

Article

Accepting the Digital Challenge: Public Perceptions and Attitudes toward Interactivity in Data Journalism

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Abstract: In the context of digitization, traditional journalism is facing transformation and innovation. Among them, the interactivity of visual graphics in data journalism is crucial for attracting and retaining online users, but few studies have examined public perceptions and attitudes toward it. In this study, we proposed a model to validate the relationship between users' perceived interactivity and their attitudes toward data journalism, and we included user affective and cognitive factors (enjoyment and engagement) related to this as possible mediating variables in the model for validation. We conducted experiments ($n = 75$) using data journalism containing map visualizations with three levels of interactivity (low, medium, and high) in China. Furthermore, an exploratory evaluation of the experimental group provided further insights into the differences in interactions between groups, and the emerging five key concepts of data journalism design. Overall, all our hypotheses are supported, with enjoyment and engagement mediating the relationship between perceived interactivity and users' attitudes toward the news. In addition, the experimental group with higher interaction potential also reported more positive attitudes toward journalism. Therefore, if data journalism and visualization designers want to attract and retain users in the future, enhancing user interaction on news pages will be a proven method.

Keywords: perceived interactivity; enjoyment and fun; user engagement; attitude toward journalism; data journalism; interactive data visualization



Citation: Zhang, B.; Zhang, Y.; Pan, Y. Accepting the Digital Challenge: Public Perceptions and Attitudes toward Interactivity in Data Journalism. *Appl. Sci.* **2023**, *13*, 10857. <https://doi.org/10.3390/app131910857>

Academic Editors: Daniel Gonçalves and Sandra Gama

Received: 5 September 2023

Revised: 24 September 2023

Accepted: 28 September 2023

Published: 29 September 2023



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1. Introduction

In online journalism, interactive data visualization techniques are increasingly being used to convey news and opinions using data. It has become more common for the general public to use various visualizations. However, little attention has been paid to public perceptions and attitudes toward interactivity in data journalism, whether interactive visualization leads to a better reading experience for users, which, in turn, leads to a more positive attitude toward the news, and how interactivity can be better utilized to attract and retain users. Although previous studies have attempted to conceptually explain the consequences of interactions, relatively few empirical investigations have examined the consequences of interactions systematically, especially in the areas of visualization and data journalism.

Interactive data visualization has advantages in telling stories related to data, especially in making extensive, complex data more visible and attractive simultaneously. Many news websites, such as The New York Times, The Economist, and BBC News, increasingly use interactive information graphics to explain complex information in a clear and concise manner, such as the White House healthcare plan or the Chilean earthquake. Figure 1 shows a data journalism project created by the New York Times: the report How the Virus Won combines text with interactive graphics, animated simulations, and more to reveal how the epidemic got out of control intuitively. Ancker et al. consider interactive data visualization to be an innovative news element that is more engaging, interesting, and participatory than static data visualization [1]. Web-based data visualization formats provide users with the

opportunity to interact with charts and graphs by selecting and manipulating particular charts and graphs at any given time [2]. And previous studies have indeed shown that users respond well to graphical representations of the data they are allowed to process [1]. Therefore, it is more likely that data visualization will be successful in affecting user perceptions and attitudes if it can engage users with its interactive interface—as users interact with the various features, they may attribute a positive perception to the website, which may lead to a positive attitude toward its contents [3–6].

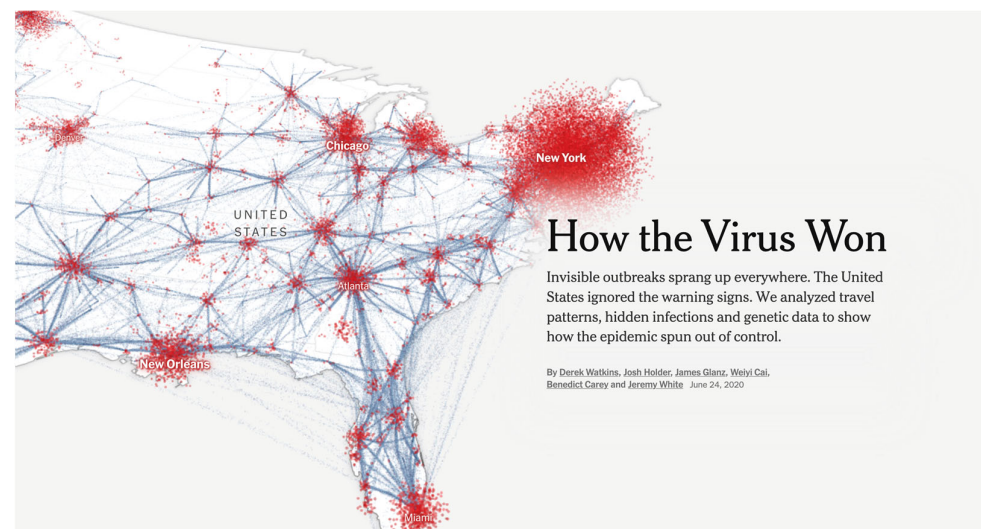


Figure 1. How the Virus Won. Source: The New York Times.

Although interactive visualization may seem attractive, little attention has been paid to how data journalism can harness interactivity to its full potential by systematically examining the various components of interactive activity related to user attitudes. Data visualization techniques and systems have traditionally been evaluated in terms of usability goals such as efficiency and effectiveness [7]. During these studies, participants are evaluated on performance-related metrics, such as their time and accuracy in completing analytical tasks. These principles have been at the center of evaluation research in HCI for decades. In the field of data visualization, usability has been emphasized as an important aspect of ensuring the ability of visualization to assist people in understanding data more effectively. Moreover, in a world filled with options, where a person's attention span is a precious resource, it is essential that designers create products that are not only usable but also memorable, enjoyable, and engaging [7,8]. A number of recent studies in InfoVis examined user experience goals such as memorability, engagement, enjoyment, and fun [7]. A growing number of researchers are realizing the value of visualization beyond performance metrics. According to Brehmer and Munzner, enjoyment is one of the three reasons for using visualization [9]. Haroz et al. argue that an important goal of some visualizations is to engage viewers (particularly in news articles) and make them pause and look [10]. Moreover, because most data journalism users are primarily general and casual users, in addition to the fact that data journalism has a storytelling nature with data, the user experience goals seem to be more intuitive to most readers than performance metrics when it comes to data journalism. In the context of data journalism, we expect that users' perceptions of interactivity will be expressed in terms of a model that includes both cognitive and affective components. It is important for users not only to evaluate whether the news is efficient and effective in providing the relevant information they seek, but also ideally feel an emotional connection to it and enjoy accessing it.

