Developing Computational Supports for Frame Reflection

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Abstract

As the number and variety of sources for political information increase, it can become difficult to attend to the complexities of political issues. This difficulty lies not only in understanding what is being said, i.e. the content of an issue, but also how it is being said, i.e., the framing of the issue. This paper presents a prototype visualization tool designed to encourage attention to, and critical reflection about, the ways in which a political issue is framed. The tool visually presents linguistic analysis of documents about the issue of cap and trade. Results show that tool use interacted with participants' prior views in affecting their ability to suggest novel framings of the issue, one potential indicator of frame reflection. Tool use also mediated participants' exposure to different viewpoints. These findings help provide insights on how the design of tools for civic participation can help promote thoughtful, reflective political engagement.

Keywords: political framing, frame reflection, natural language processing, information visualization, sustainability

Introduction

An increasing amount of political content, information, and discussion occurs online, both in relatively novel media, such as blogs, as well as through online versions of more traditional news sources, such as newspapers. However, much of the political discussion online is highly balkanized (Adamic & Glance, 2005; Hargittai, Gallo, & Kane, 2007), with some work suggesting that many people simply surround themselves with like-minded sources (Garrett, 2009; Munson & Resnick, 2010).

This divisiveness results from more than just differences in interests, priorities, or values. Rather, the seeming irreconcilability of political controversies is often due to differences in how issues are framed. Terms such as “tax relief,” “death panels,” “global warming,” and “racial quotas” have famously rallied citizens around causes that are actually quite complex. Furthermore, the way in which an issue is framed—how a problem is explained, to what other problems it is linked, how potential solutions are evaluated, etc.—has a significant impact on people’s perception of the issue and their prescriptions for action (Hart, 2010; Maibach, Roser-Renouf, & Leiserowitz, 2009; Price, Nir, & Cappella, 2005). A related vein of research on “frame reflection” (Schön & Rein, 1994), critical thinking about how issues are framed, has shown that people are more likely to reach agreement on an issue if they can first come to understand the various frames being applied, both others’ and their own.

The question, then, is how to encourage attention to issues of framing. Aside from the challenge of convincing people to scrutinize their own assumptions, identifying and analyzing frames requires close, detailed reading of texts, analysis and coding by trained researchers, and synthesis of those data through

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statistical calculations or expert interpretation (Gamson & Modigliani, 1989). These challenges are exacerbated when considering the volume of political content and discussion produced on a daily basis. Novel computational techniques, however, enable analysis of vast quantities of textual data with relative speed and ease, transforming this challenge—an abundance of content—into a valuable resource: a wealth of data. Since framing is often evidenced by linguistic patterns, it may be possible to leverage existing computational linguistic techniques to draw attention to patterns that are indicative of framing.

In this paper, we suggest that such computational text analysis tools may be useful in promoting political frame reflection. We present a prototype information visualization tool that shows associations between groups of words, identified via selectional preference learning (Resnik, 1993; Ritter, Mausam, & Etzioni, 2010). This tool does not identify frames *per se*; rather it identifies and presents visually linguistic patterns that may be relevant to framing. This system was evaluated via a controlled laboratory study where participants used the system to familiarize themselves with documents discussing the cap and trade approach to carbon emission regulation. Not only is cap and trade a contentious political issue rife with potential framings, but it also pertains to the recent interest in sustainable HCI, particularly with respect to how HCI can be relevant to political aspects of sustainability (DiSalvo, Sengers, & Brynjarsdóttir, 2010). Our results not only indicate that the system played an important role in aspects of frame reflection, but they also point to certain aspects of the system's design as more or less effective at promoting attention to framing. Our primary contribution is not the specific design presented here, but rather the notion of computational supports for frame reflection, the insights gained about how we might design them, and suggestions for how we might evaluate those designs. These insights not only provide important guidance for system designers building tools to facilitate political discussion, but they also help us better understand the processes of framing and frame reflection.

Related Work

Political Framing

In order to make sense of their interactions with one another, people frame their experiences (Goffman, 1974). Frames help people "locate, perceive, identify, and label," that is, organize and give meaning to, information about experience in the world. A frame consists of a variety of components, including "keywords, stock phrases, stereotype images" (Entman, 1993, p. 52), "metaphors, exemplars, catchphrases" (Gamson & Modigliani, 1989, p. 3), and other devices that provide an interpretive lens or "package" (Gamson & Modigliani, 1989) through which to perceive and make sense of facts or events. Frames define what counts as a problem, diagnose what is causing those problems, make moral judgments about problems and those involved, and suggest remedies for resolving the problems (Entman, 1993). Put simply, frames are a way of organizing our world.

