Unveiling The Dynamics of Digital Action: Exploring Text Accumulation

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Abstract

The aim of this paper is to synthesize the intrinsic dimensions of the subject with analytical sociological models of collective action, thereby uncovering a more universally applicable framework for roles and interactions within digital action contexts. This paper posits Text Accumulation as an explanatory mechanism for online collective action. Text Accumulation phenomenologically characterizes the concentration of actor engagement within specific areas of the Internet. This paper delineates the internal mechanisms governing the fluctuation of Text Accumulation, contingent upon dimensions such as media dissemination, technological regulations, and self-cognitive processing. We integrate adaptive networks, stochastic games, and neighborhood mimicry strategies to formulate a comprehensive stochastic dynamics model—a type of Agent-Based Model (ABM).

Keywords: Text Accumulation, self-integration, collective action, ABM

1. Introduction

Research in disciplines like digital sociology and political communication has long emphasized the significance of digital action. Within the realm of online collective action, scholars have predominantly engaged with two overarching perspectives. One approach views digital action as politically significant, focusing on identity change and the forms of collective action on the internet(Shahin, S., Ng, Y. M. M. , 2022). Conversely, another viewpoint emphasizes the pervasive dissemination of opinions and emotions on social media platforms, drawing parallels to Le Bon's concept of Crowd Behavior(Neubaum, G., Krämer, N. C. , 2017).The former simplifies the internal dimensions of actors, focusing on macro-level action states, while the latter characterizes collective psychology itself using theories from social psychology such as Intergroup Emotion Theory (IET)(Mackie, D. M., 2008). Meanwhile, theoretical strand within digital sociology emphasizes the role of the internet in creating fragmented subjects(Turkle Sherry, 2011).

There exists an explanatory gap between psychology and group dynamics, making it difficult for existing research to engage in dialogue with each other. ABM helps bridge the gap between micro and macro research perspectives. This article extracts core assumptions from social psychology, sociology, and communication studies, proposing mechanistic explanations for the evolution of internet collective action from micro to macro levels and formalizing them. Finally, these explanations are validated using an Agent-Based Modeling (ABM) approach.

2. Conceptual Definition and Variable Explanation

2.1. Conceptual Definition

Text Accumulation phenomenologically characterizes the concentration of actor engagement within specific areas of the Internet. It refers to the textual scale, consistency, and emotional intensity of text production within a specific online domain. It serves to characterize the dissemination of information across public internet platforms and its influence on actors' actions.

self-integration. Individuals possess dynamic cognitive-emotional-action systems and interpersonal self-construction systems, which form the basis of self-identity and a unified psychological state. Self-integration is an internal retrospective-constructive process through which individuals reconcile and construct their actions. Central to our mechanisms is the concept of "self-integration" which hinges on two primary factors. Firstly, it underscores individuals' introspection regarding their behaviors, manifested through micro-actions like liking or commenting. Secondly, it relies on the coherence of meanings within individuals' social trajectories, indicating the extent to which multiple micro-actions are interconnected. The manifestation of individuals' micro-actions within media spaces varies significantly based on their perceived roles and levels of self-integration. For instance, individuals who identify as "prudent staters" and exhibit high levels of self-integration are less inclined to conform to crowd behavior or engage in random commentary.

2.2. Variable Explanation

The variables required for the mechanism in this paper include Individual speech behavior; Individual referencing behavior; Individual self-reflection degree and self-integration degree; and Individual self-role, which respectively provide formal definitions for individual speech behavior, referencing behavior, self-reflection degree, self-integration degree, and individual role.

The following formulas express the individual i's speech at time t (as in formula 1), along with the region l's new speech

state at time t (formula 2).

$$\begin{aligned} X_i(t) &= (x_i^1(t)...x_i^N(t)) \\ &= (M_i^1(t)...M_i^N(t)) \odot (Y_i^1(t)...Y_i^N(t)) \\ &\in (0 \cup S^k)^N \\ &M_i^1(t) \in \{(0)_k, (1)_k\}, \\ &\| \ x_i^l(t) \ \| = 0 or 1 \end{aligned} \tag{1}$$

$$A_l(t) = \underset{i \in V}{U}\{X_i^l(t)\}, A[\,0 : t\,] = \underset{0 \le m \le t}{U} A_l(m) \tag{2}$$

In these formulas, S_k normalization implies that the direction of $x_i^l(t)$ represents viewpoints, with the angle representing the difference in viewpoints.

