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Research on the Perception of Cultural Ecosystem Services in Urban Parks via Analyses of Online Comment Data

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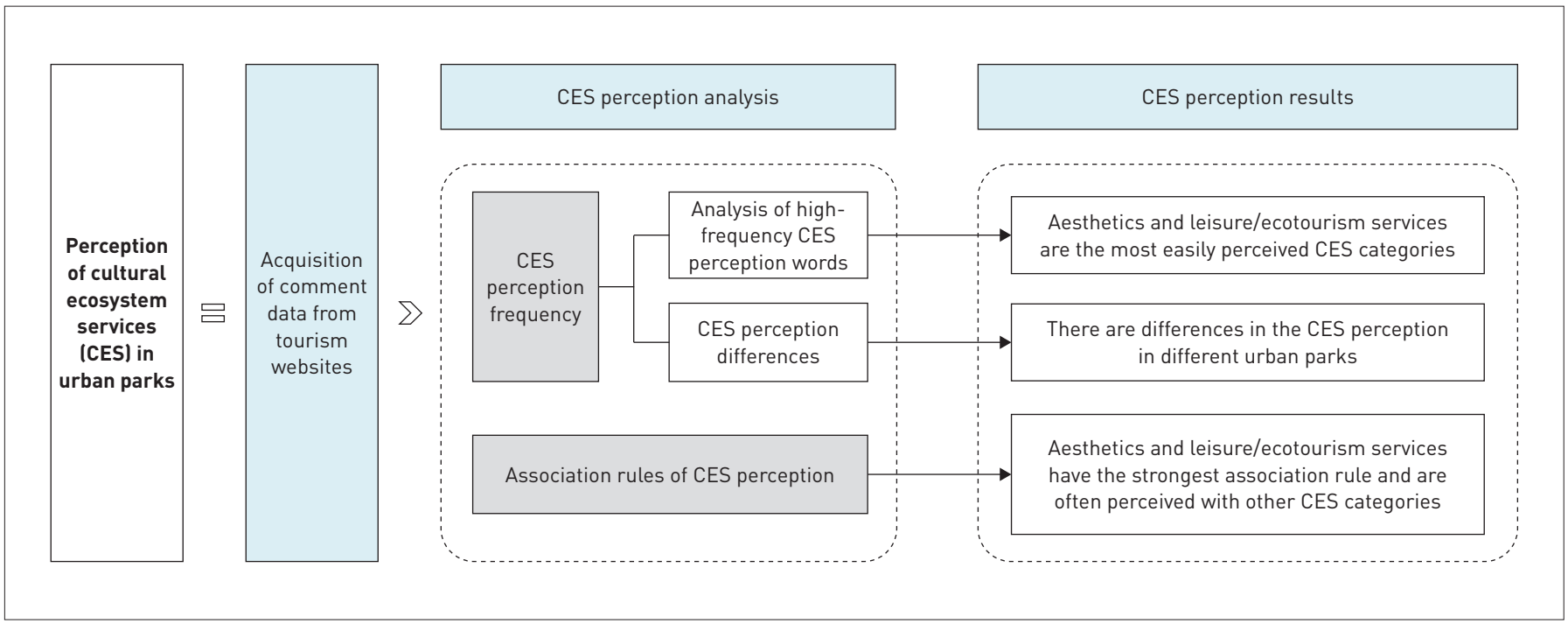
GRAPHICAL ABSTRACT



HIGHLIGHTS

- Aesthetics and leisure/ecotourism services are the most easily perceived CES categories in urban parks
- There are differences in public's perception of CES categories in different urban parks
- Aesthetics and leisure/ecotourism services have the strongest correlation and are often perceived with the services of cultural heritage, spiritual/religious value, and artistic inspiration

KEYWORDS

Urban Parks;
Cultural Ecosystem Services;
Landscape Perception;
Online Comment Data;
FP-Association Rule;
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ABSTRACT