Framing can significantly impact perceptions of political issues. For example, in debates over nuclear power, different frames—such as nuclear power as economic development, or nuclear power as Frankenstein's monster—were used in different historical periods to justify decisions and legislation in support of, or against, nuclear power (Gamson & Modigliani, 1989). Another study (Price et al., 2005) found that, in the context of group discussion about gay civil unions, framing interacted with individuals' previous political ideologies; participants reacted strongly to a frame that conflicted with their view, becoming more extreme in their position. These studies show how framing can have a significant impact on interpretations of, and recommendations for addressing, contentious issues.

The work presented here draws on these insights but takes a slightly different approach. Rather than arguing for the use of one specific frame or another, we explore the design of systems intended to support awareness of, and reflection upon, framing. Schön and Rein (1994) argue that complex policy debates can become intractable when stakeholders approach the situation using different frames. They describe, as one example, a decade-long policy controversy about homelessness in Massachusetts. At the time, three dominant frames for the issue—social welfare, access to the market, and social control—all provided different prescriptions for addressing homelessness. The controversy was only resolved by a reframing that synthesized key elements from each of these frames. Thus, Schön and Rein argue that the process of *frame reflection*, critical examination of the various frames applied to an issue and consideration of alternative framings, can enable productive discussion and resolution of such complex

debates. This paper, then, argues for the use of computational tools that draw attention to, and encourage reflection on, framing in the context of political issues.

Selectional Preference Learning

Many indicators of framing noted above, such as "keywords, stock phrases" (Entman, 1993, p. 52), "metaphors, exemplars, [and] catchphrases" (Gamson & Modigliani, 1989, p. 3), may be evidenced by linguistic patterns. Many computational techniques have been developed for identifying such linguistic patterns. For this tool, we used a technique called selectional preference learning (Resnik, 1993). For example, words for liquids or fluids tend to occur in specific grammatical relationships with verbs such as "pour," "flow," "freeze," or "evaporate." That is, liquids *select for* these verbs. Calculating selectional preferences of common terms in political corpora, such as "senate" or "tax," may help draw attention to how those concepts are being framed.

Several different methods for calculating selectional preferences have been developed, e.g., (Resnik, 1993; Ritter et al., 2010). The tool described here uses Ritter et al.'s (2010) approach, which employs probabilistic topic modeling to calculate relatively robust results from even limited data.

Textual Visualization and Political Analysis

This paper draws on previous work involving visualizing textual patterns or political data. The online tool ManyEyes (Viégas, Wattenberg, van Ham, Kriss, & McKeon, 2007) provides a few different visualizations for text data. Most of these are relatively simple, involving pure word counts or in some cases co-occurrence data. While potentially interesting, they did not seem particularly well-adapted to our purposes here.

With respect to political data, Opinion Space (Faridani, Bitton, Ryokai, & Goldberg, 2010) uses principal components analysis to project opinions expressed by users onto a two-dimensional "space" of opinions, using patterns that emerge in the data rather than traditional ideological axes. ConsiderIt (Kriplean, Morgan, Freelon, Borning, & Bennett, 2012) uses commenting and summarizing to facilitate the process of multiple parties understanding each other during political discussion. While thematically related, the computational techniques involved in these projects differ from the one used here.

The systems most similar to that in this paper involve computational analysis of political text. ManyBills (Assogba, Ros, DiMicco, & McKeon, 2011) uses topic modeling to analyze text of proposed legislation in the US Congress. The system aims to make apparent what bills are actually about as well as portions of the bill that seem unrelated to the overall focus of the legislation. metaviz (Baumer, Sinclair, & Tomlinson, 2010) uses computational metaphor identification to analyze political blogs in order to identify, and draw attention to, conceptual metaphors. metaViz resembles the tool in this paper, in that the goal is promoting critical thinking and reflection. As such, some components are influenced by the design of metaViz. However, metaphors are only one component of framing. The tool presented here goes further to promote more general frame reflection.

Implementation and Design Rationale

The work on framing summarized above describes how frames are linked to patterns of language. This section describes a prototype visualization meant to draw attention to one such pattern: associations between nouns and verbs.

Data

As mentioned above, the data analyzed for this paper pertain to cap and trade. We analyzed selectional preferences in 227 documents totaling 310,235 words. To collect the documents, we began by searching Google with such terms as "cap and trade," "cap and trade benefits," "cap and trade costs," "cap and trade summary," and other similar queries. The search results were then pruned to include only those that focused on cap and trade, as opposed to, e.g., mentioning cap and trade as one of several legislative items before Congress. The resulting documents came from websites for nonprofit environmental organizations, electrical utility and oil industry groups, governmental agencies, consumer

organizations, and other similar entities. Some documents contained overviews of different approaches to global warming, while others were more focused critiques or endorsements of cap and trade legislation. Some were directed to a general readership while others were targeted to narrower political or industry groups. In addition, we used the Proquest Historical Newspapers archive to locate editorials and opinion pieces about cap and trade that ran in national newspapers between January 1, 2009 and July 2011. An effort was made during document collection to represent the variety of arguments made for and against cap and trade programs. We then sorted documents into three categories based on whether they contained solely arguments in favor of cap and trade (Pro), solely arguments against cap and trade (Con), or a mix of arguments for and against (Mixed). We expected that each of these positions would likely frame cap and trade differently, and allowing users to see this distinction might help them interpret the visualized linguistic patterns. Table 1 summarizes each of these three corpora.

