BIG DATA OR SMALL STORIES? EXEMPLIFICATION AND INTERACTIVITY EFFECTS ON SHAPING PERCEPTION AND ATTITUDE OF SOCIAL ISSUES

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ABSTRACT

With the rising popularity of “big data”, an unanswered question is the extent to which laypersons are ready, willing and able to make sense of the information embedded in large-scale data. In order to make this data more accessible to readers, journalists tend to present statistical content about social issues and problems by accompanying them with exemplars or case studies that illustrate the data pattern. But, these exemplars do not always fully capture the complexity of the data patterns, yet they end up playing an important role in shaping user perceptions of the issue because they are more vivid than baserate information. How can we counter this biasing effect of isolated, non-representative exemplars and make readers pay more attention to baserates? Journalists have tended to employ visualization techniques to attract greater reader attention to baserates, but with limited success. This dissertation proposes that interactive visualization of big data is the answer. Interactive visualization can increase information processing of the baserates through two potential mediators: Vividness and Engagement. Interactive information visualization can make the pallid baserate information more vivid and therefore easier to process. Alternatively, by requiring users to act on the visualization, it can draw their attention to the baserate information and therefore serve to engage them with the data-rich content.

The study design involved a 2 (baserate-exemplar consistency) × 3 (interactivity of information visualization) × 2 (issue topic) mixed-design experiment. Participants were asked to read news reports about climate change and same-sex marriage depicted with a combination of exemplifying cases and information visualization of baserates. By empirically examining the interactivity effects in individuals’ issue perception formation and related outcomes, this study revealed distinctive mechanisms through which interactive visualization affects users’ information processing and emotional responses. The findings show that interactive visualization is positively associated with user psychology, and further leads to perceived vividness and user
engagement with the content. Compared to static visualization, interactive visualization is effective in motivating systematic processing of the baserate information, which positively influences accuracy of issue perception as well as personal attitude. Results help uncover the psychological processes through which individual perceptions are influenced by journalistic evidence, baserates in particular, in a highly visual and interactive media environment. The study also generates useful findings to inform ethical journalistic practices and effective interface designs for communicating big-data information.
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INTRODUCTION

We are facing an increasingly large amount of data—data from governmental archives, scientific research, public polls, banking and business transactions, sensors, social media, and other sources. The masses of data promise new insights for all fields such as governance, businesses (McAfee & Brynjolfsson, 2012; Chen, Chiang, & Storey, 2012), science (Frankel & Reid, 2008), public health (Murdoch & Detsky, 2013), and beyond. With the rising popularity of “big data”, an unanswered question is to what extent the laypersons are ready, willing and able to make sense of the information embedded in the large-scale data. Despite the wide availability of data, however, individuals’ use of “big data” is constrained by their data literacy—the capability to obtain and use data (Schiold, 2004), and their tendency to neglect the pallid and uninteresting statements (Taylor & Thompson, 1982). As a result, the layperson use of “big data” has been scarce.

In order to facilitate sense-making of overwhelming quantities of data, visualization has been adopted to represent non-figural information (Ben-Chaim, Lappan, & Houang, 1989), overview patterns (Shneiderman, 1996), test associations (Zhou & Feiner, 1998), and evaluate outcomes (Yi, Kang, Stasko, & Jacko., 2007). Other than these scientific and analytic use purposes, a more “casual” use of data visualization (Pousman, Stasko & Mateas, 2007) has been proposed, in hope to deploy its communicative (Frankel & Reid, 2008) and storytelling (Kosara & Mackinlay, 2013; Segel & Heer, 2010) capacities to facilitate and engage laypersons with “big data.”

This growing phenomenon of “datafication” (Mayer-Schönberger & Cukier, 2013) has impacted journalism significantly. Journalists have adopted various kinds of information graphics and visualizations, such as charts, maps, type-based and illustration-based graphics, to present statistical information about social issues and problems, which otherwise may not fit into the
limited space (Stovall, 1997). Visualizing news using information graphics (or, infographics) and visualizations is considered as “an apt way for dealing with two challenges of modern journalism: disclosing big data and presenting complex information in a way that is easy to comprehend” (Smit, de Haan, & Buijs, 2014).

However, are these static visualizations effective in conveying data-driven information to news readers? Visualization research (e.g., Heer, Bostock, & Ogievestkey, 2010; Lankow, Ritchie, & Crooks, 2012; Smiciklas, 2012) has shown evidence that static visualization on their own have positive cognitive and psychological effects. But, when static visualization is embedded in a news story, it does not appear as effective in engaging users with the statistical information. Some studies have found that static visualization seems to help individuals grasp a story’s information quickly (Pasternack & Utt, 1990) and positively affect reader comprehension, recall, and attention-getting ability (Griffin & Stevenson, 1996). Others have found that, however, data visualization functions merely as aid and context to the textual component of a news report. News reports tend to accompany visualized data information with individualizing cases and stories that exemplifying the issue depicted in news stories, and these exemplifying cases are likely to outweigh the data information. When visualized data information is competing reader attention with textual exemplars, readers still rely heavily on the text of a news report, and treat infographics and visualizations more or less as an “eye-catching” design component (Stone & Hall, 1997).

This effect can be partially explained by exemplification theory, which dictates that exemplifying information has a stronger influence on reader impression than the statistical information, or, baserate information. In empirical studies that specifically investigated the effects of exemplars versus baserate information in the form of static visualization, scholars (Sundar, 1991; Chang, 2000) have found limited effects of the baserate information on reader issue perceptions when exposing readers to both types of information simultaneously. Rather, readers formed their perceptions of the issues primarily based on the individualizing stories and
quotations. These empirical findings of print news are applicable to online news, as content analyses of news websites indicate that digital journalism has generally follow the same structure of print news, rather than “reinventing” itself (Barnhurs, 2010); online news sometimes even shows a “visual poverty” relative to print, “with identical text but less visual variety and fewer images” (p.555). In other words, data visualization in online news still has to compete with the personal anecdotes and quotations in influencing news viewers’ perceptions and attitudes.

How can we make “big data” more usable for users’ perception and attitude formation when they are inevitably accompanied with “small stories” that are inherently more attractive? Interactive visualization—computer-supported, interactive visual representations of data (Card, Mackinlay & Shneiderman, 1999)—appears to be a promising option to engage individuals with the statistical data, and facilitate consumption and comprehension of data-rich news content.

Computer scientists and human-computer interaction (HCI) researchers have argued that interactive visualization, compared to static visualization, can better facilitate news storytelling (Segel & Heer, 2010) and sense-making of unstructured data (Cohen, Hamilton, & Turner, 2011) by providing dynamic visual presentation and occupying more sensory channels than vision.

Communication research of interactivity (Sundar, Jia, Bellur, Oh, & Kim, 2014) provides further evidence that the interactivity affordance of an interactive visualization interface can enhance user absorption and elaboration of the content, and further influence user cognition and attitudes. The same belief is held in some newsrooms as well (Lewis & Usher, 2013). Since the mid-2000s, news organizations (e.g., The New York Times, The Guardian) have started to set up dedicated units staffed with programmers familiar with journalism, or the so-called “programmer-journalists” (Parasie & Dagiral, 2012), to design and produce “news applications” – online presentations, databases, interactive maps, etc. (Royal, 2010), which enable readers to conduct their own fact-checking (Stray, 2010). Some renowned news corporations and organizations have dedicated sections of their news websites featuring stories with interactive visualizations (e.g., http://www.nytimes.com/newsgraphics/2013/12/30/year-in-interactive-storytelling/), and even
offered courses and workshops to train journalists to create interactive visualization (e.g., http://www.theguardian.com/guardian-masterclasses/data-visualisation). Independent news organizations and start-ups (e.g., ProPublica, PolitiFact) specialized in data-driven journalism have also contributed greatly to this expansive aspect of journalism.

Despite the enthusiasm, however, we know little about how effective interactive visualization is as a tool to convey data-rich information to news consumers. Can interactive visualization make “big data” more attractive and usable than “small stories” when shaping individuals’ issue perceptions and attitudes? Would interactivity engage individuals with the visualized data information in spite of the accompanying, attractive exemplars, or is exemplification effect too strong to counteract, even with interactive visualization tools? If interactive visualization does make baserate information more influential in the process of perception formation, what are the underlying mechanisms that make interactivity effective in enhancing individuals’ utilization of baserate information? It is therefore important to examine the potential moderating effects of interactivity on the exemplification effect in order to understand what kind of role interactive visualization plays in a news report to influence individual information processing and perception.

My dissertation proposes to investigate the influence of interactivity on individuals’ use of visualized baserate information in the process of constructing issue perceptions and informing personal attitudes. The objectives of this dissertation research include examining the effectiveness of using interactive visualization, as opposed to static visualization, to encourage individuals’ utilization of baserate information and to decrease the biasing effects of exemplars on individuals’ perception and attitudes of social issues. Furthermore, cognitive and psychological mechanisms underlying such effects will be explored. Interactive visualization can increase information processing of the baserates through two potential mediators: presentational vividness and user engagement. Interactive visualization is likely to engage individuals sensorially and/or behaviorally, and through these two mechanisms enhance information processing of the
visualized baserates, which may counteract the dominant effect of exemplifying information and facilitate individuals to form accurate perceptions and informed attitudes.

This dissertation research aims at empirically examining if interactive visualization can make the baserate information more vivid and engaging, and, as a result, increase information processing of statistical evidence in news reports of social issues. In other words, interactivity will moderate the exemplification effect shaping individuals’ perceptions and attitudes of social problems and issues depicted in news. This dissertation research is among the first to explore the impact of interactive visualization as a news component on individual issue perception and personal attitudes. Findings from it will extend research of exemplification effects in a highly visual and interactive media environment, and shed light on identifying ideal journalistic practices for better utilizing today’s exponentially growing “big data” in order to both accurately inform and actively engage the increasingly technology-savvy online news readers.

This dissertation proposal will first present an overview of the proposed research. Following that, exemplification theory will be reviewed, with an emphasis on the dominant effect of exemplar distribution on issue perception and attitude, despite the availability of baserate information, even when presented with static visualization. Then, the effectiveness of interactive visualization influencing information processing, issue impression and attitudes will be discussed, leading to the proposal of two potential mechanisms of the theorized effects: (1) the vividness mechanism, and (2) the user-engagement mechanism. The two mechanisms will be discussed in further detail, based on which the hypothetical relationships will be proposed. Finally, individual-difference factors that may moderate the interactivity effects and/or the exemplification effects, e.g., issue involvement, need for cognition, and power usage, will be discussed accordingly. Based on the literature review, an experimental study design is conducted to empirically examine the hypothetical effects of interactivity moderating the dominant, biasing effects of exemplars on issue perceptions and personal attitudes through enhanced vividness and user engagement.
Chapter 1

LITERATURE REVIEW

News readers rely heavily on news representation of social issues (Chiricos, Padgett & Gertz, 2000; Cohen, Adoni & Drori, 2006) to construct their perception of social reality (e.g., Entman, 1992) and opinion climate (e.g., McLeod & Detenber, 1999). The choice of journalistic evidence is found to have a substantial impact on audience’s information processing (e.g., Scheufele, 1999) and perceptions (e.g., Perry & Gonzenbach, 1997). Exemplification theory, in particular, characterizes the distinct effects of two major types of information—baserate information (abstract and statistical information that indicates the overall status of the issue under consideration) and exemplifying information (concrete and individual experiences that illustrate the single cases of the phenomenon)—used as journalistic evidence in news stories to depict a social issue. News reports tend to follow a fixed pattern of supplementing abstract, general statements with concrete, individualizing cases to depict and explain the social issues in ways that are “both understandable and interesting” to the readers (Zillmann, Gibson, Sundar, & Perkins, 1996). However, the colorful and vivid exemplars tend to have a stronger influence on reader perceptions than the valid but boring baserates (Zillmann et al., 1996). After reading a news report with both exemplifying and baserate information, the readers’ perception of the social issue will only depend upon the exemplars, and when the exemplars are extreme cases and exaggerating the issue, they will mislead individuals to form a distorted perception, despite the accurate baserates (Gibson & Zillmann, 1994).

Different approaches to increase the influence of baserate information on issue perception, such as changing the precision of the baserate information (e.g., Zillmann et al., 1996) or enhancing its vividness using multimedia presentation (e.g., Sundar, 1991; Chang, 2000), have only showed limited to no effect. Visualizing baserates with static visual formats, such as tables and charts, in particular, seems to positively influence reader recall of the baserate information;
however, baserate information still fails to influence reader issue perceptions as much as the exemplars (Sundar, 1991; Sundar, Zillmann & Perkins, 1992; Chang, 2000).

A revisit of the exemplification theory seems needed, as data sets are growing in size, complexity and importance in today’s life, and consequentially becoming an increasingly essential type of journalistic evidence. Large volumes of data collected by governments, research institutes, corporations and even individuals, ranging from meteorological and environmental data to financial and personal health data, can reveal useful information if properly curated, managed and processed. Like all fields, journalism hopes to take advantage of the increasing amount of data as a component of news reporting. Following this emerging trend, interactive visualization has been adopted in hope to facilitate individual use of data-rich information. We are seeing an increasing number of interactive visualization in online news content, ranging from interactive maps of crime data (e.g., USA Today’s “U.S. Mass Killings since 2006”) to data visualizations of the U.S. economic status and forecast (e.g., the New York Times’ “Budget Forecasts, Compared with Reality”). These interactive visualizations not only represent a larger scale of statistical information than the non-interactive visualization through its dynamic display, but also allow users to play with the visualization through its interactive features.

As indicated in computer science and human-computer interaction research on visualization and graphics, interactive visualization can amplify cognition (Card et al., 1999) and facilitate understanding of the statistical information (Ben-Chaim, Lappan, & Houang, 1989). A literature review of interactive visualization suggests that its powerful effect on cognition primarily lies in its interactive qualities and elements, and manifests through individuals’ actual use of these elements (e.g., Shneiderman, 1996; Yi et al., 2007). According to communication research of interactive media, interactivity can engage users to be more absorbed in the communicative process (Sundar, 2008). In the context of journalism, interactive news interface allows a higher level of tinkering (play and experimentation with the news product) and participation (Lewis & Usher, 2013). However, these studies have only looked at the effect of
interactive visualization as a stand-alone application, without testing its influence on individual cognition or perception when it is accompanied with exemplifying information.

Therefore, it is important to empirically examine if interactive visualization as a news component is influential enough in shaping reader perceptions, when it is competing with exemplars. This new combination of news content—interactive visualization of baserate information and verbal representation of exemplars—lends itself to the ongoing research of exemplification effects. Is interactivity as an interface affordance capable of enhancing readers’ use of the otherwise abstract and pallid baserates when they form perceptions of the social issues as well as their personal attitudes? Is interactive visualization able to convey baserate information to the readers and influence their perceptions and attitudes more successfully and accurately than static visualization? If so, what are the underlying mechanisms through which baserate information becomes more influential? In other words, it is crucial to understand if and how interactivity as an affordance of the online news interface may alter exemplification effects on readers of information processing and perception formation.

Therefore, for my dissertation research, I propose the following research question:

**RQ:** Can interactive presentation of baserate information in online news of social issues counter the biasing effect of exemplars on reader issue perception and attitudes toward the social issues in discussion?

In order to investigate this research question, the following sections will first provide an overview of exemplification theory and empirical studies relevant to this study. Then, the use of interactive visualization to counter the exemplification effect is discussed. Specifically, two distinct mechanisms through which interactive visualization enhances readers’ emotional responses and systematic processing of baserate information are proposed, theorizing that interactive visualization can influence individuals’ issue perception and attitude by increasing the presentational vividness of the baserate information and by enhancing user engagement with the baserate content.
Exemplification Effects

Baserate information is able to provide an accurate and representative overview of a given social issue, and is therefore a key component of news reports. However, the statistical data can be rather complex and challenging to understand. In order to make this data more accessible to readers, journalists tend to present statistical content about social issues and problems by accompanying them with exemplars or case studies that illustrate the data pattern. This attempt usually fails to help readers understand the baserates better. Instead, the exemplars that do not always fully capture the complexity of the data patterns end up attracting reader attention away from the baserates and distorting their perceptions. In other words, under conditions of informational competition (Taylor & Thompson, 1982), i.e. when baserates and exemplars are provided at the same time, baserate has relatively little influence on reader issue perception, a phenomenon that is well documented by exemplification research in communication.

Exemplification theory (Zillmann, 1996) defines baserate information as abstract or general information that is often presented in statistical or quantitative descriptions, which are assumed to reflect a more accurate and representative assessment of the overall issue that is being discussed and are intended to facilitate readers to put the issue into perspective. Exemplars, on the other hand, are concrete and episodic information that illustrates the issue or phenomenon through individualized cases, usually with a small number of detailed examples that are often selected for their vividness or emotional appeal rather than for “a commitment to impartial, balanced reporting” (Zillmann & Brosius, 2000). Indeed, exemplars used in news stories rarely actually reflect the representative presentation of cases in baserates, as “the man-bites-dog paradigm of news dictates that stories dwell on that which is unique and unusual” (Sundar, 2003). What is more alarming is that the slanted exemplars have a strong appeal with the readers and tend to be processed more elaborately. Consequently, exemplars would have a strong and lasting
effect on individual impressions, which would override the impact of baserates, especially when one contradicts the other.

Empirical studies have demonstrated exemplification effects that reader perceptions are more influenced by exemplars than baserate information. Therefore, if a news report features misleading, extreme illustrations of individual cases, reader perceptions are more likely to be distorted. For instance, Gibson and Zillmann (1994) have found that, even though statistical information was provided in the news report illustrating the majority of carjacking victims without any physical harm, participants who viewed distorted exemplars (carjacking victims with severe injuries or being killed) were more likely to consider carjacking as a serious national problem compared to those who viewed less distorted exemplars. Besides the distortion of exemplars, even when exemplars present a divergent view of oppositional cases, the distribution of exemplars would still have an influential effect on issue perception. For instance, Zillman, Perkins, and Sundar (1992) have revealed the effect of exemplar distribution on reader estimation of the occurrence of events. The researchers exposed participants to news magazine stories about weight loss and regain, with selective, representative and mixed distributions of exemplars and counter-exemplars. The findings indicated that the representative exemplar distribution led to the highest accuracy in terms of issue perceptions, while the selective exemplification led to an overestimation of the minority cases. The effect of exemplar distribution was short-termed, and diminished to pre-existing perceptions over time. Interesting, when exemplars portrayed exemplifying cases that were somewhat contradictory, the precision of baserate information (exact numbers versus general descriptions) showed a lasting effect such that accuracy was higher for people exposed to precise baserate information than for those exposed to imprecise information. Similarly, Brosius and Bathelt (1994) exhibited similar results by exposing a group of college students with radio news discussing the public opinion about some university-related issues, and found that exemplars had a strong effect on the perceived distribution of public opinion and participants’ personal opinion about the issues, while baserate information showed
almost no impact. An experimental study (Zillmann et al., 1996) further investigated the effect of exemplar distribution on reader perceptions of unfamiliar issues. The results showed a strong and stable exemplification effect, which could be prolonged especially when readers do not hold well-defined prior beliefs associated with the depicted issue. These studies (e.g., Brosius & Bathelt, 1994; Gibson & Zillmann, 1994; Zillmann, Gibson, Sundar, Perkins, 1996) have shown that the distribution of contrasting exemplars, which is either representative or discrepant from the actual situation, can affect the way that people perceived the distribution of public opinion or the likelihood of events, and can also influence the participants’ own opinion.

Why do exemplars have such strong effects on reader perception and attitude? Some researchers argue that it is because individuals tend to depend on heuristics, or mental shortcuts (Fiske & Taylor, 1991), for making economically efficient judgments about probabilities. One of the heuristics that individuals may rely on is the representativeness heuristic, which refers to how individuals make judgment about the probability of category membership depending on the similarity between features of the target to the essential features of the category (Kahneman & Tversky, 1972). In other words, when exposed to a certain distribution of individual cases, individuals may disregard the baserate information and rely solely on the individual cases to estimate the ratio or percentage of similar cases. This tendency is reinforced especially when people have difficulties processing baserate information, and cannot rely on this type of information for making judgments about a social issue (Brosius, 2003). This efficient estimation, however, is inevitably achieved at the expense of accuracy.

Availability heuristic is another explanation proposed to explain the misleading effects of selective aggregation of exemplars. It is argued that case information has been the only type of information available for people to form their judgments in their everyday communication situations, whereas statistical evidence and summary descriptions from a mass group are “beyond our experiential horizon” until recently (Brosius, 2003). Therefore, individuals tend to rely on readily available and easily accessible instances or associations to make estimates of frequency or
likelihood. The subjective feeling of ease prevents actual information retrieval or construction, which is needed for utilizing baserate information. Therefore, exemplifying cases, being the recently activated and easily retrieved memories are likely to influence reader perceptions, leading toward misjudgment and overestimation.

These explanations are criticized for not fully uncovering the qualities of exemplars that distinguish themselves from baserates in influencing information processing. A vividness explanation is regarded as a more convincing explanation of exemplification effects (e.g., Chang, 2000; Sundar, 2003; Taylor & Thompson, 1983; Tran, 2012). Comparatively, exemplars are “inherently more colorful, engaging, emotional and interacting,” whereas baserates are “dull, terse, boring, and for most people, difficult to picture in their minds” (Sundar, 2003, p. 287).

Compared to the pallid baserates in the forms of broad statements or numerical facts, exemplars seem to “possess more vividness and emotional proximity” (Brosius, 2003, p. 180). The illustrations of personal accounts, anecdotes and quotations in news reports appear to be highly vivid, concrete, authentic, or dramatic, more so than the broad statements or numerical facts (Brosius & Bathelt, 1994). This greater level of vividness of case information may explain individuals’ reliance on case information over baserate information. On one hand, vivid information leads to higher level of information processing, which enhances elaboration and recall of the information (Smith & Shaffer, 2000). Therefore, exemplifying information is more easily retrieved when individuals need to form their perceptions, and tends to have an overpowering effect over the pallid and dull baserates (Nisbett & Ross, 1980). On the other hand, vivid exemplars are able to evoke emotional responses from news readers (Fiedler, 1988; Sundar, 2003). As the impression the pallid baserate information makes diminishes over time, the emotionally interesting stories can linger longer in memory (Taylor & Thompson, 1983). Therefore, the vivid exemplars can have a lasting effect in influencing readers’ perceptions and attitudes.

