A Two-Stage Variable-Scale Clustering Method for Brand Story Marketing of Time-Honored Enterprises

Ai WANG*, Xuedong GAO

Abstract: Brand story, as a communication tool of brand's core values, is proven to be effective in building consumers' trust and loyalty. This paper focuses on the story's protagonist identification and story's audience segmentation problem of consumers' brand storytelling, so as to support managers making brand marketing decisions. After building the scale space signature that characterized the story feature, an object pair scale transformation mechanism (Object Pair-ST) is proposed, which enables to realize the collaborative transformation of the encoded scale feature of both story's protagonists and audiences. According to the Object Pair-ST mechanism, a two-stage variable-scale clustering method (Two-stage-VSC) is put forward. The method could obtain the matched story clues (including the elements of plots, characters, causality and chronology) for every audience cluster as well as the matching degree, which are ordered by the hotness degree of consumers' interest. Experiments collected 11877 real review data on the 2022 first sales platform of time-honored enterprises, Tmall. The comparative experimental results indicate that for various types of brands, the proposed method Two-stage-VSC could always keep the granular deviation of each audience cluster at a low level while accurately identifying its protagonist cluster's story clues with the highest matching degree.

Keywords: scale feature; storytelling; time-honored brand; variable-scale clustering

1 INTRODUCTION

Stories move people more easily, which is no exception in the brand marketing scenarios [1]. Considering the narrative modes of story's protagonists, brand stories are able to be classified into brand storytelling [2, 3] and consumers’ (brand) storytelling [4]. The former mode refers to brands (firms) that tell their own stories (like the brand foundation story, CEO and spokesperson’s story, history of brand successes or crises, etc.) themselves [5-7], while increasing empirical studies figure out that it was the latter mode that had great advantage of improving consumers' brand attitudes, because the story's audiences usually recognize those stories generated by other brand consumers as less biased [8, 9].

With the continuous application of emerging digital techniques in the communication field, consumers are more easily to participate in spreading and sharing their brand stories [10]. The impact factors on how brand story design should influence consumers' brand attitude are investigated widely. For instance, Ref. [11] shows that compared with underdog brand biographies, the top dog brand biographies could be more likely to enhance consumers' perceived competence. Ref. [12] illustrates that the theme of brand stories has a significant impact on consumers' brand attitude, and the story authenticity plays a mediating role. Ref. [8] further finds out that the relationship between story’s protagonists (brand consumers) and story's audiences (target consumers) moderates the influence of story authenticity on brand attitude.

Moreover, time-honored enterprises pay much more attention on brand story marketing, owning to their long-term accumulation of brand history and cross-age customers [13, 14]. As intangible assets, traditional skills of time-honored enterprises naturally play a significant role on the intangible cultural protection [15]. Their enterprise archives also record decades of social change, having great economic, cultural and even legal value, which jointly contribute to the development of the commercial civilization [16].

However, how to utilize the stories generated by consumers to improve the performance of brand marketing still poses many challenges to time-honored enterprises. On the one hand, dynamic audience interest could directly influence the communication effect of brand stories. On the other hand, how well the chosen story matches audience interest also determines consumers' brand attitude.

Therefore, this paper studies the story’s protagonist identification and story’s audience segmentation problem of consumers’ brand storytelling. The main contributions of our research are summarized below:
- In order to characterize the feature of brand stories, the scale space signature is established. Compared to the scale space model in Ref. [27], the proposed encoded scale space with signature is capable of mapping the hierarchical structure relationship between scales to the vector space.
- As for the relation between story's protagonists and audiences influences on the effect of brand story marketing, an object pair scale transformation mechanism (Object Pair-ST) is proposed, that enables to realize the collaborative transformation of the encoded scale feature of both protagonists and audiences, instead of the single object-focused transformation mechanism in Ref. [28-30].
- A two-stage variable-scale clustering method (Two-stage-VSC) is put forward based on the Object Pair-ST, which could obtain matched story clues for every audience cluster as well as the matching degree.

The paper is organized as follows. Section 2 presents relevant research works, including digital transformation of time-honored enterprises, brand story marketing and variable-scale data analysis methods. Section 3 is the main part methodology of our research. The experiment design and experimental results discussions are described in Section 4. The paper is concluded in detail in Section 5.