Related to the aforementioned factor, this study aims to develop a model of perceived interactivity, including cognitive and affective outcomes, and subsequent effects on user attitudes in the context of data journalism. Many researchers have argued that attitudes

consist of both affective and cognitive components [11]. Teo et al. argue that emotional components refer to feelings that occur without conscious thought that are expressed in verbal statements of emotions; the cognitive component is the idea and belief that is formed by conscious thought and can be expressed in verbal statements of beliefs and values [12]. In our model, which includes the cognitive–affective structure of user engagement, engagement is considered an intermediate position between cognition and affection, which can be expressed specifically as cognition engagement and affective engagement. As part of our research, we are also interested in the perception of interactivity in relation to enjoyment and fun, which is often considered a component of affect in many studies. In summary, perceived interactivity was proposed to influence user engagement and enjoyment in this study, as well as how enjoyment and user engagement would, in turn, influence users' attitudes toward the news.

The second objective was to explore user perceptions of visualizations with different interaction levels in data journalism. Through ANOVA and qualitative analysis, we further explored how users interact with and perceive interactive visualizations in data journalism. This helped us better understand design elements in data journalism and gain further insights, which complemented our quantitative analysis. The comparison between different experimental groups regarding positive and negative user experiences not only validates our model but also addresses the utility of data journalism design practices. Our experiments were conducted in China, as the data journalism industry in China has a large user community and demand. However, we consider that the findings in this paper can be extended to relevant research and practice on a global scale.

A brief description of our theoretical framework and research model is presented at the beginning of this paper. Next, hypotheses are developed based on previous research on HCI and visualization domains, and then we present the results of our investigation. The article concludes by discussing the implications of the findings for both academics and practitioners.

2. Theoretical Background

As stated by Ducoffe, attitude can be examined through the lens of affect and cognition; affect and cognition together contribute to attitudes toward web advertising [13]. Ajen [14] also proposed that attitudes are multi-component and influenced by both cognition and affection. Cyr et al. [15] created a model of perceived interactivity, including cognitive and affective outcomes, and subsequent effects on loyalty. These investigations serve as the foundation of our model.

Our study focuses on user experience goals beyond performance, so purely cognitive constructs (e.g., effectiveness, efficiency, etc.) are out of our scope for now. According to Saket et al. [7], their review of the evaluation of user experience in visualization examined a variety of academic journals and online articles that focused on user experience objectives, including memorability and recall, engagement, enjoyment and fun. There have been several studies examining the memorability of visualized images, which refers to the ability to remember and recall visual information. However, no strong correlation appears to be found between perceived interactivity and memorability in relevant studies, so we have not included memorability and recall in our model at this time. We focus more on user experience goals in terms of enjoyment and user engagement.

It is obvious that interaction is an important component of visualization and data journalism. Veglis and Bratsas [16] identify three forms of interaction brought about by data visualization: transmission (simple interaction that serves little function other than to convey additional information about the element), consultation (providing multiple views of the same data), and conversation (which receives data input and allows the user to significantly alter the visualization). In addition, there is extensive discussion and interest in the issues of actual and perceived interactivity in the academic field. Perceptual measures emphasize the “experience of interaction” [17]. Wojdyski posited that, if users perceive that a particular piece of content provides them with more interactivity, they are

likely to have a more positive attitude toward that piece of content [2]. Wei et al. found that perceived interactivity has a major impact on attitude, which, in turn, affects the user's intention to remain in social media [18]. Bucy and Tao argue that the influence of interaction on attitudes is mediated by perceived interactivity [19]. Wu [20] summarized the related empirical research regarding the influence of perceived and actual interactivity on website attitudes. The results indicate that perceived interactivity consistently and positively impacts communication outcomes such as attitudes toward the website, attitudes toward the brand, and purchase intentions [20]. In general, whether higher potential interactions can be realized for either interaction participant greatly depends on how interactions are perceived [20]. We are focusing, in this study, on the relationship between users' perceptions of interactivity and their attitudes, which we define as allowing users to access and control information in data journalism in a variety of ways that are both personalized and responsive [15]. For example, users can control the speed, order, and variables of the information they access through interaction. Meanwhile, from a technical perspective, the fluency of the interaction and the timeliness of the feedback to the user may also be key factors affecting the user's perception of interactivity.

A description of the elements of the model and the evidence supporting the hypothesized relationships are detailed below. In our study, we proposed a model between perceived interactivity and user attitudes. More specifically, we are interested in determining whether perceived interactivity affects user enjoyment and engagement and whether these constructs are precursors to user attitudes. We use perceived interactivity as the independent variable, and enjoyment, user engagement, and user attitudes toward data journalism as dependent variables, with enjoyment and engagement as mediating variables. For this study, the relevant concepts were defined as follows:

Perceived interactivity: Perceived interactivity provides the user with a variety of methods for controlling and accessing information on the site, both personal and responsive [15].

Enjoyment: Davis defines enjoyment as a feeling that causes a person to experience pleasure [21].

Engagement: User engagement refers to the emotional, cognitive, and behavioral connections that exist between a user and a resource at any given point in time and possibly over time [22].

Attitude: Attitude is defined as the tendency to respond in a particular way to a particular class of objects [12,23].

3. Hypothesis Development

3.1. Enjoyment

It is important to note that, despite the extensive discussion and study of fun and enjoyment in psychology and human–computer interaction [24,25], these aspects have not been explored in much detail in data journalism and visualization, despite the fact that enjoyment is often cited as a reason to consume visualizations [9]. Skelly [26] notes that variation can be utilized to exploit the element of curiosity or surprise. Moreover, Davenport et al. maintain that a certain level of unpredictability is crucial to a fun experience [27]. The stimuli provided by novel, interesting, or even exciting divisions of labor, content, presentation, or interaction indirectly facilitate goal attainment [28]. In other words, if people feel pleasant, they will use the visualization more effectively to accomplish their tasks, and they will be more likely to engage in enjoyable activities, which will enhance their reading experience. Therefore, it is reasonable to assume that users' goals of fun and enjoyment have research value in the field of data journalism.

