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Analysis of Practical Applications of Data Storytelling: A Case Study of Data Journalism (Postprint)

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Abstract

[Purpose/Significance] Data storytelling achieves the integrated association and fusion of data, visualization, and narrative, which facilitates public perception and cognition of complex data and enhances data reuse rates.

[Method/Process] By extracting 260 data news story titles from Xinhua Net and distilling high-frequency words, 27 health-related hotspot data news stories were identified. Based on grounded theory and employing qualitative analysis software NVivo11, three-level coding was conducted on the hotspot data news stories, ultimately yielding 11 initial categories of data news practice, which were further distilled into 6 main categories.

[Results/Conclusion] A theoretical model and characteristics of the data storytelling practice path were derived. Data stories can be applied to knowledge discovery, data interpretation, service value-added, and other aspects.

Full Text

Data Storytelling in Practice: An Analysis of Data Journalism

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Abstract

[**Purpose/Significance**] Data storytelling integrates data, visualization, and narrative to help the public perceive and comprehend complex data, thereby improving data reuse rates. [**Method/Process**] We extracted 260 data news story titles from Xinhua Net and identified high-frequency terms to select 27

health-related hot-topic data news stories. Using grounded theory and the qualitative analysis software NVivo 11, we conducted three-level coding of these data news stories, ultimately obtaining 11 initial categories and 6 main categories of data news practice. [**Result/Conclusion**] This study yields a theoretical model and characteristics of the data storytelling practice path. Data stories can be applied to knowledge discovery, data interpretation, service value-added, and other aspects.

Keywords: data storytelling; data news; NVivo 11; grounded theory; logical narration

1. Introduction

The field of data science is dedicated to enhancing public data awareness. However, complex, obscure, dry, and dynamically growing massive datasets make it difficult for the public to extract valuable data resources and clarify relationships between data, resulting in high-value data resources being shelved [1]. R. Kosara and J. Mackinlay [2] note that humans excel at conveying information through stories and visualization. Data storytelling combines visualization and narrative to create semantic interconnections, endowing data with logic, revealing hidden value, and sharpening public data cognition. The data science field employs data storytelling to reveal implicit relationships between data, giving data the power to speak, explain, persuade, and guide.

Current research on data storytelling includes theoretical framework analysis, technical development, and scenario application. (1) **Theoretical Framework:** The concept of data stories lacks academic consensus, with related terms including data storytelling, visual storytelling, data narration, and data news, all manifesting as "data + visualization + narrative." Chao Lemen et al. [3] argue that data storytelling connects data to specific scenarios and uses narrative to reveal data relationships. F. El Oua et al. [4] define data stories as structured information organization typically represented through visualization. C. Zhang [5] proposes that the theoretical framework of data storytelling comprises the product layer, knowledge system layer, and user layer, aiming to externalize tacit knowledge to create new knowledge. Currently, data storytelling lacks a universal theoretical model, and a guiding framework urgently needs construction [6].

(2) **Technical Development:** Since the proposal of data storytelling, academia has explored automated story generation technologies, including designing automated generation systems and constructing technical framework guidelines. J. Ni et al. [7] used deep learning to extract triples from disaster news and graphically presented disaster event evolution, finding that data narratives help the public deeply understand disaster development. Chao Lemen [8] combined data science and data engineering to propose an automatic data story generation process and design a

reference architecture for story engineering. D. Shi et al. [9] developed a new data story generation system, Calliope, which automatically converts spreadsheet data into data stories and verified its operability through controlled experiments. H. O. Obie et al. [10] developed the Gravity system, which integrates the entire process of creating visual data stories, arranges visualization sets in logical sequences, supports coherent narration and visual effects, and reduces public cognitive load. Y. R. Cao et al. [11] proposed the VisGuide system to assist users in creating contextual visualization sequence data and structured data stories. While technology improves data story generation efficiency, system universality remains low and operational barriers persist for the public.

(3) **Application Scenarios:** Data storytelling applications mainly include data news, business presentations, academic communication [3], and open data [12]. Xu Xiangdong [13] identifies linear, combinative, and interactive narratives as three methods for news storytelling, providing theoretical support for "telling stories with data." Li Yan et al. [14] used text analysis based on the Data Journalism Handbook to elucidate data news storytelling principles. V. J. C. Arevalo et al. [15] argue that storylines in scientific communication enhance scientific innovation. N. Ó. Brolcháin et al. [16] note that data storytelling helps users of open data platforms better access raw data information. Wang Ping et al. [12] used single-case research and the "5W" communication theory to propose an implementation model for government open data storytelling.

