buildings

MDPI

Article

User Behavior and Emotion Analysis of Sports Venues Based on Social Media Reviews: The Case of Tianzhu, Shunyi, Beijing

Yuehan Wu and Yinong Li *

College of Urban and Rural Planning, Beijing Forestry University, Beijing 100080, China; wuyuehan@bjfu.edu.cn
* Correspondence: liyinong@bjfu.edu.cn

Abstract

Research on urban space usage based on social media data has attracted growing attention, particularly in urban parks. Sports venues, as important built-environment facilities, have also begun to be examined through online reviews of satisfaction and sentiment, but systematic, theory-driven, multidimensional coding of user behavior and emotion across different venue types remains underexplored. This study extends a park-based analytical framework to eight paid sports venues in Tianzhu, Shunyi, Beijing, using 5317 Dianping and Meituan reviews. A five-dimension analytical framework was constructed covering Physical Activity (PA), Children's Physical Activity (CPA), Social Interaction (SI), Positive Emotion (PE), and Service Perception (SP), combining manual coding, Tencent word-embedding expansion, and a hybrid matching strategy (jieba segmentation for PA/CPA and substring matching for SI/PE/SP). The main contributions are: (1) a theory-driven multidimensional behavior-emotion coding framework adapted to sports venues; (2) systematic comparison of child-oriented and adult-oriented venue types; (3) operationalization of SP as a first-pass indicator of the institutional/service layer of space production, with its measurement limitations explicitly assessed; and (4) a hybrid matching strategy that accommodates the distinct semantic forms of behavioral and evaluative vocabulary. The study provides transferable analytical tools and evidence-based design and management implications for sports venues as built environments.

Keywords: social media data; text mining; behavior analysis; sentiment analysis; built environment; production of space theory

1. Introduction

1.1. Research Background

As important facilities within the urban built environment, urban sports venues play a positive role in promoting residents' physical and mental health as well as social interaction. However, traditional research on sports venue usage has largely relied on questionnaire surveys and on-site observation, which are limited by small sample sizes and high costs, making it difficult to capture large-scale, fine-grained user behavior patterns [1,2]. In recent years, social media data—with its advantages of large sample sizes, low cost, and real-time availability—has been widely applied in studies of urban park usage and, increasingly, of sports venues [1,3].

At the methodological level, prior studies have demonstrated the feasibility of extracting behavioral and emotional dimensions from social media reviews of urban spaces, predominantly in public park contexts [2]. Recent studies of sports venues have examined user

Check for updates

Academic Editor: Antonio Caggiano

Received: 1 August 2026
Revised: 12 October 2026
Accepted: 24 October 2026
Published: 2 November 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

satisfaction and sentiment through online comments [3], multi-dimensional visitor perceptions of sports parks [1], and service quality frameworks for urban sports facilities at the urban scale [4]. However, these studies have not yet combined a theory-driven scheme with systematic comparisons across venue types. In addition, within user evaluations of paid spaces, feedback on venue operations and management (e.g., price, facilities, and services) accounts for a very high proportion. This dimension—seldom addressed in park research—is crucial to understanding the user experience at sports venues and connects user behavior to the physical and institutional design of the built environment.

Viewed through the lens of production of space theory [5], this dimensional gap is not accidental. Lefebvre deconstructs the social production of space into three interrelated dimensions: "spatial practice," "representations of space," and "representational spaces." Free parks are characterized by public openness, with relatively transparent institutional arrangements; therefore, Su & Sun's four-dimension framework can already effectively cover the two levels of spatial practice (PA, CPA) and representational spaces (PE, SI) [2]. Paid sports venues, in contrast, require users to enter through a transaction, and their institutional arrangements—pricing, booking, coaching, and service protocols—exert a strong constraining effect on how space is used. This institutional layer is not salient in free park contexts, yet it is crucial for understanding user behavior and evaluations in paid spaces. Therefore, we introduce a corresponding new dimension, namely Service Perception (SP), as an operational measure of this institutional/service dimension.

The study site is located in Tianzhu Town, Shunyi District, Beijing—situated in the core area of the Capital Airport Economic Demonstration Zone and adjacent to Beijing Capital International Airport. As a key international sports and cultural district in Shunyi, Tianzhu Town was incorporated into the "1 + 3" modern industrial system under the *Shunyi District Master Plan (2017–2035)*—a development framework led by the airport economy and supported by international sports, cultural creativity, and comprehensive health as its core pillars. The eight sports venues in the study area cover diverse business types—forming a venue cluster centered on high-end sports training with a coexistence of diverse business formats. These venues exhibit significant variation in operational models, service pricing, and user composition, providing a rich research context for analyzing user behavior and perception characteristics across different types of sports venues.

Based on the above analysis, this study proposes the following research questions: (1) How can the analytical framework originally developed for park reviews be transferred and applied to the sports venue context? (2) What unique characteristics do the behavioral and emotional dimensions of sports venue users exhibit? (3) What differences exist in the dimensional distribution across different venue types? (4) Is the newly added Service Perception dimension valid at both theoretical and empirical levels? (5) How does it correspond to the institutional space dimension in production of space theory?

The contributions of this study are fourfold. First, we provide a theory-driven multidimensional behavior-emotion coding framework that transfers and extends the park-based framework to sports venues while explicitly operationalizing the institutional/service dimension through SP. Second, we conduct a systematic comparison of child-oriented and adult-oriented venue types, defined a priori by business type and operating model. Third, we introduce SP as an operational measure of the "representations of space" layer in paid venues, connecting user reviews to the built environment and service conditions that mediate spatial practice. Fourth, we develop a hybrid matching strategy—jieba segmentation for PA/CPA and substring matching for SI/PE/SP—that responds to the distinct semantic forms of behavioral and evaluative vocabulary in Chinese social media text.

1.2. User Behavior Research at Urban Sports Venues

Sports venues are not only physical carriers of sports activities but also integral components of urban public life. Scholars have conducted extensive research on sports venues across dimensions such as spatial planning and layout [6,7], socio-economic benefits [8], and spatial satisfaction in commercial sports complexes [9]. At the user behavior level, existing studies have predominantly employed methods such as the SOPARC systematic observation method [10] and questionnaire surveys [11] to investigate users' activity types, usage frequency, and satisfaction at sports venues.

While providing detailed observations, traditional research methods also exhibit notable limitations. Although systematic observation methods such as SOPARC can objectively record users' exercise types, intensity, age groups, and gender, they struggle to capture subjective experiences, affective evaluations, and underlying motivations [12]. Questionnaire surveys, while capable of obtaining subjective data on satisfaction, perceived quality, and behavioral intentions, suffer from limitations such as small sample sizes, recall bias, and social desirability bias, with survey costs increasing exponentially as sample size grows. In recent years, studies have begun exploring the use of internet big data for sentiment mining at sports venues. Zou et al. [3] combined deep learning, topic analysis, and social network analysis to extract consumer satisfaction and its influencing factors from online reviews, finding that activity type, course design, and facility conditions were core drivers of positive evaluations, while coach attitude, integrity, and qualifications could trigger negative evaluations. Taking the Nanjing Youth Olympic Sports Park as a case study, Chen & Han [1] used web text analysis and sentiment analysis to investigate visitors' multi-dimensional perceptions of the sports park, categorizing feedback into six key domains and finding that social interaction elicited the most positive emotions, whereas management services received the lowest evaluations. Collectively, these studies demonstrate that social media data provide a novel data foundation and methodological pathway for sports venue research; our study builds on them by adding a theory-driven, dimension-specific coding scheme and systematic venue-type comparison.

In the domain of service quality and consumer satisfaction research at sports venues, traditional methods still dominate. Through a questionnaire survey, Ma & Kaplanidou [13] examined the relationship between service quality perception and behavioral intentions among international baseball consumers, finding that consumers with high team identification were more sensitive to service quality. Castillo-Rodriguez et al. [11] conducted a case study on perceived quality at sports centers in southern Spain, identifying facility maintenance, staff professionalism, and ancillary services as key factors influencing overall user satisfaction. Brown et al. [14], through a survey of 603 London Olympics spectators, found that sports involvement and place attachment had a significant impact on revisit intention. More recently, Yang & Tang [4] developed a multidimensional spatial evaluation framework for assessing service quality in Shanghai's urban sports facilities, examining accessibility, variegation, and coherence across municipal to community levels. Their study highlights that service quality in sports venues is a spatially heterogeneous construct requiring integrated assessment approaches—a perspective that aligns with the multidimensional analytical framework adopted in this study. However, these traditional survey methods are constrained by their spatiotemporal scope and sample size, making it difficult to fully reflect the authentic experiences of sports venue users [15]. At the methodological level, Yue & Dai [15] proposed an ant-colony-algorithm-based method for predicting urban nationwide fitness demands, while Wan & Tang [16] designed an optimization algorithm for equipment allocation in smart urban community amateur sports training—demonstrating, from different angles, the application potential of data-driven methods in sports facility research.

Notably, as paid spaces, sports venues exhibit user behavior patterns that differ from those of free and open-access parks. Chen [7] investigated the planning and management of large-scale urban sports venues in China, noting that operational models, pricing strategies, and service provision directly affect users' usage frequency and satisfaction. Commercial sports complexes likewise face bottlenecks between spatial configuration and user satisfaction, suggesting that architectural and spatial variables matter for how users evaluate sports spaces [9]. Unlike urban parks, sports venue users' behavioral choices are jointly constrained by multiple factors, including price, transportation accessibility, facility quality, and course scheduling. Moreover, the post-pandemic era has witnessed a heightened awareness of nationwide fitness and an upgrade in sports consumption, further driving the functional transformation of sports venues—from single sports facilities toward comprehensive spaces integrating fitness, social interaction, and leisure.

However, existing research still lacks a systematic deconstruction and analysis of the multi-dimensional behavioral and emotional characteristics of sports venue users during their usage experience, and in particular, comparative studies on the differences in user behavior patterns across different venue types remain scarce. Furthermore, while existing studies have examined user satisfaction and behavioral intentions through survey-based approaches, the role of physical spatial characteristics of venues in shaping user experience remains underexplored. Spatial attributes such as court orientation, spectator sightlines, circulation paths, and amenity placement may influence how users navigate, interact, and evaluate their experience within sports venues. This aspect warrants further investigation, and the present study begins to address it by compiling venue-level spatial profiles alongside social-media-derived behavior and emotion data.

1.3. Social Media Data and Urban Space Research

With the development of Web 2.0 technologies, local lifestyle service platforms such as Dianping and Meituan have accumulated vast amounts of user-generated content. These data offer advantages such as large sample sizes, fine granularity, and strong timeliness, providing an unprecedented data foundation for urban research. These data have proven particularly valuable for investigating people's perceptions of the built environment and their behavioral responses within it [17]. In recent years, scholars have leveraged social media data to achieve fruitful results in studies of park usage analysis [2], tourism destination perception [18], and urban renewal evaluation [19].

The application of user-generated content (UGC) in urban research has evolved from simple visit counts to semantic-level behavioral and emotional analysis. Ilieva & McPhearson [20] reviewed the application potential of social media data from the perspective of urban sustainability, noting that such data can compensate for the limitations of traditional data through the advantages of large sample sizes, low cost, and real-time availability. Kandt & Batty [21] further positioned such studies as an integral part of urban analytics, emphasizing their bridging role between big data and urban policy. Within the specific domain of park usage research, Donahue et al. [22] used Flickr geotagged photos to analyze the drivers of urban park visitation in the Twin Cities, USA, finding that park area, facility diversity, and surrounding population density were key variables influencing visitation frequency. Plunz et al. [23] analyzed the sentiment orientation of park-related Twitter posts in New York City and proposed a social-media-based approach for assessing park well-being, validating the analytical effectiveness of social media data at the emotional level. Kim et al. [24] further employed Google Maps user reviews and an opportunity algorithm to evaluate quality equity in Los Angeles urban parks, finding that safety concerns were the most serious aspect of service inadequacy in low-income and minority communities.

At the level of methodological innovation, researchers have continuously explored how to extract structured behavioral and perceptual information from massive volumes of unstructured text. Huang et al. [25] proposed an approach integrating deep-learning-based social media data analysis with questionnaire surveys to quantify multi-dimensional perceptions of urban parks, finding that social media data and survey data exhibit good complementarity in extracting perceived dimensions of parks. In a parallel vein, Li & Wang [17] applied NLP-based sentiment analysis to Dianping reviews of 129 urban street spaces in Shanghai, constructing a perception lexicon and quantifying citizens' emotional responses across six types of built environment elements. Zhang et al. [26] introduced the Post-Occupancy Social Media Evaluation (POSE) framework using New York's Bryant Park as a case study. Combining descriptive statistics with social network analysis, they identified and quantified the interactive relationships among park activities, settings, and emotions. Gao & Fang [27] used Flickr photo data to investigate the influence mechanism of urban park spatial characteristics on joggers' emotional responses, finding that the accessibility and integration of green spaces were positively correlated with the frequency and uniformity of emotional responses. Collectively, these studies demonstrate that social media data can capture not only binary information on whether a space is used but also deeper semantic insights into how it is used and how users feel about it.

