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

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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.) them selves [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 mechanismin 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 connects the decision-making hierarchies of both business managers and data specialists towards the same object.

What's more, data mining results evaluation is another stage that requires the participation of both business managers and data specialists [29]. The granular deviation (GrD) is one of the evaluation indexes to measure the scale transformation effect. Taking the clustering task as an example, the GrD is defined as the knowledge granularity [31, 32]. $G(v/A^\lambda)$ divided by the intra-class deviation of each cluster, where v represents the global object set and A^λ represents the observation ruler (dimension).

Tab. 1 depicts the summary of the relevant literature compared with our research work, from the aspects of the scale space model, multi-scale data model, scale transformation mechanism and variable-scale data analysis method. Ref. [28] proposes the binary multi-scale data model and the relevant hybrid variable-scale clustering method (Hybrid-VSC), which solves the clustering problems with categorical structured data and text unstructured data. Ref. [29] combines the VSDA with the case-based reasoning theory, and puts forth the variable-scale case-based reasoning method (VSCBR). It was the space variable-scale scheduling algorithm for the digital vehicle-to-grid platform (V2G-LST) proposed in Ref. [30] that firstly realizes the collaborative transformation of two observation scales (i.e., the space and time scale).

However, all the algorithms above only focus on the scale transformation of single types of objects, which is not suitable for the brand story marketing scenario with both story's protagonists and audiences.

Table 1 Summary of the relevant literature compared with our research work

Variable-scale data analysis theory	The Hybrid-VSC method [28]	The VSCBR method [29]	The V2G-LST method [30]	The proposed method
Scale space model	Scale space	Scale space	Space-time scale space	Encoded scale space
Multi-scale data model	Binary multi-scale data model	Multi-scale knowledge base	Multi-scale data model	Encoded binary multi-scale data model
Scale transformation mechanism	Generalized scale transformation	Radical and conservative scale transformation	Lightning-scale transformation	Object pair scale transformation
Variable-scale data analysis method	The hybrid variable-scale clustering	The variable-scale case-based reasoning	The space variable-scale scheduling	The two-stage variable-scale clustering

3 RESEARCH METHODS

As the variable-scale data analysis theory (VSDA) has the advantages in automatic business understanding for digital transformation from the enterprise side [22, 27], as well as the behavioral feature segmentation from the

consumer side [28], this section studies the brand story marketing problem based on the VSDA.

Definition 1 (Scale space signature): Given a scale space model $\boxed{A^r}$ of observation ruler (dimension), A^r the signature of one scale value V_{sp}^r in $\boxed{A^r}$ is a digital

position code following the order of ruler-scale-value, i.e., $V_{sp}^r \Leftrightarrow r - s - p$, where $\left\|A^r\right\| = \{CC, VS\}$, the concept chain $CC = \langle CH_1, CH_2, ..., CH_S \rangle$, the value space $VS = \left\{ V_{sp}^r \middle| p \in N^+ \right\}$.

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.
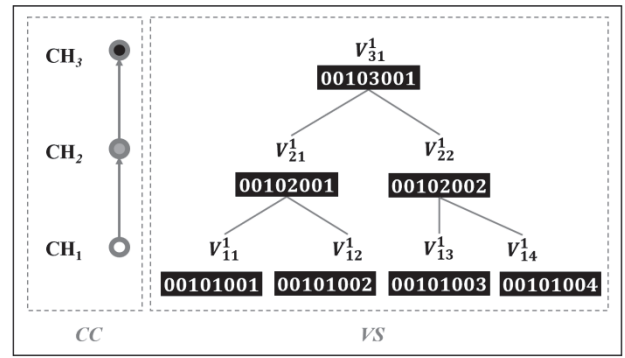

Figure 1 Example of the encoded scale space model

Tab. 1 further depicts the encoded binary multi-scale data model $BD^S = \left(\upsilon, A^S, V^S, f^B \right)$ based on the scale space signature, where all the features of object set $\upsilon = \{x_1, x_2, ..., x_6\}$ are interpreted by its signature code. Hence, object x_i could be characterized as the scale feature (signature) vector $\overset{\bullet}{x_i} = \left(\overset{\bullet}{V_{sl}^r} \right), \left(s, l, r \in N^+ \right)$, e.g.,

$$\overset{\bullet}{x_i} = \left(00101001, 00102002, 00202003, 00302005, 00401006 \right).$$