In summary, data storytelling research remains exploratory: Most findings focus on data science, journalism, and computer science, with limited exploration in library and information science; Story generation technical methods have achieved results in computer science, but extension to other fields awaits verification; Universal theoretical frameworks and models need further exploration. Data news offers rich cases and mature practices for data storytelling, with methods, tools, and strategies worth borrowing. This study uses grounded theory to deconstruct the data news implementation process, clarifying data storytelling paths from a micro perspective.

2. Research Design

2.1 Research Method

Grounded theory is a flexible yet systematic qualitative research method that inducts new theory from raw data, allowing constructed theories to be traced back to original data, making it suitable for exploratory research stages [21-22]. As data storytelling practice remains in early development, grounded theory is appropriate. B. Glaser et al. [23] assert that "everything is data," including interviews, observations, reflections, texts, pictures, and videos, which can bridge the gap between theoretical and empirical research in social sciences. Since data news presentations are not raw materials, this study does not analyze data

news content but observes and summarizes the representational characteristics of texts, data, and images, which still constitute raw data. Following grounded theory principles—problem emergence → data collection → data processing → initial theory construction [24]—the overall research framework is shown in Figure 1 [Figure 1: see original paper].

2.2 Sample Selection

Xinhua Net is a domestic media organization that pioneered data news practice. Its "Data News"column covers extensive scope and leads peers in professionalism, having published nearly a thousand issues [25]. The column has 10 categories. Since "Political Economy" and "Lecture Room" are policy interpretation news, these categories were excluded. From the remaining 8 categories, 260 valid data news items were selected (collected from July 9, 2019, to July 9, 2020). The distribution of news types and quantities is shown in Table 1 .

Xinhua Net' s data news covers multiple life aspects with broad coverage, focusing on livelihood and hot events. The categories include: "Data View" (showcasing data visualization technology), "First Time" (reporting domestic major news through data storytelling), "Data on People' s Livelihood" (publishing public life events), "Data Geek" (black technology displays with limited content), "Knowledge Boost" (popularizing daily life knowledge), "Humanities Talk" (analyzing life trajectories and culture through data), "Health Decoder" (publishing health-related data news), and "Cartoon Life" (presenting anime through data graphics).

Analyzing data news titles helps identify hot topics. A word cloud generated using BDP is shown in Figure 2 [Figure 2: see original paper]. The 260 data news items mainly covered terms such as confirmed cases, Beijing, new cases, medical records, and pneumonia, showing a preference for health topics. Due to the COVID-19 pandemic, health became a social focus, leading to the selection of 27 health-related data news stories as the grounded theory sample.

2.3 Data Coding Process

Data news is an application of data storytelling, with planning, topic selection, theme refinement, data extraction, and visualization jointly constructing data stories [26]. Two PhD students completed the coding process, with results discussed by four PhD students and one domain expert, and theoretical saturation tested by one PhD student.

2.3.1 Open Coding Open coding is the initial stage of grounded theory, involving breaking down collected data and assigning concepts [27]. Xinhua Net data news exports in JPG and PNG formats as images, each representing a data news story composed of narrative text, data, and visual charts. Using NVivo 11, each news story was coded to summarize characteristics of data storytelling construction. Each trait appearing in a data news story was coded only once

regardless of frequency. Through constant comparison, discussion, and sorting, 413 original statements and 50 initial concepts (a1-a50) were obtained, refined into 11 initial categories (A1-A11). Due to space limitations, only partial data are listed; open coding results are shown in Table 2 .

2.3.2 Axial Coding Axial coding discovers relationships between categories through clustering based on open coding [28]. From the 11 initial categories, association, summarization, and integration yielded 6 main categories (B1-B6): multi-source data, narrative voice, visual effects, narrative logic, linked applications, and auxiliary information. Axial coding results are shown in Table 3 .

2.3.3 Selective Coding Selective coding deepens relationships between main categories, refines core categories, and describes phenomena through "storylines" [29,30]. This study systematically analyzed the 6 main categories, sorted their relationships with data storytelling practice, and established a relational structure shown in Table 4 .