Table 1
Size of each corpus in the data set

Corpus	Documents	Words
Con	120	153,906
Mixed	69	107,124
Pro	38	49,205

These documents were all parsed using a typed-dependency parser (De Marneffe, MacCartney, & Manning, 2006), the results of which were used to calculate selectional preferences (Ritter et al., 2010). Each noun then selects for a group of related verbs with a group of related grammatical relations. For example, the noun “offset” selects for the verbs “sell,” “buy,” “give,” “auction,” and others with “offset” as mainly the direct object and sometimes the passive subject. These selectional preferences are computed for each corpus.

Visualization

The visualization then presents the selectional preference results. The visualization tool described here was developed using D3 [http://mbostock.github.com/d3/]. The tool starts by showing nouns that appear in each corpus with greater frequency than in general English, as derived from (Kilgarriff, 1996). Each word is color coded based on the key to indicate the corpus from which it comes (Figure 1, left). The user can either click on a noun to see with what verbs it is associated, or can use the search box (Figure 1.a) to narrow the list.

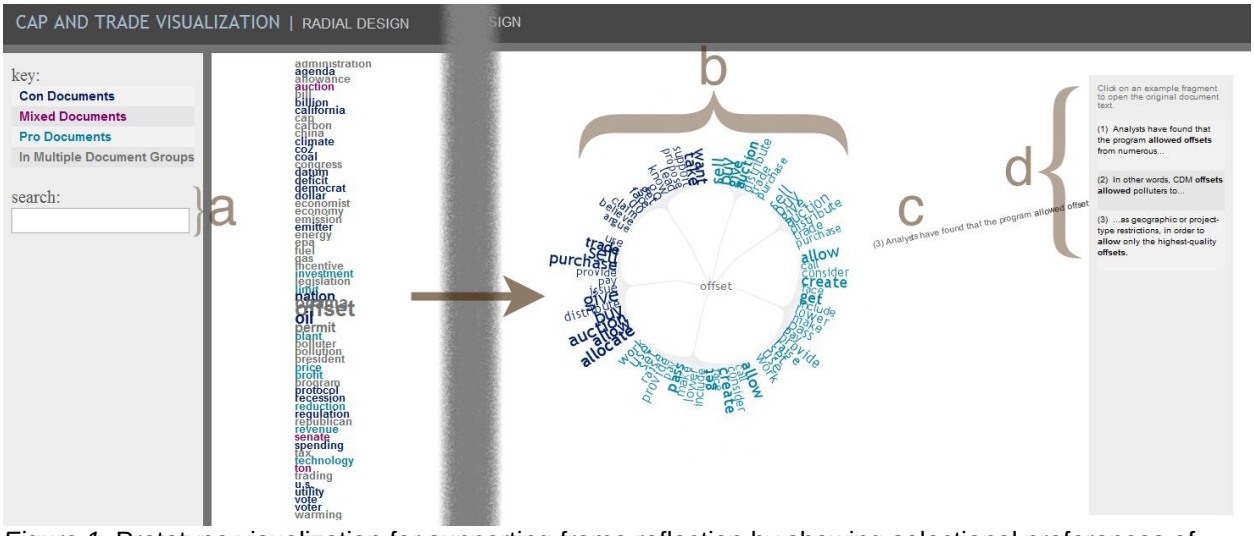

Figure 1. Prototype visualization for supporting frame reflection by showing selectional preferences of relatively frequent nouns.

Clicking a noun hides the top-level list and shows the verbs for which that noun selects, grouped by similar grammatical relations. Verbs are scaled based on a logarithmic transform of the strength with which the chosen noun selects for them and are arranged in a circle around the noun (Figure 1.b). We paper prototyped and mocked-up several different layouts for this view, including more traditional table styles. Such rectilinear layouts often had a stronger implied ordering and importance, e.g., top-to-bottom, while the circle layout provided greater flexibility in reading order and interpretation. The "offset" example described above is shown in Figure 1. Again, verbs are color-coded to indicate the corpus from which they come. The left-hand side key is cropped here but is still shown in the visualization.

Clicking on a verb shows an example of the association, for example, where "offset" occurs with the verb "allow" (Figure 1.c), with the number in parentheses indicating how many other similar examples there are. Clicking the example fragment opens a side bar that shows all of these similar fragments (Figure 1.d). Clicking any of the fragments then opens the original text of the document from which it came, with the fragment highlighted.