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

υ	A^1			A^2		A^3		A^4	
	00101001	00101002	00102002	00201004	00202003	00302004	00302005	00401006	00402004
x_1	1	0	1	0	1	0	1	1	0
x_2	0	1	1	1	0	1	0	1	0
x_3	1	0	0	0	1	0	1	1	0
x_4	0	0	1	1	0	0	1	0	1
x_5	0	1	0	0	1	1	0	1	1
x_6	1	0	0	0	0	1	0	1	1

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 $Audience - BD^S = \left(\upsilon^A, A^S, V^S, f^B \right)$, the hotness degree of the audience cluster X_i^A is:

$$HD\left(X_i^A \right) = \frac{\left| X_i^A \right|}{\underset{j}{max}\left(\left| X_j^A \right| \right)} \tag{1}$$

where audience cluster $X_j^A \left(j = 1, 2, ..., n \right)$, $U_{j=1}^n X_j^A = \upsilon^A$ and $X_i^A \subseteq \upsilon^A$, and $\left| X_j^A \right|$ 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

$Pr otagonist - BD^S = \left(\upsilon^P, A^S, V^S, f^B \right)$, the matching degree between a protagonist cluster X_k^P and an audience cluster X_i^A is:

$$MD\left(\left\langle X_i^P, X_i^A \right\rangle \right) = \sum_{k=1}^r \sigma\left(V_{iK}^P \right) \Bigg/ \overset{\bullet}{x_i^A} \tag{2}$$

$$\sigma\left(V_{iK}^P \right) = \begin{cases} 1, \text{ if atl east one value of } X_i^P \text{ under } A^k \text{ is } 1 \\ 0, \text{ if all values of } X_i^P \text{ under } A^k \text{ equal to } 0 \end{cases} \tag{3}$$

where protagonist cluster $X_k^P \subseteq \upsilon^P$, encoded observation dimension set $\overset{\bullet}{A^S} = \left\{ \overset{\bullet}{A^1}, \overset{\bullet}{A^2}, ..., \overset{\bullet}{A^r} \right\}$, $\overline{x_i^A}$ is the cluster center of audience cluster X_i^A and $\overset{\bullet}{x_i^A}$ is the scale feature (signature) vector of $\overline{x_i^A}$, $\left| \overset{\bullet}{x_i^A} \right|$ is the number of signature in vector $\overline{x_i^A}$.

Algorithm 1 *Two-Stage Variable-scale Clustering* (*Audience* $-$ *BD^S*, *Protagonist* $-$ *BD^S*, *SS*, α) // *Audience* $-$ *BD^S* is the binary multi-scale data model of audiences (target consumers), *Protagonist* $-$ *BD^S* 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^S*, and obtaining the satisfied audience clusters $X_j^A \left(j \in N^+ \right)$ with the *GrD* and scale feature. // see Section 2.3.

Step 2: Establish the scale feature (signature) vector of all the audience cluster centers $\overline{x_j^A} \left(j \in N^+ \right)$, and calculate the hotness degree $HD \left(X_j^A \right)$ of each cluster via Eq. (1).

Step 3: Identify the cluster X_i^A with the highest hotness degree of the current audience set, and compare every signature in scale feature vector $\overline{\overset{\cdot}{x_i^A}}$ with all the scale value $\overset{\cdot}{V_{sp}^r} \left(r, s, p \in N^+ \right)$ in *Protagonist* $-$ *BD^S*.

Step 3.1: If the absolute value of the difference between one $\overset{\cdot}{V_{sp}^r}$ and a signature of $\overline{\overset{\cdot}{x_i^A}}$ is equal to 0, keep the values of all story's protagonists under A_r in *Protagonist* $-$ *BD^S* the same.

Step 3.2: If the absolute value of the difference between one $\overset{\cdot}{V_{sp}^r}$ and all signatures of $\overline{\overset{\cdot}{x_i^A}}$ exceeds

10^5, set the values of all the story's protagonists under A^r in *Protagonist* $-$ *BD^S* to 0.

Step 3.3: Otherwise, scale up $\overset{\cdot}{V_{sp}^r}$ following *SS* until the absolute value of the difference between the transformed $\overset{\cdot}{V_{sp}^{r\prime}}$ and a signature of $\overline{\overset{\cdot}{x_i^A}}$ is equal to 0, keep the values of all story's protagonists under A^r in *Protagonist* $-$ *BD^S* the same.