Following the vividness principle, researchers and journalists attempted to increase news
readers’ use of baserate information in perception and attitude formation by boosting the vividness of baserates. Different visual formats such as maps, charts, and diagrams were present statistical relationships. The static visualization did appear to aid reader understanding of the news content (Griffin & Stevenson, 1992) and focus reader attention on the visualized information (Ramaprasad, 1991). However, when static data visualizations and verbal descriptions of exemplars are placed side by side, visualized baserates do not seem vivid enough to counter the dominant, biasing effects of exemplars. For instance, Sundar (1991) empirically examined the effectiveness of boosting the vividness of baserate information by presenting it in the form of infographics. While exemplars were provided in text, pie charts were utilized to illustrate statistical information in the news stories. But the visualization failed to produce significant effects on issue perception. Considering that individuals might differ in their capability of understanding the infographics, the author reanalyzed the data with the participants who reported the news stories as easy to read. This analysis revealed a positive effect of infographics on reader recall. However, this effect was only short-term and outlived by the exemplar effects. Similarly, in another experimental study, Chang (2000) found that using bar-charts to visualize poll results, compared to showing the same baserates in a textual format, could enhance immediate recall of the baserates; however, there was still no evidence showing that the vivid presentation influenced the utilization of baserate information in the participants’ process of issue perception.

Why is the effect of static visualization on enhancing vividness of baserate information so limited? Why does its impact on reader recall not translate into an impact on issue perception? Based on the vividness principle, one possible explanation is that, even though static visualization is vivid enough to attract attention and improve recall, impression from this type of visual presentation is not as strong as the dominant effect of exemplars, hence the lack of effect on long-term recall and issue perception. In other words, in order to boost the influence of baserates on issue perception and attitudes, baserate information needs to be presented in a more vivid, visual
and arousing format than simple static visualization. Indeed, scholars (e.g., Jarman, McClune, Pyle, & Braband, 2012) have found that adding extra presentational features to simple graphics can significantly improve rhetorical power to convey abstract, non-visual concepts or relationships. Moreover, animation (Diao & Sundar, 2004) or visual changes as simple as a gradually loading image (Sundar & Wagner, 2002) can significantly influence attention orientation, content memory and emotional arousal. Conversely, static visualization in the forms of bar charts and pie charts may be too simplistic in representational design to support the meaning making and interpretation, or to represent a sensorially rich visual reality to provide the vividness as Steuer (1992) conceptualized. In order to further increase the vividness of baserate information, this dissertation research proposes to use interactive visualization, instead of static visualization, to present the statistical facts in news reports.

   Based on exemplification theory and the empirical findings discussed above, it is hypothesized that, without interactive visualization, when baserate information is presented in verbal formats or in the format of static visualization, readers’ recall, issue perceptions and attitudes will be primarily influenced by the vivid exemplifying information. That is to say, regardless of the general information described in the baserates, the exemplars featured in a news article will determine how readers perceived the social issue depicted in the news. When asked about the likelihood of an event or the overall situation of an issue, readers will form their estimations and perceptions based on the different types (i.e. supportive versus opposing) of exemplars instead of the baserates. In other words, if the exemplars illustrate an event or issue inconsistently with what the baserates describe, readers’ recall, issue perception and personal attitude are more likely in accordance with the exemplar distribution rather than being influenced by the accurate baserate information. Therefore, the selection of exemplars, or the distribution of exemplars, will determine the accuracy of readers’ recall and perception, as well as their attitude toward the social issue.

   \textbf{H1: Exemplar-baserate consistency, compared to exemplar-baserate inconsistency, will}
lead to a higher level of accuracy in *baserate recall* (H1a), *exemplar recall* (H1b) and *issue perception* (H1c), and better *personal attitude toward the issue* (H1d).
Using Interactive Visualization in News Content

More often than not, news articles present readers with isolated, non-representative individual cases, which are more influential than baserate information in determining readers’ information processing of, and emotional responses to, the news content, and therefore bias readers’ issue perceptions and attitudes. How can we counter this biasing effect of the exemplars and make readers pay more attention to baserates? As discussed previously, journalists have tended to employ static visualization to attract greater reader attention to baserates, but with limited success. This dissertation proposes that interactive visualization is the answer. Interactive visualization is able to support cognitive activities in scientific and analytic contexts; its use in news reporting shows promise of facilitating news readers’ processing of baserate information, and thus diminish the biasing effects of exemplars.

As defined by Card et al. (1999), interactive visualization, or information visualization, is “the use of computer-supported, interactive visual representations of data to amplify cognition” (p.7). Interactive visualization first emerged as a remarkably useful tool for scientific discovery and presentation (Friendly, 2008). Later, numbers pertaining to people—societal, medical, and economic data—began to be gathered in large quantity and periodic series, and the usefulness of the data for decision-making, planning and governing began to be recognized. Therefore, interactive visualization became widely used in more domains such as public health and macro economy for data analysis and policy making. Most recently, the widespread of personal computers and mobile computing devices, as well as the rapid development of computing technologies, makes interactive visualization accessible for individual and layperson use. Use of interactive visualization is now not limited to educational, scientific, or work purposed; rather, it can be spotted in news websites, in personal health applications, and for aesthetic purposes. Pousman, Stasko and Mateas (2007) have classified this type of use-cases as “casual information visualization”, that is for everyday users to use interactive visualization to construct personally meaningful information. Specific to its use in the news domain, Sundar, Jia et al. (2014) have
proposed a concept of “news informatics”, referring to the use of interactive visualization for obtaining the filtered as well as unfiltered data about public affairs and social issues in relation to news events.

Compared to traditional, non-interactive visual presentations, interactive visualization is especially useful for its cognitive merits (Kerren, Stasko, Fekete & North, 2008). Its dynamic presentation facilitates the generation of a mental model of the data, while its interactive functions enable users to simplify the large-scale data by filtering out noise from useful data to find patterns interesting to the users. Everyday use of interactive visualization, e.g., as a content component of a news report, can encourage absorption with the data, contribute to analytic insights (e.g. identifying relationships, testing alternative hypotheses), and facilitate elaboration, which may lead to reflective insights (insight of the meanings to oneself and one’s relation to the world), through interacting with the actual data (Pousman et al., 2007), which is not possible in static visual formats.

Integration of interactive visualization into journalistic practices has gained popularity in the emerging field of “computational journalism” (Cohen, Hamilton, & Turner, 2011), which is otherwise referred to as “computer-assisted reporting” (Cox, 2000), “data journalism”, “precision journalism”, “programming journalism” (Royal, 2010), or news informatics (Sundar, Jia et al., 2014). Large-scale data “that would otherwise not fit a print or broadcast story are now grouped, connected and presented in an interactive fashion for readers (or, more accurately, users) to select, access, customize and consume in an idiosyncratic manner” (Sundar, Jia et al., 2014). This new form of news reporting involves the computer-assisted processes of discovery, analysis, presentation, aggregation, personalization, archive and sensemaking of news topics from compilations of public records, private databases and the widely-available consumer data in terms of Web searches, online discussions, tweets, and text messages, in large volume (Cohen, Hamilton, et al., 2011; Flew, Spurgeon, Daniel, & Swift, 2012; Halevy & McGregor, 2012).
Interactive visualization as a useful tool to present and communicate a high volume of data has been researched in various fields such as computer science (e.g., Card et al., 1999), human-computer interaction (e.g., Herman, Melanco, & Marshall, 2000), data mining (e.g., Fayyad, Wierse, & Grinstein, 2002), graphics (Tuftt & Graves-Morris, 1983), and visual design (Ware, 2012). Until recently have scholars started to investigate the use of interactive visualization in news media and contracts its utility to the non-interactive, static visualization. As static visualization is found ineffective in increasing the baserate vividness and usability, interactive visualization seems promising.

How would interactivity moderate the exemplification effect? There are two potential mechanisms: (1) Interactive visualization can enhance the level of vividness of the baserate information by providing improved visual presentation (sensory depth) with its dynamic display and by occupying more human senses (sensory breadth) with its tactile interaction features; and (2) interactive visualization can afford actual action possibilities, which will induce users’ psychological responses such as perceptual bandwidth and perceived contingency, and therefore enhance user engagement with the content, further influencing perception and attitudes.

In the following two sections, these two potential mediating mechanisms will be further discussed to theorize the effects of interactive visualization on news readers’ utilization of baserates: (1) From a vividness perspective, interactive visualization can serve as a vivid presentation of baserate information, and therefore attract reader attention and encourage utilization of baserates, positively influencing efficiency of information processing and post-exposure perception accuracy (e.g., Deuze, 2004; Chen & Yu, 2000; Cooke, 2003; Opgenhaffen & d’Haenens, 2011); and (2) from a human-computer interaction perspective, the interactive affordance is the primary factor underlying user engagement with interactive visualization and individuals’ utilization of the visualized information (e.g., Card et al., 1999; Shneiderman, 1996; Segel & Heer, 2010; Sundar et al., forthcoming).
The vivid and engaging qualities of interactive visualization are likely to increase news readers’ emotional responses to the baserate information as well as encourage systematic or central information processing of the baserate information, which will lead to greater accuracy in their recall of the content and their perceptions of the social issues, as well as more positive attitude toward the issues.

Thus, we can hypothesize that interactivity will have a main effect on recall, issue perception and personal attitude:

**H2**: Presence of interactivity, compared to absence of interactivity, will lead to a higher level of accuracy in exemplar recall (H2a), baserate recall (H2b) and issue perception (H2c), and more positive personal attitude toward the issue (H2e).

Further, the effect of interactivity on recall, issue perception and personal attitude results from its effect on emotion and information processing:

**H3**: Presence of interactivity, compared to absence of interactivity, will lead to higher level of emotion experienced by the participants, both in terms of valence (H3a) and arousal (H3b), as well as greater systematic processing (H3c) and less heuristic processing (H3d) of the news content.

Last but not least, the interactivity effect may moderate the effect of exemplar distribution:

**H4**: Interactive visualization will reduce the effect of exemplar distribution on recall, issue perception and attitude compared to static visualization, such that exemplar distribution will have a weaker effect on recall, issue perception and attitude when the baserate information is illustrated in interactive visualization rather than in static visualization or verbal description.
Interactive Visualization as a Vivid Presentation

Interactive visualization has the capacity to aid our thinking through its vivid presentation, or to paraphrase Card et al.’s (1999) words, it helps us understand things by “seeing” it better. Compared to a static visualization, interactive visualization provides an interactive visual presentation of baserate information, which, as discussed below, enhances presentational vividness of the baserates. As a result, interactive visualization as a vivid presentation can boost the impact of baserates, making it as influential as the vivid exemplars, if not more so, in individuals’ perception and attitude formation.

As previously reviewed from exemplification literature, one of the primary reasons why exemplifying information has a strong effect on reader issue perception is its higher level of vividness. In other words, vividness appears to be the underlying mechanism through which exemplars attract reader attention in the short term and distort reader perceptions and attitudes in the long run. Following the vividness principle, it is logical to try to boost baserate vividness in order to increase the effects of baserate information on perceptions and attitudes.

In what way can baserate information become more vivid? Vividness has been conceptualized (Nisbett & Ross, 1980) as the quality of information that attracts and holds human attention and excites imagination “to the extent that it is (a) emotionally interesting, (b) concrete and imagery-provoking, and (c) proximate in a sensory, temporal, or spatial way” (p.45). Two major approaches to operationalize vividness include a vivid message and a vivid presentation (Taylor & Thompson, 1982). Operationalization of vividness as a message feature (e.g., colorful, concrete, etc.) tends to present the information the forms of direct quotation (as opposed to paraphrased forms), emotional testimony (as opposed to calm or no testimony), threatening message (as opposed to sanitized message), etc. (e.g., Gibson & Zillmann, 1993; Gibson & Zillmann, 1998). The other approach operationalizes vividness as a presentational feature and varies the level of vividness through different presentational formats (e.g., Appiah, 2006; Tran, 2012). The message approach is not readily applicable to baserates, as baserate information can
rarely be expressed emotionally or colorfully; the vivid presentation approach, however, lends itself well as a solution to improving the level of vividness of baserates by varying the medium or technological features in communication processes.

The conceptualization of vividness as a presentational attribute can be traced to the human-computer interaction literature. Steuer (1992) defines vividness as the representational power of a medium or technology, in terms of its “ability … to produce a sensorially rich mediated environment” (p. 82). Based on this conceptualization, the level of vividness of a given message is determined by the medium features that it utilizes in its presentation, and it can be affected by two variables: sensory breadth (the number of different senses that the presentation engages) and sensory depth (the quality of the sensory information available in each perceptual channel). If either sensory breadth or sensory depth can be enhanced, the level of vividness can be increased accordingly. This conceptualization of vividness has served as a conceptual rationale for examining vividness effects as a result of the varying levels of sensory breadth when information is presented with different modalities or multimedia presentations such as pictures, audio, video, and animation (see Appiah, 2006; Coyle & Thorson, 2001; Gibson, Smith, & Hester, 2008; Smith & Shaffer, 2000; Tran, 2012).

In order to enhance the baserate vividness, static visualization has been used to engage the human vision and to make the baserates more visual. However, static visualization appears ineffective to counter the dominant effect of exemplars. Scholars (Chang, 2000; Sundar, 1991; Zillmann, Perkins, & Sundar, 1992) have found that the effect of static visualization in the forms of bar charts and pie charts is limited to influencing readers’ recall of the content, but they failed to affect readers’ issue perceptions, which were still largely determined by the exemplars. The ineffectiveness of using static visualization to enhance the influence of baserates may be due to the visual simplicity of static visualization. A more vivid presentation is needed to significantly increase the sensory depth and/or the sensory breadth, in order to provide a sensorially rich visual presentation (Steuer, 1992) that can attract readers’ attention to the baserates.
Interactive visualization appears capable of providing a higher quality of visual presentation as well as engaging more sensory channels than static visualization, serving to increase the presentational vividness of baserate information. Adding dynamic changes and transitions to static visualization, interactive visualization can better “take advantage of the human eye’s broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once” (Thomas & Cook, 2005, p.30). Moreover, interactive visualization serves both as a visual representation and as an interactive representation of the data information. The interactive features that are embedded in interactive visualization can include preview, data filters, animations, etc., which function together with the visual features to expand the sensory richness of the mediated experience, and to influence individuals’ perceptions and message processing (Moere, Tomitsch, Wimmer, Boesch, & Grechenig, 2012).

First of all, interactive visualization can enhance baserate vividness by increasing the visual sensory depth with dynamic visual presentations. The visually dynamic presentation of interactive visualization results from the dynamic queries techniques that it offers (Heer, Card, Landay, 2005), e.g., orchestrating changes in item appearance (e.g., zooming), or providing various views and animated transitions (e.g., switching between different graphics of data). The dynamic visual changes and transitions in response to viewers’ queries, compared to static visual presentations, can increase sensory depth of human vision, by improving improved quality of the visual information. Most fundamentally, as the human visual system is sensitive to movements and changes (Watson & Ahumada, 1985), the changing or moving visual objects could help orient viewer attention and change the point of view of the visualization (Gershon & Page, 2001), and make the baserate information more effectively processed than with a static presentation. Dynamically changing visualizations also have the potential to help viewers build mental models of complex change processes, which static graphics are unable to do (Lowe, 2004). Compared to static visualization that is often overloaded with values and data details that can be visually and cognitively overwhelming, interactive visualization can show details on demand, increasing the
amount of the variable space that can be examined at a single time and allowing viewers to better perceive how the data patterns are structured (Card & Mackinlay, 1997). As a consequence, dynamic visualizations are found to have an “overall advantage” over static pictures (Höffler & Leutner, 2007) in different aspects such as recognition memory (e.g., Brucker, Scheiter, & Gerjets, 2014), problem-solving (e.g., Mayer & Moreno, 2002), and procedural knowledge (e.g., Yarden & Yarden, 2009). The cognitive impact of interactive visualization’s dynamic display has the potential to help baserate information linger in memory long and therefore have a greater effect on judgments.

In addition to increasing the sensory depth of vision, interactivity can also influence the sensory breadth aspect of vividness by engaging other sensory channels than the visual sense that static visualization can occupy. This is because it offers interaction techniques, e.g., clicking, mousing-over, and filtering, through which individuals can manipulate a visual representation. These techniques engage users’ tactile/kinesthetic sensory channels by creating the association between user actions with the input device (i.e., a mouse or a tracking pad) and on-screen visual changes. In other words, the interactive features of interactive visualization have the potential to enhance the sensorial richness of a visual presentation through occupying the human sense of touch with the mediated message.

The proposition that interactivity may enhance vividness of information by engaging more sensory channels is consistent with the effects attributed to medium-based interactivity (or modality interactivity) by Sundar (2007). This kind of interactivity emphasizes the variety of modalities that the medium offers for users to experience the interface and the information that it delivers. The interactive user interface affords input modalities on the screen through “pointing tasks” such as selecting, orienting, and gesturing (Shneiderman & Plaisant, 2010), each of which is achieved through interaction techniques such as click, scroll, zoom, mouse over, and slide. These interactive input modalities afford users the ability to access, encode, and experience the visual representation in a variety of ways (Sundar, Xu, & Bellur, 2010). Hypothetically, the more
interaction techniques that an interface affords, the more vivid the presentation would appear to the viewers, and the heightened vividness will serve to enhance one’s mental representation of the information, and engender positive perceptions and accurate memory of the content, which are among the outcomes of interactive visual interfaces established in empirical studies (e.g., Sundar, Bellur, Oh, & Jia, 2011; Sundar, Jia et al., 2014). The improved recall of baserate information is likely to maintain its availability and accessibility when individuals are asked to make judgments and report perceptions.

Previous research has found some empirical evidence showing that the addition of interaction modalities can enhance the level of vividness of the mediated content. For instance, studies have shown that, by making virtual objects movable or adding new input modalities (e.g., a pen) to control virtual objects, users would perceive a higher level of vividness, in terms of sense of presence (Coyle & Thorson, 2001), experiential richness (Rozendaal, Keyson, & de Ridder, 2007), and arousal (Fortin & Dholakia, 2005). However, it remains as an empirical question if the baserate information presented with interactive visualization will be significantly more vivid than that in static visualization or verbal description, and if it will be vivid enough to compete with the exemplars that tend to dominate users’ attention and determine their perceptions.

As discussed previously, interactivity as a medium feature of interactive visualization is likely to increase the representational vividness of the baserate information by occupying the sense of touch on top of engaging the human visual sense better. As a result, when combining interactive visualization of baserates and textual exemplars together in a news report, reader issue perceptions are more likely to be accurate even when the exemplars represent the issue disproportionally, compared to readers to view the news report with the same exemplars together with a static visualization or a verbal description of the baserates. When the exemplar distribution is consistent with the baserates, readers who view the interactive visualization and the static visualization will not differ significantly in terms of perceptions and attitudes. In other words,
interactive visualization of baserates, compared to static visualization and verbal description, will lead to a higher level of baserate vividness, and therefore, a higher level of emotionality as well as elaboration of the message. Because of its effect on baserate vividness, which in turn affects information processing and emotion, interactive visualization will diminish or eliminate the biasing effect of exemplar distribution, such that exemplar distribution will have a weaker effect on issue perception and attitudes when baserates are presented with interactive, rather than static, visualization.

Hence, we can hypothesize the vividness effect as follows:

**H5**: Presence of interactivity, compared to absence of interactivity, will lead to greater user perceptions of *presentational vividness* (H5a) and *message vividness* (H5b).

**H6**: Perceived vividness mediates the relationship between interactivity and issue perception.
**Interactive Visualization as an Engaging Information Exploration**

The power of interactive visualization in facilitating utilization of baserate information is not limited to its presentational vividness. To fully realize the effectiveness of interactive visualization as external cognitive aids (Scaife & Rogers, 1996), HCI scholars (e.g., Card et al., 1999) argue that viewers need to be engaged with actual use of interactive visualization. Thus, the most prominent influence of interactive visualization on perception formation lies in its potential to induce user interactions and enable active information exploration (Shneiderman, 1996).

Instead of simply “seeing” the pattern of the statistical information, news viewers have to engage with the information through information-seeking activities. Indeed, individuals are now assuming a more active role; instead of viewers or audience, they become “information seekers” (Kawamoto, 2003), “users” (Lievrouw & Livingstone, 2002), and “active users” (Deuze, 2004).

The interactivity affordances of an interactive visualization interface are perceivable action possibilities: The interaction techniques such as click, drag and mouseover, are designed and implemented so that users perceive performing actions upon these targets as meaningful, useful, and leading towards an expected outcome. By providing these interaction techniques, interactive visualization functions as a direct-manipulation interface that affords intuitive user actions to reveals patterns, clusters, gaps, or outliers at the users’ command (Shneiderman, 1996).

Fundamentally, the interaction techniques help to orient users’ attention to these action possibilities, which engage their tactile senses at the same time while engaging their visual senses. The natural mapping (Norman, 2002) of user actions and the resulting visual outcomes can increase users’ perceptual bandwidth. Moreover, underlying these interaction techniques is the affordance of back-and-forth information exchanges between the user and the interface: when users submit a data query, interactive visualization will instantly display the specific information in response to the data query. As users further specify data parameters, ranges or patterns, the visualization will be modified as a result of the accumulated specifications. The reciprocity of communication (Stromer-Galley, 2000) and the continuous feedback (Goffmann, 1981) can
positively affect users’ perception of the interface contingency (Sundar, 2007). The psychological responses to interactivity, in terms of perceptual bandwidth and perceived contingency (discussed in more details in the following paragraphs), are elicited by the actual interactions that users perform toward an interactive interface, and can lead a higher level of user engagement. The heightened user engagement, in terms of cognitive absorption (Agarwal & Karahanna, 2000) and information elaboration (Petty & Cacioppo, 1986), can further shape user perceptions and attitudes (Sundar et al., forthcoming).