Urban parks are an important part of urban ecosystems and can provide beneficial cultural ecosystem services (CES) to urban residents. The integration of geospatial and online comment data and relevant data mining have become a mainstream approach to the research on CES perception. This paper takes 10 typical urban parks in the central districts of Jinan, China as examples, and collects park users' online comment data from tourism websites. Based on content analysis, high-frequency CES perception words and their perception frequencies are obtained to reveal the disparity of CES perception in different urban parks. FP-association rules are applied to examine the correlations between the perception of CES categories. Main findings are as follow. 1) Aesthetics and leisure/ecotourism services are the most easily perceived CES categories in urban parks. 2) There are differences in public's perception of CES categories in different urban parks: aesthetics service in Baihua Park and Wulongtan Park, leisure/ecotourism service in Jinan Forest Park, and education/knowledge service in Quancheng Park, Zhongshan Park, Huashan Lake Park, and Jinan Zoo can be better perceived by the public. And 3) the perception of CES categories of urban parks is correlated. Aesthetics and leisure/ecotourism services have the strongest correlation and are often perceived with the services of cultural heritage, spiritual/religious value, and artistic inspiration. The study enriches the empirical research on CES perception via analyses of online comment data, clarifies the patterns of public's CES perception in urban parks, and provides a scientific reference for the planning, design, and management of urban parks, showing a significance for improving CES supply and spatial quality of urban parks.

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1 Introduction

Cultural Ecosystem Services (CES) is the non-material benefits that humans derive from ecosystems for spiritual life, cognitive development, educational reflection, recreation and leisure, and aesthetic experiences[1][2]. With aesthetic, recreational, educational, and spiritual functions, urban parks can provide CES for urban residents to relieve stress and promote physical and mental health[3], who in turn expect an improvement in park service, spatial design, and management[4]. Exploring users' CES perception of urban parks will not only help understand the actual needs of the public and improve their well-being, but also provide a scientific evidence for the planning, design, and management of the parks[5].

In terms of research subjects, existing Chinese and international CES perception studies focus on perceptual variation across ecosystems[6][7] and stakeholders[7]~[11], the influence of biophysical, socio-demographic, and institutional factors on perception[10][12]~[15], and the use of perception as a means to CES assessment, mapping, and quantitative research[13][16], explore stakeholders' socio-cultural preferences[17][18], and the relationship between CES and landscape characteristics[19][20]. However, research on the correlations between perceived CES categories in urban parks is rare, and few scholars have explored how different CES categories are perceived in specific spaces. Compared with the traditional research methods such as questionnaires and picture surveys[17], public participation mappings[21], and workshops[22], the emerging trend to integrate geospatial data with online comment data for CES identification[23][24]—to filter and translate the mass individual usage information (e.g., geographic, semantic, emotional information) in the online comment data[25]—works more effectively in data acquisition for landscape perception research. Although most related studies use the text analysis software jiebaR[4] and Rost Content[6] for pre-processing of raw comment data, statistically analyzing and classifying high-frequency CES perception words[4][6], the correlations between perceived CES categories have been less studied.

Addressing the above gaps, this research demonstrates a case study on 10 typical urban parks in the central districts of Jinan City, Shandong Province, China by obtaining high-frequency CES perception words and their occurrence frequency via content analysis method of the public comment data from tourism websites; the paper then analyzes the differences of the perceived CES categories in different urban parks, and applies association rules to reveal the correlations among the categories, in order to inform

the CES enhancement in urban parks. The study aims to answer the following questions. 1) Which CES categories are most easily perceived by the public in urban parks? 2) What are the differences of CES perception among different urban parks? And 3) can different CES categories be perceived simultaneously in a given site?