2 LITERATURE REVIEW

2.1 Digital Transformation of Time-Honored Enterprises

Digital transformation (DT) has aroused wide attention in both academic and industrial fields globally [17, 18]. After the thorough investigation in various business
industries, the key activities of senior executives or IT&
Digital leaders (who are responsible for helping enterprises
transform their business models leveraging digital
technologies), are mainly classified into four aspects, that
is driving business change, adjusting organizational
structures, mastering talent demands and prioritizing
competency improvement [19, 20]. It can be seen that the
chief digital officers (CDOs) need to handle not only the
operational affairs but also the strategic changes during the
whole DT process [21].

The time-honored enterprises, that are famous for their
long history (established before 1956 [16]), encounter the
dilemma of preservation and innovation during the DT
process [13]. Since most of the time-honored enterprises
are not digital companies, how to apply digital technology
to improve traditional business and even create new growth
points earns the primary importance.

Although there is the predefined information system
dedicated to enterprise business capability (EBC) that
provides a technical solution to construct digital
composable enterprises [22], how to achieve automatic
business understanding accurately and effectively [23]
using historical business data still limits its performance in
time-honored enterprises.

2.2 Brand Story Marketing

With the continuous integration of advanced digital
techniques in communication field, newly emerged brand
story marketing scenarios, like consumers' storytelling and
transmedia storytelling, play a more significant role in
branding [24]. Simultaneously, many time-honored enterprises tend to use digital techniques and data mining
methods to assist the creation of their brand stories [13].

Several existing studies suggest that brand managers
could indeed enhance consumers' experience through compelling and well-designed brand stories [25]. And
when story's audience (consumers) recognize the source in
the incoming story is similar to themselves, it could imprint
more positive brand image and even influence their buying
decisions [8, 26].

Therefore, those brand story feature and consumers’
behaviours characteristics contribute to the establishment of our research model, that is the collaborative
transformation of the encoded scale feature of both story's
protagonists and audiences, in Section 3.

2.3 Variable-Scale Data Analysis Methods

In the perspective of both business managers and data
specialists, the variable-scale data analysis theory (VSDA)
provides a cross-industrial intelligent decision-making
framework covering the whole life cycle of data mining
projects [27], including automatic business understanding. Combined with the data understanding stage, the goal of
business understanding stage is to clarify the data mining
tasks, which are able to optimize the performance of
current business activities or discover new business growth
points. The scale space [28] is the bridge model that
cross-industrial intelligent decision-making
framework covering the whole life cycle of data mining
projects [27], including automatic business understanding. Combined with the data understanding stage, the goal of
business understanding stage is to clarify the data mining
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\[ \text{Definition 1 (Scale space signature): Given a scale} \]

\[ \text{space model} \mathbb{A} \]

\[ \text{of observation ruler (dimension), } A' \text{ the} \]

\[ \text{signature of one scale value } v' \text{ in } \mathbb{A} \]

is a digital
position code following the order of ruler-scale-value, i.e., $V_{rs} \leftrightarrow r - s - p$, where $\mathcal{A} = \{CC, VS\}$, the concept chain $CC = \{CH_1, CH_2, ..., CH_S\}$, the value space $VS = \{V_p : p \in N^+\}$.

In general, a data mining task with over one thousand dimensions is regarded as a high-dimensional problem [23], the first three-digit of signature is allocated for the ruler representation. Since the appropriate management scale for humans is about seven [33], considering both business manager and data specialist have their own observation scales on the same dimension, the middle two-digit of signature is assigned for the scale representation. Similar to the ruler representation, the last three-digit of signature is allocated for the (scale) value representation.

For example, Fig. 1 shows a three-hierarchy encoded scale space model of $A_1$. It can be seen that according to the scale space signature, the problem-solving space [34] of a decision problem could now be mapped to an eight-digit encoded vector space.

Table 2 Example of the encoded binary multi-scale data model

<table>
<thead>
<tr>
<th></th>
<th>$A^1$</th>
<th>$A^2$</th>
<th>$A^3$</th>
<th>$A^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_1$</td>
<td>00101001</td>
<td>00101002</td>
<td>00102002</td>
<td>00202002</td>
</tr>
<tr>
<td>$x_2$</td>
<td>00201004</td>
<td>00202003</td>
<td>00202004</td>
<td>00302004</td>
</tr>
<tr>
<td>$x_3$</td>
<td>00302005</td>
<td>00302006</td>
<td>00401006</td>
<td>00402004</td>
</tr>
</tbody>
</table>

Since the dynamic interest of story’s audiences could directly influence the communication effect of brand stories (see Section 1), the hotness degree measurement is established in Def. 2.