In addition, user control is considered an important aspect of an enjoyable experience. Allowing users to make more decisions about their interactions with technology can enhance their enjoyment. Previous research has indicated that the user-controlled exploration of information can trigger positive emotions like enjoyment or satisfaction [3], especially when the interactive features are designed to support the user's experience naturally and intuitively [29]. The research of Horning [30] demonstrated that perceived

responsiveness and control, which are dimensions of interactivity, play an important role in news credibility and enjoyment. In defining pleasant technology, Brandtzæg et al. [24] suggest that the design should make the user feel in control of the interaction. In order for the user to feel a sense of agency or personal power, it is also essential to be able to see the results of their actions. The key to creating an enjoyable experience is to provide the user with an opportunity to actively participate. Cyr et al. [15] also found that higher levels of perceived interactivity would lead to higher levels of user enjoyment. From the above, it can be concluded that users may enjoy news pages more if they feel more in control and have more space for exploration. Based on these related studies, we propose the following hypothesis:

H1a: *Users will enjoy data journalism more if they perceive a higher level of interaction.*

In the context of data journalism, we are not aware of any research that enjoyment has been tested related to user attitude; however, our study has been influenced by other similar studies. Yang and Shen found that interactive forms of transmission and consultation can enhance user enjoyment and foster positive attitudes in general [31]. Childers et al. [32] found enjoyment positively related to attitudes toward the site. Similarly, van der Heijden [33] found that enjoyment was positively related to attitudes toward the website and the frequency with which users intend to visit it. Muhammad et al. [34] studied consumer interaction with social media platforms and found that a positive social media experience generates positive emotions such as enjoyment, happiness, and self-improvement, which leads to a more positive attitude toward social media. Jin and Oh [35] also found that users who experience positive emotions show more positive interface evaluations and attitudes toward interactive websites. Therefore, we conclude that:

H1b: *Higher enjoyment predicts a more positive attitude toward the news.*

3.2. Engagement

In fact, interactive aspects of visualization typically contribute considerably to a high level of user engagement and enjoyment. The relationship between interactivity, user engagement, and attitudes has not received much attention in the field of visualization and data journalism, but studies on this topic have been discussed for a very long time in the HCI field. From the perspective of the user gratification theory, interactivity has been shown to promote emotional and social gratification, which are both important indicators of sustained media engagement [36,37]. According to several studies, participants randomly assigned to higher interaction conditions demonstrated more engagement with online advertising than those in lower interaction conditions [38]. McMillan et al. [39] found a strong positive correlation between all measures of perceived interactivity and engagement. Past research has demonstrated that modality interactivity can increase user engagement by altering users' perceptions and attitudes toward mediated material in various contexts [40–42]. These results indicate that users may be more motivated to engage and process content if there is more interactivity, engaging them with content they might not otherwise attempt to consume. Hence, the following hypothesis is offered:

H2a: *A higher level of user-perceived interactivity will lead to a higher level of engagement in data journalism.*

We also wanted to test the relationship between user engagement and user attitudes in the context of data journalism. Pavlou and Stewart [43] suggested that active participation in the advertising process may be an important element of advertising effectiveness. A variety of studies have used Zaichowsky's Personal Involvement Inventory (PII) [44] to measure the extent to which individuals participate in online activities [39,45–47]. Generally, these studies found that user engagement is positively related to attitude toward websites [39]. We, therefore, argue that:

H2b: *Higher user engagement will predict a more positive attitude toward the news.*

3.3. Enjoyment and Engagement

Even though enjoyment and engagement are two different concepts [48], some visualization studies use them interchangeably. In this case, they are related but not identical. Enjoyable activities are also usually very engaging, but it is clear that it is possible to be deeply engaged in an activity even if it is not necessarily exciting and enjoyable. Engagement is a complex process that combines multiple influences to encourage a sense of flow and fluid interaction, fulfilling arousal and the pleasant emotions of curiosity, surprise, and happiness [49]. Furthermore, O'Brien and Toms [50] consider engagement as a category of user experience characterized by challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control. A study he conducted on user engagement found that participants (web users, shoppers, webcast viewers, and video game players) all expressed a range of positive emotions, including enjoyment, satisfaction, and fun, during the engagement period [50]. These positive emotions were considered to be a form of engagement. In summary, we propose the following hypothesis:

H3: *In addition to direct effects, perceived interactivity may influence user engagement through enjoyment, which, in turn, affects user attitudes toward the news.*

The relationship between the variables is illustrated in Figure 2. In summary, the influence of perceived interactivity on users' attitudes can be mediated by three possible mechanisms, including two parallel mediating relationships and one chain mediating relationship:

Perceived Interactivity → Enjoyment → Attitude

Perceived Interactivity → Engagement → Attitude

Perceived Interactivity → Enjoyment → Engagement → Attitude

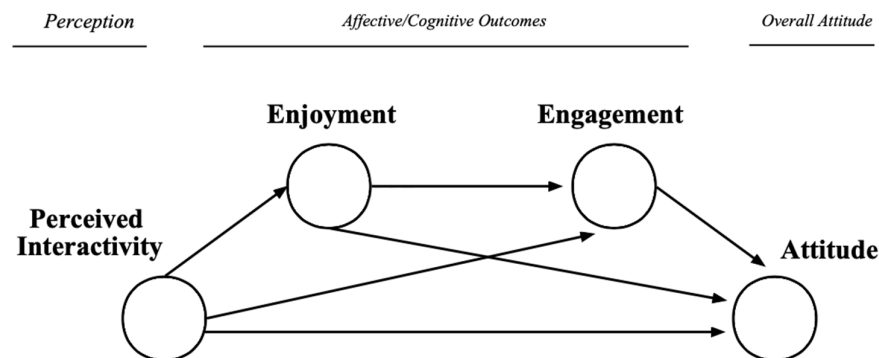


Figure 2. Proposed research model.