Step 4: Calculate the similarity of $\overline{\overset{\cdot}{x_i^A}}$ to all the story's protagonists through dividing the sum of the kth row in *Protagonist* $-$ *BD^S* by the total number of audience scale feature signatures $\left| \overline{\overset{\cdot}{x_i^A}} \right|$.

Step 5: Take all the protagonists whose similarity value is larger than α as the matched story's protagonist cluster X_i^P for the audience cluster X_i^A, that is $\left\langle X_i^P, X_i^A \right\rangle$, and calculate the matching degree $MD \left\langle X_i^P, X_i^A \right\rangle$ via Eq. (2) and Eq. (3). Also, delete all the objects in cluster X_i^A 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.
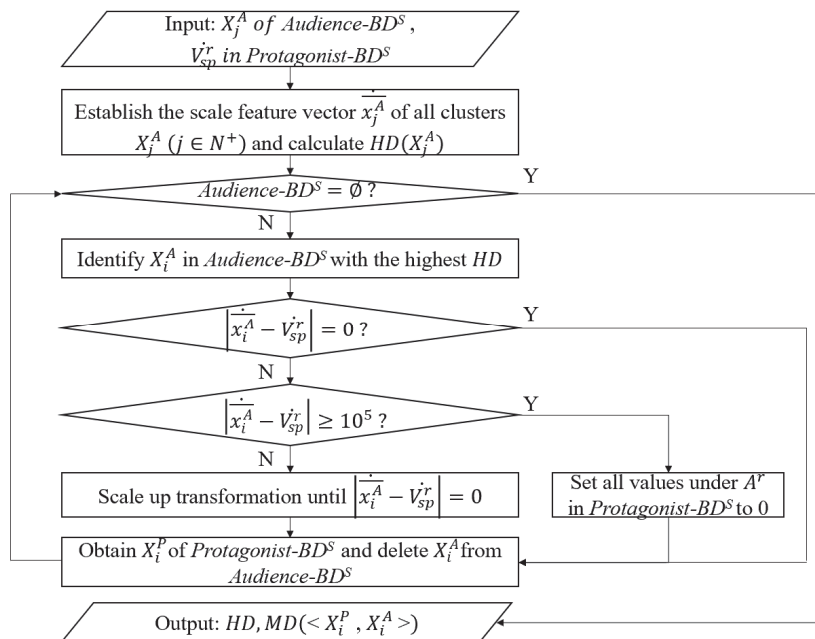

Figure 2 The mechanism of the object pair scale transformation (Object Pair-ST)

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 $\left| \dot{x}_i^A - \dot{V}_{sp}^r \right|$ is equal to 0, keep the values of all story's protagonists under observation ruler A^r the same; if the absolute value exceeds 10^5, set the values of all the story's protagonists under A^r to 0; Otherwise, scale up $\dot{V}_{sp}^r$ 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 $O(t\varphi)$, where t is the time complexity of the meta clustering method, $\varphi = \min(m, s^r)$, 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 Chinatime-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 reached100 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 real raw review data of the top-selling products from four typical time-honored enterprises (that is Tongrentang, Pientzehuang, Hengyuanxiang 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 themedicine brand Tongrentang

\<Story's protagonists, Audiences\>	GrD	Consumers' interest	Hotness Degree	Story clues	Matching Degree
$\left\langle X_1^P, X_1^A \right\rangle$	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.	0.833
$\left\langle X_2^P, X_4^A \right\rangle$	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.	1.000
$\left\langle X_3^P, X_2^A \right\rangle$	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".	0.200
$\left\langle X_4^P, X_5^A \right\rangle$	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.	0.667
$\left\langle X_5^P, X_3^A \right\rangle$	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.	0.667

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	Matching Degree
$\left\langle X_1^P, X_3^A \right\rangle$	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.	0.600
$\left\langle X_2^P, X_2^A \right\rangle$	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.	0.750
$\left\langle X_3^P, X_5^A \right\rangle$	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.	1.000
$\left\langle X_4^P, X_4^A \right\rangle$	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.	1.000
$\left\langle X_5^P, X_6^A \right\rangle$	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.	0.500
$\left\langle X_5^P, X_1^A \right\rangle$	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.	0.800

Table 5 Experiment results of the Two-stage-VSC method on the clothing brand Hengyuanxiang

