our results can be transferred to platforms where visualizations are presented along with longer accompanying text, such as online news sites. We propose continuing the study in the context of news articles for future work.

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