Viewpoint polarization implies $A_l = \{x_1, x_2\}$,and $\text{simcos}(x_1, x_2) \approx 0$

M indicates whether one is speaking, and Y represents opinions.

Assume only one issue is being considered, then let $Y_i^m(t) = Y_i^n(t), \forall m, n \in \{1, ...n\}$ be denoted as $Y_i(t) \in S^k$.

$\odot$ represents the Hadamard product.

The following formulas represents the individual i's referencing behavior, the C represents comment and the D represents denial.

$$R_i(t) = (R_{i1}(t)...R_{in}(t)) \in Z_i^n \tag{3}$$

and

$$R_i(t) = C_i(t) \oplus D_i(t) \tag{4}$$

Moreover, the self-reflection degree of individual is $T_i(t) \in [\,0, 1\,]$ and the self-integration degree of individual is $I_i(t) \in [\,-1, 1\,]$.

The role of the individual can be categorized into two types: one type pertains to active participants in relevant topics, while the other refers to dormant participants. It can be represents as $R_i \in \{-1(doramnt), 1(active)\}$

3. Mechanisms

3.1. The Attributes of Online Action

The actions on the internet manifest as a form of information dissemination, primarily presented through symbolic text.

Unlike offline interactions, in the online spaces engineered for public discourse by algorithms, each new interactive piece of information serves as a "site" for discussion. Unless under specific settings, these pieces of information have the potential to be seen by subscribers and non-subscribers alike.

Due to the fact that interaction within these spaces doesn't require physical presence, online interactions possess spatial transcendence. These spaces, due to algorithmic design, offer various low-cost interaction methods, allowing an actor to generate numerous online actions with low barriers to entry.

Within this vast textual environment, individual attention remains limited. Due to differing feedback mechanisms set by algorithms, these micro-actions enter human actors' self-awareness either reinforced or weakened, thus mediating human perception of the consequences of their actions.

Furthermore, apart from the low threshold of digital actions, as a form of information interaction, its dissemination rules differ from those in physical space. Cyberspace is a topological space, where nodes and relationships determine its core.

As online spaces are not confined by physical space but possess a topological structure, the distance between actors in this topological space depends on the continuity and intensity of interaction. Due to the uncertainty of whether micro-actions by actors bring feedback influenced by algorithms, and given the strong publicity of spaces, the distance between different actors in these spaces undergoes significant changes over time.

The essence of the small-world phenomenon lies in the fact that networks are not homogeneous and have central nodes. The uneven topological structure of the World Wide Web exhibits characteristics of power-law distribution. The more spaces for interaction and dissemination that are engaged by a greater number of actors, the more they attract further continuous participation, leading to the aggregation of texts.

3.2. The Relation Between The Self and Online Action

Continuous interaction can reproduce social relationships in three aspects: (1) the reproduction of actors' roles (including positions and linguistic traits), (2) the reproduction of relationships between actors, and (3) the reproduction of norms throughout the interaction.

Human beings possess organized dynamic cognitive-emotional-action systems and interpersonal self-construction systems, which form the basis of self-identity and a unified psychological state.

The issuance of social actions by human actors typically involves certain motivations, which may be immediate or ongoing. In spaces where publicity is strong and actions are encouraged by algorithms, even immediate motivations can lead to visible actions, leaving textual traces.

Self-integration and subsequent perception of behavior constitute an intrinsic retrospective-construction process. Attitudes and perceptions towards behaviors generated online are related to whether platforms provide feedback on these behaviors.

Due to the uncertainty of distances between actors in online spaces with strong publicity, it becomes challenging for different actors within the same space to reproduce stable and widely recognized social relationships (or situations/contexts). Conversely, in more closed-off spaces with relatively equal levels of interaction between actors, such as QQ groups, stable social relationships can be formed, and roles, interpersonal relationships, and norms can be continuously reproduced through interaction.

Due to the continuous influx of new information, for individual actors engaging in ongoing interactions in highly publicized spaces, unless they specifically arrange to interact in a new space (such as adding a personal account or joining a group), the number and intensity of interactions decrease over time. Eventually, new interactions cease, and the reproduction of relationships among these core actors also stops, leaving behind

only textual traces. In essence, individual instances scarcely produce sustained social relationships.