In the Chinese context, local lifestyle service platforms such as Dianping and Meituan—containing detailed user review texts and rating information—have become important data sources for urban space research. Su & Sun [2] proposed a hybrid method of manual coding + word embedding expansion + machine-learning-assisted coding using Dianping review data, extracting four dimensions—physical activity, children's physical activity, social interaction, and positive emotion—from 23,910 park reviews, achieving a fine-grained deconstruction of park use behavior. Taking Shanghai as a case study, Huai et al. [28] compared the consistency between social media data and survey data in measuring park visitation, satisfaction, and their influencing factors, finding that the two data sources showed good consistency at the macro level but diverged at the micro level. Zuo Yanlei [29] assessed the cultural ecosystem services of urban parks in Beijing and analyzed their influencing factors using social media data, further extending the application boundaries of social media data in urban space research.

Extending this line of inquiry further, Tang & Zhao [30] combined grounded theory with social media text and image analysis to evaluate public perception of cultural heritage value across 12 historic urban parks in Shanghai, demonstrating the applicability of mixed-method approaches to perception research in Chinese built environments. More recently, Zhai et al. [31] developed an innovative analytical framework by quantifying the two-dimensional emotional characteristics of Valence and Arousal; their study revealed complex human–environment emotional interactions under extreme climatic conditions—demonstrating that social media text analysis can capture fine-grained emotional responses to built environment characteristics. These studies provide the methodological foundation and empirical experience for the present study.

1.4. Hybrid Methodological Framework: From Parks to Sports Venues

The hybrid methodological framework proposed by Su & Sun [2] serves as the methodological foundation of this study. The framework comprises three core steps. (1) Manual coding and seed keyword extraction: a small number of samples are drawn from the review data through stratified sampling for manual coding, and seed keywords corresponding to the theoretical dimensions are extracted. (2) Word embedding expansion: the semantic space of a pre-trained Chinese word embedding corpus (Tencent AI Lab Embedding) is utilized to expand seed keywords into semantically similar terms.

(3) Machine-learning-assisted coding: the expanded keyword library is applied to automated annotation of the full sample.

The theoretical rationale of this method is that the quality of seed keywords directly affects the effectiveness of word embedding expansion, while the semantic coverage of the word embeddings determines the recall rate of automated annotation. A large number of existing studies have demonstrated that seed keywords extracted through manual coding achieve high precision and that combining them with semantic expansion via word embeddings can significantly improve recall, thereby achieving a balance between precision and recall.

In this study, we introduced two important extensions to the original framework. First, we added the Service Perception (SP) dimension to reflect the characteristics of sports venues as paid spaces. Second, we adopted a hybrid matching strategy—combining jieba word segmentation matching with text substring matching—to accommodate the optimal matching accuracy for different dimensions.

The theoretical rationale for the first extension was detailed in Section 1.1: within Lefebvre's framework [5], the institutional arrangements of paid spaces exert a strong shaping effect on user behavior, yet the original four-dimension framework did not cover this aspect. The addition of the Service Perception dimension enables the analytical framework to simultaneously capture spatial practice, representational spaces, and the institutional space, thereby providing a more complete characterization of user experience at paid sports venues.

The second extension stems from the corpus characteristics of Chinese social media text. Sports behavior vocabulary (e.g., "打球" (play ball), "训练" (training), "滑冰" (skating)) mostly appears as single-character or two-character words and exhibits high generality across different sports. Applying exact matching after jieba word segmentation can effectively avoid false positives caused by substring inclusion (for example, "打球" would not be falsely matched to the character "球" in "打球鞋" (basketball shoes)). In contrast, evaluative vocabulary (e.g., "停车不方便" (inconvenient parking), "环境很好" (nice environment), "前台热情" (friendly front desk)) mostly consists of compound phrases or fixed collocations with rich semantic variation. Text substring matching can capture these signals more comprehensively, avoiding the omission of semantic units caused by overly fine-grained word segmentation.

Furthermore, the hybrid matching strategy serves as a key technical enabler for the successful implementation of this methodological transfer. By tailoring the matching approach to the semantic features of each dimension, this strategy contributes to improving annotation accuracy in Chinese social media text and offers a reference for method selection in similar tasks in future research. It should be noted that the strengths of this hybrid framework lie in its strong interpretability, low requirement for labeled sample size, and flexible adaptability to different theoretical frameworks. However, its performance is highly dependent on the quality of the seed keyword library and the domain coverage of the word embeddings, and it may have coverage gaps for low-frequency vocabulary or emerging expressions. Future studies could incorporate pre-trained language models for semantic similarity computation to further improve the annotation accuracy of dimensions with low F_1 scores.

2. Materials and Methods

2.1. Study Area and Data

The study site is located in Tianzhu Town, Shunyi District, Beijing, which lies in the core area of the Capital Airport Economic Demonstration Zone. In recent years, centered on the development of the Tianzhu International Sports and Cultural District, the area has

pursued a development orientation toward high-end cultural and sports formats. At the present stage, building upon high-end sports training, a cluster of sports complexes, training venues, and recreational facilities has gradually taken shape. This study selected eight representative sports venues within the area as research subjects (Table 1). Their distribution is shown in Figure 1, and they cover diverse business types, including ice sports, ball sports, and comprehensive recreation. Their spatial characteristics—indoor/outdoor organization, floor area, court and rink counts, and vertical structure—are summarized in Table 1 and provide the built-environment context for interpreting user behavior and emotion patterns.

Table 1. Basic information of the study venues.

Venue Name	Type	Total After Cleaning	Outdoor/Indoor	Venue Scale	Venue Functions/Facilities
3A Ice Space	Ice sports	869	Indoor	Located in two adjacent factory buildings, with a total area of 5000 m^2. Among them, the ice rink area is 3760 m^2	Three ice rinks at the Tianzhu site; the facilities of the venue include a land training area, physical training center, cafe, etc.
Yuanli Sports Center	Comprehensive sports	113	Mixed	Covers an area of over 12,000 m^2, with 6000 m^2 of outdoor activity space (excluding the parking lot)	Provide professional sports venues, integrating over twenty sports such as tennis, football and basketball.
Guantu Family Sports Center	Parent–child sports	2641	Indoor	Covers an area of approximately 5000 m^2, including an 800 m^2 dining area	Includes six main theme areas and over 30 playable facilities.
Qihangjia T-one Basketball Club	Basketball training	30	Indoor	Total area is over 3000 m^2, among which the basketball court covers an area of 1800 m^2	Equipped with a complete set of safe and high-quality basketball facilities inside.
Zongyu Badminton Hall	Badminton	641	Indoor	Covers an area of over 2000 m^2	Layouts 14 competition-grade courts.
Jushan Basketball Club	Basketball	448	Indoor	Covers an area of over 2500 m^2	Includes 3 standard fields and one children's area.
PartyMars	Indoor amusement park	484	Indoor	The structure is similar to the 3A Ice Space, covering an area of over 8000 m^2	Equipped with three major trend-based sports matrices, 8 theme areas, and 114 facilities all in one.
Feifan Power Tennis Club	Tennis training	91	Indoor	Covers an area of approximately 5000 m^2	Including 6 international standard courts and 7 youth transition courts.

The research data were sourced from two platforms, Dianping and Meituan, through web scraping of user reviews for the eight venues over the past five years. The data were collected in July 2026 and include four fields: anonymized usernames, ratings (1–5 stars), review content, and review timestamp. The two platforms yielded a total of 8323 raw records, which were reduced to 5317 valid reviews after data cleaning steps including cross-platform deduplication and short-review filtering. Detailed steps of the data cleaning process are described in Section 2.4.

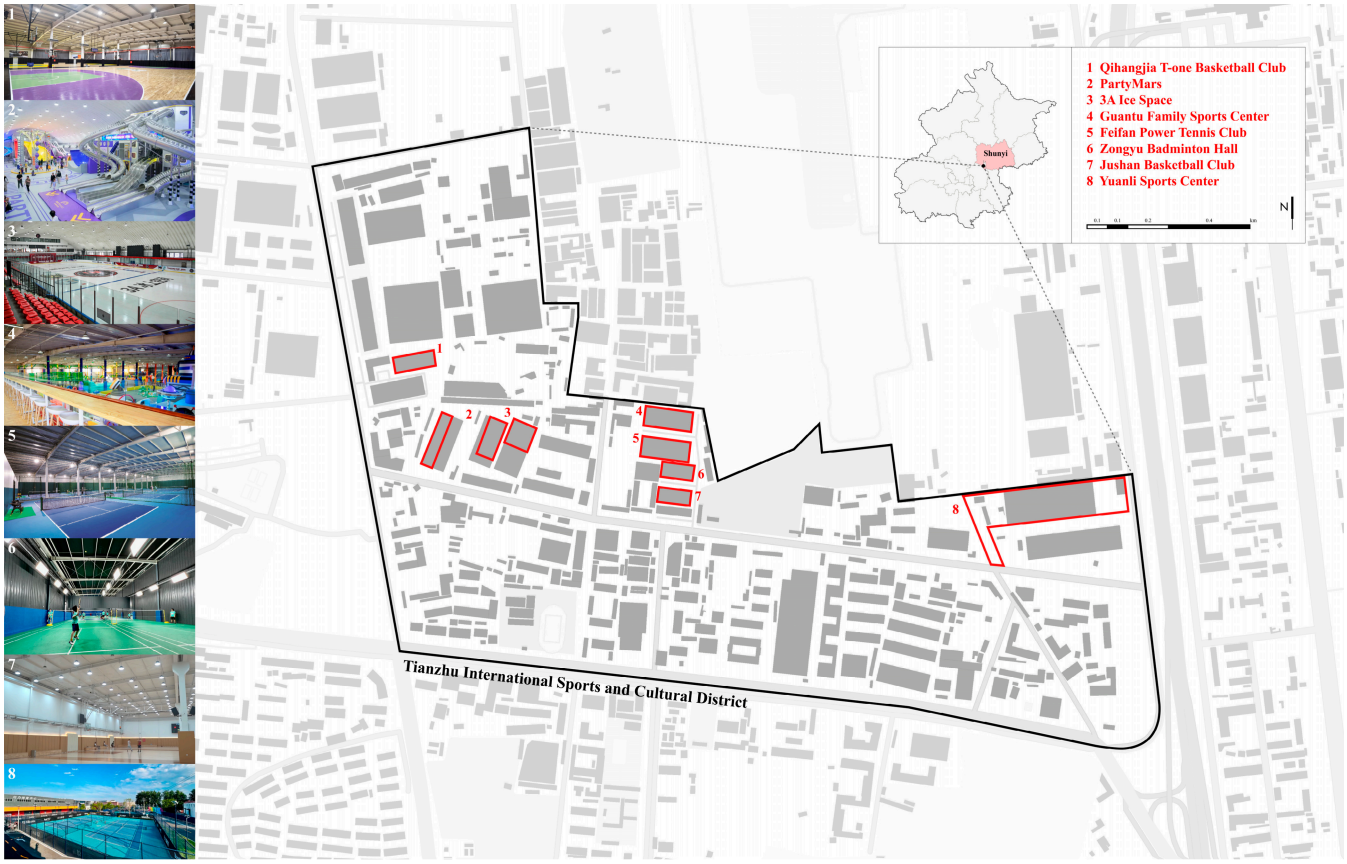


Figure 1. Distribution of the study venues.

To support the comparative analysis, the eight venues were pre-classified into two groups on the basis of business type and operating model, not on the basis of any outcome measure: a child/family-oriented group (3A Ice Space, Guantu Family Sports Center, PartyMars), whose primary market is parent–child activities and youth training, and an adult-sports-oriented group (Yuanli Sports Center, Qihangjia T-one Basketball Club, Zongyu Badminton Hall, Jushan Basketball Club, Feifan Power Tennis Club), whose primary market is adult recreational and training participation. This a priori grouping is used in Section 3.5.