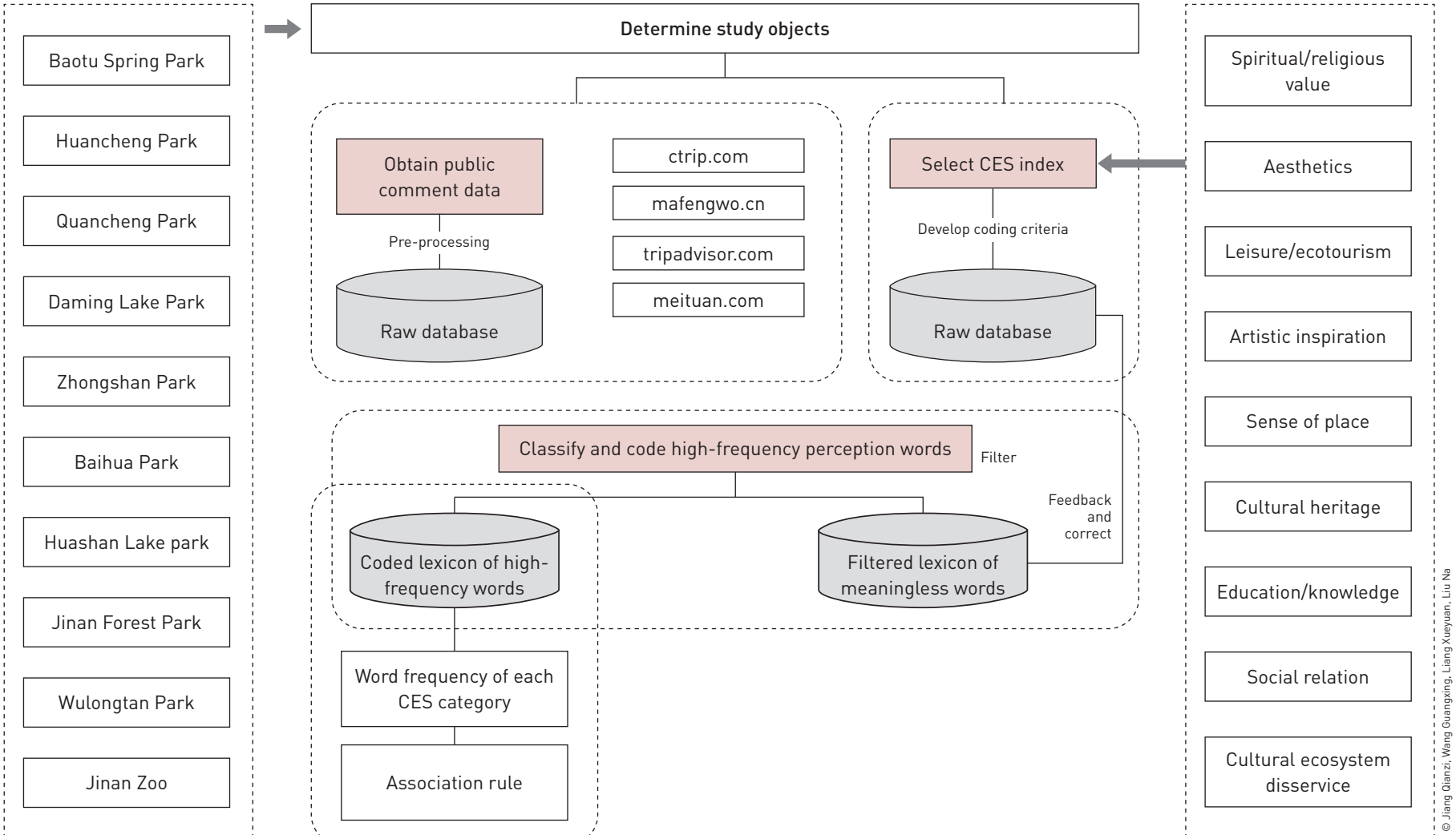
2 Data Acquisition and Data Processing

2.1 Sample Selection

The research selected a study area enclosed by the bypass expressway in Jinan City, covering five administrative districts: Lixia, Shizhong, Licheng, Huaiyin, and Tianqiao. The research referred to relevant regulations by the Urban Green Space Classification Standard (CJJ/T85-2017), and sourced from the statistics on the size and running status of public parks in the study area from the green space distribution data of the OSM (Open Street Map) in June 2021, the park POI data of AMAP, and the park list in the Jinan Urban Green Space System Plan (2010–2020). All these parks were ranked by the number of comments they received on tourism websites. Finally, 10 representative urban parks were selected through a comprehensive consideration on factors such as size, type, number of comments, and location (Table 1)[7].