Even if sustained social relationships are established, due to the continuous emergence of new spaces and their large numbers, the process of new viewpoint interactions repeats rapidly and incessantly. Typically, each participation by an actor occurs in unfamiliar spaces without established social relationships.

These processes lead to a greater gap between the behavior of actors in online actions and their self-awareness compared to offline actions. This gap needs to be addressed through a self-integration process to shape self-identity, which often neglects many low-threshold online actions.

3.3. Text Accumulation and online Action

The more a space aggregates text, the more it attracts participation. Under typical algorithm settings, spaces with higher participation already contain a plethora of viewpoints. (1) Simply through micro-actions like liking or copy-pasting, one can replace the process of expressing oneself through typing. (2) Even if one expresses oneself through typing, they are more likely to get lost amidst the text. Hence, the more a space has already aggregated text (or surpassed a certain level of aggregation), the less likely it is for the actions of participating actors to be responded to by other actors. Consequently, it becomes less likely for them to become actors engaging in continuous interaction within that space. In other words, within the networked social actions under conditions of text aggregation, the social roles of actors do not exist within a context of continuous reproduction through action.

Apart from actions and interactions displayed on personal pages, the process of self-integration brought about by other actions is influenced by algorithms, leading to increased fluctuations in the degree of self-integration and stability of social roles when engaging in a particular action.

Text accumulation as an inevitable trend in social actions within spaces of high publicity further amplifies the influence of algorithms on actors' self-awareness. This diminishes actors' perception of the consequences of their actions, thereby promoting further text aggregation.

4. Formalization

Based on the relationships between the concepts described above and the mechanisms of mutual influence, this section formalizes the mechanism and describes the evolutionary process mentioned earlier.

4.1. Similarity Mapping

$$Sim\_cos(x,y) = \frac{X^T\ Y}{||X||||Y||} = X^T Y(x,y \in S^1) \tag{5}$$

$$\begin{aligned} S\_Sim(x_i(t)) &= \sum_{k,l} Sim\_cos(x_i^k(t), x_i^l(t) \\ &= \frac{\frac{1}{n^2}\sum_{k,l} \mathbf{x_1^k(t)}^\top x_i^l(t)}{||x_i^k||||x_i^l(t)||} \\ &= \frac{1}{n^2}\sum_{k,l} \mathbf{x_1^k(t)}^\top x_i^l(t) \in [-1,1] \end{aligned} \tag{6}$$

$$\begin{aligned} I\_Sim(x_i(t), x_j(t)) &= \frac{1}{n^2}\sum_{k=l}^{N} Sim\_cos(x_i^k(t), x_i^k(t) \\ &= \frac{1}{N}\sum_{k=l}^{N} \mathbf{x_1^k(t)}^\top x_i^k(t) \in [-1,1] \end{aligned} \tag{7}$$

4.2. Mechanism of Evolution

This section includes the evolution of text, referencing behavior, self-reflection, and the degree of self-integration.

First, let's consider the process of text evolution. Take k=1:

$$Y_i^*(t) = exp(2\pi I\theta_i(t)) = exp(IY_i(t)), \theta_i(t) \in [0,1] \tag{8}$$

The following formula represents whether an actor speaks depending on the individual's role, degree of self-integration, and the similarity of the text's opinion:

$$\begin{aligned} &P(M_i^l(t+1) = 1) \\ &= F(R_i, I_i(t+1), \frac{1}{K}\sum_{Y_i(t)} I\_Sim(Y_i^*, Y)) \end{aligned} \tag{9}$$

The following formula represents the evolution of indexing behavior, describing that both large and small differences in opinions can trigger indexing behavior, meaning individuals tend to express supporting or opposing opinions:

$$\begin{aligned} P(R_{i,j}(t+1) = 1) = G(&Sim\_cos(Y_i^*(t+1), Y_j^*(t+1), \\ &\frac{1}{Sim\_cos(Sim\_cos(Y_i^*(t+1), Y_j^*(t+1)}) \end{aligned} \tag{10}$$

The evolution of self-reflection is influenced by the number of times an individual's speech is indexed.

$$\begin{aligned} T_i(t+1) &= H(\frac{\sum_{j\in V} R_{ji}(t)}{\sum_{k,l} R_{kl}(t)} \\ &= \frac{\sum_{j\in V} R_{ji}(t)}{\sum_{k,l} R_{kl}(t)} \end{aligned} \tag{11}$$

