Interactive Narrative Research on Government-Citizen Interaction Data from a Distributed Cognition Perspective

Authors: Zhang Liman, Zhang Xiangxian, Sun Shaodan, Sun Shaodan

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Abstract

Purpose/Significance: Government-citizen interaction data holds significant value for improving social governance. This paper, from a distributed cognition perspective, applies interactive narrative concepts to the analysis of government-citizen interaction data, providing a novel perspective and research approach for efficiently conveying the value of such data. Method/Process: Drawing upon distributed cognition theory from psychology and interactive narrative concepts from story engineering, this study employs an interdisciplinary research methodology to identify and analyze the cognitive subject, cognitive object, and cognitive environment of interactive narratives for government-citizen interaction data. On this basis, an interactive narrative model for government-citizen interaction data is proposed from the cognitive object perspective, while the implementation pathway for such interactive narratives is explored from the cognitive environment perspective. Results/Conclusion: Compared with traditional static narratives, interactive narratives offer greater flexibility, and distributed cognition theory provides a systematic theoretical framework for implementing interactive narratives in government-citizen interaction data, offering important guiding significance for leveraging the decision-making empowerment value of such data.

Full Text

Research on Interactive Narrative of Government-Citizen Interaction Data from the Perspective of Distributed Cognition

Zhang Liman[1], Zhang Xiangxian[2], Sun Shaodan[1]
[1]School of Cyber Science and Engineering, Nanjing University of Science &

Technology, Nanjing 210094
[2]School of Business and Management, Jilin University, Changchun 130022

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Abstract

[Purpose/Significance] Government-citizen interaction data holds significant value for improving social governance. Grounded in the perspective of distributed cognition, this paper applies interactive narrative concepts to the analysis of government-citizen interaction data, offering a novel perspective and research framework for efficiently transmitting the value of such data. **[Method/Process]** Drawing upon distributed cognition theory from psychology and interactive narrative concepts from storytelling engineering, this study employs an interdisciplinary research approach to deconstruct the cognitive subject, cognitive object, and cognitive environment of interactive narrative for government-citizen interaction data. Based on this foundation, we propose an interactive narrative model from the cognitive object perspective and explore implementation pathways from the cognitive environment perspective. **[Result/Conclusion]** Compared with traditional static narratives, interactive narrative offers greater flexibility, while distributed cognition theory provides a systematic theoretical framework for implementing interactive narrative of government-citizen interaction data, offering important guidance for realizing the decision-making empowerment value of such data.

Keywords: Distributed cognition; Government-citizen interaction data; Interactive narrative; Data insight
Classification Number: G350

With the advancement of digital government construction, data has emerged as a new production factor, and leveraging the value of government data represents the key to empowering social governance and service decision-making [1]. Government-citizen interaction data, exemplified by 12345 government service hotlines, government social media platforms, and leadership email systems, contains public appeals, attitudes, and propositions [2], offering crucial value for governments to capture social sentiment promptly and identify governance shortcomings. Therefore, insightful analysis and cognitive utilization of government-citizen interaction data constitute essential measures for achieving data-driven management and decision-making.

Currently, both government agencies and third-party institutions have estab-

lished analysis platforms for government-citizen interaction data, aiming to achieve integrated collection, multi-dimensional analysis, and intelligent application. Examples include the "Efficient Fujian" 12345 Big Data Analysis and Judgment Platform [3], the Haikou Citizen Service Smart Linkage Platform [4], and the 12345 Social Sentiment Analysis Platform developed by third-party data companies [5]. However, these platforms' analytical capabilities largely remain at the level of statistical "daily reports," "weekly reports," or "visualization dashboards," lacking deep-level data mining and application. Moreover, they fail to adequately consider audience cognitive needs when presenting analytical results, resulting in suboptimal efficiency and effectiveness of data insight. As one method of data presentation, data narrative employs relevant technical methods and narrative strategies to represent the intrinsic logic and semantic relationships underlying data [6], conveying data value to audiences through intuitive and comprehensible storytelling forms, thus providing new insights for analyzing government-citizen interaction data. Nevertheless, current data narrative research primarily targets general users with limited cognitive and analytical capabilities [7], emphasizing narrative appeal to attract user attention while predominantly employing passive, unidirectional transmission modes that lack flexibility. Government workers, as public administrators, typically possess higher professional competence and certain data analysis capabilities along with autonomous insight awareness [8]. They prioritize how narrative products can assist different decision-making tasks over personal interest satisfaction. In such contexts, traditional unidirectional narrative models cannot meet their flexible data insight needs. Currently, research on applying interactive narrative to assist government insight into interaction data remains extremely scarce, particularly for this specialized user group.

Given these limitations, this paper employs interdisciplinary research methods to explore the feasibility of applying interactive narrative concepts to government-citizen interaction data analysis from a distributed cognition perspective. By analyzing the theoretical connotations of distributed cognition, we deconstruct the elemental relationships in interactive narrative of government-citizen interaction data. We subsequently propose interactive narrative models from both data-driven and user-driven perspectives and explore implementation pathways, aiming to deepen the theoretical framework of distributed cognition, expand application scenarios for interactive narrative, and provide new perspectives and guidance for realizing the decision-making empowerment value of government-citizen interaction data.