4. Methodological Approach

4.1. Participants

We recruited 75 participants (31 males and 44 females) through voluntary recruitment at the Guilin University of Aerospace Technology in Guangxi Province, China. The participants encompassed sophomores, juniors, and seniors (with most participants being between 18 and 24). They have backgrounds in design and journalism (including visual communication design, digital media arts, journalism, and communications) and are familiar with charts, graphs, and online news. Participants all indicated that they had experience with the Internet and read online news. All participants volunteered to participate in the study and had no conflicts of interest.

4.2. Task Design and Treatments

To answer our questions, we conducted a between-subjects experiment with 75 college students. The experimental design is a one-way controlled experiment with three separate groups and three interaction levels of data journalism (containing visualization charts

at different interaction levels). The different levels of interactivity described here are categorized according to Christoph and Satran [51], who classified the degree of interactivity into seven levels based on the type of control available to the user from low to high, including pace, sequence, media, variables, transactions, objects, and stimulation. In our experiments, three different interaction levels of data visualization were designed to correspond to user control of speed, speed and order, speed, order, and variables. We decided to use a fairly simple interactive data visualization that user could hover the mouse over for more specific information or to filter the database to display specific categories of data, as they represent typical interactions with graphical content used in online news. The experiment was conducted in a computer classroom on campus, where the three versions of the experimental materials were distributed in equal quantities to different desktops through the randomized distribution function of the school's instructional management system, and recruited participants were seated randomly. Each subject will be randomly assigned to one of three interaction levels of experimental material and will be exposed to only one level or condition. The website will remain accessible to visitors for as long as they choose, with a "Read Complete" button at the bottom of each page. At completion, they will be required to complete an online survey that is linked to the website.

Besides the items measuring the various constructs of the proposed model, the interview was conducted with two open-ended questions. The first question asked respondents to describe what they liked about this data journalism. The second question asked how they perceived the map visualization and interactive features of the news.

4.3. Stimuli

The data journalism was adapted from a piece of news published on Caixin.com (titled "Alert from the Kidneys of the Earth") and redesigned to correspond to three levels of interactivity. The article discusses the status and distribution of wetland conservation in China. The distribution of the number of wetlands in each province in China and the List of Wetlands of International Importance are presented in a map visualization following a brief introduction to the topic and its development. On the map, the number of Wetlands of International Importance in each province, the selected batches, and the wetland directories are displayed. This article contains a total of 1058 words. The news will be presented in Chinese, depending on the participants' backgrounds. The differences between the three groups only concern the data visualization design. Table 1 shows the descriptions of the map visualizations for the three groups (Appendix B):

Table 1. Description of the three groups.

Interactivity Level	Description of the Visualization and Available Control
Low-interactivity (<i>n</i> = 25)	It is not possible to manipulate the content in the visualization. The map, the number of wetlands in each province, the selected batches, and the wetland directories can be seen directly.
Medium-interactivity (<i>n</i> = 25)	Participants can interact with the map via mouse hover to show the number of corresponding provinces, the selected batches, and the wetland directories.
High-interactivity (<i>n</i> = 25)	Participants can filter the data categories by the left navigation bar (show all/by wetland selected batches/by wetland distribution number) and mouse hover to interact with the map to show the number of corresponding provinces, the selected batches, and the wetland directories.

4.4. Measures

The measure of perceived interactivity was taken from a scale developed by Liu [52] to assess the interactivity of websites. The factor structure selected included Active Control and Synchronicity, with two items. The participants' enjoyment of data news was

adapted from a study of web interfaces by Hassanein and Head [53], with three items. The user engagement measure in this study was adapted from O'Brien and Toms's User Engagement Scale [54] and involved factors such as Aesthetics, Endurability, Novelty, and Involvement, with four items. The measure of user attitudes was adapted from Sundar and Kalyanaraman's Web Site Perception Scale [55], with three items. A seven-point Likert scale was used to measure all of these items, with 1 representing complete disagreement and 7 representing complete agreement. The pre-test showed that the scale's reliability was not affected in any case [56]. Specific items of the scale can be found in Appendix A.

In addition, 15 participants were involved in a pre-test, including Ph.D. students in interaction design and visual designers with more than five years of experience in the field. The pre-test showed that the experimental materials met the preconceptions of the three interaction levels of the study—low, medium, and high—and that all three sets of experimental materials contained their respective interaction manipulations. In addition, they were requested to make comprehensive comments on any phrasing or conceptual ambiguity. The phrasing of a few items was modified slightly to eliminate any potential misinterpretation. For example, some participants indicated that they did not know whether they needed to memorize certain data in the piece of journalism during the reading process. Hence, at the beginning of the formal experiment, we made it clear that participants could read the piece of journalism as they normally would, without memorizing it intentionally, to avoid affecting their reading experience and the experiment's results. In addition, based on participant feedback and the literature review, "visualization charts" in the scale were replaced with "data journalism"; e.g., "I found my visit to this visualization chart enjoyable" was replaced with "I found my visit to this data journalism enjoyable" to reflect participants' perceptions of the overall journalism more accurately.

5. Results

5.1. Manipulation Test

Participants felt more interactive ($M = 5.32$, $SD = 0.96$, $F = 3.880$, $p < 0.05$) with the data journalism in the condition that included a high-interactivity data visualization than in the condition that embedded a medium-interactivity data visualization ($M = 4.96$, $SD = 0.79$) and a low-interactivity data visualization ($M = 4.56$, $SD = 1.12$).

5.2. Measurement Validation

The construct assessment results are presented in Table 2. Cronbach's alpha and composite reliability are used to assess internal consistency. Cronbach's alpha value was 0.929, which is well past the thresholds recommended by Rivard and Huff [57] and Nunnally [58]. This indicates a high level of reliability, while the composite reliability (CR) for each measurement dimension exceeded the recommended threshold of 0.7 [59]. A confirmatory factor analysis (CFA) was conducted for a total of four factors and 12 analytical items, including structural, convergent, and discriminant validity. The standardized loading coefficient values for each factor exceeded the recommended threshold of 0.7 [59], indicating a strong correlation. In addition, convergent validity was demonstrated as the average variance extracted (AVE) for all structures [60] ranging from 0.549 to 0.771 and exceeding 0.5, indicating high convergent validity. Subsequently, the discriminant validity was investigated between the four factors using the Pearson correlation coefficient and AVE square root values. As per Fornell and Larcker [60], the square root of the average variance extracted (AVE) should be greater than its highest correlation between the construct and any other construct. According to Table 3, the discriminant validity test satisfied Fornell and Larcker's [60] criteria. In general, the analyses indicate that the scales demonstrated sufficient evidence of internal consistency, convergent validity, and discriminant validity to be included in the model.