The degree of self-integration is influenced by the self-reflection and the consistency of self-awareness.The interaction

rules between them are as follows:

$$
\begin{aligned}
I_i(t+1) &= J(T_i(t+1), S\_Sim(x_i(t))) \\
&= \beta J_i(t+1) + (1-\beta) S\_Sim(X_i(t)) \\
&= \frac{\beta \bullet \sum\limits_{J \in \vee} R_{ji}(t)}{\sum\limits_{k,l} R_{k,l}(t)} + (1-\beta) \frac{1}{\{Rkl(t) \neq 0\}} \sum_{k,l} \mathbf{X_i^h(t)}^{\top} x_i^l(t)
\end{aligned}
\tag{12}
$$

4.3. Operating Rules

$$F(x_1, x_2, x_3) = \alpha x_1 x_2 + (1-\alpha) x_3 \tag{13}$$

$$G(x_1, x_2) = x_1 + x_2 \tag{14}$$

$$H(x) = x \tag{15}$$

$$J(x_1, x_2) = \beta x_1 + (1-\beta) x_2 \tag{16}$$

Based on the above evolutionary mechanisms, we have derived preliminary relationships between self-integration and viewpoint evolution. In the next section, we simulated these mechanisms and obtained some preliminary evolutionary patterns and conclusions.

5. Simulation

The paper has currently drawn some exploratory conclusions, from which several rules regarding Text Accumulation have been summarized. We provide an overview and explanation of an Agent-Based Model (ABM) developed to simulate the dynamics of opinion formation in online social networks. The ABM aims to investigate how individual behaviors contribute to the emergence of collective phenomena.

The ABM operates under the following assumptions:(1)Agents have bounded rationality, they have different degrees of self-integration;(2)They are affected by the environment, our paper, is mainly about Text Accumulation;(3)The accumulation of texts and self-integration do not have a one-way influence but rather interact cyclically, leading to further aggregation of network texts.

In the simulation results obtained in this paper, the following conclusions can be drawn:

Figure 1 illustrates the influence of self-integration/role on the quantity of text. The horizontal axis represents the range of self-integration levels from 0.3 to 0.7, while the color reflects the proportion of roles. It can be observed that as the degree of self-integration increases, the quantity of text also increases.

Figure 2 illustrates the relationship between the number of texts and different proportions of roles, under a specific degree of self-integration. As the proportion of active participants increases (from blue to brown), the number of texts also increases.

Figure 3 reflects the changing distribution of opinions within the model. It shows that the distribution is relatively concentrated in the initial stage, becomes more diverse and complex in the middle stage, and eventually returns to a relatively concentrated state in the later stage.