Table 1: Basic information of sample parks

Park name	Park area (hm^2)	Year built	Park type	Park features	District located in	Number of comments
Baotu Spring Park	10.5	1956	Themed	Famous cultural park with spring water and humanistic landscape	Lixia District	16,405
Huancheng Park	26.3	1986	Themed	A belt park that connects several spring groups around the city		362
Quancheng Park	46.7	1986	General	Formerly a botanical garden, now an urban central park with multiple functions		628
Daming Lake Park	86.0	1958	General	A historic tourist attraction named after Daming Lake		7,650
Zhongshan Park	3.1	1904	General	Small cultural and recreational park surrounded with residential areas	Shizhong District	129
Baihua Park	18.0	1986	General	A park with mainly lush vegetation and flowering landscapes	Licheng District	192
Huashan Lake Park	625.0	2018	General	A suburban mountainous scenic area with the ancient architecture of Huayang Palace		88
Jinan Forest Park	64.9	2010	General	An urban park integrating recreational, educational, and emergency refuge functions	Huaiyin district	166
Wulongtan Park	5.4	1985	Themed	A park named after the best spring among the four major spring groups in Jinan with landscape features such as lakes, pools, streams, and docks	Tianqiao District	2,789
Jinan Zoo	60.0	1959	Themed	An educational park and scientific base about animals		15,490



1. Data processing diagram of this research

2.2 Data Acquisition and Processing

The research data were collected and processed in four steps (Fig. 1).

1) Data acquisition and pre-processing: crawl comments from tourism websites, then clean, segment, vectorize, and structure the textual data.

2) Determining CES perception categories and coding rules: select CES perception indicators specific to urban parks and construct coding rules accordingly.

3) CES perception word classification and coding: a team of experts classify and code all comment data using Delphi method; high-frequency perception words with codes are included in the Perception Lexicon, and the other words in the comments are included in the Filtered Lexicon.

And 4) correlation analyses on perceived CES categories: calculate the occurrence frequency of each perceived CES category in each park, and identify the correlations of these categories between parks.

2.2.1 Online Comment Data Acquisition and Pre-processing

This research selected the comments from the tourism websites including Ctrip, Mafengwo, Tripadvisor, and Meituan. These websites are highly popular in China and have a similar data structure, which made the data collection and processing easier. The data cover user names, comments and release dates, ratings, and photos. On June 24, 2021 the researchers searched with the keywords “Jinan + park name” (in Chinese) and obtained 46,181 data items, including park names, ratings, comments, and release

dates, with a total of 1,362,607 Chinese characters. The research data was carried out on June 24, 2021 for information collection, spanning from February 9, 2009 to June 23, 2021.

Online comment data are usually fragmented, categorized, and heterogeneous[26], so irrelevant data should be eliminated. Existing word segmentation tools are unable to recognize new technical terms and would lead to mis-segmentation—for example, "生态旅游" (eco-tourism) would be segmented into "生态" (ecological) and "旅游" (tourism)—which impacts the accuracy of coding results. After eliminating irrelevant data and repeated words, the study introduced Jieba thesaurus tool in Python, which can overcome such a mis-segmentation problem. For a comprehensive examination, the researchers counted the total number of segments and the occurrence frequency of each, then identified the segments occurring more than twice as high-frequency CES perception words[22]. Finally, the high-frequency CES perception words about each park were sorted by frequency, and the analysis results were visualized using the word cloud generator Weiciyun.

2.2.2 Perceived CES Categories and Coding Rules

Based on previous relevant studies[24][27], this study screened 9 CES categories: spiritual/religious value, aesthetics, leisure/ecotourism, artistic inspiration, sense of place, cultural heritage, education/knowledge, social relation, and cultural ecosystem disservice (Table 2). These CES categories were used as the codes, based on their corresponding interpretations.

Table 2: CES category and coding criteria

CES category	Code	Indicators connotation	Coding criteria
Spiritual/religious value	C1	Spiritual, religious, and other solemn activities associated with the values offered by the park	Religious beliefs or landscape features can provide users with a context for objectification on a spiritual level
Aesthetics	C2	Delightful visual experience of the beautiful scenery in the park	Enjoy the beautiful views of the park
Leisure/ecotourism	C3	Recreation and leisure activities in the park	Access to recreational activities (e.g. eco-tourism, fishing, and other outdoor recreational activities)
Artistic inspiration	C4	Artistic appreciation inspired by the park landscape	The view is reminiscent of poetry, paintings, and other works of art or literary figures
Sense of place	C5	Public sentiment towards a park or a particular site within a park	Recalling to a particular experience or feeling about the scene
Cultural heritage	C6	The cultural and historical values offered by the park	Reflecting historical buildings, cultural facilities, and regional culture in the park
Education/knowledge	C7	Public educational opportunities and scientific services offered by the park	Gaining knowledge from the park or describing the park's science facilities
Social relation	C8	The social interactions between people that take place in the park	Mentions about the interactions with others or group activities
Cultural ecosystem disservice	ES-	Ecological services in the park that are detrimental to users	Negative comments about the park