Table 2. The results of the construct assessment.

Construct Indicators	Indicator's Loadings	Composite Reliability	Average Variance Extracted
Perceived Interactivity_1	0.735	0.708	0.549
Perceived Interactivity_2	0.746		
Enjoyment_1	0.770	0.860	0.673
Enjoyment_2	0.879		
Enjoyment_3	0.809		
Engagement_1	0.673	0.838	0.565
Engagement_2	0.738		
Engagement_3	0.841		
Engagement_4	0.745		
Attitude_1	0.964	0.909	0.771
Attitude_2	0.894		
Attitude_3	0.764		

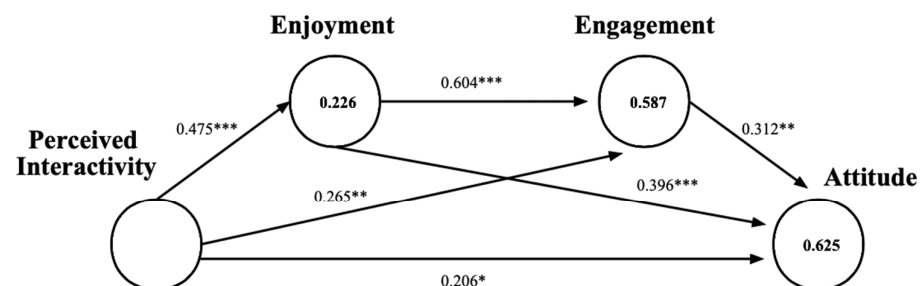
Table 3. Discriminant validity of constructs.

	Perceived Interactivity	Enjoyment	Engagement	Attitude
Perceived Interactivity	0.741			
Enjoyment	0.475	0.821		
Engagement	0.552	0.730	0.752	
Attitude	0.567	0.721	0.715	0.878

Note: Diagonal elements (in bold) represent the square roots of AVEs of constructs.

5.3. Hypothesis Test

Figure 3 presents the path analysis results. H1 argues that the effect of perceived interactivity on users' attitudes toward data journalism will be mediated through enjoyment. From the path coefficients in the figure, it is clear that perceived interactivity positively predicts users' enjoyment level ($b = 0.475$, $p < 0.001$). The user's enjoyment level positively influences their attitude toward the news ($b = 0.39$, $p < 0.001$). According to H2, user engagement will mediate the effect of perceived interactivity on user attitudes. The results show that perceived interactivity positively predicts user engagement ($b = 0.26$, $p < 0.01$). The user's engagement level positively influences their attitude toward the news ($b = 0.31$, $p < 0.01$). In addition, H3 suggested that perceived interactivity may influence user engagement through enjoyment, which, in turn, affects user attitudes toward the news. The results showed that perceived interactivity positively predicted users' enjoyment ($b = 0.475$, $p < 0.001$), users' enjoyment level positively influenced users' engagement ($b = 0.604$, $p < 0.001$), and users' engagement level positively influenced their attitude toward the news ($b = 0.312$, $p < 0.01$).



1.*:p-value <0.05 **p-value <0.01 ***p-value <0.001

2. The value in bold is the R square value of the factor in the structural model

Figure 3. Results of path analysis.

A mediation analysis was conducted using Hayes' process (Model 6) [61] with 5000 replicate samples and 95% confidence intervals. The results of the mediation analysis are presented in Table 4. The indirect effect value of perceived interactivity influencing user attitudes through enjoyment was 0.221 with a 95% confidence interval [0.072–0.394], and the indirect effect value of perceived interactivity influencing user attitudes through engagement was 0.097 with a 95% confidence interval [0.002–0.243], both excluding 0. In summary, hypotheses H1a, H1b, H2a, and H2b of this study were accepted. According to the results of the analysis, the third mediated path had a mediated effect value of 0.105, with a 95% confidence interval of [0.010–0.223], excluding 0. H3 was accepted.

Table 4. Mediation test.

Indirect Paths	Effect	95% BootCI
Perceived Interactivity → Enjoyment → Attitude	0.221	[0.072~0.394]
Perceived Interactivity → Engagement → Attitude	0.097	[0.002~0.243]
Perceived Interactivity → Enjoyment → Engagement → Attitude	0.105	[0.010~0.223]

Note: Bootstrap samples of confidence intervals for percentiles = 5000.

5.4. Exploratory Analysis of Qualitative Data

After participants completed the questionnaire, semi-structured interviews were conducted to collect preferences and feedback, which were analyzed 3–5 times by the main author using informal coding techniques in the interview transcripts. Finally, the focused categories were synthesized into the following five main concepts:

Aesthetics: Visual design qualities that contribute to the attractiveness or pleasant appearance of the news interface. The concept is embodied in codes such as “visually appealing”, “eye-catching”, “colorful”, and “having a sense of design.”

Emotion: Emotion refers to design elements that evoke emotions. The codes “fun”, “novel”, “engaging”, and “satisfying” are examples of emotional properties.

Functionality: The components of the news structure and visualization, such as information design, navigation, and layout. Codes may include “data are intuitively clear”, “easy to obtain”, and “easy to remember.”

Interactivity: This refers to giving users a variety of opportunities to interact with the news. Examples of codes include “a sense of feedback and control”, “change from passive reception to active interaction”, and “more accessibility.”

Narrative: This refers to the sequence of the news narrative. This concept is encapsulated by codes like “too much text”, “lengthy”, and “lack of rhythm”.