**Perceptual Bandwidth**

Interactive visualization affords interactivity primarily as a medium feature, as discussed in the previous section, through different interaction techniques. This aspect of interactivity, called *modality interactivity* (Sundar, 2007), refers to the interaction techniques afforded by a given interface that are suggestive of action possibility and functionality (Sutcliffe, 2009). For instance, in an interactive visualization, visual objects that become highlighted or change in size or color when users mouse over them imply details-on-demand possibilities; zoom tools are indicative of potential to enlarge a portion of the visualization for closer scrutiny; a slider is suggestive of sliding activities to change the range of data (e.g., years); dragging tools indicate the mobility of virtual objects inside a given information space; and so on. These interactive features are calling for user actions, e.g., navigation, selection, and distortion, with the interactive visualization interface (Ward & Yang, 2004), and user actions, e.g., to identify, locate, reveal, rank, distinguish, associate, correlate, or generalize, directly with data (Zhou & Feiner, 1998). By providing these interaction techniques, an information visualization interface can elicit direct user actions with the visualized information.

Interactivity as a medium feature has profound psychological impact. As discussed in the previous section, interaction techniques can engage several of the human sensory channels. However, whether users can be actually absorbed and immersed in this sensorial experience is
dependent upon whether they will exert actual actions to the interface. Using Reeves and Nass’s (2000) perceptual bandwidth argument, an ideal interface should be a perceptually rich environment that reconfigures reality and makes it more accessible to the users. For instance, compared to static visualization, animated content or video content can increase perceptual bandwidth or “viewability” by showing visual changes and transitions that serve as imitations or metaphors of real-world motions (Peker, Divakaran, & Sun, 2001). Different from animated content or video content, interactive content shows visual changes in response to users’ own motion activity. As users’ motion activity preludes the emergence of the visual content or visual changes, interactive visualization can make use of users’ instantaneous perceptual bandwidth more effectively than animation and video. Modality interactivity that resembles the manipulability of the real world in a virtual reality would afford greater perceptual bandwidth (Reeves & Nass, 2000) for experiencing the mediated content and allow users to intuitively interact with the interface. Perceptual bandwidth, operationalized as user perceptual assessments (i.e., ease of use, natural mapping and intuitiveness) of the interface, can be expanded when an interface offers multiple interaction techniques that allow users to perform actions more naturally than mouse-clicks could allow. As interactive visualization provides an intuitive way of obtaining information, users are able to construct a mental representation of the content that is likely to be richer than a non-interactive interface.

Perceptual bandwidth has also been known to mediate the relationship between interactivity and user engagement in terms of absorption (see detailed discussion later), which further leads to improved cognitive responses and positive attitudes to the information (Sundar, Bellur, Oh, Xu, & Jia, 2014). It describes why users will experience ease of information processing when the actual affordances match with the perceived affordances (Norman, 1999). Interaction techniques offered in an interactive visualization are likely to orient user attention to, and induce user interactions with, these modalities as well as the data information embedded with these modalities, and therefore increasing their user engagement with the interface and the
information. Enhanced information processing of the baserate information can further lead to a more accurate perception of the issue and potential attitudinal change based on the baserate content.

**Perceived Contingency**

Most fundamentally, many scholars have conceptualized interactivity by looking at the way that messages are presented in the process of communication. Modeling after interpersonal or face-to-face communication, researchers (e.g., Brennan & Hulteen, 1995; Schramm, 1954; Schudson, 1978) have contrasted interactive communication with non-interactivity communication in terms of message *exchange* versus message *transmission*. In human-computer interaction, factors such as two-way communication (McMillan & Hwang, 2002), reciprocal message exchange (Stromer-Galley, 2000) and system responsiveness (Heeter, 1989) have been considered as important components of interactivity.

When performing actions on an interactive visualization interface, other than being engaged through multiple senses experiencing the mediated content, users are likely to feel that they are involved in a two-way information exchanges with the system: on one hand, users can actively perform actions to submit their data queries and call up information as they explore the visualization; on the other hand, the interface uses these actions as commands to provide dynamic display of information upon users’ request. This constant interchangeability of sender and receiver roles evoke a sense of dialog (Burgoon, Bonito, Bengtsson, Ramirez, Dunbar, & Miczo, 1999), or “perceived contingency” (Sundar, Bellur, Oh et al., 2014), a psychological response to the interconnectedness of message exchange. The interface’s feedback is not simply contingent upon users’ immediately preceding input, but upon previous inputs that are relevant to the latest request throughout the course of interaction. In the case of interactive visualization, the visualization takes shape based on an accumulation of users’ prior actions and displays detailed information in response to user actions as well. As a result, users are likely to view the
visualization as an outcome of their interaction history, the detailed information as contingent upon their requests and inputs, and the interface as more interactive and responsive (Rafaeli, 1988). Moreover, if an interface keeps track of users’ prior inputs and displays information that is apparently tied to users’ inputs, users are likely to perceive the information to be unique to their inputs and particularly relevant to their interest. Previous studies have found that a higher level of perceived contingency has indeed led to user perception of message relevance as well as cognitive elaboration of the information (Bellur & Sundar, 2013). The perceived relevance and the enhanced cognitive elaboration are likely to influence how users perceive the social issue depicted in the news as well as their attitude toward the issue.

By affording the action possibilities to let users behaviorally control the mediated content, interactive media engage users in a “reciprocal and bidirectional way” (Sohn, 2011, p.229). Perceived contingency is theorized to play a mediating role in determining user engagement with interactive media (Sundar, 2007), and empirical research (Sundar, Bellur, Oh et al., 2014) has demonstrated its mediating effect, and that it positively influences user attitudes and behavioral intentions toward the interface and the content that it conveys. Compared to static visualization, interactive visualization is able to evoke a greater level of perceived contingency, which in turn will enhance user engagement and influence user perceptions and attitude as well.

**User Engagement**

As discussed previously, user engagement mediates the relationship between psychological responses to interactive visualization and users’ perceptions and attitudes. Specifically, the interactivity affordance of interactive visualization is likely to elicit user actions toward the visualization and evoke users’ psychological responses to the interactions. The psychological feeling of intuitiveness and reciprocity contributes positively to users’ engagement with the baserate information depicted in the interactive visualization, and therefore enhances
information processing and emotional responses, which in turn determine issue perceptions and attitude. This “action” view of interactivity effects (Sundar, Jia et al., 2014) highlights the important role that user engagement plays in transferring the psychological impact of interactive media to perception and attitudinal outcomes.

User engagement is a multi-dimensional concept, and is defined in various ways (e.g., Agarwal & Karahanna, 2000; Chapman, Selvarajah, & Webster, 1999; Jennett, Cox, Cairns, Dhoparee, Epps, Tijs, & Walton, 2008; Laurel, 1993; Oh, 2013). Some of the definitions concern its temporal dimension: e.g., time spent, temporal disassociation, focused attention, etc. Some concern its cognitive dimension: e.g., absorption, immersion, elaboration, transportation, flow, etc. While others concern its fun dimension: e.g., intrinsic interest, curiosity, playfulness, etc. Empirical research has demonstrated that user engagement with the medium is determined by medium features such as interface interactivity (O’Brien & Toms, 2008) and user control afforded by the interface (Webster & Ho, 1997). As the level of interactivity increases, user engagement with the interface and its content also increases (Sundar, Jia et al., 2014).

Heightened user engagement can hold users’ interest and maintain arousal (Sutcliffe, 2009). Based on the limited-capacity theory (Lang, 1995) and research on motion effects of visual stimuli (Gati & Tversky, 1987), the cognitive absorption as well as the emotional arousal is argued to entail information processing of the visual information (Sundar & Kim, 2005). Recent research on interactive media has also demonstrated that, the more interactive an online interface is, the more cognitively absorbed users become and the more thoughts based on the content that they generate as a result of enhanced information elaboration. This indicates that users are not only highly engaged with the interface but are also engaged with the mediated information, an outcome that is especially important for this study. It shows promise that interactive visualization is likely to engage individuals with the baserate information that it presents and lead to greater information processing and emotional responses that will influence issue perceptions and personal attitudes. By engaging users with the content, interactivity can positively influence
users’ behavioral intentions toward the content, and motivate users to store the content for future use or discuss the content with others (Sundar, Bellur, et al., 2014).

In summary, by eliciting user actions through its interactivity affordances, interactive visualization will positively influence user psychology, i.e. perceptual bandwidth and perceived contingency. The more positive perceptions of perceptual bandwidth and contingency serve to enhance user engagement, as well as information processing and emotional responses, with the baserate information depicted in the interactive visualization. Greater information processing and emotionality of the baserates will facilitate users to form more accurate perceptions and more positive attitudes of the social issues, therefore balancing or countering the strong impact that exemplifying information might have on individuals’ issue perception.

In other words, interactive visualization of baserates, compared to static visualization, leads to a higher level of user engagement, through psychological mediators such as perceptual bandwidth and message contingency. Because of its effect on user engagement, interactive visualization will diminish or eliminate the biasing effect of exemplar distribution, such that exemplar distribution will have a weaker effect on issue perception and attitudes when baserates are presented with interactive visualization rather than static visualization or verbal description.

Specifically, we can propose the following hypotheses about the effects of interactivity on engagement with interactive visualization:

**H7**: Presence of interactivity, compared to absence of interactivity, will lead to a higher level of perceptual bandwidth (H4a) and perceived contingency (H4b), and therefore lead to a higher level of user engagement in its three dimensions—time (H4c), absorption (H4d) and fun (H4e).

**H8**: User engagement mediates the relationship between interactivity and issue perception.

The presence of interactivity is likely to affect users’ behavioral intention toward the news content as well:
**H9**: Presence of interactivity, compared to absence of interactivity, will lead to more positive behavioral intentions toward the news content.

Figure 1 illustrates the psychological, cognitive and affective mechanisms through which interactivity influences user recall, issue perception and attitude, as outlined in the hypotheses H2\&3, as well as H4-9.

![Figure 1: Theoretical model of interactivity effects.](image)

Furthermore, I hypothesize that perceived vividness and user engagement mediate the moderation of interactivity on the exemplification effect:

**H10**: Interactivity will reduce the effect of exemplar distribution on issue perception through mediating variables such as perceived vividness and user engagement, such that exemplar distribution will have a weaker effect on issue perception when the baserate information is presented in interactive visualization that leads to greater perceived vividness and user engagement than static visualization and verbal description.

Figure 2 illustrated the mediated moderation model of interactivity effects. It shows that the moderation of interactivity on exemplification effect is mediated by perceived vividness and user engagement.
In order to examine the effect of exemplification and interactivity on individuals’ issue perceptions and attitudes toward social issues, it is important to ensure that individuals expose themselves to the news content to the extent that they at least process the information in a passive or superficial way. Therefore, users ought to be moderately involved or interested in the news topic; uninvolved users are likely to neglect the message regardless of its presentational formats or formal features. Some individual-difference factors such as issue involvement can directly determine issue perceptions and attitudes, regardless of the level of interactivity or the consistency of exemplar distribution. Individual-difference factors that might influence issue perception and attitudes are therefore discussed in the following section, and are used as covariates in this study.
Individual-Difference Factors

Previous literature has identified a number of individual-difference variables that may directly determine issue perceptions or attitudes, or motivate information processing or emotional responses regardless of message features or medium features. Others might influence individuals’ use of communication technology, or hinder understanding of specific types of information. Individual-difference factors that may influence the outcome variables, such as issue involvement, need for cognition, statistics familiarity, cognitive style, and power usage, are discussed in more detail below and are used as covariates in this study.

Issue Involvement

Information processing of a message is not only dependent upon the factors discussed before, but is also dependent on the importance or relevance of a message topic to the recipient. Issue involvement (Zimbardo, 1960), or the various terms describing the same notion, such as personal relevance (e.g., Petty, Cacioppo & Haugtvedt, 1992), personal involvement (Thomsen, Borgida, & Lavine, 1995), ego-involvement (Sherif & Hovland, 1961), issue salience (Knobloch, Carpentier, & Zillmann, 2003), issue importance (Petty & Wegener, 1998), and attitude importance (e.g., Boninger, Krosnick, Berent, & Fabrigar, 1995), refers to “the extent to which the issue is relevant to some aspect of oneself, i.e., one’s beliefs, possessions, values, groups, etc.” (Petty & Wegener, 1998, p.29). How much an individual cares about an issue determines the way he or she would process the issue-related information. According to the heuristic-systematic model of information processing (Chaiken & Eagly, 1989; Chaiken & Trope, 1999) and the elaboration likelihood model (Petty & Cacioppo, 1979), when individuals are engaged in systematic or central processing, their judgments are formed through scrutinizing all relevant information and thinking about the information in relation to their knowledge of the issue. However, because of the cognitive effort that systematic processing requires, individuals may turn to the alternative route, heuristic or peripheral processing, which requires minimal
information input and cognitive capacity, unless they are otherwise motivated (Chaiken & Eagly, 1989). It is evident that, compared to less involving issues, topics of high personal relevance would motivate individuals to engage in a greater amount of information processing, trigger a higher level of sensitivity to argument quality, and lead to better cognitive outcomes (e.g., Chaiken, 1980; Petty & Cacioppo, 1994). High issue involvement would encourage thinking and elaboration, which would increase persuasive effects of the strong arguments, but decrease persuasion if arguments were weak.

Empirical research of exemplification effects (Zillmann et al., 1992; Zillmann et al., 1996) has revealed that baserate precision, rather than exemplar distribution, determines post-exposure accuracy when exposing participants to a highly involving news topic, indicating participants’ active processing and utilization of baserate information in their perception and attitude formation. The inconsistent exemplar distribution in particular was dismissed by participants, who might have discerned the inconsistency between exemplars and baserates as they were engaged in the active information processing as a result of high issue involvement. In contrary, when the news articles concerned about a less involving topic, the findings showed a dominant effect of exemplar distribution and no effect of baserate precision on issue perception. The differential results from these two experiments have demonstrated the direct effect of issue involvement on information processing. Furthermore, Gunther and Christen (1999) have found that, towards highly involving topics, participants appeared to have well-established opinions and therefore the news report had little influence on their personal opinions.

Therefore, individuals ought to be moderately involved in a news topic to process the news content to an extent. Meanwhile, it is important to note that issue involvement can motivate systematic or central information processing, and determine whether individuals may maintain their pre-existing attitudes rather than being influenced by the news content. Therefore, the effect of issue involvement needs to be controlled in the data analyses.
Need for Cognition

Need for cognition is defined as “the tendency for an individual to engage in and enjoy thinking” (Cacioppo & Petty, 1982, p.116) and “a need to understand and make sense of the experiential world” (Cohen, Scotland, & Wolfe, 1955, p.291). Individuals of high need for cognition tend to organize, elaborate, and evaluate the information (Cohen, 1957), and can recall the content of print news more accurately than those low in need for cognition (Cacioppo, Petty, & Morris, 1983). The same results were found in other communication contexts as participants were asked to recall video content (Lassiter, Briggs, & Bowman, 1991), visual content (Mueller, Keller, & Dandoy, 1989), and brand names (Heslin & Johnson, 1992). In addition to better recall, individuals of high need for cognition are also more attentive to the quality of the information or arguments. They are more likely to elaborate on the arguments in a persuasive message, and therefore, their attitudes are more likely to be determined by the quality of the arguments than those who are low in need for cognition (Petty, Wells, & Brock, 1976). Inconsistent arguments, for instance, are less likely to influence the perception and attitude formation of individuals with high need for cognition, than consistent arguments. Conversely, individuals low in need for cognition are more likely to rely on heuristic or peripheral cues, such as the number of arguments that a message contains (Petty & Cacioppo, 1984), to determine their attitudes (Chaiken, Axsom, Hicks, Yates, & Wilson, 1985). In short, high need for cognition is likely to increase information processing, which will lead to a higher degree of accuracy of issue perception, compared to those with a lower level of need for cognition. Participants with greater need for cognition are prone to process the information more systematically, and therefore tend to be more accurate in their recall and issue perception.
Statistics Familiarity

When processing base rate information in the forms of numeric or statistical data, individuals’ ability to engage in active processing is constrained by their knowledge and familiarity with numbers and statistics. Zillmann, Callison and Gibson (2009) have found that arithmetic aptitude, or numeracy (Lipkus, Samsa, & Rimer, 2001; Peters, Hibbard, Slovic, & Dieckmann, 2006), a measure of capabilities of understanding arithmetic expressions and solving arithmetic problems, has a unique impact on information processing. Individuals with well-developed arithmetic abilities are more likely to pay more attention to the numeric information in news content, process it more actively, and recall and use it more proficiently than those with less-developed arithmetic abilities (Zillmann et al., 2009, p.399).

Most recently, Sundar, Jia et al. (2014) have adopted a self-report approach to measure statistics familiarity, which asks individuals about their perceived familiarity and competence with statistical information. Individuals who self-reported as more familiar and competent with statistics are more likely to perceive data visualization interfaces as usable, controllable, and intuitive, than those who self-reported as less familiar and competent. These results indicate that individual differences in statistics familiarity or numeric ability can whether individuals can effectively understand and utilize the statistical information in the news content.

Visual versus Verbal Cognitive Style

Specific to this dissertation research that involves both forms of visual and textual information, a distinction between a visual versus verbal cognitive style is needed, as the two arguably differ in their mechanisms of information processing. According to linguistic researchers (Whorf, 1956; Brown & Lenneberg, 1954; cited in Paivio, 1971), verbal stimuli can facilitate perceptual discrimination and recognition memory because of its high codability (the extent to which a verbal associative meaning is distinctive from another). Images, on the other
hand, are more ambiguous in meanings and require verbal coding to specify their meanings (Clark, 1969). Dual coding theory (Paivio, 1986) suggests that, while certain individuals are visual learners (visualizers), others are verbal learners (verbalizers). The two cognitive styles are distinguished in terms of “thinking with words or images” (Mayer & Massa, 2003, p.833) and can be used to predict learning outcomes (e.g., Plass, Chun, Mayer, & Leutner, 1998) and decision making (e.g., Parker, Srinivasan, Lempert, & Berry, 2014) in different mediated environments. In a recent study of online learning, Höfler and Schwartz (2011) have found that, not only do verbalizers learn better in verbal environment and visualizers learn better in visual environment, there is also a difference in their learning results after viewing dynamic versus non-dynamic presentations. Results have shown that individuals inclining to a visual cognitive style have performed significantly better with dynamic visualization than with static pictures, whereas individuals inclining to a verbal cognitive style have performed relatively better with static pictures. Therefore, in this dissertation research, participants’ cognitive style may determine whether they will prefer an interactive visual presentation or a static/verbal one. As exemplars are presented verbally while baserate information is presented visually in most of the cases, it is likely that verbal learners will exhibit a stronger exemplification effect, whereas visual learners will show a weaker exemplification effect. The positive effect of interactive visualization may be most prominent for visual learners.

**Power Usage**

As the mediated messages in this dissertation research are presented on an interactive medium, information processing of the messages will also vary depending on participants’ knowledge of and former experience with interactive media. Whether individuals are capable and comfortable in actively viewing and interacting with online news content will influence their perceptions and attitude. McAlearney, Schweikhart & Medow (2004) used the label of “power
users” to call those users who value and rely heavily on new technologies. Similar to the term of “expert users” (Norman, 1991) that refer to individuals who tend to feel more natural toward the technology, the term of power usage is adopted (Marathe, Sundar, Bijvank, van Vugt, & Veldhuis, 2007; Sundar & Marathe, 2010) to describe skillful and experienced technology users who are self-motivated to learn about newer technologies. In contrast, non-power users are less interested and less willing to invest time and effort to adopt and learn the technologies on their own. Sundar and Marathe (2010) have conceptualized power usage as an individual-difference variable that captures individuals’ “motivation, efficacy, expertise, and demonstration of evolved technology use” (p.305).

Power usage is found to have a significant moderating effect on the influence of interactive features of the new media on user experience, perception and attitude. Sundar, Bellur, Oh, Xu and Jia (2014) have found that power users are engaged with highly interactive interfaces, with more positive perceptions. The positive interface assessment and enhanced user engagement further lead to positive evaluations of the message content. Because power users are better equipped with capabilities and skills to use communication technology, they are more likely to experience “flow” (Sutcliffe, 2009) than non-power users when the interface affords more interactive features.

In this study, power usage is likely to have a significant impact on the effects of interactivity, as interactive visualization may require users to have a high level of power usage to better use it. Therefore, power users are more likely to make good use of interactive visualization, and become better informed by the baserate information presented in the interactive visualization.
Summary

My dissertation proposes to re-examine exemplification effects in the context of interactive media, and to investigate the effect of interactivity on encouraging the use of baserates during the process of shaping individuals’ issue perceptions and attitudes. As the Internet and media in general take a “visual turn” (Mitchell, 2002; Schwartz, 2004), researchers have looked into multimedia presentations as a way of enhancing information processing of baserate information, resulting in limited progress. However, interactive media may counteract or eliminate exemplification effects in more ways than multimedia presentation. First of all, interactive media are not as limited in terms of time or space, as is the case with traditional media such as radio, newspapers and television. The interactive components of media content, such as slideshows, interactive visualization and hyperlinks, offer opportunities for journalists to include large volumes of data or information in online news coverage. Interactive visualization of “big data,” in particular, contains much richer information compared to traditional presentational formats, and this richness makes it possible for users to engage in a deeper level of information processing by browsing various data points, testing all sorts of data associations, and modifying different visual representations. Secondly, dynamic visual presentations and interaction techniques offered by interactive visualization have the potential to significantly enhance the presentational vividness of baserate information. Therefore, interactive visualization is likely to show a far more significant effect on improving the use of baserates through its vivid representations than the static visualization. Most fundamentally, the interactivity affordance of interactive visualization can induce user actions toward the interface and the visualized baserates. It allows users to actively access, alter and analyze the data that make up those baserates. By enhancing users’ perceptual bandwidth and providing more contingent responses to user actions, interactive visualization tools can make it more likely for users to be cognitively engaged with baserate information. Increased information processing as a result of the heightened engagement with baserates will likely counter the biasing effect of exemplars. Figures 3 and 4 illustrate the
conceptual and statistical models that specify the moderating effects of interactivity on exemplification effects in influencing issue perception and personal attitudes, and the mediating effects of vividness and user engagement, respectively.

Figure 3: Conceptual model of moderation of interactivity on exemplification effects on issue perception and personal attitude through vividness and engagement.