2.2.3 Classification and Coding of High-Frequency CES Perception Words

First, the study organized an expert team of 5 professionals①. In the first round of coding, each team member categorized and coded a list of high-frequency CES perception words. In the second round, the professionals switched their word lists, and the researchers marked the words with inconsistent codes. Such a cross-coding repeated several times until the team reached consensus on all the coding results. There completed the coding of all high-frequency CES perception words. The researchers then tagged these words in a "word-code" format, forming the Perception Lexicon. All the irrelevant segments (i.e., those other than the high-frequency CES perception words in the comments) formed the Filtered Lexicon. The study further filtered the Perception Lexicon by using Excel VBA macro language to eliminate errors and duplicate coding items. Finally, the study calculated the perception frequency of all CES categories in the parks to determine the main CES categories in each park. The equation for the perception frequency of a CES category is as below:

$$F_{CESj} = \frac{n_{CES}}{n_j} \quad (1)$$

where F_{CESj} is the perception frequency of a certain CES category in park j, n_{CES} is the occurrence times of high-frequency CES perception words mentioning that CES category, and n_j is the total occurrence times of all high-frequency CES perception words mentioned in park j.

2.2.4 CES Correlation Analysis

Data mining can reveal the underlying relationships among independent itemsets, which is adopted by this study to analyze the correlations among the perceived CES categories. The correlations can be explained as "association rules" and expressed as $X \rightarrow Y$, where X represents the condition of the association rule and Y represents the continuation of a series of transaction items related to X[28]. Frequent itemset is a collection of transactions that frequently occur together that may indicate a certain cause-and-effect relationship between the transactions. It is a common prior step for mining association rules[29][30]. FP-Growth algorithm is a new association rule mining algorithm proposed by Han et al.[31], which took Frequent Pattern (FP) tree as the basic form to mine frequent itemsets. This algorithm compresses and stores the itemsets, and supports direct extraction of data, improving the mining efficiency[32]. The specific application steps are as follows.

1) Use Excel VBA to replace each codable high-frequency CES perception word in online comments as a "frequent item," then count the support (i.e. number of occurrence) of each frequent item.

2) Sort all frequent items in descending support value to form a frequent item index table L.

3) Using Excel VBA to replace the high-frequency CES perception words with codes and eliminate irrelevant words, each online comment was transformed into a frequent itemset (e.g., a comment was transformed into the itemset [C1, C2, C7, C8]).

And 4) reorder the frequent items in each frequent itemset according to the index table L, construct the FP decision tree in Python with the frequent itemsets, and plot the calculated node chains, to obtain the set of association rules between the perceived CES categories in each park.

3 Research Results

3.1 Statistic Analysis of High-Frequency CES Perception Words

The statistical analysis of word frequency revealed that the number of high-frequency CES perception words in the collected comments was 1,185, accounting for 23.7% of all perception words and 84.1% of the total occurrence frequency. Among them, high-frequency CES perception words reflecting aesthetics and leisure/ecological services have a higher frequency, indicating that the public most easily perceives these two CES categories. About Daming Lake Park, Quancheng Park, and Wulongtan Park, the words describing aesthetic preferences such as "scenery," "flowers," and "landscape" appeared most frequently. About Baihua Park, Jinan Zoo, Jinan Forest Park, and Zhongshan Park, words such as "walking," "tourism," and "fitness" that describe recreational activities accounted for the highest percentage. The frequency of "cruise" was relatively high in Huancheng park (Fig. 2).

In addition, cultural heritage, education/knowledge, and cultural ecosystem disservices were also more easily perceived. The public can perceive cultural heritage services by visiting historic buildings and heritages in the parks. For example, about Huashan Lake Park, the words including "Huayang Palace" and "history" reflected people's perception of the historical and cultural qualities of the park. Parks with interpretation systems and educational facilities were likelier to offer perceivable education/knowledge services. For example, Zhongshan Park sets up a Book Corner, and

① The professionals were professors or senior graduate students who have academic knowledge about the perception of ecosystem services in landscapes, and some of them are the research team members.