2.2. Five-Dimension Analytical Framework

Based on the four-dimension framework, this study added the service perception dimension, forming a five-dimension analytical framework. Within Lefebvre's production of space theoretical framework [5], the representations of space dimension of paid venues—encompassing pricing strategies, management systems, and service procedures—exert a significant shaping effect on users' spatial practices. This dimension is not salient in free park contexts, yet it is crucial for understanding user behavior and evaluations in paid spaces. The addition of the Service Perception dimension provides a first operational approximation of this institutional/service dimension; its measurement validity is examined and qualified in Section 3.1. The operational definitions and example keywords for each dimension are presented in Table 2.

The coding work shall follow the following rules: (1) A single review can be labeled with multiple dimensions simultaneously. (2) When a review contains descriptions of both adult and children's activities, CPA is prioritized to reflect the dominant scenario of family users, with PA coded as negative. (3) Service Perception is coded when a review contains at least one explicit reference to venue operations or management. It records topic presence

only; it does not encode whether the evaluation is positive, and it excludes external factors such as weather or transportation.

Table 2. Operational definitions of the five-dimension analytical framework.

Dimension	Abbreviation	Operational Definition	Example Keywords
Physical Activity	PA	Any sports, fitness, or exercise activity personally engaged in by the user	Playing ball, running, swimming, lifting weights, yoga
Children's Physical Activity	CPA	Explicit mention of children's participation in sports activities or training	Children learning to swim, youth fitness, taking kids, baby
Social Interaction	SI	Mention of activities with others, social relationships, or community belonging	Hanging out with friends, sports buddies, club, team building
Positive Emotion	PE	Expression of positive affect such as satisfaction, enjoyment, or willingness to recommend	Happy, satisfied, awesome, hidden gem, recommend
Service Perception	SP	Presence of an explicit mention of venue operations and management, including price, facilities, or services; a polarity-neutral binary indicator	Parking price, front desk, coach, facilities

2.3. Research Method Workflow

The methodological workflow of this study consists of three stages (Figure 2):

Stage 1—Data collection and cleaning: review data are collected from the Dianping and Meituan platforms and undergo deduplication, cleaning, and standardization to produce a structured dataset.

Stage 2—NLP text mining: several samples are drawn from the filtered reviews through stratified sampling and coded for the five dimensions. Seed keywords are extracted from the coding results, then undergo manual review to remove noise and merge synonyms, forming an initial seed keyword library. Cosine similarity is then computed for each seed keyword to obtain semantically similar terms. After manual screening to remove noise, an expanded keyword library is formed. Finally, the hybrid matching strategy is applied to perform automated dimension annotation on the valid reviews, and the annotation accuracy is validated against the manually coded sample.

Stage 3—Supplementary analysis and cross-validation: the ROST CM6 text sentiment analysis tool (version 6.0; ROST Team, Wuhan University, Wuhan, China; accessed 10 July 2026) is employed to conduct an independent sentiment analysis on the full sample, which is then cross-validated with the keyword annotation results. Welch's t-test and the Mann–Whitney U test are used to describe differences in the five-dimension detection rates between the two pre-defined venue groups. Pearson correlation analysis is conducted to describe the association patterns among the dimensions. These supplementary analyses aim to validate the robustness of the keyword annotation results from multiple perspectives and to provide descriptive, hypothesis-generating support for venue operation strategies.

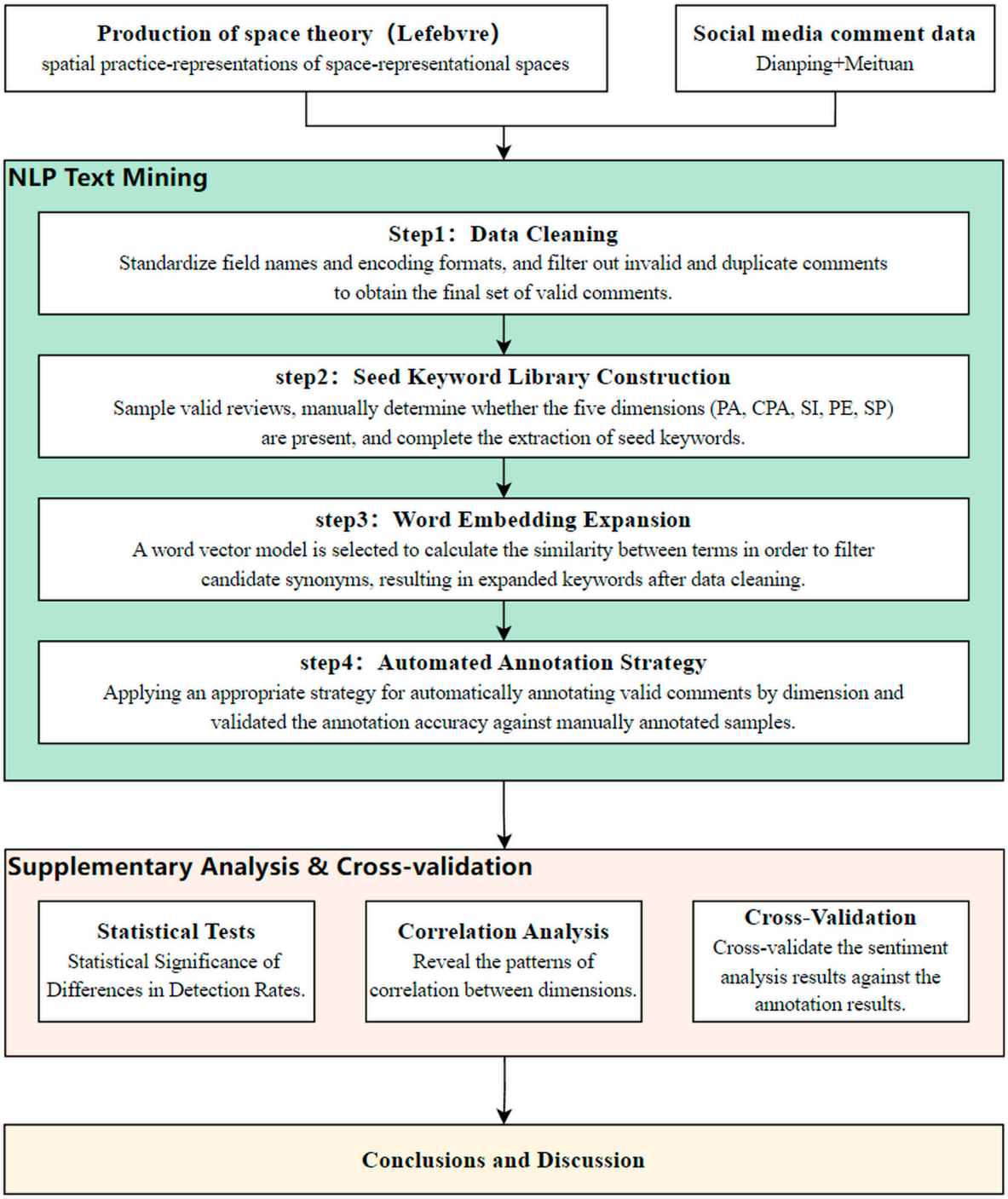


Figure 2. Research technical workflow.

2.4. Data Cleaning

Data cleaning comprised the following steps (Table 3):

(1) Standardizing field names and encoding formats: Dianping used GBK encoding and Meituan used UTF-8 encoding; both were uniformly converted to UTF-8-SIG. (2) Extracting venue names from file names. (3) Removing whitespace and noise from text. (4) Filtering out records with review text fewer than 5 characters. (5) Filtering out records with ratings < 1 or >5. (6) Deduplicating by the composite key of [review text, rating] to eliminate duplicate reviews posted by the same user across the two platforms.

Table 3. Statistical results of each data cleaning step.

Cleaning Step	Description	Removed	Remaining
① Raw data merging	Dianping (3096) + Meituan (5227)	—	8323
② Review length filtering	Removed reviews with fewer than 5 characters	35	8288
③ Rating range filtering	Filtered anomalous records with ratings < 1 or > 5	251	8037
④ Cross-platform deduplication	Deduplicated by [review text + rating] to eliminate duplicate reviews between platforms	2720	5317

Ultimately, 5317 valid reviews were obtained from the original 8323 raw records.

2.5. Seed Keyword Library Construction

The seed keyword library was constructed through the following steps:

(1) Coding sample extraction: from the 5317 cleaned reviews, stratified systematic sampling was conducted by venue, drawing approximately 28 to 37 reviews per venue while considering rating distribution, resulting in a total of 227 reviews. In addition, 100 reviews that were not part of this development sample were coded by the authors under the same protocol and served as an independent test set; none of these 100 reviews was used for lexicon construction, noise cleaning, or strategy selection.

(2) Manual coding: researchers read each review and determined whether each of the five dimensions (PA, CPA, SI, PE, SP) was present (binary 0/1 labeling), recording the specific phrases or vocabulary supporting each dimensional judgment in a keywords_evidence field.

(3) Seed keyword extraction: the keywords_evidence from all 227 coded reviews was aggregated, word frequencies were tallied by dimension, and keywords with a frequency ≥ 1 were retained.

(4) Manual review: synonyms were merged, noise words were removed, and domain expert knowledge was supplemented.

This process yielded 388 seed keywords in total, with the distribution across dimensions presented in Table 4.

Table 4. Distribution of the seed keyword library.

Dimension	Seed Keywords	Examples
PA	26	Playing ball, training, attending class, skating, rock climbing, trial lessons
CPA	36	Children attending class, kids, taking children, parent–child, children
SI	11	Hanging out with friends, sports buddies, team building, club
PE	22	Happy, satisfied, recommended, fun, worth recommending
SP	293	Good environment, professional coaches, convenient parking, expensive, poor service

2.6. Word Embedding Expansion

This study selected the tencent-ailab-embedding-zh-d100-v0.2.0-s (Tencent AI Lab, Shenzhen, China; accessed 10 July 2026) as the word embedding model, which contains

2 million entries with 200-dimensional vectors, covering common Chinese vocabulary, with a file size of 3.82 GB. The resulting expansion statistics are summarized in Table 5.

Table 5. Word embedding expansion statistics.

Dimension	Seed Keywords	Candidate Expanded Terms	Terms After Cleaning	Expansion Ratio
PA	26	201	215	8.3×
CPA	36	180	196	5.4×
SI	11	66	72	6.5×
PE	22	287	295	13.4×
SP	293	3408	3661	12.5×

The expansion method involved computing the cosine similarity between each seed keyword and all 2 million entries in the word embedding space, retaining the top 15 (similarity threshold ≥ 0.55) as candidate synonyms. For compound seed keywords not found in the embedding vocabulary, jieba word segmentation was applied first to decompose them into individual words before expansion.

The word embedding expansion results underwent a four-step cleaning process: (1) Removing seed keywords unrelated to sports venues. (2) Cross-dimension relocation, manually correcting keywords assigned to the wrong dimension. (3) Within-dimension deduplication, retaining only one instance when the same term appeared multiple times in the same dimension. (4) Removing grammatical function words such as "与" (and), "以及" (as well as), and "好啊" (okay).This process ultimately yielded 4439 expanded keywords.

The variation in expansion ratios across dimensions reflects the semantic concentration of seed keywords in each dimension. PE and SP exhibited higher expansion ratios (13.4× and 12.5×), indicating that their seed keywords occupy a more dispersed semantic space with abundant substring matches, whereas PA and CPA had relatively lower expansion ratios (8.3× and 5.4×), suggesting that sports behavior vocabulary has more clearly defined semantic boundaries.

2.7. Automated Annotation Strategy

The hybrid matching strategy was adopted after systematic comparison of three alternative strategies. For the PA and CPA dimensions, jieba word segmentation matching was used: after segmenting the review text, each segmentation unit was checked against the keyword set. For the SI, PE, and SP dimensions, text substring matching was applied, where a keyword was considered a match if it appeared as a substring of the review text. Experiments showed that keywords in the PA and CPA dimensions predominantly consist of single-character and two-character words, making jieba word segmentation matching effective in reducing false positives from substring matches, whereas keywords in the SI, PE, and SP dimensions are mostly compound phrases, where substring matching can capture semantic signals more comprehensively. Furthermore, during automated annotation, when the same review detected both PA and CPA, CPA was assigned higher priority than PA, a mutual exclusivity rule that ensured mutually exclusive dimension labeling. The implications of this rule for the PA-CPA correlation are discussed in Section 3.6.

Development performance was checked against the 227 development reviews; final performance was evaluated on the independent test set of 100 manually coded reviews using precision, recall, and F_1 score. The F_1 score is the harmonic mean of precision and recall, calculated as:

$$F1 = \frac{2PR}{P + R} \quad (1)$$

Strategy C was fixed before test-set evaluation on semantic grounds (Section 1.4). We report all three strategies on the independent test set for transparency: C matched Strategy A's precision for PA and CPA (1.00 and 0.94), achieved a mean F1 of 0.79, and reproduced the pre-specified pattern; no test-set result influenced the choice of method. The performance comparison is presented in Table 6.