Figure 4: Statistical model of moderation of interactivity on exemplification effects on issue perception and personal attitude through vividness and engagement.
My dissertation seeks to examine the effectiveness of utilizing interactive visualization to enhance the influence of baserate information on issue perceptions and attitudes, while varying the consistency of exemplar distribution. Interactive visualization as a useful tool to engage individuals with representative information of social issues holds promise in increasing perception accuracy of the social reality and influencing issue attitudes. My dissertation will further investigate the mediating effects of vividness and user engagement in this process. Results will help uncover the psychological processes through which individual perceptions are influenced by journalistic evidence, either in the form of “big data” or “small stories,” in a highly visual and interactive media environment. The study will also generate useful findings to inform ethical journalistic practices and effective interface designs for enabling laypersons to make better sense of the overwhelming volume of data presented to them.
Chapter 2

METHOD

Overview

A 2 (Exemplar Distribution) × 3 (Interactivity) × 2 (News Topic) mixed-design experiment was conducted. News Topic was a within-subject variable, while the other two independent variables were between-subject variables. Six versions of the two online news stories, one on the topic of causes and consequences of climate change, the other on the topic of the changing attitude toward same-sex marriage, were created as the experimental stimuli. Specifically, in each of the news reports, baserate information was provided in static visualization, interactive visualization, or verbal description; while supportive and opposing exemplars were provided in verbal format only, and the distribution of supportive and opposing exemplars were varied to be either proportionally consistent, or inconsistent, with what the baserate information described. Participants were asked to browse one of the versions of the two news stories and then indicate their perceptions and attitudes in response to each of the news stories.

Participants

A total of 205 research participants were recruited for the study, among which 133 participants were recruited from undergraduate classes at a large Northeastern university, and were compensated with extra credit for their participation. The remaining 72 participants were recruited from an online crowdsourcing service, namely Amazon Mechanical Turk. Previous research has found that Mechanical Turk participants are more demographically diverse than standard Internet samples and typical American college samples (e.g., Buhrmester, Kwang, & Gosling, 2011), and produce reliable results consistent with standard sampled participants.
(Goodman, Cryder, & Cheema, 2012). Qualification requirements were set for Mechanical Turk participants, including country for residence (United States only) and a prior approval rate of 95% or higher (a percent of prior Mechanical Turk tasks submitted by the participant that were subsequently accepted by the researchers), which was found to ensure high-quality data (Peer, Vosgerau, & Acquisti, 2013). Only Mechanical Turk users who met these eligibility requirements could view this research project and choose to undertake the task. Preliminary data analyses showed that student participants did not differ significantly from the Mechanical Turk participants in their research responses, and therefore the responses were combined into one dataset for further analyses. A partial sample of the total participants was used for the final data analyses: thirty-six participants who were uninvolved in the issues depicted in the news reports were eliminated from the dataset. The standard for low involvement was using scores of issue involvement lower than mean minus one standard deviation, a criterion that has been seen in learning assessment (e.g., Bekele & Menzel, 2005) and psychology (e.g., Krause, 1986). The final dataset consisted of 169 participants, with 111 participants recruited from the undergraduate classes and 58 from Mechanical Turk.

**Procedure**

Participants were asked to come to the research laboratory to participate in this experimental study. They were told that the study was to investigate individuals’ news consumptions and that they would view two online news reports and fill out online questionnaires.

After providing consent to participate in the study, participants first were asked to fill out an online pre-test questionnaire that measures demographic and individual-difference variables, such as age, gender, education, political ideology, religiosity, need for cognition, statistical familiarity, cognitive style, power usage, issue involvement, etc. Upon completion of the pre-test
questionnaire, participants were randomly assigned to one of the six between-subject conditions to view one of the six versions of the news stories.

In all conditions, participants were asked to read two news articles, in random order, one concerning the human-factor causes and weather consequences of climate change, the other concerning the divided and evolving public opinion of same-sex marriage. Right after they finished reading each of the two news articles, participants were asked to fill out a post-test questionnaire that measured outcome variables such as information processing, emotions, issue perceptions and personal attitudes regarding the social issue depicted in the news article, as well as mediating variables such as perceived vividness, perceptual bandwidth, perceived contingency, user engagement. The same procedure was repeated after participants finished reading the second news article. Participants were thanked and debriefed after they completed the procedure.

**Stimuli**

Six versions of the two news stories, a total of twelve online news stories, were created for a $2 \times 3 \times 2$ mixed-design experimental study with variation of Exemplar Distribution: consistent with baserate information, and inconsistent with baserate information; Interactivity of Baserates: *interactive* information visualization of baserate information, versus a *non-interactive* or static visualization of the baserate information, and additionally, a non-visual control condition in which baserate information is presented in verbal descriptions; and News Topic: a public opinion-related social issue of same-sex marriage, and a scientific topic of climate change.

**News Topics**

The two news topics were concerned about two highly controversial social issues: same-sex marriage and climate change. The two news topics were selected from a pretest that surveyed
68 undergraduate students, showing that, among the sixteen significant social issues (e.g., job/economy, gender equality, heath care, cyber security, immigration, etc.) identified in the 2012 Presidential Election (CNN, 2012), Gallup poll of national problems, and Pew Research Center’s national surveys of news following, same-sex marriage was rated as both personally interesting and politically important, whereas climate change was rated less interesting as a news topic and the least politically important.

**Changing Attitudes of Same-sex marriage.** Same-sex marriage is “one of the most contentious and politically charged social issues of the day” and has impacted political polls and election results (Calmes & Baker, 2012). Public opinion surveys as early as 1965 revealed largely negative attitudes toward homosexuals and homosexuality (Herek, 2002). In recent years, an increase in public support for gay rights is seen in national polls and surveys, and is argued to have resulted from the transformation of how the public thought about the issue in response to the shifts in media representation about homosexuality (Brewer, 2003). Exemplification effects, in particular, are found to influence people’s perception of gays and lesbians (Gibson, Smith & Hester, 2008; Hart & Powers, 2007). This dissertation research is aimed at examining the effects of exemplifying public opinion towards same-sex marriage on participants’ perceptions of the opinion climate and their personal attitudes toward same-sex marriage. Additionally, how interactivity may moderate the exemplification effects will also be investigated.

For the stimulus news story, information of public opinion trend (favor vs. opposition) toward same-sex marriage from 1996 to 2014, and information of the generational gap that was found in the opinion trend (younger generations are more supportive than older generations) were provided. The story was based on actual news reports that discussed the trend of public opinion toward same-sex marriage, and featured public opinion data collected by Pew Research Center (http://www.pewresearch.org/data-trend/domestic-issues/attitudes-on-gay-marriage/).

**Climate change.** Even though scientists have announced that climate impact is “very evident”, the public opinion of climate change is more divided than ever along ideological lines
(Nisbet, 2000). The percentage of population who believe that global warming is happening has decreased by almost 10% since 2008, while the percentage of population who do not believe so has more than doubled (Leiserowitz, Maibach, Roser-Renouf, Feinberg, Rosenthal, & Marlon, 2014). This is especially extraordinary to note that climate change is the top-rated threat in all other countries but the United States in a 39-nation survey (Pew Research Center, June, 2013). One possible reason is that the American news media so far has not done a good job on informing the public about the scientific consensus on the causes and consequences of climate change. The news reports tend to frame climate change as a controversial issue, contributing to the public’s skeptical view and misunderstanding of the issue (Antilla, 2005). This dissertation research proposes to utilize interactive visualization to engage individuals with the factual, numeric information of climate change in order to enhance perception accuracy and influence attitude.

For the stimulus news story, information of the current climate state, causes, and consequences of climate change was provided. In order to show how carbon dioxide emissions as a human-related factor have contributed to the warming trend, the U.S. annual temperature data from the National Climate Data Center archives (NCDC; http://www.ncdc.noaa.gov/cag/time-series/us) and the global carbon dioxide emission data from the National Oceanic and Atmospheric Administration (NOAA; http://www.esrl.noaa.gov/gmd/ccgg/trends/) were featured. In addition, information of annual frequency of tornadoes from 1980 to 2012 and amount of climate disaster damage from NOAA was also provided.

**Exemplar Distribution**

The baserate information in the news story of same-sex marriage described the increase in the percentage of the U.S. population who were in favor of same-sex marriage over the years from 1996 (27% in favor) to 2014 (54% in favor), while the percentage of the U.S. population in opposition to same-sex marriage had been in decline (from 65% in 1996 to 39% in 2014). The exemplar distribution consistent with this baserate information featured seven supportive
exemplars (e.g., direct quotes expressing supportive views: “There really is not another issue out there that has gained so much support so fast;” “It is good that people can have the opportunity to embrace their own identity fully;” etc.) with five oppositional exemplars (e.g., direct quotes describing attitudes against same-sex marriage: “History leaves no doubt that marriage exists to connect children to their mother and father;” “Marriage is about a whole lot more than two people who love each other. It’s about conscience rights and religious liberty;” etc.), whereas the inconsistent condition featured only two supportive exemplars with ten opposing exemplars. The news story also provided baserate information emphasizing a greater percentage (66%) of the Millennial Generation (born 1981-1995) had expressed support for same-sex marriage, compared to other generations such as Generation X (52%), Baby Boomers (41%) and Silent Generation (35%). A consistent exemplar distribution featured more supportive exemplars than opposing exemplars of the younger generation, whereas the inconsistent condition featured more opposing exemplars than supportive exemplars of the younger generation.

In the news story of climate change, the baserate information presented the association between the increasing trends of annual temperatures and annual carbon dioxide emissions, as well as the association between the warming trend and the increase in tornado frequency and damage between 1980 and 2013. Exemplar distribution consistent with the baserates featured seven exemplars, all supporting carbon dioxide emissions as a human factor contributing to the warming climate (e.g., “There is mounting evidence that harm to the nation will increase substantially in the future unless global emissions of heat-trapping gases are greatly reduced”) and the effect of climate change on severity of weather disasters (e.g., “Extreme weather of all sorts has been increasing around the Northern Hemisphere; (Sandy) is the kind of situation we’d expect to see more of as greenhouse gases continue to build up in the atmosphere and sea level continues to rise.”). In the other condition in which exemplar distribution was inconsistent with baserates, one supportive exemplar (e.g., “Climate change, once considered an issue for a distant future, has moved firmly into the present”) and sixe oppositional exemplars (e.g., “There is no
scientific proof that CO2 emissions are the dominant cause of the minor warming of the Earth’s atmosphere;” “We count the tornadoes, we count hurricanes. None of those are increasing;” etc.) were provided.

**Baserate Interactivity**

Baserate interactivity was operationalized as the degree to which the news interface affords ways of performing actions toward the content. In the high-interactivity condition, baserate information was presented in the form of interactive visualization that afforded a variety of interaction techniques (i.e. click, mouseover, drag), through which participants could perform actions such as data selection, visualization modification, etc. In contrast, baserate information was presented in a static visualization in the low-interactivity condition, and in textual format in the verbal description condition.

**Measurement**

A pre-test questionnaire was administered before exposing participants to the stimulus website, which measured participants’ demographics, pre-existing knowledge and attitude of the social issues, and individual difference variables such as power usage, statistical familiarity, visual learning preference, need for cognition, etc. A post-test questionnaire was administered after website interaction, and measured perceived vividness, perceptual bandwidth, perceived contingency, user engagement, information processing, emotional responses, recall, issue perceptions, and personal attitudes. The order of the two social issues was alternated randomly.

**Mediating Variables**

Four variables comprising perceived vividness, perceived perceptual bandwidth, perceived contingency and user engagement were hypothesized as the mediating variables in this
study. The following descriptions and Table 1 reported the statistics of the mediating variables based on the measures of the same-sex marriage news story.

(a) Perceived vividness: Participants’ perceived vividness of the exemplars, the presentational format and the news messages were measured using items derived from Collins and Taylor (1988). Exemplar vividness was measured by asking participants to rate their agreement with two statements: “Specific examples of the issue were provided in the news report;” and “The news report featured very concrete stories,” with a Cronbach’s $\alpha = 0.79$. Presentational vividness was measured with two items: “In general, the news story was vividly presented;” and “To me, personally, the news story was vividly presented,” with a Cronbach’s $\alpha = 0.96$. Message vividness was measured by asking participants to rate the news report with ten items: “Interesting,” “important,” “attention-getting,” “colorful,” “lively,” “emotional,” “exciting,” “arousing,” “graphic” and “vivid,” with a Cronbach’s $\alpha = 0.88$.

(b) Perceptual bandwidth consisted of three theoretical aspects as identified by Sundar, Bellur, Oh, Xu and Jia (2014): natural mapping, intuitiveness, and ease of use. Natural mapping was measured by asking participants their agreement with “The way that I used to control the changes on the website seemed natural,” and “The functions on the website were natural;” Intuitiveness was measured by eliciting participants’ agreement with the statement, “My interaction with the website was intuitive.” Both were adapted from Witmer and Singer (1998). Perceived ease of use was measured by asking participants their agreement with “This website is easy to use.” These four items were combined to form a perceptual bandwidth measure (Cronbach’s $\alpha = 0.87$).

(c) Perceived contingency was measured using eight items adapted from Sundar et al. (2012), looking at the extent to which the system took into consideration participants’ prior inputs. The scale consisted items such as “The website’s responses were dependent on my actions;” “I felt as if the website gave an exclusive response to my actions;” “My interactions with the site felt like a back and forth conversation,” “I felt as if the information on the website
was well connected to my actions;” “I felt like I was engaged in an active dialogue with the website;” “My interactions with the site felt like a back and forth conversation;” “I felt as if the site and I were involved in a mutual task;” and “The site responded quickly to my inputs and requests,” with a Cronbach’s α = 0.93.

(d) User Engagement was measured with a scale established by Sundar et al. (2010). The scale consisted three dimensions of user engagement, including time, measured with three items such as “Time appeared to go by very quickly,” “I spent more time than I had intended,” and so on with a Cronbach’s α = 0.70; absorption, measured with four items such as “I was able to block out most other distractions,” “I was absorbed in what I was doing,” and so on with a Cronbach’s α = 0.89; and fun, measured with five items such as “I had fun interacting with the site,” “Browsing the website provided me a lot of enjoyment,” and so on, with a Cronbach’s α = 0.90.

Table 1: List of mediators

<table>
<thead>
<tr>
<th>Mediators</th>
<th>Reliability index (Cronbach’s α)</th>
<th>M &amp; SD</th>
<th>Scale anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Perceived vividness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Exemplar vividness</td>
<td>0.79</td>
<td>M = 5.00</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.21</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M = 4.88</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.47</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M = 4.55</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.06</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(ii) Presentational vividness</td>
<td>0.96</td>
<td>M = 4.83</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.10</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(iii) Message vividness</td>
<td>0.99</td>
<td>M = 3.94</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.30</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(b) Perceptual bandwidth</td>
<td>0.81</td>
<td>M = 4.83</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.10</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(c) Perceived contingency</td>
<td>0.93</td>
<td>M = 3.94</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.30</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(d) User engagement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Time</td>
<td>0.63</td>
<td>M = 3.87</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.17</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(ii) Absorption</td>
<td>0.89</td>
<td>M = 4.75</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.21</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>(iii) Fun</td>
<td>0.90</td>
<td>M = 3.97</td>
<td>1 = Strongly Disagree to 7 =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 1.24</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

Outcome Variables

Seven variables comprising information processing, emotion, recall, issue perception, issue attitude, attitude toward the content and behavioral intention toward the content were
hypothesized as the outcome variables in this study. The following descriptions and Table 2 report the statistics of the outcome variables based on the measures of the same-sex marriage news story, unless otherwise indicated.

(a) Information processing. Measurement of systematic and heuristic processing is derived from earlier work of Eveland, Shah and Kwak (2003); Griffin, Dunwoody, Neuwirth, and Giese (1999); Neuwirth, Frederick, and Mayo (2002); Perse (1990). A set of five items are established as measurement of systematic processing, including items such as “I thought about the information in news story about the … issue related to other things I know;” “I found myself making connections between the information I got from news story about the … issue and information I got elsewhere;” “I tried to relate the ideas in the news report to my own life;” “Based on the information I received from the news report, I found myself thinking about what actions should be taken by policy-makers;” and “I tried to think of the practical applications of the information I get from the news report,” with a Cronbach’s $\alpha = 0.89$. Measurement of heuristic processing consists items measuring three different aspects: 1) Topic difficulty is measured with four items, e.g., “It took a lot of mental effort to understand how the parts of the news report about the … issue fit together;” “I had difficulty seeing how the information in the news report about the … issue fits together into a story that can make sense overall;” etc. 2) Selective scanning is measured with two items, including “When I read the news report about the … issue, I only paid attention to the portion that seems important;” and “When I read the news report about the … issue, I only paid attention to the portion that seems interesting.” 3) Skimming is measured two items, including “I generally skimmed through the news report about the … issue;” and “When I read a news report about the … issue, I did not spend much time thinking about the information.” The eight-item scale yielded a Cronbach’s $\alpha = 0.88$.

(b) Emotional responses. The emotional responses toward the news content were measured using the semantic-differential scales from Bradley and Lang (1994). The measurement consisted of two dimensions: 1) Valence (or pleasure), measured with six pairs of descriptors,
e.g., “unhappy – happy,” “annoyed – pleased,” etc., with a Cronbach’s $\alpha = 0.91$; and 2) Arousal, measured with five pairs of descriptors, e.g., “relaxed – stimulated,” “calm – excited,” etc., with a Cronbach’s $\alpha = 0.82.$

(c) Recall. Recall measurement consisted of two aspects—baserate recall and exemplar. For the issue of same-sex marriage, items were used to assess participants’ recall both exemplars, such as the Supreme Court decisions cited in the news report and individuals interviewed in the news, using four questions, and baserates, in terms of what percentage of the U.S. population supports versus oppose same-sex marriage, and what percentage of the different generations support versus oppose same-sex marriage, using four questions. For the issue of climate change, participants are asked to recall exemplars with four questions regarding personalities being interviewed and scientific report being cited, as well as baserates with three questions regarding the amount of temperature change, carbon dioxide emissions, and tornado frequencies. Additive indices were created to reflect the number of questions that participants answered correctly. Participants also answer open-ended questions that ask them to write down the news content that they remember and describe the activities that they have performed on the website.

(d) Issue perception. For the issue of same-sex marriage, participants estimated the future trend of public opinion in five years by indicating their agreement with the statements: “I believe that more Americans will become in favor of legalizing same-sex marriage in five years;” “I believe that more Americans will become opposed to legalizing same-sex marriage in five years;” and “I believe that the Millennial Generation will be more likely to favor same-sex marriage than the older generations in five years,” Cronbach’s $\alpha = 0.72$. They were also asked to report how certain they feel about these estimations that they make. For the issue of climate change, participants were asked to estimate the seriousness, trend and impact of climate change; the five-item scale yielded a Cronbach’s $\alpha = 0.90$. After providing their estimation, participants were asked how certain they feel about the estimations.
(e) Personal attitude. For the issue of same-sex marriage, participants were asked to express their support of or opposition to same-sex marriage, with a three-item scale (Cronbach’s α = 0.92). They were also asked about their general attitude toward the gay and lesbian individuals with three items derived from the attitude toward lesbian and gay men (ATLG) measure (Herek, 1994), with a Cronbach’s α = 0.88. For the issue of climate change, participants were asked to express their beliefs or doubts of climate change, as well as the causes and consequences of climate change. They were also asked about their attitude toward climate policies (Leiserowitz, 2006) and self-efficacy (Kellstedt, Zahran, & Vedlitz, 2008).

Table 2: List of outcome variables

<table>
<thead>
<tr>
<th>Outcome Variables</th>
<th>Reliability index (Cronbach’s α)</th>
<th>M &amp; SD</th>
<th>Scale Anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Information processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Systematic processing</td>
<td>0.89</td>
<td>M = 5.09 SD = 1.07</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(ii) Heuristic processing</td>
<td>0.88</td>
<td>M = 3.25 SD = 1.20</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(b) Emotion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Emotional valence</td>
<td>0.91</td>
<td>M = 4.48 SD = 1.07</td>
<td>Semantic differential</td>
</tr>
<tr>
<td>(ii) Arousal</td>
<td>0.82</td>
<td>M = 3.95 SD = 0.94</td>
<td>Semantic differential</td>
</tr>
<tr>
<td>(c) Recall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Baserate recall</td>
<td>N/A</td>
<td>M = 1.27 SD = 1.31</td>
<td>Multiple-choice questions</td>
</tr>
<tr>
<td>(ii) Exemplar recall</td>
<td>N/A</td>
<td>M = 2.12 SD = 1.00</td>
<td>Multiple-choice questions</td>
</tr>
<tr>
<td>(d) Issue perception</td>
<td>0.72</td>
<td>M = 5.91 SD = 0.96</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(e) Personal Attitude</td>
<td>0.92</td>
<td>M = 5.71 SD = 1.69</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(f) Behavioral intention toward the content</td>
<td>0.90</td>
<td>M = 3.83 SD = 1.45</td>
<td>1 = Extremely Unlikely to 7 = Extremely Likely</td>
</tr>
</tbody>
</table>

Individual-Difference Variables

Before exposed to the experimental stimuli, participants were asked to answer questions measuring a number of individual-difference variables. This pre-test questionnaire started with questions about demographic information (i.e. age, gender, ethnicity, education level and
educational background), followed by questions measuring religiousness, political ideology, attitude toward science, need for cognition, numeracy, cognitive style, pre-existing issue involvement, attitude and knowledge, and power usage.

(a) Religiosity. The level of religiousness was measured using three items from Allport and Ross (1967), asking participants to indicate their agreement with statements such as “I would describe myself as a very religious person;” “My religious beliefs are what really lie behind my whole approach to life;” and “I try hard to carry my religion over into all other dealings in life,” with a Cronbach’s $\alpha = 0.88$.

(b) Political ideology. Two items adapted from Wright, Erikson and McIver (1985) were used to measure participants’ partisanship and ideology. Specifically, participants were asked: “Generally speaking, do you consider yourself a Republican, a Democratic, or an Independent?” and “How would you describe your views on most political matters? Generally speaking, do you consider yourself a conservative, moderate, or liberal?” This two-item scale yielded a Cronbach’s $\alpha = 0.88$.

(c) Attitude toward science. Four items were adapted from Nisbet, Scheufele, Shanahan, Moy, Brossard and Lewenstein (2002) and Miller, Pardo and Niwa (1997) to measure participants’ attitude toward science and scientific findings. The scale consisted items including “Science makes our way of life change too fast;” “On balance, the benefits of scientific research have outweighed the harmful results;” “We depend too much on science and not enough on faith;” and “It is not important for me to know about science in my daily life,” yielding a Cronbach’s $\alpha = 0.71$.