1.1 Government-Citizen Interaction Data

Government-citizen interaction data refers to large-scale behavioral or trace data generated during the interactive process where citizens submit appeals to government in the e-government context and government responds accordingly [9], reflecting the interconnected and interactive outcomes between citizens and government in social governance. This data possesses dual attributes of big data

and service governance [10]. On one hand, government-citizen interaction data is massive, multi-sourced, and significantly unstructured, posing challenges for efficient government cognition of public core appeals [8]. On the other hand, it holds rich social governance value, enabling governments to identify emerging, trending, and concentrated social issues [11], thereby providing foundations for precise governance and decision optimization.

Capturing public appeals constitutes the prerequisite for improving social governance [8]. Some scholars have employed data mining methods to identify appeals; for instance, Feng Xiaodong et al. used text mining to explore public interests and emotional tendencies [12], while Hu Jiming et al. extracted and presented appeal focal points from government Weibo comments using deep learning [13]. Additionally, given the strong decision-making orientation of interaction data, research on its decision-making empowerment value has become critical. For example, R.K. Das et al. identified appeal priorities from interaction data to clarify decision-making urgency [14], while O.B. Driss et al. proposed a text semantics-based appeal content analysis framework using government social media data to empower government decision-making practice [15]. These studies provide methodological references for extracting appeal information from objective interaction data, yet they exhibit certain limitations: First, they emphasize the data mining process while neglecting the presentation of mining results, potentially causing cognitive disconnects between data mining and utilization that affect value transmission. Second, information transmission modes predominantly feature unidirectional, static government acquisition, with relatively few studies on automatically extracting appeal information and proactively providing it to government agencies through interactive models. Third, they focus on specific aspects of appeal information without adequately integrating concrete decision-making scenarios, necessitating strengthened research on multi-dimensional comprehensive information acquisition.

1.2 Interactive Narrative

Data narrative represents a structured information combination that presents "insights discovered from data" through comprehensible "storytelling" [6]. Interactive narrative, as a type of data narrative, emerges from storytelling engineering against the backdrop of computer science and artificial intelligence development [16]. By opening interactive ports for audiences based on traditional data narrative, it transforms information acquisition from unidirectional static to bidirectional dynamic modes, supporting active audience participation in data exploration and analysis [17], and can thus be termed exploratory narrative or multi-perspective narrative. Compared with traditional unidirectional narrative, interactive narrative allows audiences to independently determine narrative sequence and acquired information, reshaping and presenting the same event from multiple angles [18], facilitating panoramic insight into data connotations and stimulating immersive mental experiences and emotional resonance through interactive engagement.

Initially applied primarily in electronic gaming, interactive narrative enables game plots to evolve based on player system inputs, presenting three-dimensional stories that linear narrative struggles to describe completely while generating player immersion and engagement through interactive behavior [19]. Under the "user-centered" philosophy, interactive narrative concepts have begun applying to data insight; for example, Alipay' s annual bill feature integrates, analyzes, and refines users' historical consumption data, employing human-computer interaction and augmented reality technologies to narratively present user consumption profiles [20]. In academic research, J. Oh et al. consider interactive narrative a powerful tool for data insight that enhances audience emotional engagement [21]; E. Segel et al. propose author-audience dual-driven narrative models for data journalism, achieving balance between authorial intent and reader discovery [16]; and T. Proskurina proposes an interactive narrative framework for strategic brand communication contexts, supporting users in autonomously creating information acquisition paths [22]. Although interactive narrative has seen some industry application, academic research remains underdeveloped, particularly in domestic contexts, lacking systematic theoretical foundations, especially regarding explorations and discoveries in applying interactive narrative to government data analysis.

1.3 Proposal for Interactive Narrative of Government-Citizen Interaction Data from the Distributed Cognition Perspective

Psychologists Hutchins et al. [23] first proposed distributed cognition theory based on traditional cognitive views (which posit human cognition as individual information processing). Subsequent scholars extended this theory, emphasizing that cognitive tasks are distributed across internal and external representations [24]. The "distribution" in distributed cognition refers to the scope of cognition involved, emphasizing the division of cognition about a particular matter into smaller cognitive components that leverage external aids such as tools and environments to achieve comprehensive understanding [25]. Since distributed cognition fully considers the complexity of cognitive activities, it provides a systematic research perspective applicable to multi-factor cognitive analysis processes involving cognitive subjects, objects, and environments.

Enabling government workers to gain insights from interaction data requires consideration of both data characteristics—for panoramic insight from massive datasets—and audience characteristics—to reduce cognitive load. Interactive narrative can both intuitively reveal multi-dimensional data connotations and support audience autonomy in altering narrative trajectories, offering a novel solution for interaction data insight.