Importantly, the meanings of these associative patterns are left open to interpretation. For example, one might see "offset"'s association with "auction," "purchase," and "trade" as indicative of an economic approach that effectively uses a free-market to reduce carbon. Alternatively, one could read those associations as unduly emphasizing the financial aspects at the expense of discussing actual environmental impacts. Such interpretive flexibility, we suggest, helps in supporting frame reflection.

User Study

We conducted an evaluation of this tool to understand how aspects of its design might impact frame reflection. Here, we describe the study methods, the coding scheme used to assess aspects of frame reflection, our approach to analyzing the data, and the results of that analysis.

Methods

Participants, recruited from the social science subject pools at two US research universities, were asked to take part in a study about reading political content and were compensated with course extra credit. A total of 53 (30 female, 23 male) participants were recruited.

Participants began by completing a pretest about existing political views, as well as previous knowledge of and attitudes about climate change. The survey included a 15-item inventory on attitudes about global warming (Maibach et al., 2009), questions about how informed the participant felt about global warming, some factual questions about the causes and consequences of global warming, questions about the participant's prior knowledge of cap and trade, a brief summary of how a cap and trade policy would work, and a question asking whether or not the participant would support such a policy.

Participants were randomly split into two conditions. Those in the experimental condition (N=27) used the visualization tool described above. Those in the control condition (N=26) used a simple document browser: the participant would click on a corpus name, click the title of a document, and read the document (Figure 2). Before using each tool, participants watched a short video describing it. Participants were asked to spend 10 to 20 minutes using the tool and were not able to advance to the next portion of the survey until at least 10 minutes had passed.

Afterward, all participants completed an exit survey, which included the same questions from the initial survey asking about their support for cap and trade, a randomly ordered pair of questions asking the participant to state all the arguments s/he could think of for and against cap and trade (Cappella, Price, & Nir, 2002), a randomly ordered pair of questions asking the participant to name the groups of people who would be most positively affected and most negatively affected by cap and trade, a question that explained briefly what framing is and asked them to name all the frames they could think of for the regulation of carbon dioxide emissions, and some generic usability questions.

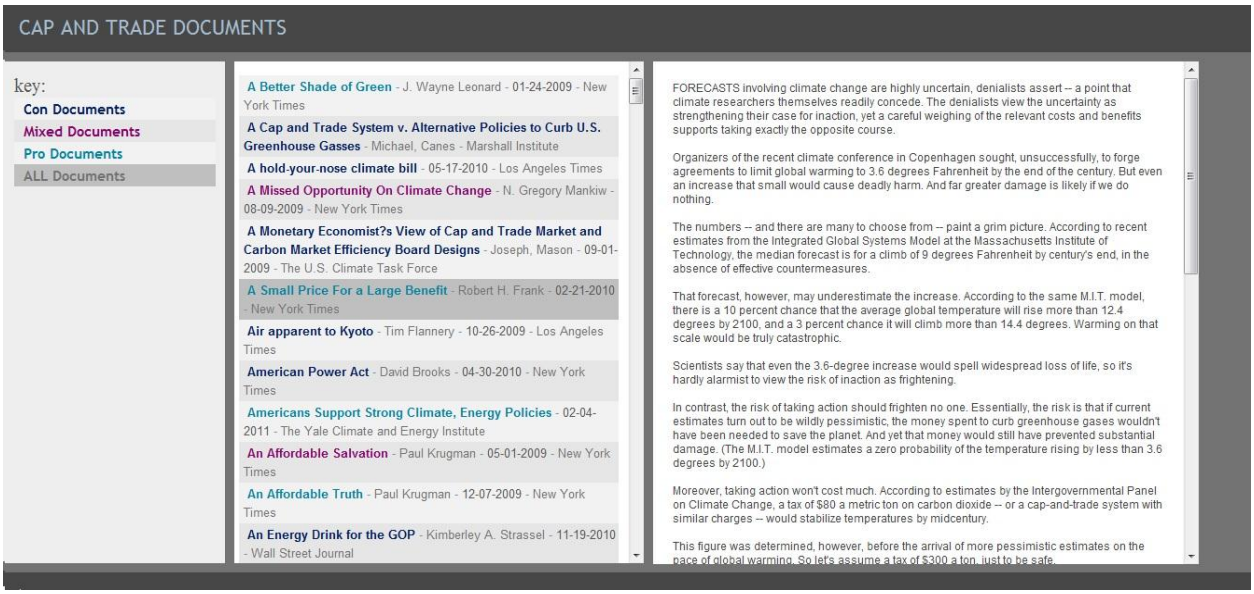

Figure 2. Document browser used in control condition.