(d) Need for cognition. Need for cognition was measured using five items derived from the 18-item short version of the need for cognition scale (Cacioppo, Petty, & Kao, 1984), such as “I prefer complex to simple problems;” “I really enjoy a task that involves coming up with new solutions to problems;” and “Thinking is not my idea of fun (reverse-coded).” The scale yielded a Cronbach’s $\alpha = 0.78$. 
(e) Numeracy. Measurement of numeracy consisted of two aspects—statistics familiarity and visual data self-efficacy. Statistics familiarity measures (Sundar, Jia et al., 2014) are derived from statistical literacy literature (e.g., Gal, 2002), including items about the five basic parts of statistical knowledge such as “I know why data are needed and how data can be produced;” “I am familiar with basic terms and ideas related to descriptive statistics;” “I am familiar with basic terms and ideas related to graphical and tabular displays;” “I understand basic notions of probability;” and “I know how statistical conclusions or inferences are reached.” Visual data self-efficacy was measured using a three-item scale from Baker and White (2003), with items such as “I am capable of using visualization to analyze data;” “Showing patterns in data helps me to learn;” and “I can understand data with the help of visualizations.” As a factor analysis indicated as one dimension, these two self-report aspects of numeracy were combined into one variable labeled as “numeracy,” with a Cronbach’s $\alpha = 0.85$.

(f) Cognitive style. Visual versus verbal cognitive style was measured using items from the Santa Barbara Learning Style Questionnaire, including items such as “I am good at learning from labeled pictures, illustrations, graphs, maps, and animations;” “I am good at learning from printed text;” and “I prefer to learn visually than verbally,” with a Cronbach’s $\alpha = 0.65$.

(g) Pre-existing issue attitude. Participants’ pre-existing attitude toward same-sex marriage was measured using three items, e.g., “Gay and lesbian couples should have the right to marry one another,” with a Cronbach’s $\alpha = 0.92$, $M = 5.75$, $SD = 1.71$. Their attitude toward climate change was measured using three items, e.g., “There is scientific consensus that Earth’s climate is warming, and it is extremely likely induced by human activities,” with a Cronbach’s $\alpha = 0.78$, $M = 5.41$, $SD = 1.17$.

(h) Pre-existing issue knowledge. Participants’ pre-existing knowledge of same-sex marriage was measured using three items, e.g., “I am very knowledgeable of the issue of same-sex marriage,” with a Cronbach’s $\alpha = 0.85$, $M = 5.05$, $SD = 1.37$. The same set of measurement
was reworded to measure knowledge of climate change, yielding a Cronbach’s $\alpha = 0.78$, $M = 5.41$, $SD = 1.17$.

*(i) Issue involvement.* Measurement of issue involvement included items from the personal involvement inventory (Zaichkowsky, 1994), using 7-point differential semantic scale, asking participants, to their view, whether the issue featured in the news story is “important – unimportant;” “boring – interesting;” “relevant – irrelevant;” “exciting – unexciting;” “means nothing - means a lot to me;” “appealing – unappealing;” “fascinating – mundane;” “worthless – valuable;” “involving – uninvolving;” and “not needed – needed.” Participants’ pre-existing issue involvement with same-sex marriage yielded a Cronbach’s $\alpha = 0.95$, $M = 4.99$, $SD = 1.44$. Their issue involvement with climate change yielded a Cronbach’s $\alpha = 0.90$, $M = 5.05$, $SD = 1.20$.

*(j) Power usage.* Power usage was measured using questions derived from previous work of Marathe et al. (2007), as well as Sundar and Marathe (2010). Twelve items asking individuals’ use, liking and dependence on communication technology were included, such as “I think most of the technological gadgets are complicated to use (reverse-coded);” “I make good use of most of the features available in any technological device;” “I make good use of most of the features available in any technological device;” “I have to have the latest available upgrades of the technological devices that I use;” “Use of information technology has almost replaced my use of paper;” “I love exploring all the features that any technological gadget has to offer;” “I often find myself using many technological devices simultaneously;” “I prefer to ask friends how to use any new technological gadget instead of trying to figure it out myself;” “Using any technological device comes easy to me. o I feel like information technology is a part of my daily life;” “Using information technology gives me greater control over my work environment;” “Using information technology makes it easier to do my work;” and “I would feel lost without information technology.” The scale yielded a Cronbach’s $\alpha = 0.82$. 
Table 3: List of individual-difference variables

<table>
<thead>
<tr>
<th>Individual-Difference Variables</th>
<th>Reliability index (Cronbach’s α)</th>
<th>M &amp; SD</th>
<th>Scale anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Religiosity</td>
<td>0.96</td>
<td>$M = 3.18$ $SD = 1.90$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(b) Political ideology</td>
<td>0.88</td>
<td>$M = 4.34$ $SD = 1.49$</td>
<td>(i) 1 = Strongly Republican, 4 = Independent, 7 = Strongly Democrat (ii) 1 = Strongly conservative, 4 = Moderate, 7 = Strongly liberal</td>
</tr>
<tr>
<td>(c) Attitude toward science</td>
<td>0.71</td>
<td>$M = 4.88$ $SD = 1.31$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(d) Need for cognition</td>
<td>0.78</td>
<td>$M = 4.60$ $SD = 1.08$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(e) Numeracy</td>
<td>0.85</td>
<td>$M = 4.62$ $SD = 0.97$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(f) Cognitive style</td>
<td>0.65</td>
<td>$M = 5.70$ $SD = 1.23$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(g) Pre-existing issue attitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Same-sex marriage</td>
<td>0.92</td>
<td>$M = 5.75$ $SD = 1.71$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(ii) Climate change</td>
<td>0.78</td>
<td>$M = 5.41$ $SD = 1.17$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(h) Pre-existing issue knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Same-sex marriage</td>
<td>0.85</td>
<td>$M = 5.05$ $SD = 1.37$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(ii) Climate change</td>
<td>0.78</td>
<td>$M = 5.41$ $SD = 1.17$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
<tr>
<td>(i) Pre-existing issue involvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Same-sex marriage</td>
<td>0.95</td>
<td>$M = 4.99$ $SD = 1.44$</td>
<td>Semantic-differential scale</td>
</tr>
<tr>
<td>(ii) Climate change</td>
<td>0.90</td>
<td>$M = 5.05$ $SD = 1.20$</td>
<td>Semantic-differential scale</td>
</tr>
<tr>
<td>(j) Power usage</td>
<td>0.82</td>
<td>$M = 5.24$ $SD = 0.81$</td>
<td>1 = Strongly Disagree to 7 = Strongly Agree</td>
</tr>
</tbody>
</table>
Chapter 3

RESULTS

This section will first present the manipulation check results, followed by the main findings of this study in four parts: The first part will report the mixed design analysis of variance (ANOVA) results, examining the main and interaction effects of the three manipulated independent variables—level of interactivity, exemplar-baserate consistency and story topic—on the following variables: recall, issue perception, issue attitude, perceived vividness, perceptual bandwidth, perceived contingency, user engagement, emotion, information processing, and attitude and behavioral intention toward the content. In general, no significant within-subjects effects (due to story topic) were found, unless otherwise indicated. In the preliminary data analysis phase, all previously proposed individual-difference variables, and the amount of time that participants spent on the interface, were used as covariates in the mixed design ANOVA tests. Only political ideology, power usage, and issue involvement appeared to significantly predict most of the outcome variables, and were included in the final data analyses. The second part will report results of the mediated moderation analyses, which examined the hypothesized moderating role of interactivity on the effects of exemplification, as well as the mediation analyses, testing the interactivity effects on issue perception being mediated by perceived vividness, perceptual bandwidth, perceived contingency and user engagement. The third part will report findings from path analyses exploring the relationships between the independent variables and outcome variables through various paths. The fourth part will report on the effects of the covariates, i.e. ideology, power usage and issue involvement.

Interactivity manipulation check. A general linear model revealed a significant main effect for the level of interactivity on the two-item, 7-point Likert-type scale that was measured to examine whether the ontological manipulation of interactivity was psychologically perceived so. A variable of perceived interactivity was created ($M = 3.94, SD = 1.54$, Cronbach’s $\alpha = 0.89$) and
was used for the analysis. The analysis showed that there was a significantly positive effect, $F(2, 166) = 43.18, p < 0.001, \eta^2 = 0.34$, indicating that the High Interactivity condition ($M = 5.16, SD = 1.27$) was perceived as more interactive than the Low Interactivity condition ($M = 3.95, SD = 1.27$), which was more interactive than the Verbal Description condition ($M = 2.97, SD = 1.27$). The Tukey HSD post hoc test showed that the three conditions differed significantly from each other at the level of $p < 0.01$.

**Exemplar consistency manipulation check.** The second manipulation in the study examined the extent to which participants perceived the news reports to be inconsistent. A single-item, 7-point Likert-type scale measuring their agreement with the statement that the news report presented too many conflicting viewpoints was measured for each of the two news reports, and a variable of perceived inconsistency was created ($M = 2.93, SD = 1.28$), $r = 0.70$. There was a significant one-tailed t-test $t(167) = -1.81, p < .05$, indicating that participants perceived the news report as more inconsistent ($M = 3.18, SD = 1.26$) when exposed to news reports with exemplar distribution inconsistent with baserates, compared to when exposed to consistent exemplars ($M = 2.83, SD = 1.27$).

**Part I: Main and interaction effects**

The analyses described below employed mixed-design analyses of variance (ANOVA) with two between-subjects independent variables, namely (i) *level of interactivity* (High, Low, Verbal Description) and (ii) *exemplar-baserate consistency* (exemplar distribution consistent or inconsistent with baserates), and one within-subjects variable, *news topics* (same-sex marriage, climate change). The results showed no significant effect of news topics, unless otherwise indicated. The initial analyses included the following covariates: Religiousness (same-sex marriage only), ideology (same-sex marriage only), science attitude (climate change only), power usage, need for cognition, statistics familiarity, cognitive style, pre-existing issue involvement (topic specific), pre-existing attitude (topic specific), pre-existing knowledge (topic specific), and
the amount of time spent on the online news website. The final results reported below were based on the analyses including the three covariates that showed significant effects, i.e. ideology, issue involvement and power usage. The main effects and interaction effects of the independent variables are reported below; the effects of covariates are discussed in Part IV of this section.

Recall, issue perception and attitude. The following set of hypotheses examined the effect of independent variables on baserate and exemplar recall:

**H1**: Exemplar-baserate consistency, compared to exemplar-baserate inconsistency, will lead to a higher level of accuracy in exemplar recall (H1a), baserate recall (H1b) and issue perception (H1c), and better personal attitude toward the issue (H1d).

**H2**: Presence of interactivity, compared to absence of interactivity, will lead to a higher level of accuracy in exemplar recall (H2a), baserate recall (H2b) and issue perception (H2c), and more positive personal attitude toward the issue (H2d).

In order to replicate the classic exemplification effect, which referred to the predictive effect of exemplar distribution on recall, issue perception and attitude when baserates were verbally presented, a mixed design ANOVA test was conducted using the data of the Verbal description conditions only. A significantly positive main effect of consistency on issue perception was found, $F(1, 57) = 4.58^*, p < 0.05$, $\eta^2 = 0.06$, indicating that exemplar-baserate consistency was associated with greater accuracy (according to the baserates in the news report) of issue perception ($M = 5.94, SE = 0.11$) than exemplar-baserate inconsistency was ($M = 5.61, SE = 0.11$). This result partially supported hypothesis H1c, establishing the classic exemplification effect such that, with verbal description of baserates, exemplar distribution significantly influenced issue perception.

Worth noting is that the exemplification effect was only significant when baserate information was presented in verbal format. As shown in Figure 5, exemplar-baserate consistency showed no significant effect on issue perception when baserates were presented in static or
interactive visualization; instead, there was a main effect of interactivity, such that issue perception was more accurate for those who viewed interactive visualization of baserates than those who viewed static visualization. There was no significant interaction effect of exemplar-baserate consistency and interactivity, \( F (2, 157) = 0.77, p = 0.46. \)

![Issue Perception](image)

**Figure 5.** Effects of consistency and interactivity on issue perception.

There were no significant effects of consistency on exemplar recall \( (F (1, 57) = 0.06, p = 0.81) \), baserate recall \( (F (1, 57) = 0.37, p = 0.55) \) or personal attitude \( (F (1, 57) = 1.47, p = 0.23) \). Thus, hypotheses H1a, b and d were not supported.

Furthermore, mixed-design ANOVA tests were conducted to examine the effect of consistency and interactivity on the three outcome variables.

**Recall.** As shown in Table 4, the two independent variables showed no main effects on participants’ recall of exemplars and baserates. There was a significant interaction effect of interactivity and consistency on exemplar recall, \( F (2,159) = 3.29, p < 0.05 \), partial \( \eta^2 = 0.04 \),
such that participants who viewed the consistent messages tend to recall less exemplifying information as the level of interactivity increased from low to high, whereas those who viewed the inconsistent messages recalled exemplars more accurately in the high interactivity condition compared to the low condition; no significant difference was found between consistent and inconsistent exemplar conditions when baserates were presented verbally (Figure 6).

Thus, the hypothesis H2a was partially supported, while Hypotheses H1a&b and H2b were not supported.

Table 4: Main and interaction effects on recall

<table>
<thead>
<tr>
<th>Recall</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exemplar Recall</td>
<td>F(2,159)=0.25</td>
<td>F(1,159)=50.31</td>
<td>F(2,159)=3.29*</td>
<td>H1a &amp; H2a</td>
</tr>
<tr>
<td></td>
<td>p = 0.98</td>
<td>p = 0.86</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Baserate Recall</td>
<td>F = 0.69</td>
<td>F = 0.70</td>
<td>F = 0.01</td>
<td>H1b &amp; H2b</td>
</tr>
<tr>
<td></td>
<td>p = 0.50</td>
<td>p = 0.41</td>
<td>p = 0.99</td>
<td></td>
</tr>
</tbody>
</table>

Note: F-tests are from mixed design ANOVA analyses. SS = Same-sex marriage. CC = Climate change. *p < 0.05.

Figure 6. Interaction effect of interactivity and consistency on exemplar recall.
There was also a significant interaction effect of news topic and interactivity on baserate recall, $F(2, 159) = 3.30, p < 0.05$, partial $\eta^2 = 0.04$, indicating that while interactivity showed no significant effect on the baserate recall of climate-change content, it had a positive effect on the baserate recall of same-sex marriage content (Figure 7). A Tukey post hoc test showed a significant difference for baserate recall between the High interactivity condition ($M = 1.63, SE = 0.18$) and the Low interactivity condition ($M = 1.17, SE = 0.17$), $p < 0.05$.

![Baserate Recall Diagram](image)

Figure 7. Interaction effect of interactivity and topic on baserate recall.

**Issue perception.** As shown in Table 5, there was a significant main effect of interactivity on issue perception, $F(2, 159) = 4.05, p < 0.05$, partial $\eta^2 = 0.05$. A Tukey post hoc test indicated that participants’ issue perception was significantly more accurate for the High interactivity condition ($M = 5.97, SE = 0.09$) than the Low interactivity condition ($M = 5.64, SE = 0.09$), $p < 0.05$. There was a significant main effect of interactivity on participants’ self-reported certainty about their estimations, $F(2, 159) = 3.34, p < 0.05$, partial $\eta^2 = 0.04$, indicating that participants
in the High interactivity condition ($M = 5.43, \ SE = 0.18$) were significantly more certain about their estimation compared to those in the Low interactivity condition ($M = 4.94, \ SE = 0.18$), $p < 0.05$. Thus, $H2c$ was supported.

Table 5: *Main and interaction effects on issue perception*

<table>
<thead>
<tr>
<th>Issue Perception</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue Perception</td>
<td>$F = 4.05^*$</td>
<td>$F = 0.48$</td>
<td>$F = 0.79$</td>
<td>$H1c$&amp;$H2c$</td>
</tr>
<tr>
<td></td>
<td>$p &lt; 0.05$</td>
<td>$p = 0.48$</td>
<td>$p = 0.46$</td>
<td></td>
</tr>
<tr>
<td>Certainty</td>
<td>$F = 3.34^*$</td>
<td>$F = 0.06$</td>
<td>$F = 0.01$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p &lt; 0.05$</td>
<td>$p = 0.94$</td>
<td>$p = 0.99$</td>
<td></td>
</tr>
</tbody>
</table>

Note: $^*p < 0.05$.

_Issue attitude_. As shown in Table 6, there were no significant main effects or interaction effects of the independent variables on attitudes toward the depicted issue and the related social phenomena or policy in general. Thus, $H1d$ and $H2d$ were not supported.

Table 6: *Main and interaction effects on issue attitude*

<table>
<thead>
<tr>
<th>Issue Attitude</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude toward the issue</td>
<td>$F = 0.47$</td>
<td>$F = 1.35$</td>
<td>$F = 0.29$</td>
<td>$H1d$&amp;$H2d$</td>
</tr>
<tr>
<td></td>
<td>$p = 0.63$</td>
<td>$p = 0.25$</td>
<td>$p = 0.75$</td>
<td></td>
</tr>
<tr>
<td>Attitude toward issue-related phenomena or</td>
<td>$F = 0.74$</td>
<td>$F = 0.41$</td>
<td>$F = 0.15$</td>
<td></td>
</tr>
<tr>
<td>policy</td>
<td>$p = 0.48$</td>
<td>$p = 0.53$</td>
<td>$p = 0.12$</td>
<td></td>
</tr>
</tbody>
</table>

In sum, the results demonstrated the classic exemplification effect but only for the Verbal description condition. The effect of exemplar-baserate consistency on exemplar recall was moderated by interactivity, such that exemplar-baserate consistency was associated with more accurate exemplar recall in the Low interactivity condition, but was associated to less accurate exemplar recall in the High interactivity condition. The findings also showed that the presence of interactivity was associated with greater accuracy of issue perceptions and enhanced certainty about the issue perceptions.

_Vividness, Perceptual Bandwidth, Contingency and Engagement_. The following
hypothesis predicted the effects of the independent variables on perceived vividness, perceptual bandwidth, perceived contingency and user engagement:

**H5**: Presence of interactivity, compared to absence of interactivity, will lead to greater user perceptions of *presentational vividness* (H5a) and *message vividness* (H5b).

**H7**: Presence of interactivity, compared to absence of interactivity, will lead to higher levels of *perceptual bandwidth* (H7a) and *perceived contingency* (H7b), and therefore positively affect user engagement in terms of temporal dissociation (H7c), absorption (H7d) and fun (H7e).

*Perceived vividness.* There were no significant effects of the two independent variables on participants’ perception of exemplar vividness. As predicted in H5a&b, there were significant main effects of interactivity on perceptions of presentational vividness, $F(2, 159) = 7.12, p < 0.01$, partial $\eta^2 = 0.08$; and message vividness partial, $F(2, 159) = 9.57, p < 0.001$, partial $\eta^2 = 0.11$ (Table 7). The perceived presentational vividness was significantly higher for the High ($M = 5.16$, $SE = 0.17$) and Low ($M = 5.12$, $SE = 0.16$) interactivity conditions than the Verbal description condition ($M = 4.41$, $SE = 0.15$) at the level of $p < 0.01$ (see Figure 8-a). The perceived message vividness was the highest for the High interactivity condition ($M = 4.72$, $SE = 0.12$), compared to the Low interactivity ($M = 4.52$, $SE = 0.11$) and the Verbal description ($M = 4.03$, $SE = 0.11$) conditions (see Figure 8-b). Thus, hypotheses H5a&b were both supported.

Table 7: *Main and interaction effects on perceived vividness*

<table>
<thead>
<tr>
<th>Perceived Vividness</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exemplar Vividness</td>
<td>$F = 0.24$</td>
<td>$F = 3.73$</td>
<td>$F = 0.17$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p = 0.79$</td>
<td>$p = 0.06$</td>
<td>$p = 0.85$</td>
<td></td>
</tr>
<tr>
<td>Presentational Vividness</td>
<td>$F = 7.12**$</td>
<td>$F = 0.60$</td>
<td>$F = 0.75$</td>
<td>H5a</td>
</tr>
<tr>
<td></td>
<td>$p &lt; 0.01$</td>
<td>$p = 0.44$</td>
<td>$p = 0.47$</td>
<td></td>
</tr>
<tr>
<td>Message Vividness</td>
<td>$F = 9.57***$</td>
<td>$F = 0.00$</td>
<td>$F = 0.82$</td>
<td>H5b</td>
</tr>
<tr>
<td></td>
<td>$p &lt; 0.001$</td>
<td>$p = 0.97$</td>
<td>$p = 0.44$</td>
<td></td>
</tr>
</tbody>
</table>

Note: **$p < 0.01$; ***$p < 0.001$. 

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Perceptual bandwidth. As shown in Table 8, the level of interactivity significantly and positively affected perceptual bandwidth, $F(2, 159) = 11.97, p < 0.001$, partial $\eta^2 = 0.13$. A Tukey post hoc analysis indicated that participants in the High interactivity condition ($M = 5.25, SE = 0.13$) reported a marginally significantly higher level of perceptual bandwidth than those in the Low interactivity condition ($M = 4.96, SE = 0.12$) did, $p = 0.08$, while participants in both of the High ($p < 0.001$) and Low interactivity ($p < 0.01$) conditions reported significantly higher levels of perceptual bandwidth than those in the Verbal description condition ($M = 4.41, SE = 0.12$). Thus, H7a was supported.

Perceived contingency. There was also a significant main effect of interactivity on perceived contingency, $F(2, 159) = 8.11, p < 0.001$, partial $\eta^2 = 0.09$ (Table 8). The High interactivity condition ($M = 4.51, SE = 0.16$) was perceived as significantly more contingent than both of the Low interactivity condition ($M = 4.06, SE = 0.15$), $p < 0.05$, and the Verbal description condition ($M = 3.67, SE = 0.14$), $p < 0.001$; whereas the level of perceived contingency of the Low interactivity condition differed marginally significantly from the Verbal
description condition, \( p = 0.05 \). Thus, hypothesis H7b was supported.