Table 6. Performance comparison of different matching strategies on the independent test set.

Strategy	PA-P	PA-R	PA-F_1	CPA-P	CPA-R	CPA-F_1	SI-P	SI-R	SI-F_1	PE-P	PE-R	PE-F_1	SP-P	SP-R	SP-F_1
A (jieba all)	1	0.56	0.72	0.94	1	0.97	0.7	0.41	0.52	0.85	0.83	0.84	0.7	0.96	0.81
B (substring all)	0.95	0.72	0.82	0.91	1	0.95	0.41	0.88	0.56	0.82	0.94	0.87	0.7	0.99	0.82
C (hybrid)	1	0.56	0.72	0.94	1	0.97	0.41	0.88	0.56	0.82	0.94	0.87	0.7	0.99	0.82

These results confirm that a one-size-fits-all matching approach is suboptimal for a multi-dimensional annotation task. The semantic nature of keywords varies across dimensions: PA and CPA keywords are predominantly short action verbs (e.g., "打球" (play ball), "跑步" (run)) that benefit from token-level matching to avoid noise, whereas SI, PE, and SP keywords are largely compound phrases (e.g., "约朋友" (meet friends), "环境不错" (nice environment), "停车方便" (convenient parking)) that require substring-level matching to capture their full semantic scope. The hybrid strategy leverages these differences dimension-specifically.

It should be noted that the selection of the hybrid matching strategy was informed by systematic preliminary experiments. In initial trials, jieba word segmentation matching was uniformly applied to all dimensions, which revealed that the recall rates for the PE and SP dimensions were low because a large number of evaluative phrases (e.g., "停车不太方便" (parking is not very convenient)) could not be matched by segmented individual words. Conversely, applying substring matching uniformly to all dimensions led to a high number of false positives in the PA dimension. The hybrid matching strategy therefore balanced the false-positive risk of substring matching in PA/CPA and the recall loss of token-level matching in SI/PE/SP; its mean F1 was close to the best-performing strategy while preserving the expected precision advantage.

3. Results

3.1. Full-Sample Annotation Results

The automated annotation results for the 5317 reviews are presented in Table 7; the final hybrid strategy was evaluated on an independent test set of 100 manually coded reviews, and the resulting precision, recall, and F1 values are also reported in Table 7. In terms of overall distribution, the Service Perception (SP) dimension exhibited the highest automated detection rate (5148 reviews, 96.8%), indicating that service-related topics were widely mentioned. Throughout this paper, SP is a polarity-neutral indicator of whether price, facilities, or service topics were mentioned. Because a high automated rate may partly reflect the breadth of the SP keyword set, Section 3.1 reports dedicated validity diagnostics (Table 8). The Positive Emotion (PE) dimension had a detection rate of 82.6%, indicating that most reviews contained positive emotional vocabulary.

Table 7. Overall detection rates of the five dimensions and independent test-set performance.

Dimension	Detected Reviews	Detection Rate	Test Precision	Test Recall	Test F1
PA	802	15.1%	100%	56%	0.72
CPA	3360	63.2%	94%	100%	0.97
SI	285	5.4%	41%	88%	0.56
PE	4394	82.6%	82%	94%	0.87
SP	5148	96.8%	70%	99%	0.82

Table 8. SP validity diagnostics: strict compound-phrase sensitivity and manual review.

Definition	SP Keywords	Full Sample Detection	Test P/R/F1	TP/FP/FN	Interpretation
Full SP lexicon	3661	5148 (96.8%)	0.70/0,99/0.82	67/29/1	Near-saturated
Strict compound phrase (≥4 characters)	1946	2633 (49.5%)	0.81/0.71/0.76	48/11/20	Higher precision, lower recall

Notes: 5317 reviews; 5148 were detected by SP (96.8%); the full SP lexicon contains 3661 keywords. Detection counts and rates refer to reviews. SP is a polarity-neutral mention indicator.

The Children's Physical Activity (CPA) dimension had a detection rate of 63.2%, indicating that children's activities and parent–child scenarios were prominent in the reviews collected in this study. This value describes the review sample and should not be interpreted as the composition of actual local sports venue clients. The Physical Activity (PA) dimension had a detection rate of 15.1%, substantially lower than CPA, partly attributable to this study's coding rule (CPA prioritized over PA when both were present), and partly reflecting the predominant business characteristics of the area's venues, namely children's training and parent–child activities. Social Interaction (SI) had the lowest detection rate at just 5.4%, indicating that direct descriptions of social behavior are relatively rare in sports venue reviews and that social interaction may exist more implicitly within the context of other dimensions.

To examine whether the high SP detection rate is a meaningful topic indicator or an artefact of broad substring matching, we computed two complementary diagnostics (Table 8). First, a strict compound-phrase subset was formed by retaining only SP keywords with an effective length of at least four Chinese characters (1946 of 3661 keywords). When this strict subset was applied, the full-sample SP detection rate dropped from 96.8% to 49.5%, while independent test set precision increased from 0.70 to 0.81 and recall fell from 0.99 to 0.71 (F1 = 0.76 vs. 0.82). Second, among the 5148 SP-positive reviews, 2633 (51.1%) contained at least one compound SP phrase; the remainder were detected only through shorter, more general terms. The most frequent hits were generic terms such as "可以" (1764 reviews), "场地" (1697), "服务" (1225), "干净" (1066), and "教练" (937). Manual review of the 100-review independent test set identified SP in 68 reviews, whereas the automated full lexicon identified 96, with 29 false positives and 1 false negative. These results indicate that the 96.8% value is an automated detection rate for the full SP lexicon. It is not equivalent to the manually verified proportion of service-topic mentions and should not be interpreted as service quality or polarity.

3.2. Dimension Distribution Across Venues

The five-dimension distribution varied across venues (Table 9, Figure 3). In child-activity-oriented venues such as Guantu Family Sports Center, PartyMars, and 3A Ice Space, CPA detection rates reached 81.8%, 72.3%, and 70.8%, respectively. These values were the highest among the three behavior-related dimensions (PA, CPA, SI), although PE

and SP were higher than CPA in these venues. CPA therefore indicates a child/family behavior emphasis rather than dominance across all five dimensions. In adult-sports-oriented venues such as Yuanli Sports Center, Feifan Power Tennis Club, Jushan Basketball Club, and Qihangjia T-one Basketball Club, PA detection rates were 38.9%, 36.3%, 30.6%, and 36.7%, respectively, and exceeded their CPA detection rates. Zongyu Badminton Hall exhibited a PA detection rate of 25.3% and a CPA rate of 16.4%, falling between the two venue categories, indicating participation by both adults and youth. The radar chart (Figure 3) shows the resulting dimensional profiles.

Table 9. Five-dimension distribution across venues.

Venue	Reviews	PA	CPA	SI	PE	SP
3A Ice Space	869	19.9%	70.8%	3.3%	84.3%	98.2%
Yuanli Sports Center	113	38.9%	21.2%	9.7%	70.8%	97.3%
Guantu Family Sports Center	2641	7.5%	81.8%	6.5%	83.8%	97.0%
Qihangjia T-one Basketball Club	30	36.7%	26.7%	6.7%	70.0%	93.3%
Zongyu Badminton Hall	641	25.3%	16.4%	3.9%	82.2%	98.6%
Jushan Basketball Club	448	30.6%	16.3%	6.0%	81.5%	94.2%
PartyMars	484	8.9%	72.3%	3.1%	79.5%	93.2%
Feifan Power Tennis Club	91	36.3%	27.5%	4.4%	75.8%	100.0%

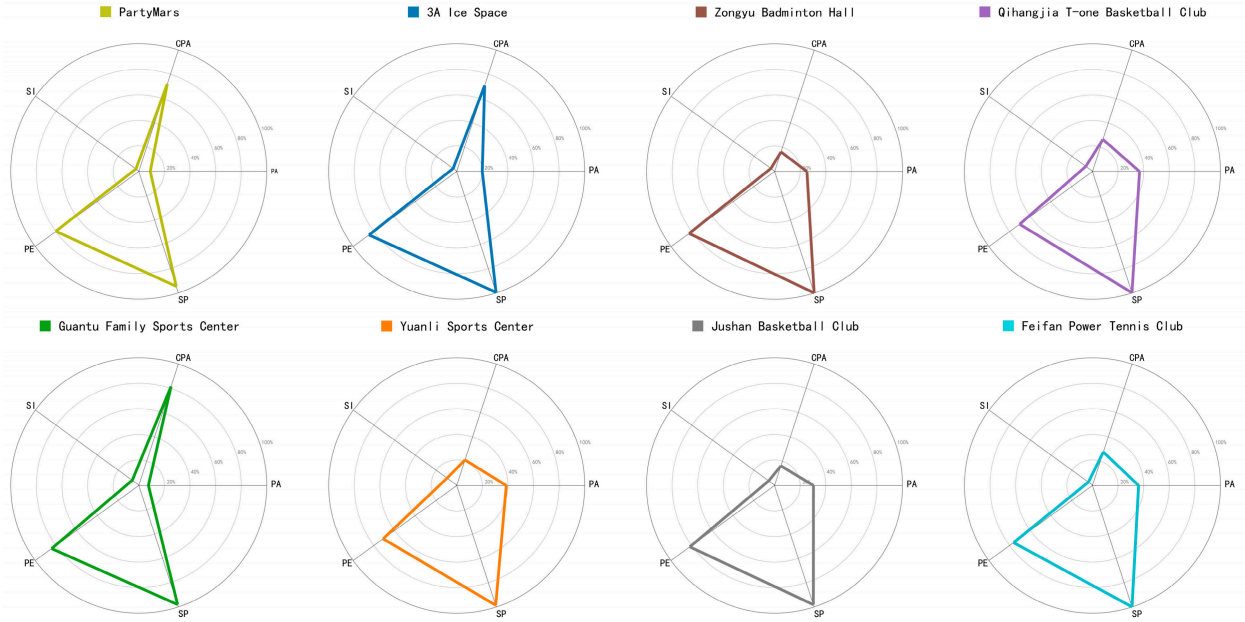


Figure 3. Radar chart of five-dimensional distribution across venues.

Across venues, SP detection under the full lexicon ranged from 93.2% to 100.0%, with a full-sample rate of 96.8%. The adult-sport-oriented venues had SP rates of 97.3% (Yuanli), 93.3% (Qihangjia), 98.6% (Zongyu), 94.2% (Jushan), and 100.0% (Feifan), matching the venue values in Table 9. Because SP is a polarity-neutral topic indicator, these values describe topic salience rather than service quality or the manually verified proportion of service-topic mentions.

3.3. Cross-Analysis of Ratings and Dimensions

The relationship between rating levels and dimension detection rates is shown in Figures 4 and 5. Figures 4 and 5 were generated from the same rating-by-dimension matrix. The SP rate was 87.9% for 3-star reviews, 97.5% for 4-star reviews, and 96.6% for 5-star

reviews; the corresponding rates were 94.4% and 100.0% for 1- and 2-star reviews, respectively. The PE detection rate was 84.9% for 5-star reviews, 79.9% for 4-star reviews, and 48.5–58.3% for reviews rated 3 stars or below. This gradient is consistent with the greater frequency of positive emotional vocabulary in high-rating reviews. Even among 1–3 star reviews, PE remained close to 50%, indicating that positive aspects may coexist with a low overall rating.

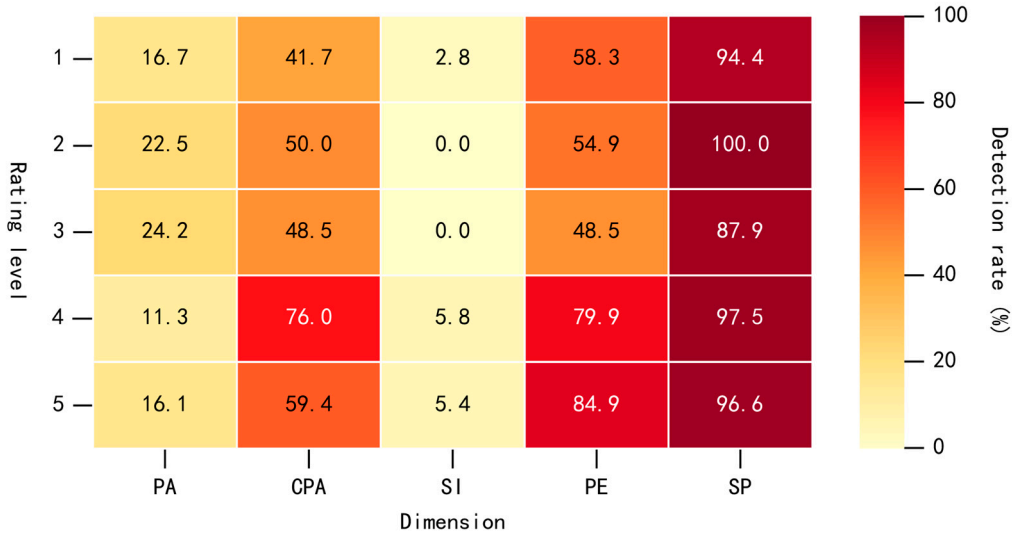


Figure 4. Rating–dimension cross-heatmap.