2.3.4 Theoretical Saturation Testing Theoretical saturation tests grounded theory results using additional data to determine whether new categories emerge and whether sampling should stop [31]. Seven health-related data news items from Xinhua Net were selected for testing. One PhD student conducted the saturation test and found no new categories, indicating theoretical saturation.

3. Theoretical Model of Data Storytelling Practice Path

3.1 Original Data News Production Process

M. Lorenz [32] proposed the data news production process: Data → Filtering → Visualization → Story, shown in Figure 3 [Figure 3: see original paper]. Data is filtered, visualized, and interpreted in specific contexts to form stories. During this process, raw data transforms into meaningful knowledge, increasing public perceived value, especially when complex data (facts) are condensed into clear stories for easier public understanding and cognition. Lorenz's research provides macro-level theoretical guidance for data storytelling studies. Building on this foundation, this study focuses more on the narrator' s dominant role and the public' s micro-level cognition of data story generation paths, necessitating a more fine-grained construction of data storytelling practice paths.

3.2 Theoretical Model Construction

Based on the coding of data news, the visualization tools and data processing procedures in data news practice cannot be obtained through coding. To ensure a complete and systematic data news practice path, literature surveys

supplemented hidden information needed for data visualization conversion [3,33-35]. Finally, a theoretical model of the data storytelling practice path was constructed from six dimensions: narrative voice, multi-source data, visual effects, narrative logic, linked applications, and auxiliary information, shown in Figure 4 [Figure 4: see original paper].

3.3 Model Analysis and Discussion

3.3.1 Narrative Voice Narrative voice refers to narrators, including planners, editors, producers, and designers. Data visualization also requires technical personnel (IT technicians, data analysts, etc.). Data story narrative voice can be human or intelligent devices, breaking traditional narrative "author"authority. Narrative voice dominates data story production throughout the entire process of "topic selection → data filtering → visual effects → narrative." Narrators' professional levels directly affect final story quality, requiring narrative voice allocation based on story topics. Among the 27 health-related data news items, technical personnel used tools such as Excel, Power BI, Tableau, Python, and R for data preprocessing, rationality testing, and visual effects implementation, forming a clearly divided narrative voice chain.

3.3.2 Multi-Source Data Data is the core of data storytelling, primarily sourced from government open data, public data, scientific research data, and commercial data. For example, "Post-90s Health Anxiety" used three data sources: DXY' s "2019 National Health Insights Report," Alibaba Data, and Analysys' s "Post-90s Health and Wellness Secrets 2019," demonstrating data source diversity and objective rigor. Story topics fall into two types: theme-driven (investigative data news) and data-driven (routine data news) [36]. Theme-driven topics focus on social livelihood hot events, while data-driven topics are determined based on existing datasets. Theme-driven data news is more popular and efficient for communication [37]. Xinhua Net' s 27 data news items are mainly theme-driven, better matching audience preferences. After topic determination, data requires: preprocessing (deduplication, format standardization, and removal of abnormal/erroneous data) to ensure accuracy; and rationality testing to verify preprocessing results and ensure no abnormal or irrational data remains.

3.3.3 Visual Effects Based on the picture superiority effect [38], data news visual effects not only improve explicit memory but also stimulate implicit memory, regulating public cognitive meaning construction and reducing data interpretation complexity. Visual effects comprise three categories: visualization statistical charts, picture displays, and single data highlighting, with visualization statistical charts being the key category. Visualization presents data as digital images using computer graphics and image processing technology to intuitively reveal hidden information [39]. The 27 health-related data news items from Xinhua Net feature rich visualization statistical charts and picture displays. For example, dynamic charts combined with timelines and data maps

represent complex data dynamically to aid understanding. Single data highlighting displays individual numbers in eye-catching colors and font sizes within text, helping the public quickly capture key information. Data news visual effects essentially simplify news stories, emphasize themes, and convey clear, concise story messages.