Table 8: *Main and interaction effects on psychological responses*

<table>
<thead>
<tr>
<th>Psychological Responses</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>( I \times C ) Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual Bandwidth</td>
<td>( F = 11.97^{***} )</td>
<td>( F = 0.16 )</td>
<td>( F = 0.30 )</td>
<td>H7a</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.001 )</td>
<td>( p = 0.70 )</td>
<td>( p = 0.74 )</td>
<td></td>
</tr>
<tr>
<td>Perceived Contingency</td>
<td>( F = 8.11^{***} )</td>
<td>( F = 0.03 )</td>
<td>( F = 0.33 )</td>
<td>H7b</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.001 )</td>
<td>( p = 0.86 )</td>
<td>( p = 0.72 )</td>
<td></td>
</tr>
</tbody>
</table>

Note: \( ***p < 0.001 \).

**User engagement.** As shown in Table 9, there was a significant main effect of interactivity on the temporal dissociation aspect of user engagement, \( F (2, 159) = 6.08, p < 0.05 \), partial \( \eta^2 = 0.04 \). A post hoc test showed the effect in a different direction than hypothesized, such that participants in the Low interactivity condition reported a marginally significantly higher level of temporal dissociation (\( M = 4.05, SE = 0.13 \)), than those in the High interactivity condition (\( M = 3.71, SE = 0.14 \), \( p = 0.08 \), and those in than the Verbal description condition (\( M = 3.61, SE = 0.13 \), \( p < 0.05 \) (see Figure 9).

Table 9: *Main and interaction effects on user engagement*

<table>
<thead>
<tr>
<th>User Engagement</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>( I \times C ) Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement - Temporal Dissociation</td>
<td>( F = 3.12^{*} )</td>
<td>( F = 0.00 )</td>
<td>( F = 0.51 )</td>
<td>H7c</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.05 )</td>
<td>( p = 0.97 )</td>
<td>( p = 0.60 )</td>
<td></td>
</tr>
<tr>
<td>Engagement - Absorption</td>
<td>( F = 0.58 )</td>
<td>( F = 1.83 )</td>
<td>( F = 1.15 )</td>
<td>H7d</td>
</tr>
<tr>
<td></td>
<td>( p = 0.56 )</td>
<td>( p = 0.18 )</td>
<td>( p = 0.32 )</td>
<td></td>
</tr>
<tr>
<td>Engagement - Fun</td>
<td>( F = 5.43^{**} )</td>
<td>( F = 0.04 )</td>
<td>( F = 0.77 )</td>
<td>H7e</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.01 )</td>
<td>( p = 0.84 )</td>
<td>( p = 0.47 )</td>
<td></td>
</tr>
</tbody>
</table>

Note: \( *p < 0.05 \); \( **p < 0.01 \).
However, an analysis of the log data of the actual amount of time spent on website showed a different pattern. The level of interactivity significantly predicted the amount of time spent on the news websites, $F(2, 159) = 3.87, p < 0.05$, partial $\eta^2 = 0.03$, showing that participants in the High interactivity condition spent a significantly greater amount of time viewing and interacting with the websites than those in the Low interactivity and Verbal description conditions (see Figure 10).
There was also a significant main effect of interactivity on the fun aspect of user engagement, $F(2, 159) = 6.43, p < 0.01$, partial $\eta^2 = 0.08$, such that participants in the High ($M = 4.20, SE = 0.14, p < 0.01$) and Low ($M = 4.12, SE = 0.13, p < 0.01$) interactivity conditions reported a significantly higher level of fun than those in the Verbal description condition ($M = 3.60, SE = 0.12$) did. There were no significant main effects or interaction effects on absorption. Thus, H7e was partially supported, whereas H7c&d were not supported.

**Emotion and information processing.** The following hypothesis predicted the effects of the independent variables on emotion and information processing:

**H3:** Presence of interactivity, compared to absence of interactivity, will lead to higher level of *emotion* experienced by the participants, both in terms of *valence* (H3a) and *arousal* (H3b), as well as greater *systematic processing* (H3c) and less *heuristic processing* (H3d) of the news content.
**Emotion.** As shown in Table 10, there was a significant main effect of interactivity on the valence of emotion, \( F(2, 159) = 6.11, p < 0.01, \) partial \( \eta^2 = 0.07. \) A post hoc analysis indicated that participants in the High \( (M = 4.21, SE = 0.08, p < 0.01) \) and Low \( (M = 4.35, SE = 0.08, p < 0.05) \) interactivity conditions reported significantly more positive emotions than those in the Verbal description condition \( (M = 3.99, SE = 0.07) \). There were no significant main effects of interactivity and consistency on emotional arousal. Instead, news topic showed a significant main effect on arousal, \( F(1, 159) = 5.733, p < 0.05, \) partial \( \eta^2 = 0.04 \). Thus, H3a was supported, whereas H3b was not supported.

Table 10: *Main and interaction effects on emotion*

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Valence</td>
<td>( F = 6.11^{**} )</td>
<td>( F = 0.25 )</td>
<td>( F = 0.87 )</td>
<td>H3a</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.01 )</td>
<td>( p = 0.62 )</td>
<td>( p = 0.42 )</td>
<td></td>
</tr>
<tr>
<td>Emotional Arousal</td>
<td>( F = 0.73 )</td>
<td>( F = 0.00 )</td>
<td>( F = 0.10 )</td>
<td>H3b</td>
</tr>
<tr>
<td></td>
<td>( p = 0.49 )</td>
<td>( p = 0.95 )</td>
<td>( p = 0.91 )</td>
<td></td>
</tr>
</tbody>
</table>

Note: \(^{**}p < 0.01.\)

**Information processing.** As shown in Table 11, there were no significant effects of the two independent variables on information processing, except for an interaction effect on heuristic processing, \( F(2, 159) = 6.51, p < 0.05, \) partial \( \eta^2 = 0.04. \) Figure 11 shows the interaction effect such that in the Verbal description condition, participants who viewed inconsistent messages were less likely to be engaged in heuristic processing than those who viewed consistent messages; however, for those who were in the Low interactivity condition, participants who viewed the consistent messages reported a higher level of heuristic processing than those who viewed the inconsistent messages did. For participants in the High interactivity condition, heuristic processing for both consistent and inconsistent messages were lower than those in the Low interactivity and Verbal description conditions. Thus, H5b was supported, whereas H5a was not supported.
Table 11: *Main and interaction effects on information processing*

<table>
<thead>
<tr>
<th>Information Processing</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic Processing</td>
<td>$F = 1.21$</td>
<td>$F = 0.36$</td>
<td>$F = 0.75$</td>
<td>H5a</td>
</tr>
<tr>
<td></td>
<td>$p = 0.30$</td>
<td>$p = 0.55$</td>
<td>$p = 0.47$</td>
<td></td>
</tr>
<tr>
<td>Heuristic Processing</td>
<td>$F = 2.12$</td>
<td>$F = 0.04$</td>
<td>$F = 3.22^*$</td>
<td>H5b</td>
</tr>
<tr>
<td></td>
<td>$p = 0.12$</td>
<td>$p = 0.84$</td>
<td>$p &lt; 0.05$</td>
<td></td>
</tr>
</tbody>
</table>

Note: *$p < 0.05$.*

![Heuristic Processing](image)

**Figure 11.** Interaction effect of interactivity and consistency on heuristic processing.

**Behavioral Intention.** Finally, the hypothesis that hypothesizes the effect of interactivity on behavioral intention toward the news content was tested:

*H9*: Presence of interactivity, compared to absence of interactivity, will lead to more positive behavioral intentions toward the news content.

As can be seen in Table 12, there was a significant main effect of interactivity on behavioral intention toward the news content, $F(2, 159) = 4.05, p < 0.05$, partial $\eta^2 = 0.05$, indicating that participants in the High ($M = 3.90, SE = 0.12$) and Low ($M = 4.22, SE = 0.15$)
interactivity conditions reported more positive behavioral intentions toward the news content than those in the Verbal description condition ($M = 3.63, SE = 0.14$) did. Thus, hypothesis H9 was supported.

Table 12: *Main and interaction effects on behavioral intention*

<table>
<thead>
<tr>
<th>Recall</th>
<th>Interactivity</th>
<th>Consistency</th>
<th>I × C Interaction</th>
<th>Hypotheses/ RQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Intention</td>
<td>$F = 4.05^*$</td>
<td>$F = 0.54$</td>
<td>$F = 0.43$</td>
<td>H6b</td>
</tr>
<tr>
<td>toward the News</td>
<td>$p &lt; 0.05$</td>
<td>$p = 0.46$</td>
<td>$p = 0.67$</td>
<td></td>
</tr>
</tbody>
</table>

Note: *$p < 0.05$.

In sum, exemplar-baserate consistency was found to influence issue perception only when baserate information was shown in verbal format. The results revealed several main effects of interactivity. Interactive visualization was found to be associated with significantly higher levels of message vividness, perceptual bandwidth and perceived contingency than both static visualization and verbal description of baserates. Interaction effects between interactivity and exemplar-baserate consistency were found to influence exemplar recall and heuristic processing.

**Part II: Mediated moderation and indirect effects.**

**Mediated moderation.** This study proposed a mediated moderation effect (H4&10 and Figure 3) such that the level of interactivity will moderate the exemplification effect through the mediating variables, i.e. user engagement and vividness. Specifically, the following hypothesis predicted the mediated moderation effects:

**H10:** Interactivity will reduce the effect of exemplar distribution on issue perception through mediating variables such as perceived vividness and user engagement, such that exemplar distribution will have a weaker effect on issue perception when the baserate information is presented in interactive visualization that leads to greater perceived vividness and user engagement than static visualization and verbal description.

The hypothesized mediated moderation is statistically equivalent to a second-stage
moderated mediation model (Hayes, 2013, Ch.11), in which the level of exemplar-baserate consistency moderates the effect of interactivity on issue perception, which is mediated by user engagement and vividness (Figure 12). Figure 13 presents the statistical model of the equivalent moderated mediation model that was used for statistical analyses in this study.

Figure 12. Second-stage moderate mediation model.

Figure 13. Statistical model of the second-stage moderated mediation.

In order to examine the proposed effect, PROCESS Model 15 (Hayes, 2013), the same
statistical model as the direct effect and second-stage moderation model (Edwards & Lambert, 2007), was executed using IBM SPSS Statistics 2011. The findings below describe the results using this method, with issue perception as the dependent variables, the level of interactivity as the independent variables, user engagement (fun) and perceived message vividness as the mediating variables, and consistency as the second-stage moderating variable. The three-level independent variable was dummy-coded into two dichotomous variables labeled as IN_Visual (0 = Verbal description, 1 = Low and High interactivity) and IN_Interactive (0 = Verbal description and Low interactivity, 1 = High interactivity).

Table 13a&b showed that, the level of interactivity showed significant effects on the two mediating variables—user engagement and message vividness. However, the hypothesized causal links between the mediating variables and the outcome variable—issue perception—were not statistically significant. There was a significant, negative conditional direct effect of interactivity (IN_Visual) when the messages were consistent. The result indicated that, when combined with consistent exemplars, the visualization of baserates was associated with a more negative issue perception compared to the verbal description of baserates. The condition indirect effects, as well as the moderated mediation effects, were not statistically significant.
Table 13a: Mediated moderation on issue perception (IN_Visual)

<table>
<thead>
<tr>
<th>_mediated moderation on issue perception (IN_Visual)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User Engagement (Fun):</strong> $R^2 = 0.07, F (1, 167) = 11.77^{***}, p &lt; 0.001$</td>
</tr>
<tr>
<td><strong>Message Vividness:</strong> $R^2 = 0.09, F (1, 167) = 16.05^{***}, p &lt; 0.001$</td>
</tr>
<tr>
<td><strong>Issue Perception:</strong> $R^2 = 0.05, F (7, 161) = 1.14, p = 0.34$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Consistency</th>
<th>Effect</th>
<th>SE</th>
<th>t</th>
<th>p</th>
<th>LLCI</th>
<th>ULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Engagement</td>
<td>0</td>
<td>-0.16</td>
<td>0.19</td>
<td>-0.86</td>
<td>0.39</td>
<td>-0.53</td>
<td>0.21</td>
</tr>
<tr>
<td>User Engagement</td>
<td>1</td>
<td>-0.38</td>
<td>0.18</td>
<td>-2.06</td>
<td>0.04</td>
<td>-0.74</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Consistency</th>
<th>Effect</th>
<th>Boot SE</th>
<th>BootLLCI</th>
<th>BootULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Engagement</td>
<td>0</td>
<td>0.01</td>
<td>0.08</td>
<td>-0.16</td>
<td>0.18</td>
</tr>
<tr>
<td>User Engagement</td>
<td>1</td>
<td>0.02</td>
<td>0.09</td>
<td>-0.15</td>
<td>0.20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Consistency</th>
<th>Effect</th>
<th>Boot SE</th>
<th>BootLLCI</th>
<th>BootULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Vividness</td>
<td>0</td>
<td>0.06</td>
<td>0.10</td>
<td>-0.15</td>
<td>0.26</td>
</tr>
<tr>
<td>Message Vividness</td>
<td>1</td>
<td>0.06</td>
<td>0.11</td>
<td>-0.13</td>
<td>0.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mediated Mediation Mediator</th>
<th>Index</th>
<th>SE</th>
<th>LLCI</th>
<th>ULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Engagement</td>
<td>0.01</td>
<td>0.12</td>
<td>-0.22</td>
<td>0.29</td>
</tr>
<tr>
<td>Message Vividness</td>
<td>-0.00</td>
<td>0.18</td>
<td>-0.27</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Table 13b: Mediated moderation on issue perception (IN_Interactive)

<table>
<thead>
<tr>
<th>User Engagement (Fun): $R^2 = 0.03$, $F(1, 167) = 5.51^*$, $p &lt; 0.05$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IN_Interactive</td>
<td>$b$ &amp; 0.40 &amp; $t$ &amp; 2.35* &amp; $p$ &amp; &lt; 0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Message Vividness: $R^2 = 0.06$, $F(1, 167) = 10.57^{**}$, $p &lt; 0.01$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactivity</td>
<td>$b$ &amp; 0.51 &amp; $t$ &amp; 3.25** &amp; $p$ &amp; &lt; 0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue Perception: $R^2 = 0.02$, $F(7, 161) = 0.51$, $p = 0.82$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>User Engagement</td>
<td>$b$ &amp; 0.02 &amp; $t$ &amp; 0.13 &amp; $p$ &amp; 0.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message Vividness</td>
<td>$b$ &amp; 0.07 &amp; $t$ &amp; 0.44 &amp; $p$ &amp; 0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactivity</td>
<td>$b$ &amp; 0.16 &amp; $t$ &amp; 0.78 &amp; $p$ &amp; 0.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistency</td>
<td>$b$ &amp; 0.28 &amp; $t$ &amp; 0.49 &amp; $p$ &amp; 0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Engagement × Consistency</td>
<td>$b$ &amp; -0.00 &amp; $t$ &amp; -0.01 &amp; $p$ &amp; 0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message Vividness × Consistency</td>
<td>$b$ &amp; -0.03 &amp; $t$ &amp; -0.12 &amp; $p$ &amp; 0.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactivity × Consistency</td>
<td>$b$ &amp; -0.12 &amp; $t$ &amp; -0.44 &amp; $p$ &amp; 0.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conditional direct effect of Interactivity on Issue Perception at values of Consistency:

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Effect</th>
<th>SE</th>
<th>$t$</th>
<th>$p$</th>
<th>LLCI</th>
<th>ULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.16</td>
<td>0.20</td>
<td>0.78</td>
<td>0.43</td>
<td>-0.24</td>
<td>0.56</td>
</tr>
<tr>
<td>1</td>
<td>0.04</td>
<td>0.18</td>
<td>0.21</td>
<td>0.84</td>
<td>-0.33</td>
<td>0.40</td>
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</table>

Conditional indirect effects of Interactivity on Issue Perception at values of Consistency:

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Consistency</th>
<th>Effect</th>
<th>Boot SE</th>
<th>BootLLCI</th>
<th>BootULCI</th>
</tr>
</thead>
<tbody>
<tr>
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<td>-0.09</td>
<td>0.18</td>
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<tr>
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<td>-0.11</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Consistency</th>
<th>Effect</th>
<th>Boot SE</th>
<th>BootLLCI</th>
<th>BootULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Vividness</td>
<td>0</td>
<td>0.04</td>
<td>0.10</td>
<td>-0.16</td>
<td>0.22</td>
</tr>
<tr>
<td>Message Vividness</td>
<td>1</td>
<td>0.02</td>
<td>0.09</td>
<td>-0.15</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Moderated Mediation

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Index</th>
<th>SE</th>
<th>LLCI</th>
<th>ULCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Engagement</td>
<td>-0.00</td>
<td>0.10</td>
<td>-0.16</td>
<td>0.23</td>
</tr>
<tr>
<td>Message Vividness</td>
<td>-0.01</td>
<td>0.13</td>
<td>-0.28</td>
<td>0.24</td>
</tr>
</tbody>
</table>
The mediated moderation results indicated that perceived vividness and user engagement were not directly causally linked to the outcome variable. As discussed in the literature review, they might influence issue perception through their effects on information processing and user emotions. Moreover, the mediated moderation did not test the mediating effects of the psychological factors such as perceptual bandwidth and perceived contingency. These psychological factors were hypothesized to influence perceived vividness and user engagement, and were found to be directly and significantly influenced by the level of interactivity. Therefore, further analyses were focused on examining the indirect effects of interactivity. Specifically, the mediations of the interactivity effects, i.e. interactivity → contingency/perceptual bandwidth → user engagement/perceived message vividness → information processing/emotion → issue perception, were tested using PROCESS Model 6 (Hayes, 2014). The following section reports the results of the mediation analyses, which utilized standardized scores of the relevant variables.

**Mediation analyses.** The analyses of mediation effects revealed significant mediations of interactivity effects on issue perception. As shown in Figure 14, the total indirect effect of interactivity on issue perception through mediating variables, perceptual bandwidth, perceived message vividness, and heuristic processing was statistically significant, total indirect effect = 0.14, SE = 0.08, p < 0.05. In particular, the analyses revealed three significantly positive indirect pathways (p < 0.05), including interactivity → perceptual bandwidth → heuristic processing → issue perception (indirect effect = 0.03 SE = 0.02), interactivity → message vividness → heuristic processing → issue perception (indirect effect = 0.01, SE = 0.01), and interactivity → perceptual bandwidth → message vividness → heuristic processing → issue perception (indirect effect = 0.01, SE = 0.01).
As shown in Figure 15, interactivity effect on issue perception was also mediated by perceived contingency, user engagement and systematic processing, with a significant total indirect effect of 0.09, \( p < 0.05 \). The analyses revealed two significant mediating pathways \( (p < 0.05) \), including interactivity → systematic processing → issue perception (indirect effect = 0.03, \( SE = 0.07 \)), and interactivity → contingency → user engagement → systematic processing → issue perception (indirect effect = 0.06, \( SE = 0.03 \)).
Part III: Structural Equation Modeling

As shown in Part I and Part II of this section, the effects of interactivity on issue perception and personal attitude were rather complex. For instance, the level of interactivity showed significant main effects on some of psychological variables (e.g., perceptual bandwidth, perceived contingency, perceived message vividness, etc.) rather than directly affecting some of the outcome variables such as recall and personal attitude. The mediation results indicated that the effects of interactivity on issue perception may involve a number of steps, such that perceptual bandwidth and perceived contingency as direct responses to interactivity may lead to perceptions of message vividness and heightened user engagement, which will enhance information processing and influence issue perception and attitude.

In order to examine the mediation paths and the multiple steps through which interactivity influences outcome variables such as issue perception, as theorized in Figure 1, a structural equation model was tested. For structural equation modeling analyses, the sample size of this study is small, but meets the minimal criteria specified by Hair (2010), who has suggested a sample size of 150 for models with seven or fewer latent variables. The following section describes the findings of SEM analyses that were aimed at exploring mechanisms through which the affordance of interactivity influences individual perceptions and personal attitude. The structural model was first tested using data of the same-sex marriage news story, followed by iterative model modification processes, and the resulting model was tested using data of the climate-change news story.

Driven by the theoretical framework and the results discussed previously, a structural model shown in Figure 16 was tested in order to understand the effects of the two key psychological variables (i.e., perceptual bandwidth and perceived contingency) and the two mediating mechanisms through perceived vividness and user engagement. The structural model hypothesized that the presence of interactivity (in this case, interactive visualization versus verbal description and static visualization) had direct effect on the two psychological variables,
perceived contingency and perceptual bandwidth, which would enhance user engagement and perceived vividness. User engagement and perceived vividness would together influence systematic information processing, which would affect issue perception and personal attitude.

Figure 16. A theoretical model of the interactivity effects.

In the structural equation modeling analyses, a dichotomous independent variable of interactivity was used, with 1 indicating interactive visualization and 0 indicating non-interactive conditions (static visualization and verbal description).

First, the measurement model with seven latent variables was examined. A confirmatory factor analysis (CFA) was conducted to examine the measurement model. Based on the CFA results, items with factor loadings lower than 0.60 were eliminated from the model (see Appendix A for items included in the measurement model). As shown in Figure 17, the measurement model yielded a good model fit, $X^2 = 364.28, DF = 231, p < 0.001, CMIN/DF = 1.58; CFI = 0.97; RMSEA = 0.059, 90\% CI LO/HI = 0.047/0.070.$ The results from the measurement model testing was informative for testing the structural model: Factor loadings of the seven latent factors were all substantial, ranging from 0.67 to 0.98, and the correlations between the latent factors that were hypothetically associated (e.g., perceived contingency and user engagement, perceptual bandwidth and perceived vividness, etc.) were moderate ($0.30 < M < 0.40$) to strong ($0.40 < M < 0.70$).
Figure 17. Measurement model of interactivity effects on issue perception and personal attitude with the same-sex marriage data. Standardized results are shown. $X^2 = 364.28, \text{DF} = 231, p < 0.001, \frac{CMIN}{DF} = 1.58; \text{CFI} = 0.97; \text{RMSEA} = 0.059, 90\% \text{ CI LO/HI} = 0.047/0.070$.

The structural model was then tested using the data of the same-sex marriage news story. Figure 18 shows the SEM model, with the model fit statistics indicating a good model fit, $X^2 = 474.70, \text{DF} = 266, p < 0.001, \frac{CMIN}{DF} = 1.79; \text{CFI} = 0.93; \text{RMSEA} = 0.06, 90\% \text{ CI LO/HI} = 0.05/0.07$. All paths in this SEM model were statistically significant at the level of $p < 0.05$, except for the path predicting the effect of user engagement on systematic processing, which was marginally significant, $p < 0.10$. 