Coding

Little is yet known about how frame reflection affects individual and group evaluation of competing positions, but several possibilities can be drawn from the literature (Cappella et al., 2002; Entman, 1993; Goffman, 1974; Hart, 2010; Price et al., 2005): frame reflection may encourage an understanding of and appreciation for competing arguments about a proposed policy; it may promote a better understanding of the policy's likely consequences for different groups of people; it may encourage people to imagine still other frames, and, accordingly, alternative positions on an issue. Our coding schema are based in part on this literature and in part on inductive analysis of sample responses. Inter-coder reliability was established on a sample of the coding categories using three coders' observations for 35 content coded categories, with Krippendorff's α=0.96. While numerous aspects of participants' responses were coded, for clarity, we only describe here the aspects of the coding schema used in the subsequent analysis.

Participants in both conditions were asked to list as many frames as they could think of for the regulation of greenhouse gases. As an example, participants were told that health care is often framed in terms of the market (with the emphasis on health care users as consumers), in terms of rights (with health care depicted as an entitlement), and in terms of other frames.

We defined a frame as a shorthand way of talking about a policy in terms of the institution that would be most involved in its implementation or that is historically associated with policy solutions of that sort (Lau & Schlesinger, 2005). For example, a "market" frame would assess cap and trade in terms of its economic benefits. In coding for distinct frames, we used respondents' own markers: for example, their enumeration of statements as "1, 2, 3," or their use of line breaks to demarcate statements. We suggest that participants who engaged in frame reflection would list a greater number of different frames.

We suggest further that respondents who had engaged in frame reflection would also identify frames drawn from a wider variety of source domains. By source domain we mean the institution associated with a particular justificatory rhetoric. For example, we coded the source domain of the frame, "people have a right to clean air" as *Law* since the justification is one of legal rights. Frames from an *Economy* domain used language associated with business, markets, industry, and economic interests. Those from an *Environmentalism* domain used language about the good of the environment, global protection, and so on. Other domains included *Ethics* (non-legal and non-environmental), *Government, Medicine*, and *Science*.

Analysis

Previous studies of framing have found that framing effects alone are often not as drastic as the interactions between framing other factors, such as previous opinions (Price et al., 2005). Therefore, rather than doing simple comparisons of the two conditions, our analysis examines which of the many factors involved are most predictive of the above described effects related to frame reflection.

To do so, we used all-subsets linear model selection with Mallow's Cp to determine which other variables were most effective at predicting each outcome described above. This approach chooses the model that has the most explanatory power, in terms of fitting the data, and the least complexity, in terms of the number of predictors included.

Table 2 describes predictors used in model selection. Pairwise interactions were included for document count variables and for the condition with the Views principal components, since framing can interact with prior views and opinions (Price et al., 2005).

Table 2
Potential predictors and their interactions included in model selection.

Predictor	Description
CondVis / CondDocs	Experimental condition; visualization (1) or document reader (0).
Views PCs	(see Table 3)
Know PCs	(see Table 4)
LegTime	Time spent reading the legislative summary, in seconds
ToolTime	Time spent using the tool, in seconds
NumDocs	Number of documents viewed
NumCon	Number of Con documents viewed
NumMixed	Number of Mixed documents viewed
NumPro	Number of Pro documents viewed
NumDocs pairwise interaction with each of NumCon, NumMixed, NumPro	
NumDocs pairwise interaction with each of NumCon, NumMixed, NumPro	

To reduce the potential for multicollinearity, some predictors were collapsed using principle components analysis. Table 3 describes two principal components related to political ideology and views on global warming, capturing 74.6% of the variance in the four variables involved. Table 4 describes two principle components for prior knowledge about global warming and cap and trade.

Table 3
Principal component loadings for views related to global warming. The Views1 component is high for liberal individuals concerned about global warming, while the Views2 component is high for liberal individuals not concerned about global warming.

Views1	Views2	VariableDescription
0.312	0.699	Self-expressed political ideology; very conservative (1) to very liberal (5)
-0.457	0.698	Views on global warming, based on (Maibach et al., 2009); alarmed (1) to dismissive (6)
-0.476	0	Initial support for cap and trade, before using tool or reading legislative summary; strongly support (1) to strongly oppose (5)
-0.684	-0.157	Final support for cap and trade after using tool; strongly support (1) to strongly oppose (5)

Table 4
Principal component loadings for prior knowledge related to global warming. Know1 is high for individuals who feel uninformed about global warming but are in fact knowledgeable, while Know2 is high for those who feel uninformed and are indeed not knowledgeable.

Know1	Know2	Variable Description
Con	120	153,906
Mixed	69	107,124
Pro	38	49,205

This analysis excludes those participants who viewed zero documents, leaving 26 control (document reader) participants and 24 experimental (visualization) participants.

Results

Participants ranged age 18 to 21 (mean 18.8, median 19), with most describing themselves as moderate (36%) or somewhat liberal (32%) and as Democrats (40%), independents (16%) or Republicans (20%). Most were either "concerned" (46%) or "cautious" (32%) about global warming, resembling to some extent the distribution among general Americans (Maibach et al., 2009).