The philosophy of distributed cognition aligns closely with the objectives of interactive narrative for government-citizen interaction data. Specifically: (1) Distributed cognition emphasizes forming comprehensive cognition through multi-

dimensionally distributed "small cognitions," facilitating panoramic insight into interaction data. (2) It posits that external tools can supplement individual cognitive capabilities, and data narrative can serve as an intuitive, comprehensible external tool, thereby guiding narrative product design. (3) It proposes that cognition also distributes across subjects' operational processes, focusing on subject-system interactive relationships and providing a theoretical framework for exploring interactive narrative pathways. Thus, distributed cognition can provide systematic cognitive paradigms and theoretical foundations for the overall design of interactive narrative for government-citizen interaction data, enhancing insight efficiency from a cognitive perspective and stimulating the decision-making empowerment potential of government data resources.

2. Elemental Analysis of Interactive Narrative for Government-Citizen Interaction Data from the Distributed Cognition Perspective

Traditional cognitive theory emphasizes the internality of cognitive subjects, considering subjects' cognitive abilities as determinants of cognitive effectiveness. In contrast, distributed cognition proposes that cognitive activities depend on the joint operation of all elements in the cognitive activity, constituting a holistic process involving cognitive subjects, objects, and all participating processes (cognitive environment) [26]. It emphasizes transferring partial cognition to subjects and environments through certain means to assist cognitive understanding, providing a systematic and feasible theoretical framework for efficient information cognition. The cognition of government-citizen interaction data in this study refers to government workers acquiring key information embedded in interaction data through specific methods in certain environments, forming decision-making judgments through insightful interaction with information. Combining the three elements of subject, object, and environment from the distributed cognition theoretical framework with the connotation of interaction data cognition, we construct a distributed cognition element relationship model, as shown in Figure 1 [Figure 1: see original paper].

2.1 Subject Element of Distributed Cognition

The subject element of distributed cognition refers to all initiators, leaders, or participants of cognitive activities, representing the basic unit for achieving cognition [27]. The cognitive subjects of government-citizen interaction data are government workers at various levels responsible for supervision, integration, analysis, and reporting of such data.

The essence of government workers' cognition of interaction data is a government big data analysis process oriented by task contexts, thus possessing both general data analysis requirements and domain-specific characteristics influenced by the dual factors of interaction data features and task contexts. Moreover, government workers are typically professionals with certain data analysis capa-

bilities, possessing stronger autonomous insight awareness and higher decision-making sensitivity than general users. They can conduct combined analysis and association discovery based on different decision-making scenarios, acquiring new insights through active exploration. Therefore, their cognitive needs concentrate on three aspects: (1) Multi-perspective insight: analyzing interaction data from multiple angles to reveal panoramic data connotations and provide comprehensive real-world foundations for government decision-making. (2) Narrative expression: reorganizing complex, disordered raw data with weak logical associations into schematic story forms that convey information plots and key elements in alignment with individual cognition. (3) Flexible analysis: constructing flexible, bidirectional data analysis models that enable government workers to independently select data scope, analytical dimensions, and presentation forms according to actual needs, satisfying data analysis requirements across different decision-making scenarios.

2.2 Object Element of Distributed Cognition

The object element of distributed cognition refers to the target of cognitive activities, emphasizing the transformation of originally complex and obscure cognitive objects into comprehensible "artifacts" through certain methods, delegating partial cognition to these "artifacts" [28] to reduce subjects' cognitive load [25]. From this perspective, the "artifact" in this study is the narrative product generated based on government-citizen interaction data, which assists government workers in insight into core information through narrative expression.

Since narrative products for government-citizen interaction data represent the result of organizing and representing data connotations using narrative tools in specific contexts, the object element primarily comprises three components: cognitive content, cognitive tools, and cognitive situation. Specifically: (1) Cognitive content refers to high-value information extracted from raw interaction data, such as appeal types and themes, appeal evolution trends, and public sentiment orientation, representing the ultimate goal of cognitive activities and the real-world foundation supporting government decision-making. (2) Cognitive tools are carriers of cognitive content designed to simplify cognitive tasks for government workers. The logically associated storytelling expression proposed in this study serves as an effective data cognition tool, guiding government workers to efficiently complete understanding, analysis, and application of content elements. (3) Cognitive situation refers to the realistic decision-making scenarios upon which cognitive content depends, such as daily supervision, public opinion early warning, and key issue detection. Placing cognitive content within specific situational frameworks can stimulate the guiding role of data resources in practice and trigger government workers' associative and creative behaviors.

2.3 Environmental Element of Distributed Cognition

The environmental element of distributed cognition refers to the comprehensive conditions, circumstances, and related matters in which cognitive activities occur, emphasizing the initiative and auxiliary role of the external environment [26] to guide cognitive subjects in transferring partial cognitive pressure to the cognitive environment [29]. Therefore, the interactive narrative proposed in this study constructs an "interactive" cognitive environment that enables cognitive objects to be transmitted to cognitive subjects through interactive systems.