3.3.4 Narrative Logic Data news narrative logic describes story panoramas through four categories: narrative form, narrative syntax, story title, and story background, forming a complete narrative structure. Narrative forms represent connection patterns between events, including: linear narrative (using timelines to show story beginnings, development, climax, and endings); extended narrative (extending main narratives to form associative narratives, predictive analysis, and spatiotemporal expansion); analogical narrative (listing different category information based on "variables" to discover data patterns); and networked narrative (reporting through information graph expansion) [40]. The 27 data news items shifted from traditional single-node to point-to-surface combined narratives, often using multiple forms simultaneously. For example, "Latest Facts on the New Coronavirus Pneumonia Epidemic" employed linear, networked, and analogical narratives. Narrative syntax includes explanatory, heuristic, exhortatory, and interrogative forms, enriching data presentation. Story titles highly condense content, while story backgrounds guide audiences and help narrators create atmosphere. Flexible narrative discourse connects multiple story plots (plot 1 + plot 2 + ···+ plot n) and matches them to multiple contexts (context 1 + context 2 + ···+ context n), achieving logical story coherence.

3.3.5 Linked Applications Data news application scenarios refer to carriers through which audiences receive data news stories, including mobile, tablet, and web interfaces. Although the 27 health-related data news items provided WeChat public accounts, mobile, and PC interfaces, problems remain: failure to adapt differentially across devices and absence of feedback mechanisms preventing audience evaluation of data news quality.

3.3.6 Auxiliary Information Auxiliary information provides audiences with more channels to understand data news, including design/production units, remarks, contact information, copyright statements, and URL links. As peripheral information throughout the data storytelling practice process, auxiliary information provides relevant channels for audiences to further obtain story information and facilitates sustained attention to data story development.

3.4 Characteristics of Data Storytelling

Based on the practice path, data storytelling exhibits three characteristics: using story backgrounds to guide audience situational perception; integrating information graphics to stimulate audience vision; and using logical storylines to connect audience cognitive schemata. Data stories introduce relevant,

rich, and interesting background information to stimulate audience curiosity and situational dependence, helping audiences clarify role settings, semantics, and behaviors within specific story contexts [41]. Information charts are selected based on data types, with different charts leading to different application scenarios [42]—K-line charts suit stock trading data, word clouds suit large text volumes and visual effects. Information charts stimulate visual perception. Storylines emphasize logical relationships or thinking structures between things [43], helping audiences deeply participate in data stories and enabling tacit-to-explicit knowledge transformation. Data stories can borrow storyline methods from arts and exhibitions to gradually guide audience understanding [44-45] and enrich cognitive schemata.

4. Practical Applications of Data Storytelling

Data exists across government, business, scientific research, and other domains. Data storytelling advances knowledge discovery and dissemination across disciplines. Exploring its practical applications promotes vertical extension and horizontal expansion.

4.1 Knowledge Discovery

Niu Li et al. [47] applied digital humanities concepts, methods, and technologies to archives, proposing a "discovery-reconstruction-storytelling" research path to reconstruct archival knowledge and narrate archival stories from multiple perspectives. For example, library, museum, and archive collections contain massive heterogeneous data resources. First, deep sequencing and fine-grained knowledge organization transform multi-dimensional data resources into knowledge resources. Second, based on data storytelling principles, transformed knowledge data are connected using narrative methods (e.g., spatial, linear, networked narratives) to clearly express hierarchical relationships between data, knowledge, scenarios, and events, forming point-to-surface plot structures. Finally, appropriate visualization methods are selected based on user needs. Applying data storytelling to knowledge discovery helps the public better perceive, interpret, and comprehend complex data to understand inherent knowledge and semantic relationships.

4.2 Data Interpretation

Big data technology can mine and visualize data but lacks narrative plots, hindering public interpretation. Data storytelling reveals hidden logical relationships, making massive data readable and helping audiences control data. In business, data storytelling application systems or apps can automatically generate data stories when users input data, reducing cognitive load. Additionally, enterprises use storytelling for brand marketing but now focus on consumer-centered stories to shorten psychological distance, shape brand/product images, and improve consumer participation [48]. Based on operational goals, enter-

prises collect and filter user-generated content to create data stories matching consumer cognition in specific scenarios, enabling consumers to quickly understand products and make reasonable decisions.

4.3 Service Value-Added

Data storytelling provides personalized services based on user interaction behaviors, achieving service value-added [49]. The internet has fostered a "screen-reading era" with fragmented, short, and fast reading habits that data storytelling efficiently accommodates [34]. In data stories, information graphics suit narrative spatial structures, positions, and details, while text suits abstract information, oral concepts, and logical conditions [50]. Combined encoding of graphics and text simultaneously activates multiple cognitive schemata, improving reading effectiveness. Libraries can generate universal stories from reader behavior data and display them through new media tools (network platforms, social systems, apps) to help readers select books and promote service value-added.

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