Time spent using the tool ranged from 10:04 to 25:06, with most taking slightly longer than the required 10 minutes (mean 13:35, median 11:43). Experimental participants spent slightly longer on average (14:10 > 13:02), but not significantly so ($p=0.34$). Experimental participants also saw fewer original documents than in the control condition ($6.08 < 8.15$, $p=0.02$), though the experimental condition also showed visualizations of patterns across all the documents.

Across both conditions, we saw some evidence for frame reflection. When asked to list framings for regulation of CO_2 emissions, participants suggested up to five different frames (mean 2.5, median 3), drawing on up to four different domains (mean 2.0, median 2). To reiterate, those participants who viewed zero documents are excluded here. As expected, we saw no main effect for use of the visualization on either number of frames or number of domains.

We next present the model selection results, i.e., which variables were most predictive of our indicators of frame reflection. Each model is described in terms of the coefficient and significance for each predictor (* $p=0.05$, ** $p=0.01$, *** $p<0.001$). Interactions are shown as variable names separated by a colon. These model selection results are both useful results themselves and help draw attention to relationships for subsequent exploration.

For the total number of frames participants suggested, the most predictive factors were better knowledge about global warming and viewing more documents. Since neither of these factors pertain to the experimental condition, we do not investigate this result further. However, the model for the number of domains on which participants' frames drew (Table 5) shows two important results. First, the strongest and most significant predictor was participants' prior knowledge about global warming; more knowledgeable participants drew on more source domains when suggesting new frames. Second, the experimental condition interacted with participants' prior views in predicting the number of source domains.

Table 5
Model for the number of domains on which participants' new frames drew. $F_{6,43}=4.542$, $p=0.0012$.

Predictor	Coefficient
Know2	-0.568 ***
NumMixedDocs	0.352 **
Views1:CondDocs	-0.183
Views1:CondVis	0.200
Views2:CondDocs	-0.115
Views2:CondVis	0.266

To examine this interaction further, we conducted ANCOVAs with Views1 and Condition, and with Views2 and Condition. For Views1, no significant effects were found. With Views2 and Condition, there were no main effects for either Views2 (F1,46=0.96, p=0.33) or Condition (F1,46=0.01, p=0.95), but there was a significant interaction effect (F1,46=7.11, p=0.011).

The Views1 and Views2 components differ primarily in their weighting for the Maibach et al. Maibach et al., 2009) global warming perceptions scale. Thus, we also examine the relationship between Maibach et al. segment and condition, finding that, again, neither segment ($F_{1,46}$=0.05, p=0.82) nor Condition ($F_{1,46}$=0.01, p=0.91) alone are significant, but their interaction is ($F_{1,46}$=8.27, p=0.006) (see Figure 3). Specifically, in the control (document browser) condition, participants who were less concerned about global warming exhibited less evidence of frame reflection, whereas in the experimental (visualization) condition, those participants exhibited more evidence of frame reflection. Checking other factors in the model (Know2 and NumMixedDocs) indicates no other similar interactions.

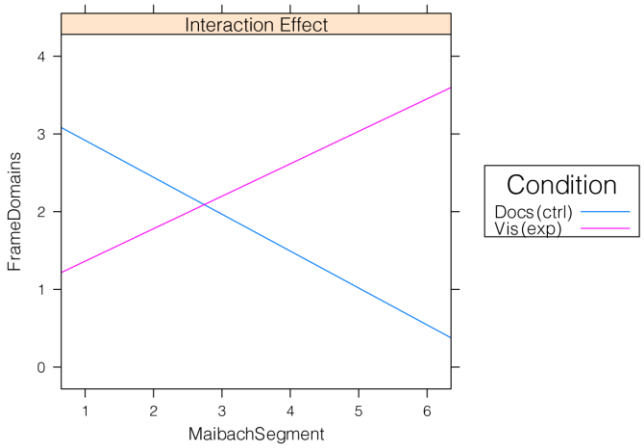

Figure 3. Use of the visualization interacted with views on global warming (Maibach et al., 2009) in predicting the number of domains on which a participants' novel frames draw. In the control condition, those who thought global warming less of an issue drew on fewer domains, but the visualization condition reversed that trend.

In summary, two important findings emerge here. First, both prior knowledge and prior opinions about global warming were significantly related to indicators of frame reflection. Moreover, these prior views interacted with use of the visualization tool; in the control condition, participants less concerned about global warming drew on fewer source domains when suggesting new frames, but the visualization condition reversed this trend. Second, the relative proportions of Con, Mixed, and Pro documents also influenced participants' thinking, a finding examined in more depth by subsequent follow-up analysis.

Follow-up Analysis

Tool Usage. To examine use of the visualization tool, we conducted further model selection analyses with data only from participants who used the visualization tool (N=24). From Table 2 above, we included those predictors that pertain to use of the tool (i.e., everything from ToolTime down). We also included the predictors and interaction in Table 6.

Table 6
System usage variables used as predictors.