Since the interactive environment emerges during subjects' cognitive processes toward objects, environmental elements rely on object elements and involve three aspects: content interaction, tool interaction, and situational interaction. Specifically: (1) Content interaction emphasizes the accurate transmission of government-citizen interaction data connotations, achieving efficient flow from cognitive objects to cognitive subjects. (2) Tool interaction focuses on the design and implementation of narrative forms, connecting narrative plots in ways that align with government workers' cognitive logic. (3) Situational interaction emphasizes the perception and satisfaction of differentiated task requirements to provide full-scenario data insight services. Within this interactive environment, the interactive system transmits government workers' data insight needs to cognitive objects while feeding back the core value of cognitive objects to subjects, achieving effective value transmission of government-citizen interaction data.

Therefore, implementing interactive narrative for government-citizen interaction data from the distributed cognition perspective should generate "artifacts" that assist government workers' cognition by employing narrative expression as the tool, core data resources as the content, and government decision-making as the situation. This enables government workers to gain panoramic insight into data connotations through interaction with "artifacts," reducing cognitive load and enhancing participation awareness and immersive experience through interactive narrative' s logical association, intuitive visualization, and flexible interaction.

3. Model Construction for Interactive Narrative of Government-Citizen Interaction Data from the Distributed Cognition Perspective

The preceding analysis indicates that cognitive subjects transfer partial cognition not only to "artifacts" but also to interaction processes with "artifacts." Therefore, implementing interactive narrative for government-citizen interaction data from the distributed cognition perspective primarily involves two stages: designing narrative products (focusing on data presentation results) and designing narrative systems (focusing on data exploration processes). The former requires preset narrative models to present data content in appropriate forms, while the latter necessitates exploring interactive pathways to clarify data exploration stages. This section investigates interactive narrative models for government-citizen interaction data, standardizing the logic and form of data

presentation to generate "artifacts" that satisfy government workers' cognitive and insight needs.

Distributed cognition emphasizes forming "comprehensive cognition"from "small cognitions" distributed across different levels. In interactive narrative, each user operation presents corresponding narrative products, enabling users to form "small cognitions" about specific data features. After multiple interactive stages, narrative plots detach from linear patterns and exhibit more complex narrative structures under the combined effects of data features and user operations, achieving balance between data value transmission and user cognitive understanding while completing "comprehensive cognition" of panoramic data connotations. Therefore, designing narrative models must both unleash data potential and consider user initiative, approaching from dual perspectives of data-driven and user-driven approaches. W. Weber et al., based on varying user participation levels, propose two interactive narrative modes: interface-responsive and path-selective [30]. The former achieves interaction through primary operations like clicking and dragging, following data characteristics to unfold narrative logic, while the latter employs more advanced operations like hovering and inputting to allow users to autonomously generate new data storylines, stimulating autonomous insight awareness. Drawing on this framework and combining cognitive objectives for government-citizen interaction data, this paper proposes two modes: embedded narrative under data-driven approaches and emergent narrative under user-driven approaches.

3.1 Data-Driven Embedded Narrative Mode

Embedded narrative, also termed "story within a story," embeds important storylines extracted from raw data into narrative trajectories before narrative initiation. Users trigger charts, audio, or animations on pages through selection, clicking, and dragging operations according to page prompts, thereby unfolding storylines layer by layer with interactive actions. Since embedded narrative enables users to gradually deepen data cognition along unfolding paths, its application to government-citizen interaction data narrative can leverage data initiative to achieve progressive data decomposition, extraction, and presentation according to data patterns, ensuring objectivity in data insight. Moreover, this "gradual unfolding" narrative form can display global information views within limited narrative interfaces while supporting further exploration of specific details, better aligning with user mental models that progress from simple to complex [31] and facilitating government workers' insight efficiency into data connotations.

Embedded narrative requires pre-setting narrative mainlines that trigger multi-dimensional plot development through different branch clues, ultimately reaching different story endings. The narrative structure presents a "trunk-branch-leaf" tree pattern, where the "trunk" represents the narrative framework or main axis, aiming to reveal overall data profiles; the "branch" represents narrative subplots, aiming for more detailed analysis and presentation of key nodes; and

the "leaf" represents concrete expressions of subplots, further enriching, interpreting, and extending branch plots. Users advance narrative mainlines layer by layer through interaction with the three-level "trunk-branch-leaf" structure, achieving data expansion and drilling. Drawing on this narrative structure, data-driven embedded narrative for government-citizen interaction data comprises three stages: overview, focus, and association, as shown in Figure 2 [Figure 2: see original paper].

(1) **Overview**: Generally, government-citizen interaction data contains multiple dimensions including publication and reply times, thematic content, involved government departments, and public satisfaction levels, with different dimensions revealing data connotations from different angles. Therefore, the overview stage should treat dimensions as units, presenting multi-dimensional data features in chart form through extraction, integration, and visual presentation after processing. This enables government workers to grasp macroscopic data profiles while accessing specific dimension details through further click interactions, achieving extended data presentation.

(2) **Focus**: This stage involves further revelation of specific dimension data, with "focus" manifesting in two aspects: First, based on data representation results and current tasks, government workers concentrate data insight focus on specific modules, such as prioritizing content expression of public appeals within current timeframes. Second, after selecting specific modules, data mining methods extract core focal features from data sets, such as extracting core theme words from appeal content, enabling government workers to rapidly focus on key data features and enhance insight efficiency.