Definition 2 (Hotness Degree): Given the story’s audience binary multi-scale data model $Audience = BD^S = (\nu, A^S, V^S, f^B)$, the hotness degree of the audience cluster $X_i^A$ is:

$$HD(X_i^A) = \frac{|X_i^A|}{\max_j(|X_j^A|)}$$

where audience cluster $X_j^A (j = 1, 2, ..., n)$, $\nu_{j, A} X_j^A = \nu^A$ and $X_i^A \subseteq \nu^A$, and $|X_j^A|$ represents the number of objects in cluster $X_j^A$.

What’s more, the other challenges for time-honored enterprises implementing brand story marketing in Section 1 show that, how well the chosen story matches audience interest also determines consumers’ brand attitude. Therefore, the matching degree is proposed (see Def. 3).

Definition 3 (Matching Degree): Given the story’s protagonist encoded binary multi-scale data model $Protagonist - BD^S = (\nu, A^S, V^S, f^B)$, the matching degree between a protagonist cluster $X_i^P$ and an audience cluster $X_i^A$ is:

$$MD\left((X_i^P, X_i^A)\right) = \sum_{k=1}^{n} |\sigma(V_{ik}^P) - \hat{x}_i^A|$$

where protagonist cluster $X_i^P \subseteq \nu^P$, encoded observation dimension set $A^S = \{A^1, A^2, ..., A^T\}$, $\hat{x}_i^A$ is the cluster center of audience cluster $X_i^A$ and $\sigma(V_{ik}^P)$ is the scale feature (signature) vector of $\hat{x}_i^A$, $|\hat{x}_i^A|$ is the number of signature in vector $\hat{x}_i^A$.  

Figure 1 Example of the encoded scale space model
Algorithm 1 Two-Stage Variable-scale Clustering (Audience − BD^5, Protagonist − BD^5, SS, α) // Audience − BD^5 is the binary multi-scale data model of audiences (target consumers), Protagonist − BD^5 is the encoded multi-scale data model of story’s protagonists (brand consumers), SS is the scale space of observation dimension, α is the similarity threshold.

Step 1: Consumers segmentation using the binary variable-scale clustering algorithm on Audience − BD^5, and obtaining the satisfied audience clusters $X^A_j (j \in N^+)$ with the GrD and scale feature. // see Section 2.3.

Step 2: Establish the scale feature (signature) vector of all the audience cluster centers $\bar{x}^A_j (j \in N^+)$, and calculate the hotness degree $HD(X^A_j)$ of each cluster via Eq. (1).

Step 3: Identify the cluster $X^A_i$ with the highest hotness degree of the current audience set, and compare every signature in scale feature vector $\bar{x}^A_i$ with all the scale value $V^r_{sp}$ ($r, s, p \in N^+$) in Protagonist − BD^5. 

Step 3.1: If the absolute value of the difference between one $V^r_{sp}$ and a signature of $\bar{x}^A_i$ is equal to 0, keep the values of all story’s protagonists under $A^r$ in Protagonist − BD^5 the same.

Step 3.2: If the absolute value of the difference between one $r_{sp}V$ and all signatures of $\bar{x}^A_i$ exceeds 10^5, set the values of all the story’s protagonists under $A^r$ in Protagonist − BD^5 to 0.

Step 3.3: Otherwise, scale up $r_{sp}V'$ following SS until the absolute value of the difference between the transformed $r_{sp}V'$ and a signature of $\bar{x}^A_i$ is equal to 0, keep the values of all story’s protagonists under $A^r$ in Protagonist − BD^5 the same.

Step 4: Calculate the similarity of $\bar{x}^A_i$ to all the story’s protagonists through dividing the sum of the kth row in Protagonist − BD^5 by the total number of audience scale feature signatures $x^A_i$.

Step 5: Take all the protagonists whose similarity value is larger than α as the matched story’s protagonist cluster $X^P_i$ for the audience cluster $X^A_i$, that is $X^P_i \subset X^A_i$, and calculate the matching degree $MD(X^P_i, X^A_i)$ via Eq. (2) and Eq. (3). Also, delete all the objects in cluster $X^A_i$ from the audience set.

Step 6: If there are still objects left in the audience set, go to Step 3; otherwise, go to Step 7.

Step 7: Output clustering results, including the GrD and scale feature of all the audience clusters, accompanied by the matched story’s protagonist clusters and their hotness degree, scale up transformed feature (which is decoded to the text state by SS) as well as matching degree.