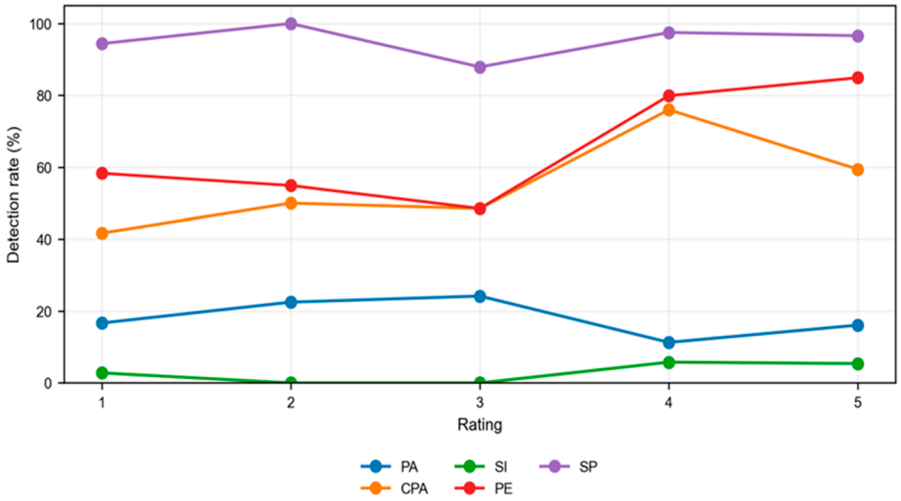


Figure 5. Rating–dimension trend chart.

SP detection ranged from 87.9% to 100.0% across rating levels, with the minimum at 3 stars. This variation describes how often service-related language was automatically detected, not whether those mentions were manually verified as service topics or whether they were favorable or unfavorable. The rating-dimension cross-analysis shows two patterns. First, PE remained near 50% in 1–3-star reviews, indicating that positive affect can coexist with a low overall rating. Second, CPA peaked in 4-star reviews at 76.0%, which is consistent with family-oriented use of these venues.

3.4. Cross-Dimension Co-Occurrence Analysis

The conditional co-occurrence probabilities P(B | A) and Jaccard coefficients are shown in Figure 6; rows are conditioning dimensions (A), and columns are target dimensions (B).

When SI was present, P(PE|SI) = 91.6% and P(CPA|SI) = 73.0%. For CPA and SP, 3299 reviews contained both dimensions, giving P(SP|CPA) = 3299/3360 = 98.2% and P(CPA|SP) = 3299/5148 = 64.1%. Because SI has an independent-test F_1 of 0.56, these patterns are treated as exploratory.

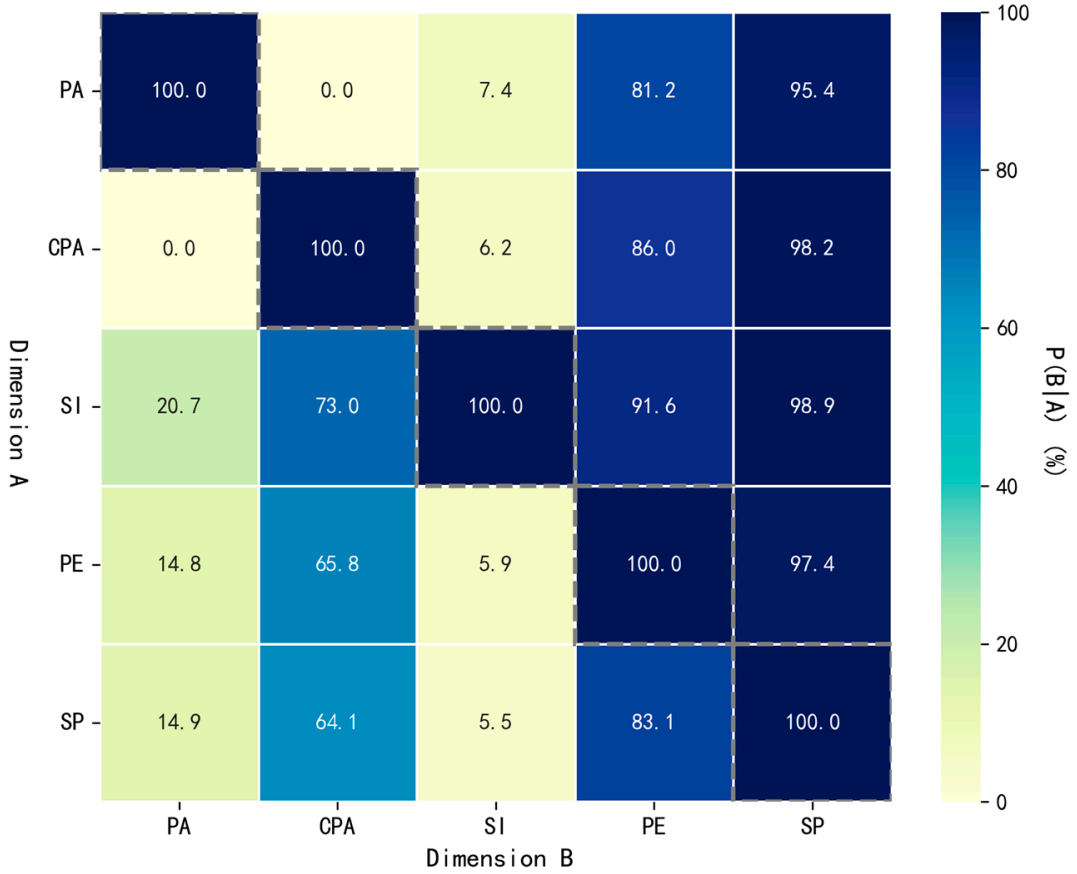


Figure 6. Heatmap of conditional co-occurrence probabilities among dimensions.

The Jaccard matrix (Figure 7) provides a symmetric overlap measure that is less sensitive to the high prevalence of PE; by construction, J(A,B) = J(B,A). The SI-PE coefficient is 0.059: 261 reviews contained both SI and PE, so 261/(285 + 4394 − 261) = 0.059, and the reverse PE-SI cell is also 0.059. The PE-SP coefficient is 0.813. For PA and the two highly prevalent dimensions, the values are distinct: the PA-PE coefficient is 0.143, whereas the PA-SP coefficient is 0.148. These Jaccard coefficients measure set overlap and are not conditional probabilities: for example, P(PE|PA) = 651/802 = 81.2% and P(SP|PA) = 765/802 = 95.4%, and these quantities should not be confused with J(PA,PE) = 0.143 or J(PA,SP) = 0.148. The high conditional probability P(PE|SI) = 91.6% should not be interpreted as a strong association, because PE was present in 82.6% of all reviews. Given the low F_1 for SI, the SI-PE pattern remains exploratory.

Further analysis of intra-venue co-occurrence patterns (Figure 8) reveals functional positioning differences across venue types. Training-oriented venues (e.g., 3A Ice Space, Guantu Family Sports Center) showed prominent CPA-PE co-occurrence, consistent with youth-training scenarios. Adult-oriented venues such as Yuanli Sports Center and Jushan Basketball Club showed stronger PA-PE co-occurrence. Zongyu Badminton Hall had considerable co-occurrence with both PA and CPA, consistent with participation by adults and youth. Given the measurement limits of PA and SI, these venue-level patterns are exploratory.

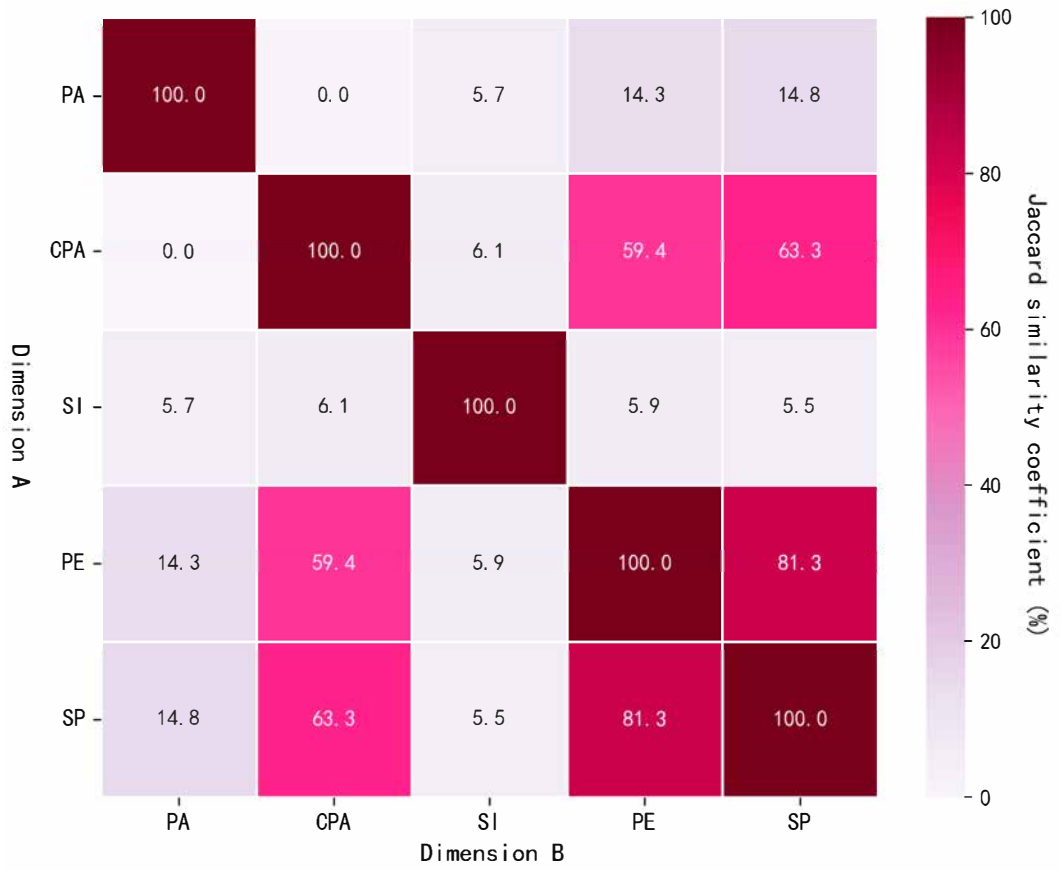


Figure 7. Heatmap of Jaccard similarity among dimensions.

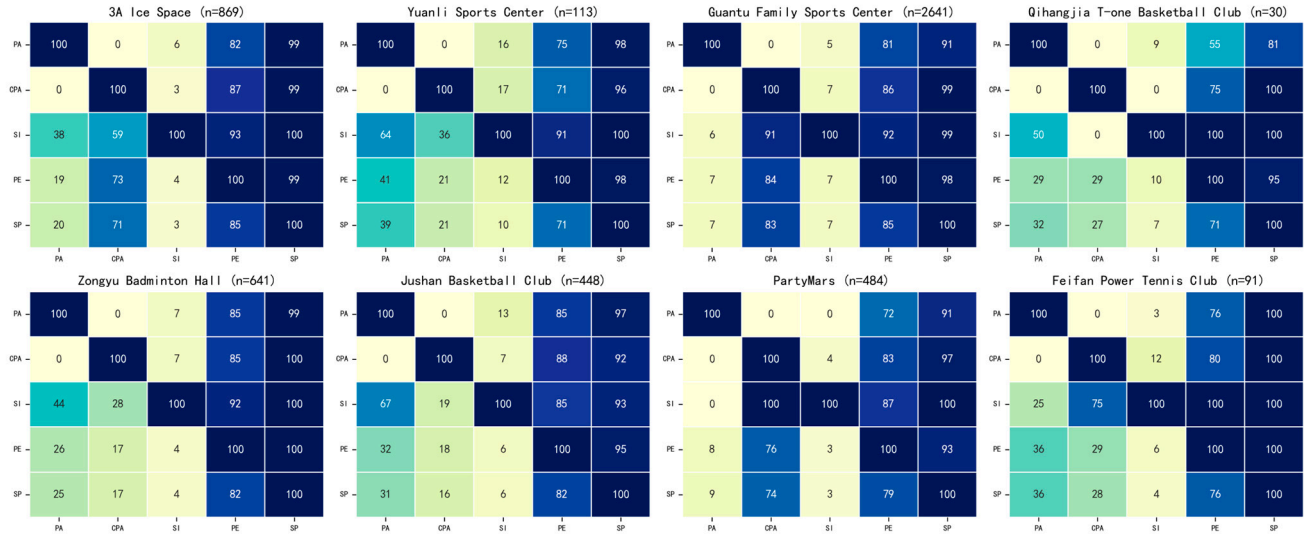


Figure 8. Comparison of conditional co-occurrence patterns by venue.