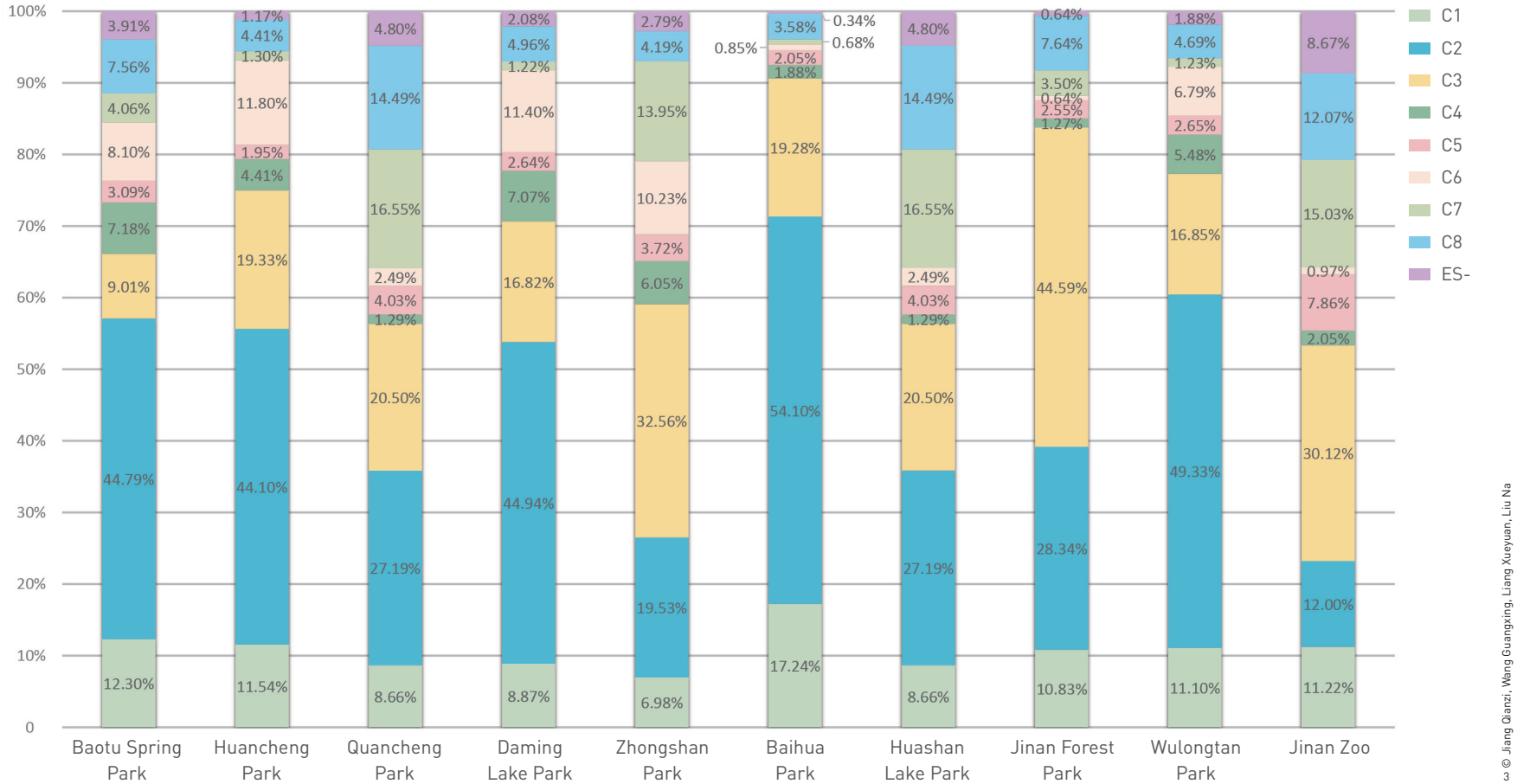
2. Cloud analysis of high-frequency CES perception words in the urban parks. Other CES categories are not listed because the numbers of their high-frequency perception words were too small to generate cloud analysis charts.