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Figure 18. Structural equation model of interactivity effects on issue perception and personal attitude with the same-sex marriage data. Note: Standardized path coefficients with significance levels are shown. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; and +$p < 0.10$.

Table 14 shows the parameter estimates of the measurement model and the structural model. The results indicate that the structural equation model fit well with the data of the same-sex marriage news report. Compared to non-interactive presentational formats, interactive visualization led to increased perceived contingency and perceptual bandwidth. These two psychological factors were positively associated with user engagement and perceived vividness, which were both positively associated with systematic processing, even though the relationship between user engagement and systematic processing only reached marginal significance ($p < 0.10$). Furthermore, systematic processing was found to strongly and positively associated with issue perception, which in turn was positively associated with personal attitude toward the issue of same-sex marriage.
Table 14: *Standardized and significance levels for the structural model (same-sex marriage).*

<table>
<thead>
<tr>
<th>Parameter Estimate</th>
<th>Standardized</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Perceived Contingency → SSContingency₁</td>
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<tr>
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</tr>
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<tr>
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<tr>
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</tr>
<tr>
<td>Perceptual Bandwidth → SSPerceptualBandwidth₃</td>
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<td>.00</td>
</tr>
<tr>
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</tr>
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<tr>
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<tr>
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<tr>
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<tr>
<td>Issue Perception → Personal Attitude</td>
<td>.43</td>
<td>.00</td>
</tr>
</tbody>
</table>
Next, after the structural equation model was fitted with the same-sex marriage data, the model was further evaluated using the data of the climate change news story. As shown in Figure 19, the model yielded acceptable model fit statistics, $X^2 = 541.65$, $DF = 290$, $p < 0.001$, $CMIN/DF = 1.87$; $SRMR = 0.08$, $CFI = 0.91$; $RMSEA = .07$, 90% CI LO/HI = 0.052/0.080, indicating that the SEM model fitted the climate-change data well.

Figure 19. Testing the SEM model with the climate change data. $X^2 = 541.65$, $DF = 290$, $p < 0.001$, $CMIN/DF = 1.87$; $SRMR = 0.08$, $CFI = 0.91$; $RMSEA = .07$, 90% CI LO/HI = 0.052/0.080.

Note: Standardized path coefficients with significance levels are shown. ***$p < 0.001$; **$p < 0.01$; and *$p < 0.05$.

Table 15 shows the parameter estimates of the measurement model and the structural model for the climate change data. The results indicate that the structural equation model fit well with the climate change data, with the path between user engagement and systematic processing becoming statistically significant ($p < 0.05$) in this story. The strength of the path between issue perception and issue attitude changed from moderate to high, with a dramatic increase in the variance of issue attitude being explained by issue perception.
Table 15: Standardized and significance levels for the structural model (climate change)

<table>
<thead>
<tr>
<th>Parameter Estimate</th>
<th>Standardized</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>Issue Perception → Personal Attitude</td>
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In sum, the analyses showed that the structural equation model (Figure 16) was well fitted for both of the same-sex marriage data and the climate change data. The results indicate that the psychological variables such as perceived contingency and perceptual bandwidth played a mediating role in the relationships between interactivity and other outcome variables. Specifically, perceived contingency and perceptual bandwidth mediated the effects of interactivity on user engagement and perceived vividness, which were predictive of participants’ systematic information processing. Furthermore, the results showed that systematic information processing led to more positive issue perception, and issue perception was positively associated with personal attitudes.

**Part IV: Effects of covariates.**

This part of the results section describes the effects of covariates, i.e. ideology, power usage and issue involvement, which emerged as statistically significant predictors of the mediating and outcome variables.

**Political ideology.** Political ideology, from highly Republican/conservative to highly Democrat/liberal, was found to significantly positively predict issue perception, $F(1, 159) = 4.91, p < 0.05$; and personal attitude, $F(1, 159) = 21.35, p < 0.001$.

**Power usage.** Power usage, from low to high, was found to significantly positively predict issue perception, $F(1, 159) = 7.06, p < 0.01$; personal attitude, $F(1, 159) = 20.13, p < 0.001$; perceived presentational vividness, $F(1, 159) = 8.38, p < 0.01$; perceptual bandwidth, $F(1, 159) = 7.28, p < 0.01$; absorption, $F(1, 159) = 5.55, p < 0.05$; and attitude toward content, $F(1, 159) = 11.94, p < 0.01$.

**Issue involvement.** Issue involvement was found to significantly positively predict issue perception, $F(1, 159) = 19.27, p < 0.001$; perceived presentational vividness, $F(1, 159) = 10.45, p < 0.01$; perceived contingency, $F(1, 159) = 4.72, p < 0.05$; emotional valence, $F(1, 159) =
10.97, \( p < 0.01 \), and arousal, \( F(1, 159) = 12.99, p < 0.001 \); systematic processing, \( F(1, 159) = 28.51, p < 0.001 \); and behavioral intention toward the content, \( F(1, 159) = 31.80, p < 0.001 \).

**Summary of Findings**

This chapter has provided the details of how the two manipulated variables, interactivity in particular, created significant effects and influenced outcomes related to participants’ viewing of news stories with baserate and exemplar information. The major findings are summarized below.

**Effects of exemplar distribution.** Manipulation of exemplar distribution had a significant effect on the perceived inconsistency of the news report. As established in the exemplification literature, exemplar distribution also had a significant effect on participants’ issue perception. However, such an exemplification effect was only present when the baserates were presented verbally (see results on p. 67). The exemplification effect diminished to non-significance when baserates were presented with static or interactive visualization. Therefore, when analyzing with the full dataset, no significant main effects of exemplar distribution on recall, issue perception and personal attitude were found.

There is also an interaction between exemplar distribution and interactivity influencing participants’ exemplar recall. When baserates were presented with static visualization, exemplar-baserate consistency was associated with greater accuracy of exemplar recall; however, when baserates were presented via interactive visualization, exemplar-baserate consistency was associated with lower accuracy of exemplar recall.

**Effects of interactivity.** Interactivity of the baserate presentation had a significant effect on perceived vividness of the presentational format and the news message. It also led to significantly higher levels of perceptual bandwidth, perceived contingency and user engagement with the news content. There were also significant main effects and indirect effects of
interactivity on issue perception. Mediation tests and SEM analyses showed that the two psychological variables, perceptual bandwidth and perceived contingency, played an important role through which interactivity influenced issue perceptions. The mediation models indicated that there were potentially two different paths through which interactivity functioned to affect issue perception. One path was through perceptual bandwidth to perceived vividness and reduced heuristic processing. The mediation results showed that the presence of interactivity led to a higher level of perceptual bandwidth and perceived message vividness. Increased message vividness serves to reduce heuristic processing, which would negatively influence issue perception. The other path was through perceived contingency and user engagement, showing that the presence of interactivity led to greater perceived contingency and enhanced user engagement, further leading toward increased systematic processing, which positively predicted issue perception.

The SEM analyses presented a structural model that further showed the causal relationships between the psychological factors, indicating that the psychological responses to interactivity enhanced user engagement and user perception of message vividness. Both vividness and engagement served to increase systematic processing of the news content, leading toward greater accuracy of issue perceptions and more positive personal attitude.

The next chapter will interpret these results in light of theoretical mechanisms tested and also discuss their practical implications.
Chapter 4

DISCUSSION

The purpose of this study is to explore if and how interactive visualization of baserate information, as a presentational format and as an active data exploration process, influences users’ psychology, information processing and emotion, further enhancing the effectiveness of baserates on their recall, issue perception and personal attitude, in order to counteract the biasing effects of exemplifying information. This chapter will discuss the main findings and the key contributions of this study.

One of the primary contributions of this study is to examine the three formats to present baserate information—verbal description, static visualization and interactive visualization. Previous exemplification studies that have investigated the effectiveness of visually presenting baserates (e.g., Chang, 2000) have used somewhat oversimplified visual formats (e.g., bar charts, pie charts, etc.) that are inadequate for conveying the intricate statistical information (big-data information in particular) that we have today. Going one step beyond the more sophisticated static visualization that is currently used in online news content, this study contrasts interactive visualization to these two presentational formats, providing both theoretical implications for the emerging field of computational journalism, and practical implications for the design of effective online journalistic tools and interfaces.

**Interactivity enhances Perceived Vividness**

Findings from this study extend existing literature on vividness as a presentation feature (e.g., Appiah, 2006; Tran, 2012) by establishing the effect of interactivity on perceived vividness. Findings (Table 7 & Figure 8) indicate that interactive visualization is perceived as being significantly more vivid than verbal description, and at least as vivid as, if not more vivid than, static visualization.
This study examined three aspects of perceived vividness, specifically, exemplar vividness, presentational vividness and message vividness. The results indicated that the different formats of baserate presentation did not influence perceived exemplar vividness, ruling out the potential confound that vividly presented baserates may decrease the perceived vividness of exemplars, which may contribute to the variance in outcome variables such as issue perception. On the other hand, perceptions of presentational vividness and message vividness were significantly influenced by the way in which baserates were shown. Theoretically, interactivity could enhance vividness not only by increasing the sensory depth of a mediated environment with dynamic visual changes and transitions (Heer et al., 2005), but also by broadening its sensory breadth with tactile sensory features (Shneiderman & Plaisant, 2010). But as the data show, static visualization and interactive visualization did not differ significantly in perceived presentational vividness, which conceptually captures the depth of the visual sense. Instead, compared to static visualization, interactive visualization was perceived to have a significantly higher level of message vividness, a measure that encompasses the overall perceptual richness of the message, including sensory breadth. The differential effects of interactivity on presentational vividness and message vividness reveals the multidimensionality of interactivity effects on perceived vividness, and provides an empirical foundation for arguing that interactive visualization enhances perceived vividness differently than non-interactive visualization. As discussed above, its vivid visual qualities such as visual changes, transitions and movements, explains only a fraction of its total effect on perceived message vividness; part of user perception of presentational and message vividness may be explained by the contingent nature of interactivity, as discussed in more detail in the following section.

Hence, even though the visual changes and movements of interactive visualization did not make the presentational format more vivid than static visualization, the interactive features (or affordances) that induce user (inter)actions with the interface are able to generate a significant increase in the perceived vividness, which in turn positively influences several outcomes. As
shown in the mediation results (Figure 14) and SEM models (Figures 18 & 19), a heightened level of vividness as a result of the interface interactivity altered reader perceptions and attitude toward the social issue by influencing participants’ information processing. The impact on issue perception was not found for static visualization of baserates in previous studies (Chang, 2000; Sundar, 1991). Compared to static visualization, interactive visualization can effectively enhance perceived vividness to the extent that the positive effect is transferrable to issue perception and personal attitude. The ability to influence reader perceptions and attitudes through its impact on vividness is one reason why interactive visualization is a promising tool for facilitating individuals’ use of baserate or big-data information.

Perceptual Bandwidth and Perceived Contingency as mediators

One of the main goals of this study has been to find out in what unique ways interactivity affects the level of vividness and further reader perceptions. A review of interactivity literature has provided the theoretical foundation for identifying the psychological factors underlying user responses to the affordance of interactivity, which may help explain how interactivity influences outcome variables. The findings from this study have shown that perceptual bandwidth and perceived contingency both play a key mediating role underlying the interactivity effect, underscoring the fact that the significant effect of interactivity is not only a result of the mere presence of interactive features, but also due to the back-and-forth information exchange that it engenders. On the one hand, interactive visualization increases users’ perceptual bandwidth by diminishing the disorientation on the interface and directing their cognitive effort to the baserates. It facilitates users to obtain and manipulate the visual presentation of the baserate information in a way that is intuitive for constructing an understanding of the information. On the other hand, interactive visualization provides baserate information as a response to users’ input, which makes users experience a high level of message contingency with the interface. Because of the way in which the baserate content is delivered, interactive visualization involves users in an active
“conversation” as users process the baserate information. The two psychological factors, perceptual bandwidth and perceived contingency, appear as the immediate responses to the interactive interface, leading to greater engagement and vividness, which further impact perceptions and attitude.

Towards User Engagement. As theorized in the theory of interactive media effects (Sundar et al., forthcoming), interactivity is able to enhance user engagement by increasing perceptual bandwidth and perceived contingency, and the enhanced user engagement is said to influence cognition, attitude and behavior. Results from this study support the theory by showing that interactive visualization leads to greater perceptions of perceptual bandwidth and contingency in interactions, which were both positively associated with user engagement, leading to more positive issue perception. The mediation results and the SEM models showed empirical evidence that perceptual bandwidth and perceived contingency played an important mediating role in predicting user engagement, which further led to various outcomes.

It must be pointed out that the tools of interactivity used in this study elicited the fun aspect of engagement rather than the cognitive aspect of absorption. Participants appear to be engaged with the news content in a “fun” manner. Interactive visualization seems to evoke individuals’ interest and curiosity in the baserate information. As ordinary users tend to be indifferent toward statistical information and general statements in news content, interactive visualization shows the potential to serve as an engaging data exploration tool that affords an enjoyable experience for users to process the otherwise challenging and boring baserates. This also highlights the “casual” use of data visualization (Pousman et al., 2007) by laypersons as compared to expert and professional users. The presence of interactivity in data visualization offers lay users an opportunity to test their own hypotheses and theories, which are perceived as playful and interesting, more so when compared to observing a static visualization of the baserate information. This feeling of fun and playfulness, as an affective aspect of user engagement, can
ultimately lead to user perceptions and attitudes that are more informed by the baserate information.

This study has also revealed a significant effect of interactivity on temporal dissociation. However, the results contradict previous empirical findings, which have shown that interactivity leads to a stronger feeling of “losing track of time” (e.g., Sundar, Bellur et al., 2014). Results from this study show the opposite pattern: participants who viewed the static visualization reported a higher level of temporal dissociation than those who were exposed to the interactive visualization (Figure 9). Interestingly, the self-reported temporal dissociation is inconsistent with the log-data measurement of the amount of time that participants spent on the news website. Log-data results show that participants actually spent significantly more time on the website if they were exposed to the interactive visualization than those who were exposed to the static visualization (Figure 10). The inconsistency between the self-report results and the log-data results indicate that the stronger feeling of temporal dissociation, in this case, may not reflect the extent of immersion that participants experienced as a result of heightened engagement; instead, it may have reflected the fatigue that participants felt when they tried to process the visualized baserate information without the interactive aids that were available in the interactive visualization condition.

The divergence of self-report results and log data further highlights how involving interactive visualization is compared to static visualization. The distinction in participants’ subjective feeling may be explained by the fun experience that participants had with the interactive visualization. In other words, by evoking users’ interest and curiosity, interactive visualization makes processing of baserates less cognitively challenging and taxing.

Moreover, methodologically, the distinction between self-report data and log data shows that these two capture different aspects of user psychology in human-computer interaction. Self-report measurement of temporal dissociation, for instance, may indicate qualitatively different psychological states when administered in different communication situations or interaction
scenarios. Log data appear to be a useful complementary measure that can further reveal the actual interactions, which can be useful for explaining the self-report results. In this study, in particular, log data of time spent on the website appears to be a useful and objective indicator of immersion, whereas self-reported temporal dissociation becomes a measurement of participants’ psychological state of tiredness and, perhaps, annoyance, experienced when exposed to the stimuli.

These results provide theoretical explanations to previous empirical findings showing the ineffectiveness of static visualization. Static visualization can present various barriers for information processing, given the fact that it requires capabilities and skills to understand statistical information and visual information. Even though static visualization makes baserate information more vivid, the cognitive challenges that it imposes on readers may be the reason why it shows limited effect in influencing issue perceptions and attitudes. In contrast, interactive visualization has shown more positive effects. Different from static visualization, the interactive features of interactive visualization seem to facilitate information processing and reduce the feeling of cognitive overload. This is confirmed by its positive impact on a range of outcome variables, such as perceptual bandwidth, perceived contingency and user engagement. In other words, interactive visualization excites users by providing action possibilities and data-exploration opportunities, which makes the baserate information more usable and more involving.

**Toward Perceived Vividness.** Another key contribution of this study is to substantiate the exemplification literature, especially in the context of interactive media. It has investigated if and how the presence of interactivity may contribute to perceived vividness, and has connected interactivity literature with exemplification research by identifying the psychological factors that are key in explaining interactivity effects to explain the theoretical mechanisms through which interactivity influences vividness. The study proposed that perceptual bandwidth, as an indicator of the natural mapping of a visual interface, serves as a precursor of the experiential richness that a user could perceive. In other words, the interaction techniques embedded in an interactive
interface needs to be intuitively mapped with the different functionalities for the users to engage effectively with these features. Findings from this study support this conceptual link by showing that perceptual bandwidth positively influences user perceptions of presentational vividness and message vividness. Perceived contingency, on the other hand, is conceptualized as the perception of back-and-forth information exchange that manifests in the constant user actions and the constant system feedback that is contingent upon user actions. Theoretically, while performing the actions and receiving the contingent feedback, users will perceive a heightened level of contingency, leading to their perception of additional senses being engaged. As the data show, perceived contingency is indeed a significant predictor of perceived vividness. By specifying the psychological factors that contribute to user perception of vividness, this study shows that the contribution of interactivity to perceived vividness is in making the baserates more usable by providing intuitive and responsive tools that engage users’ vision and actions.

As many previous studies on vividness have argued, vividness is, in theory, associated with greater potential for heuristic activation. It is said to engage readers or viewers emotionally and trigger mental shortcuts in information processing. However, the results from this study show that perceived vividness is associated with reduced heuristic processing (Figure 14) and greater systematic processing (Figure 18 & 19). In order to understand these findings, one needs to realize the different mechanisms through which perceived vividness is enhanced. The different measures to enhance vividness in previous studies include using concrete and colorful language, or using visually interesting presentation formats. Both approaches modify the message at the visually perceivable level, where readers or viewers are passive recipients of the vivid message. In contrast, the perceived vividness in the current study results from the active use of the interface features. By eliciting actual user actions, interactive visualization engages users in an active manner, and facilitates users to assume an “analytic” role. Therefore, interactive features function as action possibilities rather than as perceptual cues, and motivate users to process the information in a more systematic/central way rather than in a heuristic/peripheral way. This result
also provides empirical evidence to the theory of interactive media effects (Sundar et al., forthcoming), which differentiates between an action route of the interactivity effects and a cue route. Findings from this study show that by eliciting user actions, interactive features in the online media can influence user psychology, cognition and attitude in a highly active manner, rather than simply functioning as heuristic cues that may directly influence users’ judgments without being subjected to use.

Revealing these underlying mechanisms is helpful for understanding why message is perceived as “vivid.” Both the mediation results and the structural equation models showed the important mediating effects of perceived contingency and perceptual bandwidth. This may partially explain why previous attempts to use bar charts and pie charts to influence issue perception have failed. It may be because these presentational formats were too simplistic to provide an elaborate sensory exchange between the reader and the interface (Reeves & Nass, 2000) or to imitate a fully responsive communication process (Rafaeli, 1998) to engage users cognitively with the information.

More importantly, identifying the two psychological precursors of perceived vividness, perceived contingency in particular, sheds light on newer and more effective ways to make news content, including baserates, more vivid and influential. The findings from this study suggest that, aside from making the content more visually appealing and attention-getting, natural mapping and contingent information exchange have the potential to enhance the perceived vividness of the message. This effect is evident in both of the news topics, showing that perceived vividness is not only a result of visual presentation, the changing/moving visual objects, or the mere presence of interaction techniques. Instead, more fundamentally, it could result from the responsive or interactive nature of the interactive visualization interface, and the exclusiveness and connectedness that users experience from interacting with the highly responsive/interactive interface.

This presents us with a new approach to design interfaces for communicating big-data
content by adopting and designing toward a “conversational ideal” (Schudson, 1978). As shown in this study, subtle manipulations of interactive features, i.e. click, mouse-over and slider for data overview and detail-on-demand, are effective in enhancing perceived contingency. Other operationalizations of message contingency, such as hyperlinked content (Sundar, Kalyanaraman, & Brown, 2003), interaction history and automated dialogue (Sundar et al., 2013), may similarly trigger perceptions of contingency, leading to positive attitudinal effects.

Jointly, the two effects of interactivity—greater engagement and higher vividness—discovered in this study demonstrate the value of utilizing interactive visualization to enhance baserate vividness and engaging users cognitively. This has implications for reader-driven narrative visualization proposed by Segel and Heer (2010), whereby the interface enables story discovery on the part of the users, in contrast to an author-driven storytelling. This can be achieved by implementing 1) free interactivity (user manipulation of the visualization) and 2) non-linear ordering of messages (instead of a prescribed ordering, the path that a user takes through the visualization will be user-directed; therefore, the information will appear contingently upon user input). Further discussion on the narrative/rhetorical capacity of data visualization (e.g., Hullman & Kiakopoulous, 2011; Kosara & Mackinlay, 2013) suggest that we engage users with different manipulable layers of the visualization in order to frame the rhetoric, prioritize specific interpretations and influence perceptions. This study provides a theoretical framework that structures the two key aspects of interactivity and its two-dimensional effect, and that serves to reveal user psychology in response to the reader-driven interactive visualization, which holds the promise of engaging users by helping them construct their own stories and narratives using the statistical information provided by the interface.
**Interactivity affects Information Processing**

Going beyond engagement and vividness, how does interactivity eventually alter users’ issue perceptions and attitudes? Findings from this study reveal that the impact of interactive visualization on issue perception and personal attitude is by influencing users’ information processing. One of the mechanisms by which interactivity can shape issue perception is by reducing the amount of heuristic processing by users, so that they will not be persuaded solely by exemplifying information. As shown in the mediation results (see Figure 14), perceived vividness was negatively associated with heuristic processing, which in turn was negatively associated with issue perception. In other words, because of its high level of vividness, interactive visualization can reduce selective scanning and skimming in users’ news consumption behaviors, and therefore result in more accurate issue perception informed by the totality of news content rather than by heuristics relating to exemplars. The other mechanism is by increasing systematic information processing, which is positively associated with issue perception (see Figure 18&19). Both perceived vividness and user engagement contribute to systematic information processing. This shows that interactive visualization has the potential of encouraging users to think about the message systematically, to relate the message to other things that they knew, or to think of practical applications of the information.