Predictor	Description
NounsClicked	Number of unique nouns clicked on from the main list
VerbsClicked	Number of verbs expanded to show example fragments
ExsClicked	The number of example fragments clicked to show all similar fragments
VerbClicked:ExsClicked – pairwise interaction	

For the total number of frames suggested, the most important factor was the number of original documents to which participants were exposed (Table 7). However, this influence was mitigated by the number of example fragments on which the participant clicked. Essentially, only seeing example fragments was not as beneficial as seeing the source documents.

Table 7
Model for which aspects of visualization usage predict number of frames. $F_{2,21}=7.709$, $p=0.003$.

Predictor	Coefficient
NumDocs	0.592 ***
ExsClicked	-0.405 **

For the number of domains on which participants' new frames drew, the single most important predictor was the number of documents viewed, though that was mitigated by the number of Pro and number of Con documents (Table 8). That is, viewing more total documents was beneficial, so long as there was not a preponderance of only Pro or Con documents. While not individually significant, the number of example fragments clicked contributed to fewer frame domains, suggesting a similar pattern as above.

Table 8
Model for which aspects of tool usage predict number of framing domains. $F_{5,18}=6.382$, $p=0.001$.

Predictor	Coefficient
ToolTime	-0.00141
NumDocs	0.994 ***
ExsClicked	-0.231
NumDocs:ProDocs	-0.0498 *
NumDocs:ConDocs	-0.0720 *

In summary, these results suggest that the visualization's impact on frame reflection seems most noticeable when participants take advantage of the features that link them back to the original content to see the visualized patterns in context rather than looking only at examples of the pattern. Furthermore, we see additional evidence that the relative proportions of Con, Mixed, and Pro documents seem to be important predictors for our indicators of frame reflection. The next subsection examines this result further.

Document Balance. In the results described above, the relative proportions of documents expressing different views on cap and trade were found to predict frame reflection. First, we compare the proportions of documents viewed in each condition with the proportions in the data set of all documents by summing the counts of documents viewed in each condition (Table 9). Both conditions differed

significantly from the data set (Ctrl: χ^2=50.21, df=2, p<0.001; Exp: χ^2=74.40, df=2, p<0.001), and the two conditions also differed from each other, but not quite significantly (χ^2=5.69, df=2, p=0.058).

Table 9
Differences among the relative proportions of documents in the data set and documents viewed in each condition; counts summed across all participants.

Corpus	Data Set	Ctrl (browser)	Exp (visualization)
Con	120 (52.9%)	65 (30.7%)	28 (20.1%)
Mixed	69 (30.4%)	45 (21.2%)	28 (20.1%)
Pro	38 (16.7%)	102 (48.1%)	83 (59.7%)

To examine these differences further, we performed stepwise model selection for three outcome variables, one each for the proportion of Con, Mixed, and Pro documents. Similar predictors were used as above, excluding those that deal with proportions of documents (NumConDocs and below in Table 5). We still include interactions between the Views principal components and the experimental condition. No model significantly predicted the proportion of Mixed documents. For both Pro and Con, there was a significant interaction between experimental condition and the Views1 component (model details omitted here in favor of ANCOVA). Focusing on the Maibach et al. (Maibach et al., 2009) segment, as above, reveals two important results. First, there is a significant main effect for condition, for both Con ($F_{1,46}$=6.03, p=0.018) and Pro ($F_{1,46}$=4.83, p=0.033) document proportions. Second, for Pro, there is a significant interaction ($F_{1,46}$=6.08, p=0.017) between condition and segment (Figure 4). Thus, in the control condition, participants exhibited something like an inverse selective exposure bias (Garrett, 2009; Munson & Resnick, 2010)—those who were less concerned about global warming read more Pro cap and trade documents, and vice versa. In the experimental condition, though, this trend was reversed, with those participants less concerned about global warming viewing more Con documents.

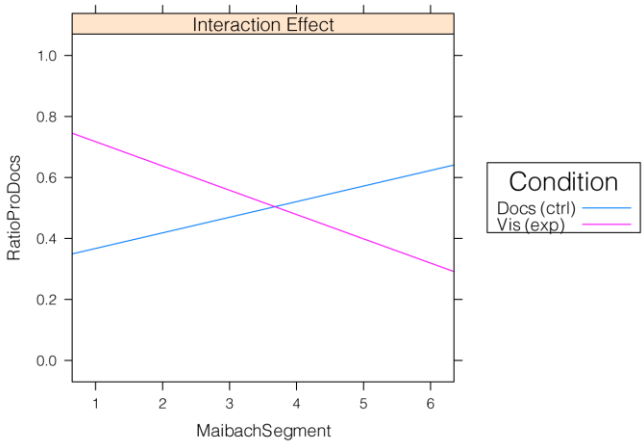

Figure 4. Use of the visualization interacted with views on global warming (Maibach et al., 2009) in predicting the ratio of Pro documents a participant viewed.