(3) **Association**: This stage supplements, extends, and associates specific module data based on the "focus" stage. On one hand, detailed supplementation of specific module data assists government workers in extended interpretation of data connotations. On the other hand, associating specific module data with other relevant data achieves synergistic value transmission between data, supporting government workers in conducting deep-value associative insight through interactive behavior.

The embedded tree narrative structure drives plot extension through branch nodes without allowing cycles, ensuring each branch plot represents a complete story trajectory. Consequently, narrative logic remains strong, aligning with user cognitive patterns from simple to complex and general to specific. However, this narrative form primarily relies on data feature traction with user interaction as a secondary element, preventing government workers from altering preset unfolding trajectories and making it more suitable for daily monitoring or preliminary insight contexts of government-citizen interaction data.

3.2 User-Driven Emergent Narrative Mode

In emergent narrative, storylines are not predefined but rather provide users with preprocessed data modules and interactive ports as creative conditions, supporting free storyline combination according to individual needs and discovering new insights from derived plot results. Therefore, it can also be termed "heuristic" narrative with multiple divergent endings [32]. Emergent narrative demands higher autonomous insight awareness from users and suits personnel with certain data insight foundations and clear objectives. Government workers generally possess certain data processing capabilities and generate differentiated data insight needs across various decision-making scenarios. Utilizing emergent narrative forms can incorporate government workers' own insight capabilities into interactive analysis processes and enable autonomous narrative content adjustment according to different needs, offering greater flexibility.

Emergent narrative provides users with fundamental, relatively independent story fragments, supporting multi-storyline connection and exploration according to actual needs to ultimately achieve coherent narrative endings. Consequently, narrative structure presents a net pattern with interwoven yet orderly plots, generally comprising three elements: "node–storyline–outcome."Nodes refer to relatively independent narrative modules within the narrative system; storylines refer to narrative trajectories autonomously added by users after selecting relevant modules; and outcomes refer to final insights derived from selected module combinations. Drawing on this narrative approach, user-driven emergent narrative for government-citizen interaction data primarily implements through three steps: positioning, combination, and summary, as shown in Figure 3 [Figure 3: see original paper].

(1) **Positioning**: Government-citizen interaction data is divided into relatively independent data units by dimension and embedded within the interactive narrative system. Government workers locate data modules and applicable algorithms relevant to their needs from the data set. Therefore, the positioning stage also serves as the demand objective analysis stage and the initial interaction link with the narrative system.

(2) **Combination**: Target data units and applicable algorithms are combined to form story subplots. Using interactive actions like dragging and inputting, users sequence and combine these subplots, commanding the narrative system to describe analysis results in corresponding order. Users can also conduct personalized settings combining insight objectives and personal preferences, such as icon types and font sizes, forming targeted narrative instructions and transmitting them to the system.

(3) **Summary**: The system generates customized narrative results based on selected modules and combination requirements, forming concise, intuitive, and logically associated summary reports that provide government workers with targeted insights regarding specific real-world problems, assisting resource allocation, public opinion early warning, and government

decision-making.

The emergent net narrative structure grants users more autonomy, revealing further connections and clues through users' linking and 牵引 of narrative modules, ultimately presenting narrative outcomes that integrate individual cognitive needs. Therefore, emergent narrative emphasizes proactive user interaction, stimulating immersive experiences and innovative awareness through participation, making it suitable for government workers' deep exploration and flexible insight into interaction data under problem-oriented specific contexts.

4. Exploration of Interactive Narrative Pathways for Government-Citizen Interaction Data from the Distributed Cognition Perspective

Distributed cognition theory posits that users transfer partial cognition not only to "artifacts" but also to interaction processes with "artifacts." Therefore, exploring interactive pathways between users and narrative systems facilitates cognition from a process perspective. Interaction essentially represents dialogue between users and systems. This section first discusses the overall logic of interactive narrative for government-citizen interaction data, clarifying the dialogue logic between users and systems, then analyzes implementation pathways, clarifying dialogue stages. Through a series of interactive functions, the system provides "invisible" services during user interaction, thereby reducing cognitive load and operational barriers.

4.1 Overall Logic of Interactive Narrative for Government-Citizen Interaction Data from the Distributed Cognition Perspective

Interactive narrative encompasses two core stages: "interaction" and "narrative." The former relates to the user end, referring to government workers commanding the system to present corresponding narrative products through proactive interactive behaviors, while the latter relates to the data end, extracting core features from raw data and associating logical rules under technical support, presenting them through concise and intuitive narrative methods. Their communication interface is the user interface: government workers submit commands for completing certain events through the user interface, and upon receiving commands, the narrative system performs calculations according to certain rules, generating corresponding narrative products and presenting them to users through the interface, achieving bidirectional communication and real-time insight between users and data. The overall logic is illustrated in Figure 4 [Figure 4: see original paper].