"reading books" is frequently mentioned. Jinan Zoo, as a themed park, is equipped with a series of recreational facilities combined with interpretative and signage systems, and "observing animals," "science and knowledge," and "signage" were mentioned the most frequently; Quancheng Park, formerly known as Jinan Botanical Garden, has established its plant tour areas, which were mentioned the most frequently. The cultural ecosystem disservices perceived by the public was mainly reflected by words such as "disappointed" and "not worth it," suggesting the gap between public demand and park service supply. Specially, users' comments such as "depressed", "monotonous," and "bare" about Daming Lake Park, Huancheng Park, and Wulongtan Park all disclose the problem of the poor insufficient aesthetic services in winter; words such as "smelly," "messy," and "muddy" about Huancheng Park and Jinan Zoo were mentioned several times, pinpointing the inadequacy in environmental management in the parks.

3.2 CES Perception Differences Among Parks

Analysis showed that the parks with higher popularity and non-local visits had more high-frequency perception words. For example, Baotu Spring Park, Daming Lake Park, and Jinan Zoo received the highest CES high-frequency perception words—21,350, 12,379, and 5,650, respectively—those about Baihua Park, Jinan Forest Park, and Zhongshan Park, which mainly serve local residents, were much less, 586, 384, and 215 for each.

All CES categories were perceived in each urban park. Still, there were differences in the perception of each categories between parks (Fig. 3). Overall, the word frequency of aesthetics and leisure/ecotourism services was relatively high in the ten parks. Baihua Park and Wulongtan Park had the highest percentage of perceived aesthetics services, 54.10% and 49.33%, respectively; Daming Lake Park, Baotu Spring Park, and Huancheng Park also accounted for more than 40%. The perception of leisure/ecotourism services varied considerably from park to park: it was highest in Jinan Forest Park at 44.59% and lowest in Baotu Spring Park at 9.01%. The word frequency of cultural heritage services was highest in Daming Lake, Zhongshan Park, and Huancheng Park, all of which exceeded 10%. Quancheng Park, Zhongshan Park, Huashan Lake Park, and Jinan Zoo all had a word frequency of education/knowledge services of over 15%, with Baihua Park being the lowest, only 0.68%. Social relations services were most frequently perceived in Quancheng Park, Huashan Lake Park, and Jinan Zoo, indicating that visitors were more willing to engage in social activities or build social relationships in these three parks. Spiritual/religious value service was perceived with a similar frequency across the parks;