3.5. Statistical Tests of Venue-Type Differences

To examine whether the association between venue type and behavioral dimensions was descriptively stable (Figure 9), the eight venues were divided into two groups defined a priori in Section 2.1. Because group membership was not derived from outcome variables, the tests are descriptive rather than confirmatory.

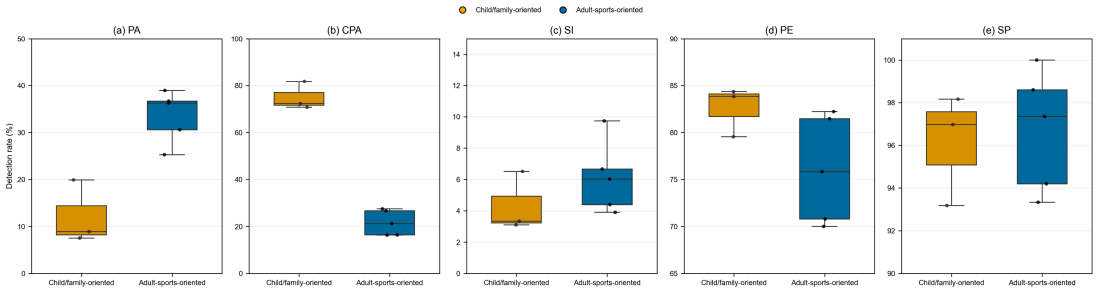


Figure 9. Boxplot of between-group differences by venue type.

Welch's t-test results showed higher PA detection rate in adult-oriented venues (M = 33.5%, SD = 5.6%) than in child-oriented venues (M = 12.1%, SD = 6.8%, t = −4.620, $p = 0.012$), with a large effect size (Cohen's d = −3.58). The mean CPA detection rate was higher in child-oriented venues (M = 75.0%, SD = 6.0%) than in adult-oriented venues (M = 21.6%, SD = 5.4%, t = 12.692, $p < 0.001$), with a large effect size (Cohen's d = 9.56). SP did not differ significantly between groups ($p = 0.777$, Cohen's d = 0.21) and remained high in both groups, which is consistent with its topic-screening interpretation (Section 3.1). Given the small number of venues, these comparisons are descriptive.

Effect sizes were Cohen's d = 3.58 for PA and Cohen's d = 9.56 for CPA. SP showed only a small absolute between-group difference (96.1% vs. 96.7%; Cohen's d = 0.21, $p = 0.777$), which is consistent with its role as a broad topic indicator.

3.6. Inter-Dimension Correlation Analysis

Pearson correlations of the five venue-level detection rates are summarized in Figure 10; the pairwise venue-level distributions are shown in Figure 11. PA and CPA were strongly negatively correlated (r = −0.865, $p = 0.006$), largely because the coding rule assigns CPA priority when both are present; this not an independent behavioral finding. PE and SP had a weak correlation (r = 0.202, $p = 0.631$; 95% CI [−0.586,0.794]). All venue-level correlations are based on only eight observations and therefore have wide confidence intervals.

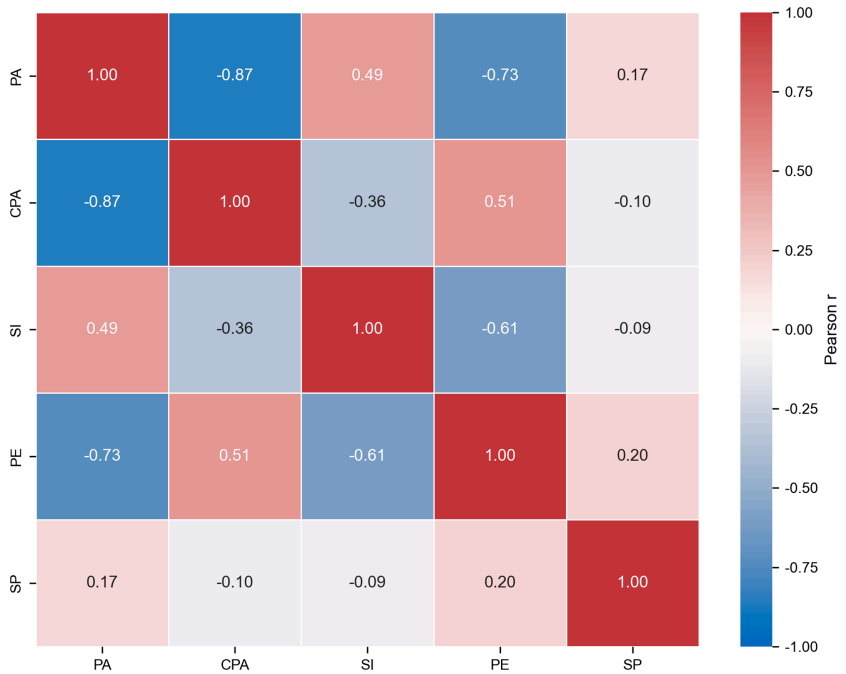


Figure 10. Correlation matrix of the five dimensions.

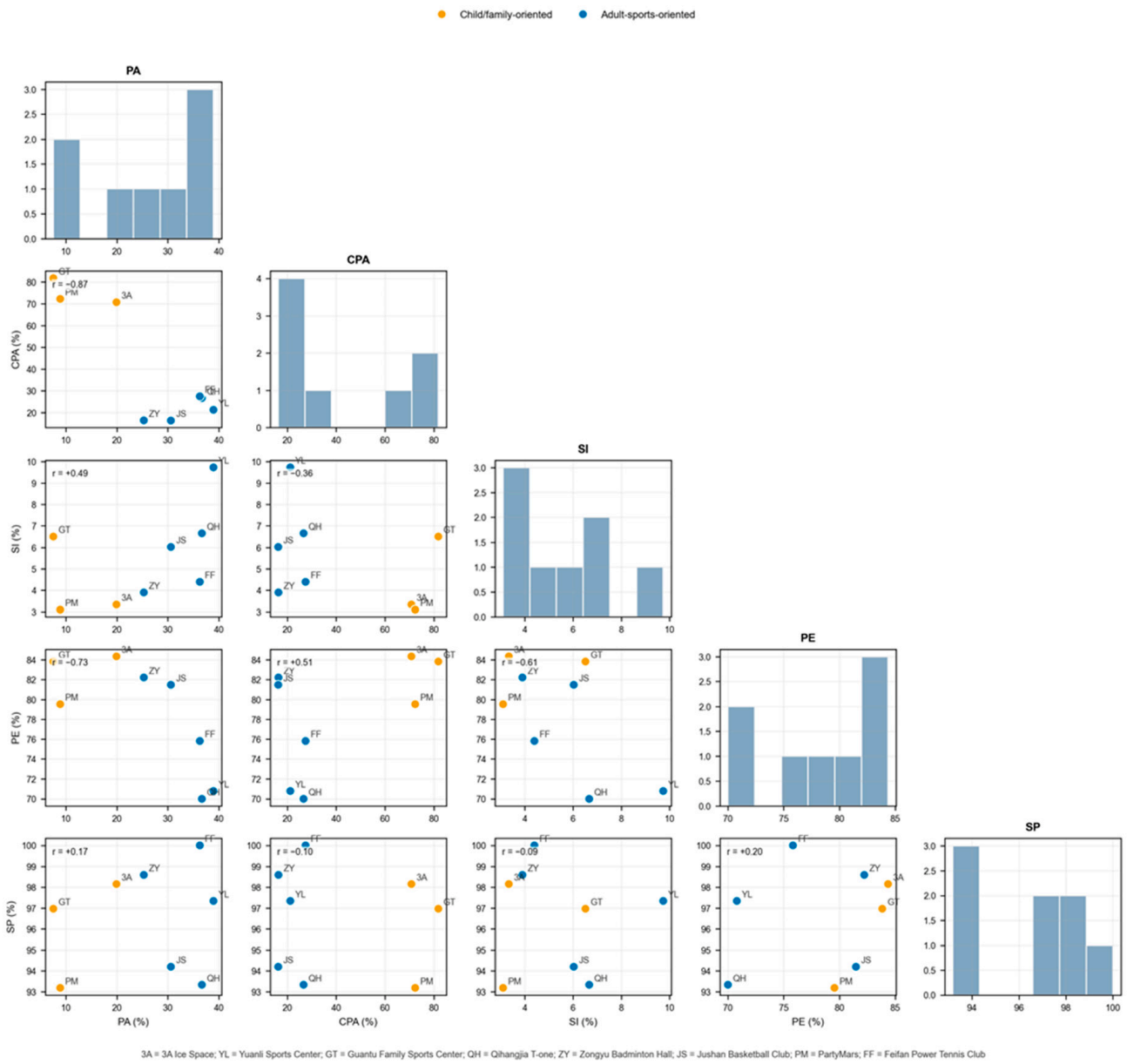


Figure 11. Scatterplot matrix of the five dimensions.

Within Lefebvre's triadic framework [5], PE can be interpreted as capturing representational spaces through affective language, while SP flags mentions of pricing, facilities, and service protocols associated with representations of space. Because SP does not encode valence and the PE-SP correlation is weak and non-significant, the present data do not support claims about unfavorable service or emotional decoupling. The theoretical link is therefore interpretive and exploratory.

3.7. Sentiment Analysis Cross-Validation

To assess the complementarity of the two methods, ROST CM6 was applied to the same reviews (Figures 12 and 13). PE is a review-level binary indicator based on positive emotional vocabulary, whereas ROST classifies the overall sentiment of the complete review as positive, neutral, or negative.

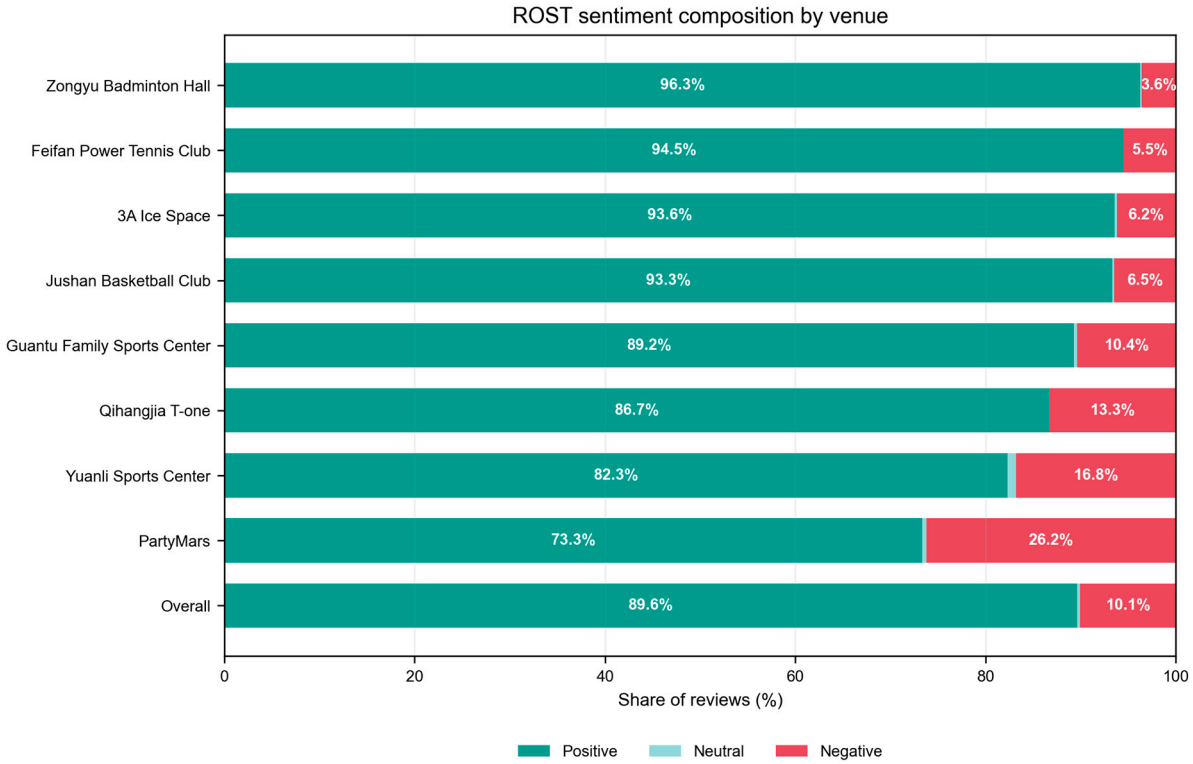


Figure 12. ROST sentiment composition for the full sample and eight venues.