<Story's protagonists, Audiences>	*GrD*	Consumers' interest	Hotness Degree	Story clues	Matching Degree
$\langle X_1^P, X_2^A \rangle$	1.581	Quality,fabric,style design,color.	1.000	It is my favorite old brand, owning first-class quality; the fabric is breathable, and workmanship is fine.	0.750
$\langle X_2^P, X_3^A \rangle$	1.827	Warmth,comfort,fashion,softness,hand feeling.	1.000	The clothes I bought last time were generous and versatile; it feels quite soft and warm.	1.000
$\langle X_3^P, X_4^A \rangle$	1.471	Logistics, packing and appearance, customer service, repurchase, cost performance.	0.667	I've been buying the spring and winter clothes here for years; packages were sent still fast during the epidemic; affordable and cheap.	1.000
$\langle X_4^P, X_1^A \rangle$	1.734	Buy for husband, father, brother, size, fit	0.692	As a regular customer, I have brought them for my husband, father and father-in-low; looks slim and fit; will introduce it to more of my friends.	0.800
$\langle X_5^P, X_5^A \rangle$	1.530	Shrinkage, deformation, pilling, shedding.	0.308	After I washed it, the color didn't fade; I wore it for a few days without pilling; it is genuine product without doubt.	0.750

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

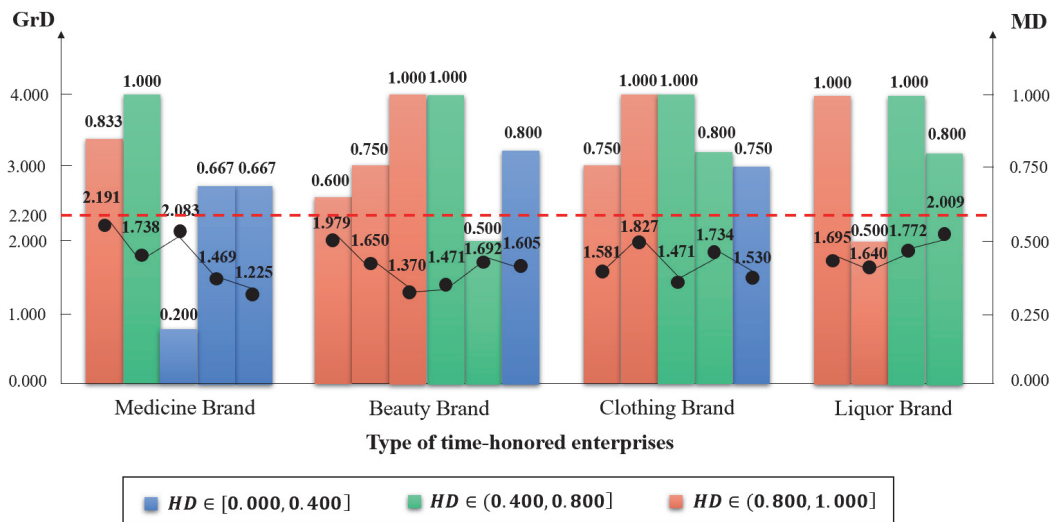| <Story's protagonists, Audiences>	*GrD*	Consumers' interest	Hotness Degree	Story clues	Matching Degree
$\langle X_1^P, X_4^A \rangle$	1.695	Gifts, buy for family, business, marriage,new year celebration	1.000	I repurchase it on a long-term basis, it delivered to my door efficiently; no leakage damage; top grade look; Customer service are professional.	1.000
$\langle X_2^P, X_2^A \rangle$	1.640	Quality, genuine product, pure grain brewing, capacity	0.875	As a recognized trustworthy brand, the quality is guaranteed; product is the same as the one from offline stores.	0.500
$\langle X_3^P, X_3^A \rangle$	1.772	Taste, aroma, feeling after drinking	0.438	The aroma is more elegant and delicate than others; I felt sweet after a sip awhile and enjoyed a lot.	1.000
$\langle X_4^P, X_1^A \rangle$	2.009	Old people,physical recuperation,adjuvant therapy.	0.438	I've been buying it for Dad since I got married more than 10 years ago;received wine and wine utensil gifts; "Jiangsu people drink Jiangsu liquor".	0.800

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 $\langle X_3^P, X_5^A \rangle$ 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 Hengyuanxiang's experimental results are displayed in Tab. 5. The object pair $\left\langle X_4^P, X_1^A \right\rangle$ 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 identity 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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