"Narrative" serves as the prerequisite for "interaction," transforming raw government-citizen interaction data into narrative products with logical associations to provide rich information resources for interactive actions. The interactive system primarily involves two aspects: data processing and narrative presentation. Data processing emphasizes the data mining process, employing

technical methods such as statistical learning and natural language processing to extract core information from raw data, forming high-value information sets. Narrative presentation emphasizes the data utilization process, using visualization and rich media technologies to express core information through narrative forms, generating high-quality narrative products. "Interaction" serves as the condition for "narrative," with users feeding back insight needs to the system through operational instructions, based on which the system presents corresponding narrative products. User needs are primarily influenced by task scenarios and individual preferences. Government workers select appropriate narrative modes according to current decision-making tasks and assign narrative storylines based on individual cognitive habits, driving gradual narrative product expansion through interaction with the system. Therefore, the "interaction" and "narrative" stages are mutually complementary. Narrative products, as external cognitive tools, can assist government workers in understanding data connotations through intuitive visualization and strong logical advantages, while the interaction process incorporates government workers' insight requirements and knowledge systems into the data analysis framework, deepening data cognition through interactive pathways and stimulating more insight inspiration.

4.2 Implementation Pathway of Interactive Narrative for Government-Citizen Interaction Data from the Distributed Cognition Perspective

Distributed cognition theory posits that interactive processes can assist cognition. Therefore, the interactive narrative pathway explored from this perspective emphasizes the active value of narrative systems, where the system guides government workers to better clarify data insight objectives and comprehend data connotations during interaction, transforming previous interaction paradigms where users operated actively while systems responded passively. This forms bidirectional interaction between narrative systems and government workers, which can be divided into three overall stages: "goal-execution-evaluation." During this process, the narrative system employs certain service strategies to guide government workers in transferring partial cognition to the interaction process, presenting and optimizing narrative results based on conveyed insight requirements. Consequently, the system end follows the pathway of "task initiation-task analysis-result presentation-result optimization," while government workers transmit insight needs regarding interaction data to the narrative system through operational behaviors, judging and feeding back satisfaction levels during system presentation. Thus, the user end follows the pathway of "need analysis-need expression-value judgment-value feedback." The overall interactive pathway is illustrated in Figure 5 [Figure 5: see original paper].

(1) **Task Initiation–Need Analysis**: Task initiation represents the initial stage of the narrative system, while need analysis constitutes government workers' primary objectives when using the system. Their organic interaction not only enables government workers to perceive their own needs

but also allows the narrative system to initially capture insight objectives, preparing for subsequent analysis and execution. Specifically, the system end sets up scenario navigation, recommending narrative modes for different decision-making contexts through question-and-answer approaches, and reduces government workers' understanding deviations through functional explanations. Under readability principles, these operation prompts are conveyed to government workers at the user end, guiding them to gradually clarify current insight tasks and individual preferences during interaction, completing need analysis.

(2) **Need Expression–Task Analysis**: Need expression represents direct feedback of insight objectives, while task analysis constitutes the narrative system' s processing stage. Their interaction process also represents the transmission of insight needs from the user end to the system end. Specifically, government workers gradually clarify insight needs with system assistance, externalizing potential needs and conveying them to the narrative system through operational behaviors such as clicking, dragging, zooming, and page-turning. This process follows the convenience principle, simplifying interactive hierarchical structures to prevent multiple navigation jumps during interaction access and reducing operational barriers in need transmission. After receiving tasks, the system first describes them in machine language, then performs fine-grained decomposition of task objectives, proactively proposing execution strategies regarding narrative modes and logical configurations to transmit to the backend, commanding it to call corresponding data and algorithms for data processing in preparation for result presentation.

(3) **Result Presentation–Value Judgment**: Result presentation refers to narrative products generated according to operational instructions, while value judgment represents users'evaluation processes of narrative products. Their interaction process also represents the transmission of narrative connotations from the system end to the user end. Since narrative essence is "information transmission" [33], the system should consider both "what to transmit" and "how to transmit" during result presentation. On one hand, data mining algorithms extract main plots from raw data, connecting storylines through preset narrative structures (three-act structure, drill-down structure, etc. [6]) or user-free-configured logic, determining presentation forms based on Gestalt principles of proximity, similarity, closure, continuity, and simplicity. On the other hand, the transmission process should follow the multi-channel principle, employing multimodal forms (charts, text, audio, etc.) to describe data connotations. After obtaining narrative products, government workers conduct value judgments on their quality, measuring accuracy, readability, and usability against insight objectives to determine whether current narrative products satisfy needs, forming autonomous judgment opinions.

(4) **Value Feedback–Result Optimization**: Value feedback represents the

process where users resubmit opinions and requirements to the system, while result optimization refers to the system' s subsequent revision and supplementation based on this feedback. Their interaction enables the narrative system to continuously approximate user needs, ultimately achieving convergence between user needs and narrative products. On one hand, government workers evaluate interactive narrative effects against expected insight objectives. If provided narrative products achieve expected goals, needs are satisfied and the interaction process concludes. If goals remain unachieved, or if new insight needs emerge during interaction, government workers feed back current insight opinions to the system, which reanalyzes insight intentions and conducts task analysis based on the immediacy principle, re-executing narrative product generation, presentation, and transmission operations to output new narrative results for government workers until task completion. During this process, the narrative system also proactively proposes service solutions based on parsed user objectives, providing government workers with new data insight ideas.