Since the relationship between story’s protagonists and audiences influences the branding effect, an object pair scale transformation mechanism (Object Pair-ST) is proposed based on the scale space signature (see Fig. 2).
After establishing the scale feature vector of all audience clusters and placing them in the descending order of their hotness degree, the collaborative scale transformation process is activated. If absolute value of the signature difference $\frac{1}{\sqrt{t}} \cdot \sum_{S \subseteq C} |V_{S}^{p} - V_{S}^{q}|$ is equal to 0, keep the values of all story's protagonists under observation ruler $A'$ the same; if the absolute value exceeds $10^4$, set the values of all the story's protagonists under $A'$ to 0; Otherwise, scale up $V_{S}^{p}$ following the scale space model until the absolute value of signature difference reaches 0.

According to the basic idea of the object pair scale transformation, a two-stage variable-scale clustering method (Two-stage-VSC) is put forward, shown in Algorithm 1. The first stage of the Two-stage-VSC is the audience segmentation, and the second stage is the protagonist identification through the Object Pair-ST.

The time complexity of the Two-stage-VSC is $O(tp\phi)$, where $t$ is the time complexity of the meta clustering method, $\phi = \min(m, s')$, $r$ is the number of observation rulers and $s$ is the maximum number of scale values in one ruler.

4 RESULTS AND DISCUSSION

4.1 Experiment Design and Data Collection

According to the consumption innovation report of intangible cultural heritage released by Aliresearch [35], there are 1128 officially recognized China time-honored enterprises in total, which are distributed in various industries, such as the medicine, clothing, liquor, food, daily necessities etc. Over 70% of time-honored enterprises have been included in the national or local intangible cultural heritage list. Moreover, Tmall became the first sales platform for time-honored enterprises in the year 2022, whose turnover jointly exceeded 30 billion yuan. Among them, there were thirty-eight time-honored brands whose platform turnover reached 100 million.

Experiments in this section aim to verify the accuracy and efficiency of the proposed two-stage variable-scale clustering method (Two-stage-VSC) in the brand story marketing scenarios of time-honored enterprises.

We collect 11877 raw real review data of the top-selling products from four typical time-honored enterprises (that is Tongrentang, Pientzehuang, Hengyuanyxiang and Yanghe) on Tmall platform during Jan 1, 2022 to Oct 31, 2022. These four enterprises are respectively in different industries (i.e., medicine, beauty, clothing and liquor), which provide crucial data foundation to explore the influence of brand types for the proposed method. All four enterprises are in the top 20 brands by the platform turnover (more than 100 million yuan).

During the data preprocessing, we set the minimum review word count to ten, so as to filter spam comments and invalid information, and obtain 4010 qualified data for further experiments. The experimental results were obtained on a personal computer with Intel Core i5 CPU @2.9 GHz and 8 GB RAM.

| Table 3 Experiment results of the Two-stage-VSC method on the medicine brand Tongrentang |
|-------------------------------------------------------------|-----------------|-----------------|-----------------|
| <Story’s protagonists, Audiences> | $GrD$ | Consumers’ interest | Hotness Degree | Story clues |
| $\{X_{i}^{r}, X_{j}^{r}\}$ | 2.191 | Effect, two courses of treatment, sixty pills at a time, no alcohol, repurchase. | 1.000 | My multiple purchases experience confirms that the quality is reliable; the usage/dosage instructions are available; effective. |
| $\{X_{i}^{s}, X_{j}^{s}\}$ | 1.738 | Logistics, packing and appearance, customer service, genuine product. | 0.405 | I scanned the source code and confirmed it real; goods arrived quickly; packing intact; customer service answers my questions actively. |
| $\{X_{i}^{t}, X_{j}^{t}\}$ | 2.083 | Lumbago, dizziness and palpitations, side effects, not suit the symptoms, sleep. | 0.139 | According to the medical advice, my family had a deep sleep after taking it twice; safer; we believe that "bitter medicine cures sickness". |
| $\{X_{i}^{u}, X_{j}^{u}\}$ | 1.469 | Changing or return the products, cost performance price reduction. | 0.101 | I found that it is always cheaper than offline stores; at a reasonable price. |
| $\{X_{i}^{v}, X_{j}^{v}\}$ | 1.225 | Old people, physical recuperation, adjuvant therapy. | 0.025 | It was bought for my own elders to keep fit and healthy. And he loves it so much. |