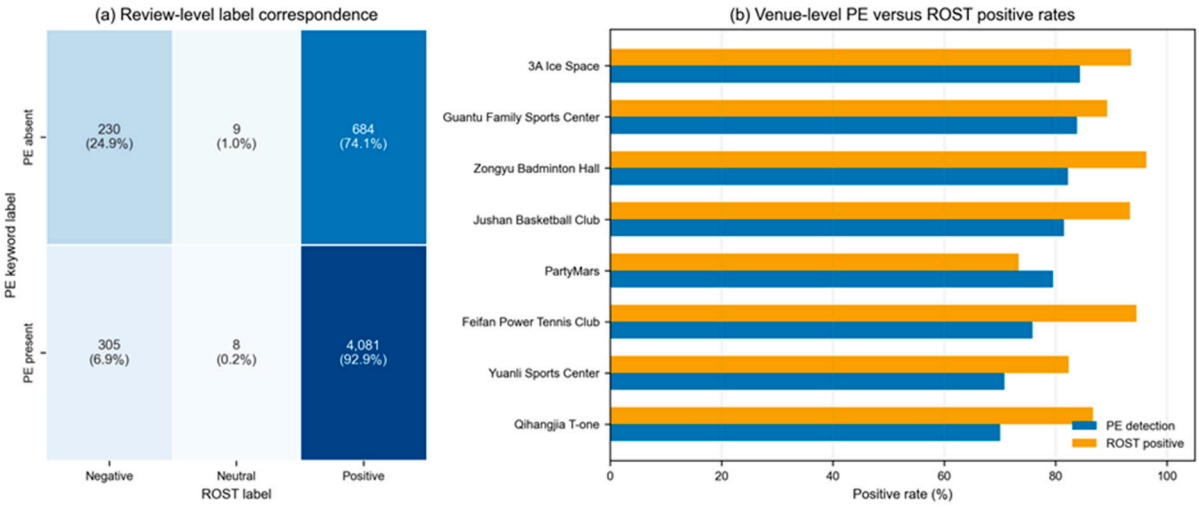


Figure 13. Correspondence between PE coding and ROST sentiment, overall and by venue.

ROST classified 4765 reviews (89.62%) as positive, 17 (0.32%) as neutral, and 535 (10.06%) as negative. Figure 12 shows the overall composition and the same three-category distribution for each venue. Among positive reviews, 58.92% were classified as highly positive.

At the venue level, Figure 13a cross-tabulates PE presence with the three ROST classes, and Figure 13b compares venue-level PE detection with the ROST positive rate. PartyMars had PE = 79.5% and ROST positive = 73.35%; although still predominantly positive, this was the lowest venue-level ROST positive rate and was accompanied by the highest negative share (26.24%). This pattern indicates a more mixed whole-review appraisal than the PE indicator alone, not a negative overall sentiment. Because ROST classifies the entire review and SP is polarity-neutral, the present results cannot determine which content drove the ROST label and do not support attribution to service quality.

4. Discussion

4.1. Methodological Contributions

The primary methodological contribution of this study is the theory-driven extension of the park-based analytical framework to sports venues. SP was added as a polarity-neutral screening indicator of service-related topics and achieved an independent test-set F_1 score of 0.82. Because generic vocabulary also contributes to SP detection, this supports feasibility rather than a fully validated SP construct (Section 3.1).

This methodological transfer is enabled by a hybrid matching strategy that applies different matching methods tailored to the semantic characteristics of each dimension. Experiments showed that sports behavior vocabulary (PA/CPA) is more suited to exact matching after jieba word segmentation, while evaluative vocabulary (PE/SP) is better suited to substring matching for generalized detection. This finding provides a reference for optimizing keyword annotation methods in Chinese social media text.

At the theoretical level, the addition of the Service Perception dimension not only carries methodological value but also reflects the structural differences in spatial production mechanisms between free parks and paid sports venues. Lefebvre's production of space theory [5] deconstructs the social production of space into three interrelated dimensions: "spatial practice," "representations of space," and "representational spaces." Within this framework, the original four dimensions (PA, CPA, PE, SI) primarily correspond to two levels: spatial practice (physical activity occurring in the physical environment) and representational spaces (emotional experience and social interaction).

Paid sports venues are service-mediated spaces users enter through booking, ticketing, or admission, and pricing, operating rules, and service procedures shape spatial practice. On the independent test set, F_1 scores were 0.97 (CPA), 0.87 (PE), 0.82 (SP), 0.72 (PA), and 0.56 (SI). SP combines relatively stable service phrases with generic terms, which explains its high automated detection rate (96.8%) but limits its interpretation as a validated perception measure. The underlying reason is that the Service Perception vocabulary (e.g., "服务" (service), "态度" (attitude), "环境" (environment), "价格" (price), "设施" (facilities)) has relatively stable semantic boundaries in Dianping and Meituan reviews, with users' evaluations following relatively fixed expression patterns. Relative to PA and SI, SP keywords include more stable service-related phrases, although the lexicon also contains generic terms whose hits inflate the detection rate (Section 3.1). In contrast, physical activity expressions are highly dependent on specific sports contexts (general terms such as "打球" (play ball), "锻炼" (exercise), and "运动" (sports) lack contextual discriminability), while social interaction signals appear in diverse short-phrase forms (e.g., "组局" (organize a gathering), "拜师" (take a coach), "约战" (arrange a match)), whose semantic variants are difficult to exhaust with a fixed keyword library.

The above methodological exploration lays the groundwork for understanding user behavior characteristics at sports venues. The following section further discusses the practical implications for venue operations management based on the five-dimension analysis results.

4.2. Implications of the Findings for Venue Operations

The five-dimension analysis results of this study offer multi-dimensional decision-making references for sports venue operations management. First, in child-activity-oriented venues (Guantu Family Sports Center CPA = 81.8%, 3A Ice Space CPA = 70.8%, PartyMars CPA = 72.3%), CPA was the most frequently detected behavioral dimension (PA, CPA, SI), although PE and SP were higher than CPA. This pattern is consistent with a family/youth-training emphasis and suggests the value of family auxiliary spaces and parent–child programming, but it does not identify individual users or establish that CPA dominates every dimension. At the operational level, family-friendly facilities (e.g., parent

rest areas, children's safety installations) could be strategically reinforced, while parent–child interactive activities and course products could be developed to enhance user retention and average revenue per customer. Second, adult-sports-oriented venues, whose PA detection rates were significantly higher at the venue level, are consistent with a user profile dominated by adult physical activity; because PA has an independent test F_1 of 0.72, this pattern is interpreted as a venue-level aggregate tendency rather than a review-level classification, and its strength should be treated cautiously. Operational implications include fostering sports communities and developing adult fitness products.

Viewed through the lens of production of space theory [5], the differentiation between the two venue types can be interpreted as different modes of spatial production. Child-activity-oriented venues, dominated by CPA, resemble a "structured reproduction" mode—children's bodies are organized and managed within an adult-designed institutionalized training system, and spatial practice is highly subordinated to representations of space (curriculum systems, coach assignments, schedules). Adult-sports-oriented venues, with higher venue-level PA, are more consistent with "self-directed participation," in which adult users independently determine the content and pace of their physical activities. This interpretation is tentative: PA detection at the review level is imperfect (test $F_1 = 0.72$), so the distinction is supported mainly at the venue-aggregate level. The contrast with Su & Sun's park-based classification [2] remains useful because, in paid venues, representations of space (pricing, membership systems, course bundling) directly shape user composition and behavior patterns.

Notably, SP detection ranged from 93.2% to 100% across venues, with a full-sample rate of 96.8%. This value is an automated detection rate and is not equivalent to the manually verified proportion of service-topic mentions. Users frequently comment on operational and facility-related aspects; however, because the high SP rate partly reflects broad and generic keyword matching (Section 3.1), this supports the inclusion of an SP-related dimension only as a content-level analytical category, not as evidence of a validated service-perception construct. However, as shown in Section 3.1, the near-saturated rate partly reflects the breadth of the keyword set; SP should therefore be interpreted through content-level analysis rather than as a dimension that discriminates between venues or rating groups. From the rating–dimension cross-analysis, the PE dimension maintained a detection rate above 48% across all rating levels, indicating that sports venue users tend to express positive emotions even when their experience is suboptimal—a finding consistent with Zou et al. [3], suggesting that venue operators should attend to the channeling and transformation of users' emotional needs in managing negative reviews.

Examining this further through the triadic framework, the PE-SP association was weak, positive, and non-significant (r = 0.202, p = 0.6311; 95% CI [−0.5860, 0.7938]). Because SP is polarity-neutral and ROST scores complete reviews, the present data cannot identify favorable or unfavorable service perceptions nor establish that service evaluations and positive affect are decoupled. SP remains a topic-screening indicator for representations of space, and the proposed relationship is retained only as a direction for future work with valence-coded SP data.

Finally, the venue spatial profiles in Table 1 link these behavioral and perceptual patterns to the built environment. Child-oriented venues with large indoor activity floors and upper rest/dining levels (e.g., Guantu, 3A Ice Space) appear to support the extended stays and family supervision reflected in high CPA and PE rates. Adult-oriented venues with multiple courts and training spaces (e.g., Yuanli's 11 tennis courts and FIBA A-level basketball courts; Jushan's three full courts plus a children's court) provide the spatial capacity for the adult participation patterns observed in PA rates. For design practice, these results suggest paying attention to family auxiliary spaces (rest areas, sightlines from waiting zones,

accessible routes), clear circulation between activity zones, and flexible multifunctional layouts that can serve both youth training and adult recreation. Direct measurement of spatial variables remains a future step (Section 4.3), as not all venues publicly report precise areas, capacities, or floor configurations.

Furthermore, it should be noted that this study analyzed user behavior and perceptions through textual review data without directly measuring the physical spatial configurations of the venues themselves. Factors such as layout efficiency, circulation design, spectator sightlines, and the ergonomic arrangement of ancillary facilities may mediate the behavioral and perceptual patterns identified here. Future research could extend the current framework by incorporating measurable spatial variables, thereby bridging the gap between architectural design parameters and user experiential outcomes captured through social media analytics.

4.3. Limitations and Future Directions

In addition, this study has the following limitations.

First, on the independent test set, annotation accuracy was relatively low for SI (F_1 = 0.56) and PA (F_1 = 0.72). The primary reason is that physical activity vocabulary (e.g., “打球” (play ball), “锻炼” (exercise), “运动” (sports)) often appears as generic expressions in reviews, lacking the discriminability to identify specific sports contexts, while social interaction signals exhibit highly diverse expression forms (e.g., short-phrase structures such as “组局” (organize a gathering), “拜师” (take a coach), “约战” (arrange a match), “认识朋友” (make friends)), making it difficult for the seed keyword library to comprehensively cover their semantic variants. Future research could introduce pre-trained language models (e.g., BERT, Word2Vec) for semantic similarity computation to replace keyword matching, thereby improving the annotation accuracy of low-F_1 dimensions. Second, the data sources of this study were limited to Dianping and Meituan, introducing platform selection bias: Meituan users are predominantly family consumers, while Dianping users are mainly young consumers. Future studies could expand to social platforms such as Xiaohongshu and Douyin to enrich sample diversity. Third, as this study was conducted in a single specific area, the number of venues collected (8) and the sample size (5317 reviews) are relatively limited. Future research should validate the generalizability of the methodological framework across more cities and venue types. Fourth, the coding rules of this study established a mutual exclusivity mechanism prioritizing CPA over PA. While this methodologically avoids double-counting in the same review, it also results in complete mutual exclusivity between PA and CPA in the annotation results (conditional co-occurrence probability = 0%), potentially systematically underestimating the true proportion of adult–child co-activity scenarios. Future research could explore multi-label classification strategies to replace the priority rule, thereby more accurately capturing the actual situations of multi-dimensional behavioral co-occurrence.