Table 5 shows the results of an ANOVA analysis. As mentioned in Section 5.1, there is a significant difference in perceived interactivity between the three experimental groups. Additionally, participants in the condition that embedded a high-interactivity data visualization had more positive attitudes toward this news ($M = 5.52$, $SD = 0.99$, $p < 0.05$) than those including the medium-interactivity data visualization condition ($M = 5.21$, $SD = 0.86$) and the low-interactivity data visualization ($M = 4.67$, $SD = 1.47$). In terms of engagement and enjoyment, the different experimental groups did not show significant differences, which we found, from our analysis, might be due to the selected visualization not being engaging enough, with more text. The data set in the material was not rich enough, and a limitation of interaction potential might be one of the reasons for the non-significance of the two measures of engagement and enjoyment. Additionally, enjoyment might be closely related to the comprehensibility of the news, which is also considered an important aspect of the reading experience [62]. If readers are frustrated by their inability to comprehend statistical information, an optimal experience may be compromised [62,63].

Table 5. Means and standard deviations for the three teams.

	T1 (n = 25)		T1 (n = 25)		T1 (n = 25)		p Value
	Mean	Sd	Mean	Sd	Mean	Sd	
Perceived Interactivity	4.56	1.12	4.96	0.79	5.32	0.96	0.025 *
Enjoyment	4.44	1.13	4.57	0.84	4.79	1.11	0.494
Engagement	4.84	1.40	4.96	0.88	5.15	0.86	0.591
Attitude	4.67	1.47	5.21	0.86	5.52	0.99	0.032 *

* $p < 0.05$.

Some interesting insights can be derived from a qualitative analysis of open-ended questions. Table 6 summarizes the positive and negative concepts that emerged from the open-ended questions and provides illustrative quotes from participants.

The positive comments from Group 1 focused on aesthetic and emotional concepts. Although the static infographics generally met the audience's basic needs in terms of aesthetics and functionality, it did not allow users to interact with the interface. Participants stated that the layout of the information made it easier to concentrate on specific information and ignore other information. Some argue that adding more interactive space and images would be more user-friendly. In terms of emotion, some participants said it was less engaging, fun, and stressful to read. There were significantly more positive comments about the concept of interaction in Groups 2 and 3 compared to Group 1. Many participants stated that this piece of data journalism was highly interactive and provided opportunities for manipulation, active choice, and improved user experience; interacting with the graphs brings visual enjoyment and is more intuitive and vivid. The increased interaction also positively impacts the functional and emotional aspects. Many participants indicated that this interactive way of exploring information made the data more intuitive, more precise, easy to locate, and easier to remember. Others indicated that interactivity made the data source more reliable and trustworthy. Previous studies have mentioned that (interactive) visualizations are becoming more and more important in news reporting, which is also a promising strategy to foster message credibility [64–66]. In terms of emotional attributes, participants indicated that the higher level of interactivity was more engaging and interesting to them than static infographics. The negative comments focused on the rhythm of the narrative and the richness of the information and media, with participants noting that long paragraphs of text tend to generate fatigue and tedium, causing them to lose interest and want to skip. Many participants expressed the desire to add more interactivity, such as increasing the number of layers of hyperlinks to provide more detailed information, as well as adding images, video, and audio to enhance the richness of the medium.

Table 6. Summary of the qualitative analysis (based on open-ended questions).

Data Journalism Experiment	Positive Emerging Concepts	Negative Emerging Concepts
G1	Aesthetics: “visually appealing”; “eye-catching”; “nice layout”; “special”; “Colorful”; “Strong aesthetic and design sense” Emotion: “Have fun”; “Engaging”; “Want to get involved”; “Contextualization”; “Curiosity”; “Create empathy and familiarity” Functionality: “Novel subject matter”	Emotion: “Less engagement and fun”; “There is pressure to read” Functionality: “The way the data are organized makes it easier to focus on certain information and ignore others” Interactivity: “Interactivity is weak”; “Adding interactive points and images would be more user-friendly” Narrative: “Infographics at the end of the article make me a little impatient”; “Too much text and concentration”

Table 6. Cont.

Data Journalism Experiment	Positive Emerging Concepts	Negative Emerging Concepts
G2	Aesthetics: “Outstanding visual novelty”; “Nice color”; “The color is in line with the theme”; “With visual impact”; “With design sense” Emotion: “Touch heartstring”; “Gratification”; “A sense of involvement and experience feeling”; “Novelty”; “Interesting” Functionality: “Data are accurate”; “Very detailed”; “Easy to remember”; “Information is clear and concise”; “Easy to access, easy to find information”; “Intuitive” Interactivity: “Interactive”; “Sense of feedback and control”; “Room for manipulation and active choice”; “Interacting with the charts brings visual enjoyment”; “Vividly”; “Interactivity enhances my reading interest”; “Arouses curiosity to continue exploring more information”; “Increased communication power of the message”	Emotion: “Tiredness easily”; “Reading pressure” Functionality: “Single form of information presentation”; “Icons and images can be added” Narrative: “Too much text”; “Lengthy”; “Lack of rhythm”; “Interactive diagrams at the end tend to make users jump out and lose interest”
G3	Aesthetics: “Uniformity of color”; “Rejuvenation”; “Novel”; “Holistic”; “Thematic Sense”; “Innovative”; “Easy to grab people’s attention” Emotion: “Very engaging”; “Interesting”; “Good experience feeling”; “Credible and convincing”; Functionality: “Data are clear and intuitive”; “Detailed” “Useful for receiving data”; “Helps with memory”; Interactivity: “Interactive”; “With control”; “Easy access to data details”; “Interactivity makes data more straightforward”; “From passive acceptance to active interaction”; “Interactive maps are novel and more intuitive”; “Interactivity makes me feel that the data source is reliable”	Emotion: “The text part tends to be boring”; “Want to skip the text” Functionality: “Could add some pictures combined with visualization” Interactivity: “Increase the number of levels of hyperlinks to get more specific information”; “Add more interactivity”; “The interaction cues were not so evident that I ignored the interaction” Narrative: “Large sections of text can be broken up”

Overall, the comments were generally consistent across experimental groups in terms of aesthetics and functionality, with participants reporting that the data news was visually appealing, attractive, colorful, intuitively clear, and easy to access. However, in the second and third groups, the perceived interactivity by users increased significantly. Participants felt more in control of the map visualization due to the interactivity. From passively receiving information to actively interacting with it, the method of acquiring information has changed. At the same time, the increased interactivity made participants feel more interested, attracted and involved, interested in exploring more information, and, subsequently, having a more positive attitude toward the news.