| Table 4 Experiment results of the Two-stage-VSC method on the beauty brand Pientzehuang |
|-------------------------------------------------------------|-----------------|-----------------|-----------------|
| <Story’s protagonists, Audiences> | $GrD$ | Consumers’ interest | Hotness Degree | Story clues |
| $\{X_{i}^{r}, X_{j}^{r}\}$ | 1.979 | Effect of moisturizing, oil control, whitening, anti-aging, absorption. | 1.000 | It worked well for me last winter in Shenzhen city; not greasy and hydration effect obvious; freckle removal. |
| $\{X_{i}^{s}, X_{j}^{s}\}$ | 1.650 | Texture, composition, autumn and winter season, fragrance. | 0.933 | I’ve been using it since the ’80s; it works well when using before going to bed in winter; moist silky and having delicate fragrance. |
| $\{X_{i}^{t}, X_{j}^{t}\}$ | 1.370 | 618 shopping festival activities, gifts, economical benefits. | 0.867 | I have been buying skincare products here and received many gift samples; prices on the 618 are cheaper than usual and more affordable than stores. |
| $\{X_{i}^{u}, X_{j}^{u}\}$ | 1.471 | Logistics, packing and appearance, customer service. | 0.667 | My goods lost during transportation, customer service reissued one immediately; conscientious sellers; packaging is exquisite and beautiful. |
| $\{X_{i}^{v}, X_{j}^{v}\}$ | 1.692 | Domestic products, repurchase, genuine products, improvement. | 0.600 | As a regular customer, I always stock up on them, and support this light of national products as well. |
| $< X_{i}^{w}, X_{j}^{w} >$ | 1.605 | Buy for mom, over 25 years old, having sensitive skin, usage | 0.400 | I am a loyal fan. The product does not harm my oily skin and has a good effect on acne; My mom always uses the brand. |
Table 5 Experiment results of the Two-stage-VSC method on the clothing brand Hengyuanxiang

<table>
<thead>
<tr>
<th>&lt;Story's protagonists, Audiences&gt;</th>
<th>GrD</th>
<th>Consumers' interest</th>
<th>Hotness Degree</th>
<th>Story clues</th>
<th>Matching Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X^x_1, X^y_1)</td>
<td>1.581</td>
<td>Quality, fabric, style design, color.</td>
<td>1.000</td>
<td>It is my favorite old brand; owning first-class quality; the fabric is breathable, and workmanship is fine.</td>
<td>0.750</td>
</tr>
<tr>
<td>(X^x_2, X^y_2)</td>
<td>1.827</td>
<td>Warmth, comfort, fashion, softness, hand feeling.</td>
<td>1.000</td>
<td>The clothes I bought last time were generous and versatile; it feels quite soft and warm.</td>
<td>1.000</td>
</tr>
<tr>
<td>(X^x_3, X^y_3)</td>
<td>1.471</td>
<td>Logistics, packing and appearance, customer service, repurchase, cost performance.</td>
<td>0.667</td>
<td>I've been buying the spring and winter clothes here for years; packages were sent still fast during the epidemic; affordable and cheap.</td>
<td>1.000</td>
</tr>
<tr>
<td>(X^x_4, X^y_4)</td>
<td>1.734</td>
<td>Buy for husband, father, brother, size, fit.</td>
<td>0.692</td>
<td>As a regular customer, I have brought them for my husband, father and father-in-law; looks slim and fit; will introduce it to more of my friends.</td>
<td>0.800</td>
</tr>
<tr>
<td>(X^x_5, X^y_5)</td>
<td>1.530</td>
<td>Shrinkage, deformation, pilling, shedding.</td>
<td>0.308</td>
<td>After I washed it, the color didn't fade; I wore it for a few days without pilling; it is genuine product without doubt.</td>
<td>0.750</td>
</tr>
</tbody>
</table>

Table 6 Experiment results of the Two-stage-VSC method on the liquor brand Yanghe