Evidently, the implementation pathway of interactive narrative for government-citizen interaction data from the distributed cognition perspective is primarily driven by the narrative system, which guides government workers to transfer data cognition requirements to the interaction process through proactive inquiry, push, and optimization actions. The system generates appropriate data narrative products accordingly, effectively reducing data cognition thresholds while leveraging government workers' autonomous insight awareness, thereby enhancing data insight efficiency and effectiveness.

Compared with general unidirectional data narrative, interactive narrative can incorporate users' autonomous analysis awareness into the narrative process, offering greater flexibility and better satisfying data insight requirements of government workers with certain professional knowledge and data analysis literacy. Applying interactive narrative concepts to government-citizen interaction data analysis can unleash data vitality while reducing users' cognitive burden, achieving effective transmission of decision-making empowerment value.

At the theoretical level, this paper innovatively applies the distributed cognition theoretical framework to analyze constituent elements of interactive narrative for government-citizen interaction data, deconstructing cognitive subjects, artifacts, and interactive cognitive relationships between them. From the artifact perspective, we propose two narrative modes—embedded and emergent—reducing subjects' cognitive load through generating logically associated narrative products. From the interactive relationship perspective, we explore a "goal-execution-evaluation" interactive pathway, assisting subjects' cognitive insight through the interactive coupling between user needs and narrative systems. This research further 完善了 the distributed cognition theoretical system, enriches theoretical foundations for interactive narrative, expands its application scenarios, and provides new research perspectives and theoretical foundations for government-citizen interaction data analysis.

At the practical level, this research offers realistic guidance for insight and application of government big data. On one hand, government-citizen interaction data plays an important role in social governance, and interactive narrative can serve as an effective tool for mining and utilizing such data, helping break data silos, activate data value, optimize the "data-governance" ecological chain, and advance digital government construction. On the other hand, interactive narrative supports government workers in customizing data presentation modes and pathways according to task contexts and actual needs, with storyline evolution changing based on inputs to the narrative system. This transforms previous cognitive paradigms of passive acceptance and linear data resource acquisition, providing feasible application solutions for improving government workers' data insight efficiency and effectiveness.

Since current research applying interactive narrative concepts to government-citizen interaction data remains extremely scarce, this paper primarily focuses on theoretical feasibility discussions and overall research 思路 for interactive narrative of such data. Moreover, due to space limitations, the practical application process of interactive narrative cannot be demonstrated within a single article. Subsequent research will further refine research granularity based on this foundation, employing prototype systems and other methods for application exploration of interactive narrative for government-citizen interaction data, enhancing this study' s application value and generalizability.

Author Contribution Statement

Zhang Liman: Manuscript writing and revision
Zhang Xiangxian: Topic guidance
Sun Shaodan: Manuscript proofreading

References

[1] Zhang Bin, Yang Wen. Research on the optimization of government information resource governance system in China in the digital era[J]. Library and Information Service, 2020, 64(11): 3-10.

[2] Hu Guangwei, Teng Jie, Liu Lu. Research on social appeal theme mining and inter-provincial differences in government-citizen interaction: Analysis based on provincial government leadership email corpora[J]. Data Analysis and Knowledge Discovery, 2021, 5(10): 15-27.

[3] Fujian Provincial People' s Government. 12345 Big Data Analysis and Judgment [EB/OL]. http://www.fujian.gov.cn/hdjl/.[2022-8-22].

[4] Haikou Municipal People' s Government. 12345 Government Service Convenience Hotline [EB/OL]. http://12345.haikou.gov.cn/12345gzjb/.[2022-5-27].

[5] DataTom. 12345 Social Sentiment Analysis Platform [EB/OL].http://www.datatom.com/cn/case/case-governance/analysis/.[2022-5-27].

[6] Chao Lemen, Zhang Chen. Data Storytelling: From Data Perception to Data Cognition[J]. Journal of Library Science in China, 2019, 45(05): 61-78.

[7] Zhou Xia, Wang Ping, Chen Weidong, et al. Government Open Data User Cognitive Schema Connection Model: From the Perspective of Data Story[J]. Information and Documentation Services, 2021, 42(04): 64-71.

[8] Zhang Liman, Wu Peng, Yin Xicheng, et al. Storytelling Description of Public Appeals in Government-Citizen Interaction Data: Integration, Reconstruction and Narrative [EB/OL].http://kns.cnki.net/kcms/detail/11.1762.G3.20221025.1134.006.html .[2022-12-27].

[9] THIERRY M , PRIYAMBODO T K . SMS and Web-Based e-Government Model Case Study: Citizens Complaints Management System at District of Gihosha -Burundi[J]. Indonesian Journal of Computing and Cybernetics Systems, 2017, 11(1): 67-76.