As a single-region case study, this research provides in-depth, context-rich insights into the specific mechanisms of user behavior within Tianzhu’s sports venue cluster—a type of knowledge that multi-city surveys with standardized indicators may sacrifice for breadth. The eight venues analyzed represent diverse business models, pricing tiers, and user demographics within a spatially bounded setting, enabling a controlled comparison that isolates venue-level effects from confounding regional variations. However, this analytical depth comes at a cost to statistical generalizability. The findings are situated within the Chinese socio-cultural context, where sports consumption patterns, platform review culture, and urban spatial policies differ markedly from those in Western or other Asian contexts. Future multi-city comparative studies—particularly those spanning different urban hierarchies (e.g., first-tier versus emerging cities) and cultural contexts (e.g., East Asian

versus European sports venue clusters)—could test the cross-contextual stability of the five-dimension framework and establish its boundary conditions.

Meanwhile, Su & Sun [2] further trained a multi-label machine learning classifier on the basis of the expanded keyword library, which represents an important direction for refining the automated annotation workflow in future iterations of this study. The near-saturated SP dimension also points to a need for content-level qualitative validation: future research could combine keyword extraction with semi-structured interviews or on-site observations to examine what specific service conditions users refer to and how spatial configurations mediate those perceptions. Direct measurement of venue-level spatial variables (area, court/rink counts, floor configuration, capacity, accessibility) would allow the venue profiles compiled in Table 1 to be tested as explanatory variables in multi-city samples.

Finally, because the SP lexicon contains generic and activity-related terms, future work should construct a curated SP lexicon that distinguishes genuine service evaluations from topic mentions and validate it with content-level annotation of SP-positive reviews.

5. Conclusions

This study constructed a five-dimension analytical framework—Physical Activity (PA), Children's Physical Activity (CPA), Social Interaction (SI), Positive Emotion (PE), and Service Perception (SP)—based on 5317 Dianping and Meituan reviews of eight sports venues in Tianzhu, Shunyi, Beijing, and interpreted the results through Lefebvre's production of space theory [5]. The conclusions answer the five research questions as follows.

(1) The park-based framework can be transferred to sports venues through two extensions: adding SP as an operational measure of the institutional/service dimension and adopting a hybrid matching strategy that uses jieba segmentation for PA/CPA and substring matching for SI/PE/SP. On the 100-review independent test set, the hybrid strategy achieved F_1 scores of 0.97 (CPA), 0.87 (PE), 0.82 (SP), 0.72 (PA), and 0.56 (SI), demonstrating that the framework is workable while highlighting dimensions that require more careful interpretation.

(2) The collected reviews show distinct behavior-emotion profiles: PE is high (82.6%), the full SP lexicon achieved an automated detection rate of 96.8%, CPA was detected in 63.2% of reviews, and PA (15.1%) is lower partly because CPA takes priority when both are present. These proportions describe the review sample; in particular, CPA should not be interpreted as the composition of actual local sports venue clients, and 96.8% should not be interpreted as the manually verified proportion of service-topic mentions. PA and SI conclusions are limited by their test F_1 values and are treated as venue-level or exploratory patterns.

(3) Pre-defined venue-type comparisons, based on business type and operating model rather than on outcome data, show descriptively consistent differences: child/family-oriented venues exhibit higher venue-level CPA rates, while adult-sports-oriented venues exhibit higher venue-level PA rates. Given $n = 8$, these comparisons are descriptive rather than confirmatory.

(4) In the collected reviews, the full SP lexicon achieved an automated detection rate of 96.8%, whereas strict compound phrases achieved 49.5%. The broader lexicon improves coverage but introduces false positives; therefore, 96.8% is not equivalent to the proportion of manually verified service-topic mentions. SP has independent-test precision of 0.70, and its lexicon includes generic terms. It is therefore best treated as a polarity-neutral screening signal that requires content-level analysis, not as a measure of service satisfaction.

(5) SP operationalizes the representations-of-space/institutional layer in Lefebvre's triad as a polarity-neutral topic indicator. Its association with PE was weak, positive, and

non-significant (r = 0.202, $p = 0.6311$). Because SP does not encode evaluation valence and ROST applies to the whole review, the present results support neither emotional decoupling nor conclusions about service quality. Future research using valence-coded SP measures is needed to test this proposed relationship.

The study has several limitations: review data come from two platforms in a single district; the number of venues is small; PA and SI annotation is imperfect; the CPA-priority rule suppresses adult-child co-activity; SP does not encode evaluation valence, and the physical characteristics of venues were compiled from public sources rather than direct measurement. Future research should apply pre-trained language models or multi-label classifiers, incorporate measured spatial variables, extend the framework across cities and venue types, and validate SP content qualitatively.

Author Contributions: Conceptualization, Y.W. and Y.L.; methodology, Y.W.; software, Y.W.; validation, Y.W. and Y.L.; formal analysis, Y.W.; investigation, Y.W.; resources, Y.L.; data curation, Y.W.; writing—original draft preparation, Y.W.; writing—review and editing, Y.W. and Y.L.; visualization, Y.W.; supervision, Y.L.; project administration, Y.L.; funding acquisition, Y.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Natural Science Foundation of China grant number 52508048.

Data Availability Statement: The review data were obtained from Dianping and Meituan and are not publicly redistributed because of platform terms of service and privacy restrictions. The de-identified derived data and analysis code are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Chen, J.; Han, J. Visitor perceptions and emotional trends in Chinese sports parks based on textual network and sentiment analysis. *Discov. Sustain.* **2025**, *6*, 1115. [CrossRef]
2. Su, T.; Sun, M. Understanding park-based health-promoting behavior and emotion with large-scale social media data: The case of Tianjin, China. *Cities* **2025**, *162*, 105987. [CrossRef]
3. Zou, Y.; Zhao, Q.; Wang, B.; Chen, G. Sentiment mining of online comments of sports venues: Consumer satisfaction and its influencing factors. *PLoS ONE* **2025**, *20*, e0319476. [CrossRef] [PubMed]
4. Yang, Y.; Tang, S. Assessment of Service Quality in Urban Sports Facilities: A Comprehensive Evaluation Framework Applied to Shanghai, China. *Buildings* **2025**, *15*, 193. [CrossRef]
5. Lefebvre, H. *The Production of Space*; Blackwell: Oxford, UK, 1991.
6. Chen, Y.; He, S.; Zhang, M.; Cai, Y. Resident demand-oriented selection and spatial layout strategy for public sports facilities. *Proc. Inst. Civ. Eng.-Munic. Eng.* **2024**, *177*, 130–143. [CrossRef]
7. Chen, Y. Research on Planning and Management of Large-Scale Sports Venues in Chinese Cities. *Open House Int.* **2019**, *44*, 76–79. [CrossRef]
8. Funahashi, H.; Cardazzi, A. Sport stadiums & land values. *Reg. Sci. Urban Econ.* **2026**, *120*, 104244. [CrossRef]
9. Chen, X.; Hu, Y. Diagnosing bottlenecks in sports space satisfaction of commercial complexes based on IPA analysis and accurate enhancement strategies: A case study of Shanghai, China. *Front. Archit. Res.* **2026**. [CrossRef]
10. McKenzie, T.L.; Cohen, D.A.; Sehgal, A.; Williamson, S.; Golinelli, D. System for Observing Play and Recreation in Communities (SOPARC): Reliability and feasibility measures. *J. Phys. Act. Health* **2006**, *3*, S208–S222. [CrossRef] [PubMed]
11. Castillo-Rodriguez, A.; Onetti-Onetti, W.; Chinchilla-Minguet, J.L. Perceived quality in sports centers in southern Spain: A case study. *Sustainability* **2019**, *11*, 3983. [CrossRef]
12. Cohen, D.A.; Marsh, T.; Williamson, S.; Derose, K.P.; Martinez, H.; Setodji, C.; McKenzie, T.L. Parks and physical activity: Why are some parks used more than others? *Prev. Med.* **2010**, *50*, S9–S12. [CrossRef] [PubMed]
13. Ma, S.C.; Kaplanidou, K. Service quality, perceived value and behavioral intentions among highly and lowly identified baseball consumers across nations. *Int. J. Sports Mark. Spons.* **2020**, *21*, 46–69. [CrossRef]
14. Brown, G.; Smith, A.; Assaker, G. Revisiting the host city: An empirical examination of sport involvement, place attachment, event satisfaction and spectator intentions at the London Olympics. *Tour. Manag.* **2016**, *55*, 160–172. [CrossRef]

15. Yue, W.; Dai, P. Research on urban national sports fitness demand prediction method based on ant colony algorithm. *Comput. Intell. Neurosci.* **2022**, *2022*, 5872643. [CrossRef] [PubMed]
16. Wan, Y.; Tang, H. Design of optimization algorithm for configuration of amateur sports training equipment in smart city community. *Comput. Intell. Neurosci.* **2022**, *2022*, 9572395. [CrossRef] [PubMed]
17. Li, L.; Wang, L. Insights into People's Perceptions Towards Urban Public Spaces Through Analysis of Social Media Reviews: A Case Study of Shanghai. *Buildings* **2025**, *15*, 3033. [CrossRef]
18. Garay, L. #Visitspain. Breaking down affective and cognitive attributes in the social media construction of the tourist destination image. *Tour. Manag. Perspect.* **2019**, *32*, 100560. [CrossRef]
19. Wang, Z.; Jie, H.; Fu, H.; Wang, L.; Jiang, H.; Ding, L.; Chen, Y. A social-media-based improvement index for urban renewal. *Ecol. Indic.* **2022**, *137*, 108775. [CrossRef]
20. Ilieva, R.T.; McPhearson, T. Social-media data for urban sustainability. *Nat. Sustain.* **2018**, *1*, 553–565. [CrossRef]
21. Kandt, J.; Batty, M. Smart cities, big data and urban policy: Towards urban analytics for the long run. *Cities* **2021**, *109*, 102992. [CrossRef]
22. Donahue, M.L.; Keeler, B.L.; Wood, S.A.; Fisher, D.M.; Hamstead, Z.A.; McPhearson, T. Using social media to understand drivers of urban park visitation in the Twin Cities, MN. *Landsc. Urban Plan.* **2018**, *175*, 1–10. [CrossRef]
23. Plunz, R.A.; Zhou, Y.; Carrasco Vintimilla, M.I.; McKeown, K.; Yu, T.; Uguccioni, L.; Sutto, M.P. Twitter sentiment in New York City parks as a measure of well-being. *Landsc. Urban Plan.* **2019**, *189*, 235–246. [CrossRef]
24. Kim, H.; Kweon, J.; Kim, J.H.; Hipp, J.R.; Lee, S. Who gets quality urban parks? A socioeconomic disparity analysis using user reviews and the opportunity algorithm in Los Angeles. *Urban For. Urban Green.* **2026**, *117*, 129266. [CrossRef]
25. Huang, W.; Zhao, X.; Lin, G.; Wang, Z.; Chen, M. How to quantify multidimensional perception of urban parks? Integrating deep learning-based social media data analysis with questionnaire survey methods. *Urban For. Urban Green.* **2025**, *107*, 128754. [CrossRef]
26. Zhang, B.; Song, Y.; Liu, D.; Zeng, Z.; Guo, S.; Yang, Q.; Wen, Y.; Wang, W.; Shen, X. Descriptive and Network Post-Occupancy Evaluation of the Urban Public Space through Social Media: A Case Study of Bryant Park, NY. *Land* **2023**, *12*, 1403. [CrossRef]
27. Gao, M.; Fang, C. Do urban park spatial features influence public emotional responses during jogging? Evidence from social media data. *J. Outdoor Recreat. Tour.* **2025**, *50*, 100864. [CrossRef]
28. Huai, S.; Liu, S.; Zheng, T.; Van De Voorde, T. Are social media data and survey data consistent in measuring park visitation, park satisfaction, and their influencing factors? A case study in Shanghai. *Urban For. Urban Green.* **2023**, *81*, 127869. [CrossRef]
29. Zuo, Y. Assessment of Cultural Services Provided by Urban Park Ecosystems in Beijing Based on Social Media Data and Analysis of Influencing Factors. Master's Thesis, Shandong Normal University, Jinan, China, 2024.
30. Tang, Z.; Zhao, Y. Perception and Evaluation of Cultural Heritage Value in Historic Urban Public Parks Based on Social Media Data: A Case Study of Shanghai. *Buildings* **2025**, *15*, 3864. [CrossRef]
31. Zhai, Y.; Lv, H.; Pan, J.; Ji, P. Impact of the Built Environment on Public Sentiment During Winter in Cold-Region Cities: A Case Study of Harbin Based on Social Media. *Buildings* **2026**, *16*, 2560. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.