Discussion

The above results provide a detailed picture of how various aspects of the visualization influenced frame reflection. Here, we consider some broader ramifications.

First, the result in Figure 3—that the visualization may have helped support frame reflection among those who did not previously think global warming a serious issue but also reduced frame reflection among those who thought it was a serious issue—might be interpreted ambivalently, i.e., the tool helped some people's critical thinking and hurt others'. However, one might alternatively argue that the participants whose frame reflection was most impacted, those who did not consider global warming a serious issue, were the participants who could likely benefit most from increased frame reflection.

Second, we see evidence that aspects of the system design meant to bring users closer to the original data—clicking a verb to reveal an example fragment, clicking that example fragment to show similar fragments, and clicking a fragment to show it used in context—led to decreased frame reflection, unless the participant followed all the way through to the original document. This finding both aligns and contrasts with Baumer et al. (2010). Their study of metaViz found that focusing on example fragments pertaining to computationally identified metaphors decreased users' critical thinking and creativity, even when the user did click through to the original document. This discrepancy could be explained in a variety of ways: metaViz is about metaphors, while the tool presented here is about framing; participants in the present study were given a less directed task when using the tool; the study of metaViz recruited Mechanical Turk workers while this study involved college students; embedding the content in the visualization, as was done here, might be more beneficial than linking to external content, as in metaViz. Future work using visualizations to promote critical thinking should attend to this tension between high-level patterns and low-level examples.

Third, the important role that the relative proportions of Con, Mixed, and Pro documents played, in addition to the differences in those proportions between the two conditions, raises the issue of selective exposure (Garrett, 2009; Munson & Resnick, 2010), i.e., seeking out information that resonates with one's prior views and avoid conflicting information. The results here contribute to this area of study in two ways. First, they show that exposure to a variety of opinions helps facilitate frame reflection. Second, the results suggest that, while participants seemed to overcome their selective exposure bias in the control condition, the experimental visualization tool may have reinforced such biases (see Figure 4). Perhaps these participants had a general tendency toward diversity- or opposition-seeking that became too difficult to enact with the visualization. Since this experiment was not designed to examine selection exposure, though, it is difficult to determine exactly what might have caused the observed patterns. However, this result does draw attention to the need for consideration of how systems for reading political content, even those not expressly designed to broaden exposure (Munson & Resnick, 2010), may impact the variety of viewpoints to which users are exposed.

Future Work

Since the results presented here indicate that certain aspects of the design were associated with frame reflection, future studies should test different variants of such a visualization to determine more precisely the impact of each feature. For example, how might frame reflection by affected if the sidebar showing all example fragments opened as soon as a top-level noun was clicked, or if the full text of the original document was never shown?

Interpretation of the results should also be tempered by the study sample: students, mostly young, mostly liberal, mostly democratic. Furthermore, the modest sample size (N=50) may have been a factor in the model selection results. Future work should explore use of such tools among other populations, as well as considering a diversity of political issues.

While this study focuses on individuals, part of the motivation for this work is improving the quality of political deliberation. Future work should examine group settings, allowing deliberators to use the tool either before or while engaging in a deliberative discussion. It will be especially important to study non-laboratory settings, such as town hall style public forums or tools designed for readers of political blogs. Such work can help provide a better understanding of how people interpret, and make argumentative use of, the visualized linguistic patterns.

Finally, tools similar to that described here may also be useful for self-reflection, wherein the visualization is based on analysis of a user's or group of users' own discussion about a particular issue. Would using such a tool impact how the user thinks about her or his own perspective on an issue? Might a user subsequently change how s/he talks about, or thinks about, the issue? Although the work presented here focuses primarily on improving critical thinking about political issues, such a perspective could apply in a wide variety of areas.

Conclusion

This paper explores the design of an interactive tool to promote frame reflection (Schön & Rein, 1994), critical thinking about the ways in which a political issue is framed. In addition to describing the design of this novel system, we present results from a controlled lab study showing that use of the tool is linked to indicators of frame reflection. Specifically, when participants were asked to suggest novel frames, there was no difference in the number of frames suggested, but tool use was associated with drawing on more unique domains in considering alternative framings. Examining these results further, we find that users who took advantage of the tool's ability to link higher-level linguistic patterns back to the original context in which they occurred exhibited greater levels of frame reflection. However, we also found evidence that study participants who used the visualization viewed slightly more documents that aligned with their own prior views than those who used a simple document browser. Thus while the tool seems effective at promoting frame reflection, it may also slightly reinforce selective exposure bias (Garrett, 2009; Munson & Resnick, 2010). This paper's primary contribution, then, is not the details of the specific visualization evaluated here, but rather working toward building an understanding of how to design, as well as how to evaluate, tools for frame reflection. These results carry important implications in terms of implementing tools that not only facilitate political participation but encourage deep, thoughtful, and reflective engagement with the complex political issues facing our society.

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