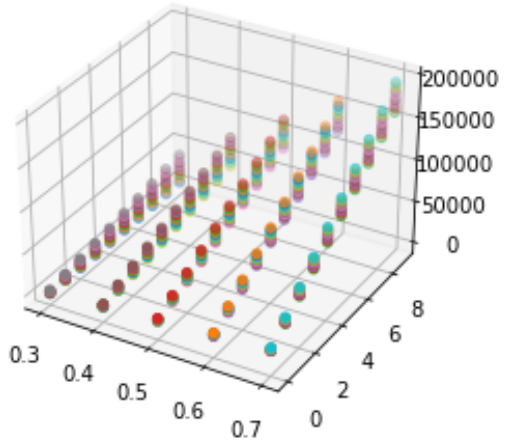

Figure 1: The influence of self-integration on the quantity of text

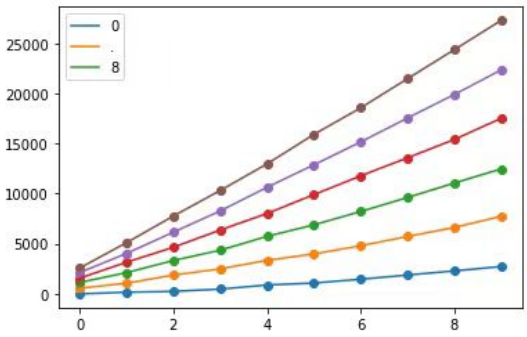

Figure 2: The influence of roles on the quantity of texts

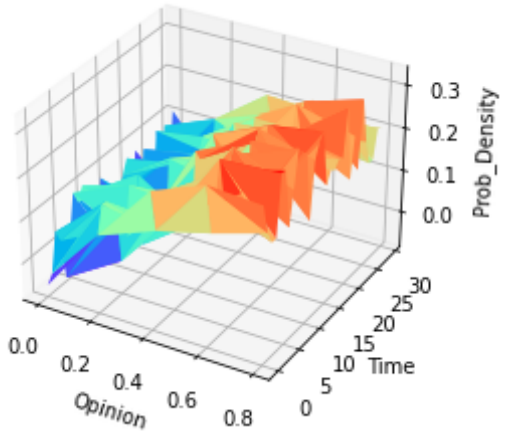

Figure 3: The change in viewpoint distribution

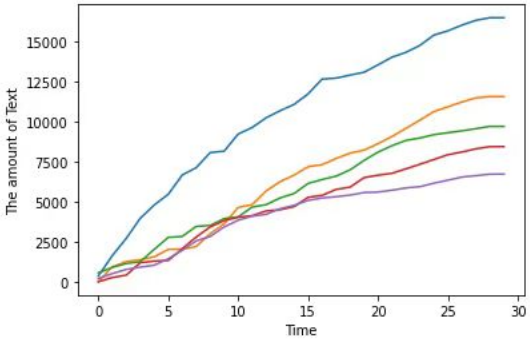

Figure 4: The impact of viewpoint polarization on text Accumulation

The final figure illustrates the impact of opinion polarization on the aggregation of text in different regions. The blue and orange areas represent regions with higher levels of polarization, where the quantity of text is relatively higher.

6. Summary

At the model level, this paper delineates the internal mechanisms governing the fluctuation of Text Accumulation, contingent upon dimensions such as media dissemination, technological regulations, and self-cognitive processing. Central to these mechanisms is the concept of "self-integration," which hinges on two primary factors. Firstly, it underscores individuals' introspection regarding their own behaviors, manifested through micro-actions like liking or commenting. Secondly, it relies on the coherence of meanings within individuals' social trajectories, indicating the extent to which multiple micro-actions are interconnected. The manifestation of individuals' micro-actions within media spaces varies significantly based on their perceived roles and levels of self-integration. For instance, individuals who identify as "prudent staters" and exhibit high levels of self-integration are less inclined to conform to crowd behavior or engage in random commentary. Collectively, these intrinsic mechanisms furnish the microfoundations essential for comprehending and modeling digital actions and the phenomenon of Text Accumulation.

At the modeling level, drawing from the outlined patterns and mechanisms, we integrate adaptive networks, stochastic games, and neighborhood mimicry strategies to formulate a comprehensive stochastic dynamics model—a type of Agent-Based Model (ABM). This model is designed to capture the numerical expression of inter-individual interactions (such as engagement within specific online areas), the evolution of viewpoints (reflecting attitudes towards particular topics), and the phenomenon of "indexing" behavior (public assessments of others). Such a model serves as a powerful tool for describing the phenomenon of Text Accumulation. Furthermore, leveraging concepts from heterogeneous mean-field theory and master equations in statistical mechanics, we derive approximate kinetic equations governing the evolution of key variables, including the degree of accumulation and media attitudes. Employing integral transformation and other analytical methods, we obtain corresponding solutions, thus facilitating an in-depth exploration of the fundamental conditions influencing text accumulation dynamics. Moreover, employing Bayesian computation techniques alongside other methodologies, we simulate and calibrate the model using real-world social media data. Through this rigorous process, we attain fitting results that validate the robustness and reliability of the model.

At the level of laws, we obtain a series of conclusions based on formal proofs, model simulation, and data validation: (1)Micro-mechanisms such as preference attachment, reputational recommendation (with high liking prevalence), information integration, and role reproduction/self-awareness significantly impact Text Accumulation levels. (2). Higher levels of viewpoint polarization contribute to increased Text Accumulation in highly public online venues. (3). Text Accumulation tends to rise when self-integration levels are low. (4). Diverse character types and the prioritization of high-reputation texts for attention resources inhibit the upward trend of Text Accumulation. These findings underscore the intertwined roles of cognitive processing, interpersonal interaction, and media regulations.

In summary, our development of a self-integration-role mediation framework offers a comprehensive explanation for the degree of Text Accumulation across various digital actions. This framework not only unveils the underlying mechanisms and stochastic dynamics models, enabling explanation and prediction but also elucidates the conditions and fundamental laws influencing this phenomenon. Through this work, we aim to offer insights and avenues for digital sociology research.

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