[10] Ma Liang, Zheng Yueping, Zhang Caiwei. Government Hotline Big Data Empowering Urban Governance Innovation: Value, Status and Issues[J]. Document, Information & Knowledge, 2021(02): 4-12+24.

[11] Li Guihua, Lin Siyan. Research on Smart Emergency System Based on Social Appeal Data[J]. Information Studies: Theory & Application, 2022, 45(05): 123-132.

[12] Feng Xiaodong, Ma Jie, Jiang Guoyin. Social Trust, Rational Behavior and Government Weibo Communication: An Empirical Study Based on Text Mining[J]. Journal of the China Society for Scientific and Technical Information, 2019, 38(9): 954-965.

[13] Hu Jiming, Zheng Xiang, Cheng Qikai, et al. Extraction and Focus Presentation of Public Opinion Views from Government Weibo Based on BiLSTM-CRF[J]. Information Studies: Theory & Application, 2021, 44(1): 174-179+137.

[14] DAS R K , PANDA M , DASH S. Prioritizing Public Grievance Redressal Using Text Mining and Sentimental Analysis[C]// 3rd International Conference on Advanced Computing and Intelligent Engineering (ICACIE).Advanced computing and intelligent engineering, INDIA: Inst Tech Educ & Res Siksha O Anusandhan, Bhubaneswar, 2018: 273-284.

[15] DRISS O B, MELLOULI S, TRABELSI Z. From citizens to government policy-makers: Social media data analysis[J]. Government information quarterly, 2019, 36(3): 560-570.

[16] SEGEL E, HEER J. Narrative visualization: Telling stories with data[J]. IEEE Transactions on Visualization and Computer Graphics, IEEE, 2011, 16(6): 1139–1148.

[17] AYLETT R, LOUCHART S . Being there: participants and spectators in interactive narrative[C]// ICVS' 07 Proceedings of the 4th international conference on Virtual storytelling. using virtual reality technologies for storytelling.

Berlin, Heidelberg: Springer, 2007: 117-128.

[18] RIEDL M O, BULITKO V. Interactive Narrative: An Intelligent Systems Approach[J]. AI magazine: Artificial intelligence, 2012, 34(1): 67-77.

[19] Crawford C. Chris Crawford on Interactive Storytelling[M]. Fang Zhou trans. Beijing: Posts & Telecom Press, 2015.

[20] Baidu Baike. Alipay Annual Bill [EB/OL]. https://baike.baidu.com/item/支付宝年度账单/12815724?fr=aladdin. [2022-12-30].

[21] OH J, LIM H S, Copple J G , et al. Harnessing the Persuasive Potential of Data: The Combinatory Effects of Data Visualization and Interactive Narratives on Obesity Perceptions and Policy Attitudes[J]. Telematics & Informatics, 2018, 35(6): 1755-1769.

[22] PROSKURINA T. Narrative visualizations: using interactive data stories in strategic brand communication[EB/OL].https://lup.lub.lu.se/studentpapers/search/publication/8949586. [2022-6-10].

[23] HUTCHINS E L, KLAUSEN T. Distributed cognition in an airline cockpit[M]//Engestrom Y, Middleton D. Cognition and communication at work. New York: Cambridge University Press, 1996: 15-34.

[24] NILSSON M , LAERE J V , SUSI T , et al. Information fusion in practice: A distributed cognition perspective on the active role of users[J]. Information Fusion, 2012, 13(1): 60-78.

[25] He Mingrui, Li Yongjian. Research on Tacit Knowledge Externalization Based on Distributed Cognition[J]. Journal of Intelligence, 2010, 29(08): 49-54.

[26] Zhou Guomei, Fu Xiaolan. Distributed Cognition: A New Cognitive Perspective[J]. Advances in Psychological Science, 2002(02): 147-153.

[27] WILSON E , SEIFERT C M , Durning S J , et al. Distributed cognition_ interactions between individuals and artifacts[J]. Diagnosis, 2020, 7(3): 343-344.

[28] Zhang Huijun, Zhang Xiaolong. Research on Complex Cognitive Activities in Visual Analytics[J]. Journal of Computer-Aided Design & Computer Graphics, 2018, 30(01): 57-67.

[29] Han Zhengbiao. Research on Driving Factors of Mental Model Evolution of Literature Database Users Based on Distributed Cognition[J]. Journal of the China Society for Scientific and Technical Information, 2017, 36(01): 79-88.

[30] WEBER W , RALL H M . Between data visualization and visual storytelling: the interactive information graphic as a hybrid form.[C]// 2012 Annual Conference of International Communication Association. Phoenix, Arizona, 2012: 1-37.

[31] Yu Han. Research on Interactive Information Visualization Applications[D]. Beijing: Beijing Institute of Technology, 2016.

[32] SMITH E. Thread structure: Rewriting the Hollywood formula.[J]. Journal of Film & Video, 2000, 51(4): 88-96.

[33] Ding Jiayou, Tang Xinyu. Research on Data Narrative and Its Application from the Perspective of Digital Humanities[J]. Information Studies: Theory & Application, 2022, 45(02): 121-128.

Note: Figure translations are in progress. See original paper for figures.