6. Discussion and Conclusions

6.1. Theoretical and Practical Contributions

Our study investigated the outcomes of perceived interactivity and the subsequent effects on user attitudes in the context of data journalism. All hypotheses related to the models developed and tested have been supported. We have confirmed the mediating role of enjoyment (affective perceptions) and engagement (cognitive–affective perceptions) between perceived interactivity and user attitudes. Thus, if online news and visualization designers wish to attract and retain users, enhancements in user interactions on news pages are warranted. Factors such as engagement and perceived interactivity have been commonly used in previous studies to examine the impact on website attitudes and in research on attitudes toward advertising and online shopping, with less relevant research

on data journalism and interactive data visualization. This study provides new insights into the merits of interactive data visualization in the context of data journalism and, therefore, is useful to researchers as well as practitioners. Our study is based on data journalism as a prototype; however, the findings can be applied to other areas of data visualization and HCI as well.

Statistically significant differences in perceived interactivity and user attitudes were found for data journalism embedded with three levels of interactive map visualizations (low, medium, and high). Although there were no statistically significant differences in enjoyment and engagement among the groups, the exploratory qualitative analysis provided some interesting insights for data journalism and visualization developers and suggested future research directions. Participants indicated a desire for the news to provide more interactivity, for example, by adding layers of hyperlinks to more detailed information of interest. To enhance the reading experience, participants also desired to enhance the richness of the medium, such as combining images, video, sound, and visualization. Interaction brings fun and enjoyment and positively influences user engagement and attitudes. Thus, interaction has a pleasure component, linking perceived interactivity to the enjoyment and fun of data journalism. It is also supported by aesthetic and emotional concepts derived from qualitative data. Additionally, the visual appeal of data journalism seems to be necessary, not only to elicit a positive impression of the news but also to trigger emotions, such as “very attractive” and “take me into the context”.

Consideration of the sequencing in narrative visualization can also influence users’ attitudes toward the news due to the narrative nature of data journalism. Hullman et al. [67] researched narrative sequencing in narrative visualization to guide the design of narrative visualizations and systems that support visual sequence optimization. For data journalism or visualization designers, interactive narrative sequences should also be considered in the design process. Furthermore, it would be helpful to investigate how interaction can be used to engage and interest users continuously during their reading process while also improving the narrative and presentation of the news.

6.2. Research Limitations and Future Directions

The study was conducted among a student population. Accordingly, the findings of this study may be generalized to a broader group of web users, as with most studies that involve student participants. However, it is important to point out that student samples are representative and appropriate for the data journalism community in general. Furthermore, the majority of respondents in this sample indicated themselves as experienced Internet users. Many of the students had some experience and understanding of news and graphics due to the relevance of their majors. And, in addition to the benefits of interactivity, previous research has also shown that the use of news with large amounts of data and visualizations with higher levels of interactivity may place a higher cognitive load on the casual user. Using (interactive) visualizations and processing news articles containing many data requires a higher level of numerical proficiency [62]. Otherwise, their understanding of articles and enjoyment of reading may be limited, and they may experience cognitive overload as a result [62,63,68]. Thus, in future studies, this should also be extended to a broader group of participants.

Although many previous studies have suggested that the effect of interaction on attitudes is mediated by perceived interactivity, perceived interactivity may play a mediating role in influencing the effect of actual interactivity on attitudes [2,19,20]. We did not test the effect between actual and perceived interactivity in the research model directly. But the results of ANOVA indicated that, in the experimental group with higher levels of interaction, users’ perceptions of interactivity and attitudes were significantly higher compared to the experimental group with medium and low levels of interaction. In future research, it would be worthwhile to incorporate actual interactivity into this model. It is necessary to take a more holistic view to analyze the effects and correlations between these structures in data news and visualization.

A piece of data journalism on an environmental topic was chosen as the basis for experimental manipulation to provide users with controlled conditions. We redesigned the news item for three different levels of interaction while ensuring the experiment was as least intrusive as possible. We extracted only a portion of the article and included only one map visualization, but, in a strict sense, there is limited space for interaction with this experimental material. In future research, experiments can be conducted with materials with higher interaction potential, such as considering the dimensions of user and user interactivity or Person interactivity. In addition, the data set is not rich enough. The ANOVA reveals no significant differences between the experimental groups in terms of engagement and enjoyment, so we speculate that this may also be a contributing factor. Additional studies could test whether the model could be further validated with more complex data, greater interaction potential, and a richer media environment.

In summary, this study aimed to examine users' perceptions in the context of data journalism. Based on these findings, it can be concluded that interactivity plays an important role in positively affecting the enjoyment, involvement, and attitude of users. In light of the fact that data visualization is becoming more widely used in various fields and is no longer restricted to a small group of experts, it is necessary to obtain a more comprehensive and in-depth understanding of users' perceptions and attitudes. As interaction technologies develop and research continues, leveraging interactions may result in a more engaging and enjoyable reading experience for users, improving their engagement and retention in data journalism.

Author Contributions: Conceptualization, B.Z. and Y.P.; methodology, B.Z. and Y.P.; software, B.Z. and Y.Z.; validation, B.Z. and Y.Z.; formal analysis, B.Z. and Y.Z.; investigation, B.Z. and Y.Z.; writing—original draft preparation, B.Z. and Y.P.; writing—review and editing, B.Z. and Y.P.; visualization, B.Z.; supervision, Y.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Survey Items

Note: Items answered on a 7-point Likert scale, with 1 representing complete disagreement and 7 representing complete agreement.

Perceived Interactivity [52]

PI-1 While surfing this data journalism, my actions decided the kind of experiences I got.

PI-2 This data journalism processed my input very quickly.

Enjoyment [53]

EJ-1 I found my visit to this data journalism entertaining.

EJ-2 I found my visit to this data journalism enjoyable.

EJ-3 I found my visit to this data journalism pleasant.

Engagement [54]

EG-1 This data journalism was aesthetically appealing.

EG-2 I consider my reading experience a success.

EG-3 The content of this data journalism incited my curiosity.

EG-4 I was really drawn into my reading task.

Attitude [55]

AT-1 This data journalism is appealing.

AT-2 This data journalism is attractive.

AT-3 This data journalism is high-quality.