Following the dual-process models (e.g., Chaiken, 1980; Petty, 1997), scholars (e.g., Liu & Shrum, 2002; Sundar, Kalyanaraman, & Brown, 2003) have argued that interactivity can serve as both a peripheral/heuristic cue and a tool that facilitates careful scrutiny of the content. In regards to information processing of news content, Bucy (2004) has argued that, due to humans’ limited cognitive capacity for processing mediated messages (Lang, 2000), interactive features that demand cognitive resources for orienting to and engaging with these features will hinder, instead of facilitating, understanding of the content. Contrary to Bucy’s (2004) findings, this study reveals that heightened user engagement as a result of interface interactivity is positively associated with systematic processing, while the message vividness as a result of the interface
interactivity is negatively associated with heuristic processing. Why would the results differ from previous findings? One of the possible explanations is that interactive features are embedded at different loci in these studies. In the Bucy (2004) study, interactive features were not an integral part of the news content; instead, they took the form of additional tasks such as voting in a poll and emailing the news organization. These tasks themselves may have presented distraction from news processing for the participants. In my study, all the interactive features were embedded within the information visualization, which depicted the baserate information as an integral part of the news content. Therefore, the interactive features attracted attention and engaged users with the focal information, and thereby increased systematic processing while reducing heuristic processing.

Thus, this study adds to the ongoing research of how interactive media may affect information processing, leading towards persuasive effects, learning outcomes and decision-making. Findings from this study provide clear guidelines for designing interactive messages that can encourage a more central/systematic way of information processing, which will shift individuals toward forming better-informed, better-reasoned perceptions.

**Interactivity shapes Issue Perception**

One of the main goals of this study has been to examine if the interactivity effects are significant enough to counter the effect of exemplification. In examining the results from this study, it seems that, in the presence of interactive visualization of baserate data, the effect of exemplar distribution diminishes. Following these findings, researchers may reconsider exemplification effects in the context of interactive media, and how medium features such as interactivity may deplete the effect of message features such as exemplar distribution. This also provides insights for journalistic practices by suggesting interface affordances and designs as effective ways of balancing the potentially biasing exemplars.
More important is the positive relationship between interactivity and users’ behavioral intention toward the news content. As the data show, interactive visualization can positively influence users’ behavioral intentions, e.g., saving, forwarding and sharing the news content. This finding may add to the motivation for reporters and editors to invest in the development and application of interactive visualization in their news reporting, as it not only eliminates the biasing effects of exemplification, but also encourages users to revisit the site, search for related content, and distribute the content to others in their network. These desirable outcomes may provide better rationale for adopting interactive visualization, which is currently not considered cost-efficient in newsrooms.

This study has also revealed rather complex mechanisms through which interactivity influences perceptions and attitudes. As discussed above, interactivity effects operate through two distinct paths, namely perceptual bandwidth → vividness and contingency → engagement. Perceived vividness and user engagement exert an impact on issue perception through their specific impact on information processing. The direction and strength of the relationships between vividness/engagement and information processing, as well as that between information processing and perception/attitude can also vary depending on the type of information that is being presented. For instance, user engagement appeared to influence systematic information processing quite weakly in the same-sex marriage story; however, its effect became more significant in the climate change story. Also, systematic processing of the same-sex marriage story appeared to strongly influence participants’ issue perception; the effect of systematic processing on issue perception was significant, but not as strong, in the climate change story. These discrepancies may have been due to the fact that participants were not as familiar with the scientific data of climate change as they were with public opinion data about same-sex marriage; therefore, their high level of engagement manifested in a greater degree of systematic processing with the unfamiliar data of climate change. The ambiguity of scientific data may have also prohibited participants from forming a strong and straightforward perception of the issue;
whereas for the topic of same-sex marriage, a higher level of systematic processing is more strongly linked with issue perception.

Despite these discrepancies, the structural model of interactivity effects on issue perception and attitude has yielded good model fits for both news topics, indicating the validity of the overall model that explains the mechanisms through which interactivity influences users’ perceptions and attitudes. For future research, it would be theoretically interesting to examine this model with various types of content and in various communication contexts. It will help further disentangle the complex effects of interactivity, and to better identify any topic-related or data typed-related effects that may moderate the influence of interactivity on information processing, perception formation and attitudinal changes. It will help better us understand how to implement interactive features strategically to amplify the positive effect of interactivity for different scenarios.

**Limitations**

This being a cross-sectional experiment, a major limitation is that it cannot examine long-term effects of interactivity on user perceptions and attitudes. Specifically, the issue of same-sex marriage is one about which many individuals hold strong, unwavering opinion. In the mixed design ANOVA analyses, it was also found that covariates such as political ideology emerged as significant predictors. It would be useful to see if and how interactivity may influence individuals’ perceptions and attitudes that may counter pre-existing perceptions and opinions. The issue of climate change, on the other hand, is not as involving. Individuals are more likely to be open-minded to new opinions or perspectives. However, being a scientific topic, there could be a learning curve for the participants to fully comprehend the information and to form their perceptions and attitudes using the information. Therefore, for both news topics, it would be interesting to observe if repeated exposures can lead to actual learning or even behavioral changes, instead of simply perceptions and attitudinal changes. Different from traditional
exemplification research, this study would benefit from conducting longitudinal studies in which participants are repeatedly exposed to the content of related topics, rather than simply administering repeated measures of issue perceptions and personal attitude. Multiple exposures over a period of time could better imitate individuals’ news consumption behaviors in the real-world scenario, and therefore help to reveal a more ecologically valid effect of interactivity on issue perception and personal attitude.

In addition, the 2 x 3 x 2 study design was focused mainly on the interactivity effects on baserate information. The current study does not address how interactive features may or may not alter the processing of, and the responses to, exemplifying information. In actuality, many news websites are starting to adopt interactive features to present exemplars, such as images and visualizations of personal stories or quotes. Does the mechanism revealed in this study that describes the interactivity effects on information processing, emotional responses, issue perception and personal attitude toward baserates apply to its effects on exemplars as well? Is it possible that, by engaging readers in more systematic information processing and by exciting readers’ intrinsic interests, an interactive presentation of exemplars could also facilitate the formation of accurate issue perception and a well-informed opinion, or would it lead to stronger exemplification effects, biased by extreme exemplars? A follow-up investigation with a news site that presents exemplifying information in an interactive format may serve to answer this question.

Furthermore, the interactive features examined in this study are quite limited. The operationalization of interactivity is mainly focused on the interaction techniques, in other words, modality interactivity; other aspects of interactivity, such as source interactivity (in the forms of user generated content) were not tested specifically. As more online news services start to provide a certain level of “sourceness” (Sundar, 2008) and many news websites offer users discussion boards to engage in back-and-forth conversations with other users, it would be both theoretically and practically important to incorporate these interactive features in future studies that investigate the interactivity effects on news consumption and processing.
Theoretical implications

This study has revealed complex theoretical paths through which news messages, interactive news content in particular, influence reader perceptions and attitudes. This study substantiates exemplification and vividness literature with useful empirical evidence, and serves as a starting point to experimentally examine the various hypothetical relationships that have been proposed or discussed in previous literature and studies. It also contributes to interactivity research by identifying the mechanisms through which it affects issue perception and by showing the multi-dimensional effects of interactivity on user psychology. Specifically, this study reveals a number of theoretical implications as follows:

1) It explains how exemplification effect is undermined by making baserate data interactive.

One of the primary aims of this study is to add to the exemplification literature that interactivity as a way of presenting baserate information and engaging readers could alter the exemplification effects. While several studies have investigated exemplification effects online, most of these studies merely used the online environment to replicate previous findings with print media, rather than theorizing about effects that are due to unique features of online media, such as heightened interactivity. This study conceptualizes interactivity as one of the key independent variables and serves to build a better understanding of how interactive media may change individuals’ use and processing of baserate information. By doing so, this study examines how individuals’ issue perceptions and personal attitudes might change when the level of interactivity and the exemplar distribution change at the same time. The findings reveal an overpowering interactivity effect that determines individuals’ issue perceptions. The classic exemplification effect was only observable in the non-interactive, verbal description condition. This raises important theoretical questions for exemplification researchers, as to what extent exemplification effects may have resulted from a passive audience, and to what extent interactive media can engage readers to overcome the dominant effects of exemplars. It also adds to the interactivity
literature how the effect of a medium feature may transcend the effect of a message feature to influence user psychology, cognition and perceptions.

2) This study offers a new mechanism by which interactivity affects issue perception.

The findings from this study not only show that interactivity has a prominent impact on individuals’ issue perception and attitude, but it also suggests the effect of interactivity is realized through two key mechanisms—vividness and engagement. Vividness as an underlying mechanism that explains how a message or a presentational format influences issue perception has been previously discussed; in particular, studies (e.g., Tran, 2014) have shown that interactivity as a medium feature enhances exemplar vividness. However, in these studies researchers have treated interactivity as merely multimedia enhancements that contribute to presentational vividness. This study reveals more complex effect of interactivity on vividness and indicates that it engages individuals sensorially in a variety of ways other than human vision. More importantly, interactive visualization is effective in shaping perceptions and attitudes not only due to its graphical presentation. User engagement emerging as a significant mediating variable indicates the importance of involving individuals actively and behavioral for influencing their perception. Engagement is a unique theoretical mechanism that contrasts interactive media with traditional media for explaining the media effects on individual psychology and perception. It highlights the fundamental changes in communication technologies that are affecting the delivery of information, the experience of audience, and the effect of the message. As scholars (e.g., Bennett & Iyengar, 2008) have warned, researchers need to rethink the effect, and the mechanisms of the effect, of the mediated messages in relation to technologies in communication processes.

3) Interactivity can be used in a way that allows vividness to aid systematic processing.

The structural approach of data analysis in this study reveals multi-step paths of the interactivity effect, among which one path shows that vividness is negatively associated with heuristic processing and positively related with systematic processing. This finding counters
common assumption in dual process literature, which has historically associated vividness with heuristic processing. Noting that most of the studies were capturing the impact of exemplar vividness on heuristic processing, it is possible that the current finding is due to the action-inducing potential of interactivity, such that users are engaged with systematic and active processing the baserate information presented via interactive visualization, and are thus less involved in the heuristic processing of exemplars. This could further explain why exemplar recall was reduced in the High interactivity condition as well as why the exemplifying information ceased to be significant in determining users’ perceptions and attitudes. Such an effect (vividness as a result of interactivity leading to systematic processing) needs to be further tested in the persuasion context, in order to investigate whether interactivity can alter the persuasive effects of messages by engaging users more systematically and actively. Such an effort will be useful for advancing media effects research in a more interactive visual media environment with users constantly immersed in it and responding to it.

4) It investigates the complexity of vividness effects and differentiates its three different aspects and how interactivity contributes to each of these aspects.

By differentiating the three different types of perceived vividness (i.e. exemplar vividness, presentational vividness and message vividness), this study is able to reveal the additive nature of perceived vividness induced by interactivity. As exemplars remained constant or very similar, all three conditions (i.e. verbal description, static visualization and interactive visualization) were rated equally in regard with perceived exemplar vividness, showing that there was no depletion of, or competition with, the perceived vividness of exemplars from the interactive features. Rather, interactivity has shown a main effect on user perceptions of the vividness of both the presentational format and the news article as a whole. Worth mentioning is that the interactivity effect on presentational vividness was less significant than that on message vividness: The High interactive condition (interactive visualization) was perceived only marginally significantly higher in presentational vividness when compared to static visualization;
however, interactive visualization differed significantly in message vividness from the static visualization. This indicates that, first, interactive visualization has the potential of achieving a significantly higher level of vividness. This supports the hypotheses of this study and has showed that interactive visualization can be more effective in influencing individual perceptions than the static visualization through the mechanism of perceived vividness. Secondly, the effect of interactive visualization goes beyond its ability to increase presentational vividness. Instead, it is translated into user perception of the entire news content as being more vivid, and further influencing other variables of user psychology, cognition and attitude. Last but not least, the perceived message vividness of a news article appears as a more significant predictor of the outcome variables than the perceived presentational vividness, a methodological contribution that could be useful for future exemplification research. Existing measurement of perceived vividness is lacking, and does a poor job distinguishing what (of a message) is perceived as vivid. This study has adapted measures from previous work and created a set of items that can capture the different aspects of perceived vividness.

5) It suggests a multidimensional view of the interactivity effects.

The study provides empirical evidence that the manipulation of adding interaction techniques on a visualization interface can induce an increased in both perceptual bandwidth and perceived contingency. This could serve as an empirical basis for a more comprehensive model of interactive media effects, based on the effects of inducing user actions with the interface. Considering that interaction techniques in this study broadened the perceptual bandwidth of users while simultaneously increasing user perceptions of contingency, we can say that a given interactive feature (or affordance) may at the same time encompass two or more conceptual aspects of interactivity, and therefore influences user psychology in a multidimensional way. Therefore, rather than a piecemeal approach that tries to isolate the specific effect of a give interactive feature, researchers should consider the multidimensionality of the effects of the interactive affordance in future interactivity research.
Practical implications

This study also has provided some insights for effectively designing interactive visualization tools for big-data information. The findings from this study show evidence of the usefulness of interactive visualization for facilitating lay persons and end-users to access, utilize and comprehend large-scale statistical information. The interactive features, such as mouse-over and slider, offered by the interactive visualization, appear to facilitate information processing of the otherwise cognitively challenging and overwhelming data-rich content.

Currently, the data visualization on news websites tends to be overly simplistic. Interactive visualization of baserate information is not a widely used component in online news, and, even when available, it offers limited interaction opportunities to the users. On the whole, the design of journalistic data visualization presents a “black box” to the news readers and allows minimal computational potential (if at all), such that the readers can do little more than viewing the processed and packaged data that reporters and editors choose for them. This design approach reflects the general concern that researchers and practitioners have long held that the news readers would not care or be able to process the baserate information. However, I propose designing the data visualization as interactive at both the data and the visualization levels, to make it more valued by, and useful to, the increasingly active, technology-savvy news readers today.

The findings from this research suggest the principles of contingency and perceptual bandwidth need to be supported in the future design of interactive visualization toward end-users. First of all, end-users’ desire for message contingency show that laypersons share the same need for interactive data exploration with expert and professional users. In fact, they may demand more flexibility in the visualization system to allow them try out their “naïve” hypotheses with the data, as their ideas may not be as guided by scientific knowledge as the expert users would. An effective interactive visualization interface needs to allow users to get information exclusive to
their inputs and inquiries, by implementing interactive data-query features such as detail-on-demand and data selection. This sense of message contingency will facilitate users to assume an “editorial” role, and therefore encourage their data exploration. That is to say, in order to help users generate insights and form their own stories, author-initiated ordering, messaging, fixed structures, and direction should be limited or eliminated; instead, a user-driven interaction and a relatively free information exploration should be allowed (Segel & Heer, 2010). Information visualization softwares such as ManyEyes and Tableau are examples of visualization tools that facilitate visualization manipulation and data analytics for end-users. These visualization tools show instant changes and informational details upon users’ input, which operationally contributes to the perception of message contingency. More generally, user experience (UX) and usability researchers should consider utilizing the factors revealed in this study as important indicators of UX for successful deployment of interactivity in big-data applications and websites. The psychological precursors, as well as the cognitive and additional outcomes, are useful measures for testing the effectiveness of interactive tools oriented toward laypersons.

Secondly, perceptual bandwidth has played an important role in increasing message vividness and evoking users’ intrinsic interest. This highlights the unique needs of end-users. Compared to expert users of interactive visualization tools, laypersons are less familiar with data analytic tools and would therefore need to exert more cognitive effort to orient their attention and locate relevant information. Therefore, they would need to rely on naturally and intuitively mapped visualization interface to process the data information that it delivers. What enhances perceptual bandwidth are the various interaction techniques that engage users through their various senses. Interaction techniques such as mouse-over and slide engage and coordinate both tactile senses and human vision simultaneously, leading to a more sensorially rich experience for the users. These interactive features can naturally map user actions with visual objects in a visualization interface, and are therefore helpful to reduce the cognitive effort required to utilize the visualization tool and help orient user attention to the information itself. Big data are
particularly challenging to understand. Therefore, design effort should be put into finding interaction techniques that match the data tasks needed to perform on the specific types of data. Previous studies on perceptual bandwidth (Sundar et al., 2014) have suggested several interaction techniques or combinations of interaction techniques that can effectively enhance perceptual bandwidth. Future designs of interactive visualization should consider using these specific features or combinations of them to be embedded in the visualization interface in order to facilitate users to better engage with the content.

Interactive visualization not only facilitates information processing, but also shows persuasive effects on users’ perceptions and attitudes. So much so that exemplification effects become insignificant when baserate information is presented via interactive visualization. This presents an exciting solution to the journalistic challenges pertaining to both attracting reader attention and presenting an unbiased story. As it is hard to display a representative view of a social issue with exemplars, journalists now can consider interactive visualization of baserates as an alternative. The strengths of interactive visualization are apparent: it can attract users to the otherwise “dull” baserates due to its high vividness, facilitate information processing of the complex data content by enhancing users’ perceptual bandwidth, engage user interest by involving them in a fun data exploration, and better inform users with the accurate and representative statistical information. Reporters and editors will still need to make important decisions such as which datasets to include and how the data should be visualized; however, findings from this study suggest that reporters and editors leave more editorial opportunities to the readers and allow them to explore the available data as freely as possible. Currently, several news organizations (e.g., The Guardian) have started using interactive visualization software such as Tableau for their online news reporting. Their experience has shown that this journalistic practice can not only engage and influence readers, but also significantly reduce news staff expenses, as well as facilitating the transition of journalists’ role from being news reporters to “content aggregators” (Cohen, Li, Yang, & Yu, 2011).
The finding that interactive visualization could engage users with systematic information processing, and help them form accurate, well-informed perceptions, also has practical implications for journalism and beyond. Interactive visualization is promising for empowering individuals to effectively access and utilize big-data information, which is helpful for informing the public about scientific topics, public health issues, as well as political and global events. As a part of news content, interactive visualization can facilitate understanding of the statistical information that was once too obscure and uninteresting to the readers. Outside of the journalistic field, interactive visualization can be used for persuasion, education and decision-making purposes. It can facilitate quick and efficient fact-checking and effectively influence personal attitudes and public opinion.

Conclusion

This study shows the effect of interactivity in delivering a more vivid presentation of baserates and engaging individuals in processing statistical information, with the potential of reducing the biases generated by distorted exemplifying information. Interactivity as both a visual presentational feature and an action-inducing affordance holds the promise for engaging individuals with information processing of abstract, challenging data-rich content, thereby shaping users’ perceptions and attitudes about public issues. Interactivity, as a feature of the medium, seems to diminish the effects of message features by allowing users to customize and scrutinize the content more deeply, thus challenging scholars to rethink media effects research in this era of interactive media. In sum, it would not be an exaggeration to say that an understanding of the interactivity effects on the formation of individual perceptions and attitudes is essential in today’s communication studies. The importance of such an understanding goes beyond journalism, and findings from research like this can help us build strategies for better presenting a
representative perspective to the public and making information more personally relevant to individuals, as we work toward better educating and engaging society in public affairs.
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*Criminology, 38*(3), 755-786.


## Appendix A. Confirmatory Factor Analysis Results of Same-Sex Marriage Data

<table>
<thead>
<tr>
<th>Factors</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptual Bandwidth</strong></td>
<td></td>
</tr>
<tr>
<td>PB1: My interaction with the website was intuitive.</td>
<td>0.91</td>
</tr>
<tr>
<td>PB2: The way that I used to control the changes on the website seemed natural.</td>
<td>0.85</td>
</tr>
<tr>
<td>PB3: The functions on the website were natural.</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>Perceived Contingency</strong></td>
<td></td>
</tr>
<tr>
<td>PC1: My interactions with the site felt like a back and forth conversation.</td>
<td>0.92</td>
</tr>
<tr>
<td>PC2: I felt like I was engaged in an active dialogue with the website.</td>
<td>0.88</td>
</tr>
<tr>
<td>PC3: I felt as if the site and I were involved in a mutual task.</td>
<td>0.82</td>
</tr>
<tr>
<td>PC4: I felt as if the information on the website was well connected to my actions.</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>User Engagement</strong></td>
<td></td>
</tr>
<tr>
<td>UE1: I felt as if my imagination was aroused.</td>
<td>0.93</td>
</tr>
<tr>
<td>UE2: I felt as if my curiosity was excited.</td>
<td>0.89</td>
</tr>
<tr>
<td>UE3: I felt my interest was evoked.</td>
<td>0.78</td>
</tr>
<tr>
<td>UE4: I had fun interacting with the site.</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Message Vividness</strong></td>
<td></td>
</tr>
<tr>
<td>MV1: The news report that I just browsed was enjoyable.</td>
<td>0.87</td>
</tr>
<tr>
<td>MV2: The news report that I just browsed was entertaining.</td>
<td>0.82</td>
</tr>
<tr>
<td>MV3: The news report that I just browsed was lively.</td>
<td>0.80</td>
</tr>
<tr>
<td>MV4: The news report that I just browsed was attention-getting.</td>
<td>0.79</td>
</tr>
<tr>
<td>MV5: The news report that I just browsed was arousing.</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Systematic Processing</strong></td>
<td></td>
</tr>
<tr>
<td>SP1: I thought about the information in the news report related to other things I knew.</td>
<td>0.90</td>
</tr>
<tr>
<td>SP2: I found myself making connections between the information I got from the news report and information I got elsewhere.</td>
<td>0.90</td>
</tr>
<tr>
<td>SP3: I tried to think of the practical applications of the information I got from the news report.</td>
<td>0.87</td>
</tr>
<tr>
<td><strong>Issue Perception</strong></td>
<td></td>
</tr>
<tr>
<td>IP1: More Americans will become in opposition to legalizing same-sex marriage in five years (reverse-coded).</td>
<td>0.75</td>
</tr>
<tr>
<td>IP2: More Americans will become in favor of legalizing same-sex marriage in five years.</td>
<td>0.71</td>
</tr>
<tr>
<td><strong>Issue Attitude</strong></td>
<td></td>
</tr>
<tr>
<td>IA1: All in all, I favor allowing gay and lesbian couples to marry legally.</td>
<td>0.98</td>
</tr>
<tr>
<td>IA2: I believe that gay and lesbian couples should have the right to marry one another.</td>
<td>0.97</td>
</tr>
<tr>
<td>IA3: All in all, I oppose allowing gay and lesbian couples to marry legally (reverse-coded).</td>
<td>0.67</td>
</tr>
</tbody>
</table>
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