<table>
<thead>
<tr>
<th>&lt;Story's protagonists, Audiences&gt;</th>
<th>GrD</th>
<th>Consumers' interest</th>
<th>Hotness Degree</th>
<th>Story clues</th>
<th>Matching Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X^x_1, X^y_1)</td>
<td>1.695</td>
<td>Gifts, buy for family, business, marriage, new year celebration</td>
<td>1.000</td>
<td>I repurchase it on a long-term basis, it delivered to my door efficiently; no leakage damage; top grade look; Customer service are professional.</td>
<td>1.000</td>
</tr>
<tr>
<td>(X^x_2, X^y_2)</td>
<td>1.640</td>
<td>Quality, genuine product, pure grain brewing, capacity</td>
<td>0.875</td>
<td>As a recognized trustworthy brand, the quality is guaranteed; product is the same as the one from offline stores.</td>
<td>0.500</td>
</tr>
<tr>
<td>(X^x_3, X^y_3)</td>
<td>1.772</td>
<td>Taste, aroma, feeling after drinking</td>
<td>0.438</td>
<td>The aroma is more elegant and delicate than others; I felt sweet after a sip awhile and enjoyed a lot.</td>
<td>1.000</td>
</tr>
<tr>
<td>(X^x_4, X^y_4)</td>
<td>2.009</td>
<td>Old people, physical recuperation, adjuvant therapy.</td>
<td>0.438</td>
<td>I've been buying it for Dad since I got married more than 10 years ago; received wine and wine utensil gifts; &quot;Jiangsu people drink Jiangsu liquor&quot;.</td>
<td>0.800</td>
</tr>
</tbody>
</table>

Figure 3 Comparative experimental results on differentiate time-horoned enterprises

4.2 Experiment Results and Discussion

Tab. 3 to Tab. 6 shows the experimental results of our proposed method Two-stage-VSC on four types of time-honored enterprises. The medicine brand Tongrentang results in Tab. 3 depict that there are five satisfied object pair <Story's protagonists, Audiences> divided by the two-stage variable-scale clustering method. Most of the audience consumers are interested in the "effect, two courses of treatment, sixty pills at a time, no alcohol, repurchase", earning the highest hotness degree 1.000. According to audience interest, the Two-stage-VSC efficiently identifies matched story clues (whose matching degree exceeds 80%) following the Object Pair-ST mechanism, such as scaling up the concept hierarchy to the usage and dosage level.

Tab. 4 shows the experimental results of Pientzehuang's beauty brand. It can be seen that the object pair \(X^x_5, X^y_5\) has the lowest granular deviation (GrD) 1.370 and the highest matching degree 1.000, which implies that both storytelling consumers and audience...
consumers pay close attention to the 618 shopping festivals and gift samples. Those could directly support brand managers making marketing strategies.

The clothing brand Hengyuanyanxiang’s experimental results are displayed in Tab. 5. The object pair \( \{X^0_1, X^1_1\} \) story clues, that "As a regular customer, I have brought them for my husband, father and father-in-law...will introduce it to more of my friends", conveys abundant characters and chronology elements for brand story design. Besides, in Tab. 6, "Jiangsu people drink Jiangsu liquor" immediately paints a vivid picture with plots and causality elements for the Yanghe's brand story.

Fig. 3 describes the comparative experimental results on all the object pairs of four time-honored enterprises. The black broken line represents the granular deviation (GrD); the height of rectangles represents the matching degree (MD); the color of rectangles represents the hotness degree (HD), where red is \( HD \in (0.800, 1.000] \), green is \( HD \in (0.400, 0.800] \) and blue is \( HD \in [0.000, 0.400] \).

It can be seen that the GrD of all audience clusters is less than a relatively low level 2.2, indicating that the proposed method Two-stage-VSC is able to accurately divide similar objects and accomplish the audience segmentation. At the same time, over 85% of audience clusters’ matching degree exceed 0.600, which demonstrates that the Two-stage-VSC could efficiently identify the most matching story clues for each audience cluster.

5 CONCLUSIONS

We address the story's protagonist identification and audience segmentation problem for brand story marketing based on the variable-scale data analysis. The research starts from the study of scale space signature considering the appropriate management scale for humans with the aim to map the hierarchical problem-solving space of a decision problem to a computable vector space.

The solution framework proposed in our research is to establish the collaborative transformation of the encoded scale feature of object pairs < story's protagonists, audiences>. An object pair scale transformation mechanism (Object Pair-ST) is proposed based on the scale space signature. As a novelty, the Object Pair-ST improves the original single object-focused scale transformation modes (i.e., the generalized scale transformation) to a hybrid bidirectional approach. Finally, a two-stage variable-scale clustering method (Two-stage-VSC) is put forth on consumers’ storytelling, considering the hotness degree of consumers’ interest. The accuracy and efficiency of the proposed Two-stage-VSC method is verified by 11877 real review data from the first sales platform Tmall. Comparative experimental results indicate that for various types of brands, the proposed method Two-stage-VSC could always keep the granular deviation of each audience cluster at a low level while identifying its protagonist cluster's story clues with the highest matching degree.

Our future work will establish the verification mechanism of the encoded scale space model to judge whether the newly established or updated scale space reaches theoretical saturation.

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