Appendix B. Data Journalism Experiments

Table A1. Description of the interactive display and available controls of the map visualization in the three groups of experimental materials.

Data Journalism Experiment	Description of the Visualization and Available Control																																																																																																																																																									
Distribution of wetlands in China and list of internationally important wetlands <table><tr><th>Province</th><th>Batch</th><th>Wetland Area (10,000 ha)</th></tr><tr><td>Heilongjiang</td><td>First batch: 1992</td><td>9</td></tr><tr><td>Inner Mongolia</td><td>Second batch: 2002</td><td>4</td></tr><tr><td>Shanghai</td><td>Third batch: 2008</td><td>2</td></tr><tr><td>Henan</td><td>Fourth batch: 2013</td><td>4</td></tr><tr><td>Guangdong</td><td>Fifth batch: 2015</td><td>2</td></tr><tr><td>Shandong</td><td>Sixth batch: 2017</td><td>2</td></tr><tr><td>Shaanxi</td><td>Seventh batch: 2019</td><td>2</td></tr><tr><td>Shanxi</td><td>Eighth batch: 2021</td><td>2</td></tr><tr><td>Shanghai</td><td>Ninth batch: 2023</td><td>2</td></tr><tr><td>Shanghai</td><td>Tenth batch: 2025</td><td>2</td></tr><tr><td>Shanghai</td><td>Eleventh batch: 2027</td><td>2</td></tr><tr><td>Shanghai</td><td>Twelfth batch: 2029</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirteenth batch: 2031</td><td>2</td></tr><tr><td>Shanghai</td><td>Fourteenth batch: 2033</td><td>2</td></tr><tr><td>Shanghai</td><td>Fifteenth batch: 2035</td><td>2</td></tr><tr><td>Shanghai</td><td>Sixteenth batch: 2037</td><td>2</td></tr><tr><td>Shanghai</td><td>Seventeenth batch: 2039</td><td>2</td></tr><tr><td>Shanghai</td><td>Eighteenth batch: 2041</td><td>2</td></tr><tr><td>Shanghai</td><td>Nineteenth batch: 2043</td><td>2</td></tr><tr><td>Shanghai</td><td>Twentieth batch: 2045</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-first batch: 2047</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-second batch: 2049</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-third batch: 2051</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-fourth batch: 2053</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-fifth batch: 2055</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-sixth batch: 2057</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-seventh batch: 2059</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-eighth batch: 2061</td><td>2</td></tr><tr><td>Shanghai</td><td>Twenty-ninth batch: 2063</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirtieth batch: 2065</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-first batch: 2067</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-second batch: 2069</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-third batch: 2071</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-fourth batch: 2073</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-fifth batch: 2075</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-sixth batch: 2077</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-seventh batch: 2079</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-eighth batch: 2081</td><td>2</td></tr><tr><td>Shanghai</td><td>Thirty-ninth batch: 2083</td><td>2</td></tr><tr><td>Shanghai</td><td>Fortieth batch: 2085</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-first batch: 2087</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-second batch: 2089</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-third batch: 2091</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-fourth batch: 2093</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-fifth batch: 2095</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-sixth batch: 2097</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-seventh batch: 2099</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-eighth batch: 2101</td><td>2</td></tr><tr><td>Shanghai</td><td>Forty-ninth batch: 2103</td><td>2</td></tr><tr><td>Shanghai</td><td>Fiftieth batch: 2105</td><td>2</td></tr></table> It is not possible to manipulate the content in the visualization. The map, the number of wetlands in each province, the selected batches, and the wetland directories can be seen directly.	Province	Batch	Wetland Area (10,000 ha)	Heilongjiang	First batch: 1992	9	Inner Mongolia	Second batch: 2002	4	Shanghai	Third batch: 2008	2	Henan	Fourth batch: 2013	4	Guangdong	Fifth batch: 2015	2	Shandong	Sixth batch: 2017	2	Shaanxi	Seventh batch: 2019	2	Shanxi	Eighth batch: 2021	2	Shanghai	Ninth batch: 2023	2	Shanghai	Tenth batch: 2025	2	Shanghai	Eleventh batch: 2027	2	Shanghai	Twelfth batch: 2029	2	Shanghai	Thirteenth batch: 2031	2	Shanghai	Fourteenth batch: 2033	2	Shanghai	Fifteenth batch: 2035	2	Shanghai	Sixteenth batch: 2037	2	Shanghai	Seventeenth batch: 2039	2	Shanghai	Eighteenth batch: 2041	2	Shanghai	Nineteenth batch: 2043	2	Shanghai	Twentieth batch: 2045	2	Shanghai	Twenty-first batch: 2047	2	Shanghai	Twenty-second batch: 2049	2	Shanghai	Twenty-third batch: 2051	2	Shanghai	Twenty-fourth batch: 2053	2	Shanghai	Twenty-fifth batch: 2055	2	Shanghai	Twenty-sixth batch: 2057	2	Shanghai	Twenty-seventh batch: 2059	2	Shanghai	Twenty-eighth batch: 2061	2	Shanghai	Twenty-ninth batch: 2063	2	Shanghai	Thirtieth batch: 2065	2	Shanghai	Thirty-first batch: 2067	2	Shanghai	Thirty-second batch: 2069	2	Shanghai	Thirty-third batch: 2071	2	Shanghai	Thirty-fourth batch: 2073	2	Shanghai	Thirty-fifth batch: 2075	2	Shanghai	Thirty-sixth batch: 2077	2	Shanghai	Thirty-seventh batch: 2079	2	Shanghai	Thirty-eighth batch: 2081	2	Shanghai	Thirty-ninth batch: 2083	2	Shanghai	Fortieth batch: 2085	2	Shanghai	Forty-first batch: 2087	2	Shanghai	Forty-second batch: 2089	2	Shanghai	Forty-third batch: 2091	2	Shanghai	Forty-fourth batch: 2093	2	Shanghai	Forty-fifth batch: 2095	2	Shanghai	Forty-sixth batch: 2097	2	Shanghai	Forty-seventh batch: 2099	2	Shanghai	Forty-eighth batch: 2101	2	Shanghai	Forty-ninth batch: 2103	2	Shanghai	Fiftieth batch: 2105	2	It is not possible to manipulate the content in the visualization. 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