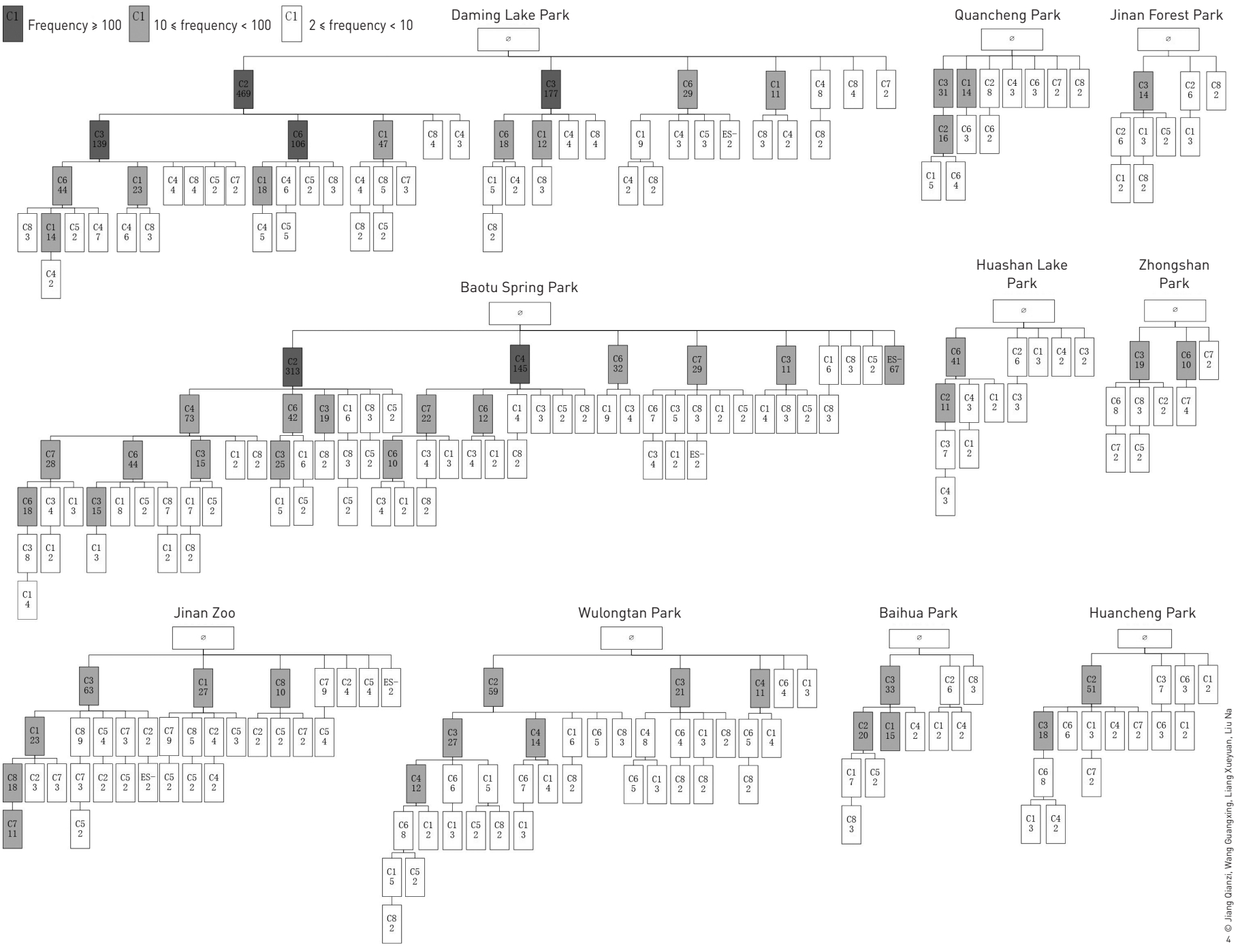


3. CES perceived frequency in the urban parks

meanwhile, few visitors (less than 10%) perceived the services of artistic inspiration or the sense of place—the latter was found with the lowest average perceived frequency at 3.50%. The average perceived frequency of cultural ecosystem disservice was not high (3.73%), among which Jinan Zoo was criticized with the most negative perception words (8.67%), followed by Quancheng Park and Huashan Lake Park (both 4.80%).

3.3 Correlation Analyses Between Perceived CES Categories

The results of association rule analyses showed that people's perception of aesthetic service was closely associated with that of leisure/ecotourism service (Fig. 4), which two CES categories established the strongest association rules in Daming Lake Park, Wulongtan Park, Baihua Park, Huancheng Park, Quancheng Park, and Jinan Forest Park, with 139, 27, 20, 18, 16, and 6 times of simultaneous occurrence, respectively. These very both services were often perceived by the public together with the services of cultural heritage, spiritual/religious value, or artistic inspiration. In Daming Lake Park, Huancheng Park, and Huashan Lake Park, these two CES categories were perceived together with cultural heritage service 44, 8, and 7 times respectively; in Baihua Park and Quancheng Park, these two were simultaneously perceived with spiritual/religious value service 7 and 5 times; in Wulongtan Park, they were perceived together with artistic inspiration service 12 times. The perception of the sense of place service established certain association rules with that of the services of aesthetics, leisure/ecotourism, artistic inspiration, and cultural heritage. Cultural ecosystem disservice was found to have associations with other CES categories about Daming Lake Park, Baotu Spring Park, and Jinan Zoo. The perception of cultural heritage service and cultural ecosystem disservice often occurred together in Daming Lake Park; there were more negative comments about Baotu Spring Park on its services of education/knowledge and social relations; cultural ecosystem disservice comments about Jinan Zoo mostly



4. CES perception association rules among the urban parks

were related to its aesthetics and leisure/ecotourism services. In addition, no association rules were found between education/knowledge services and social relations services.

4 Conclusions and Discussion

This paper examines the public perception of CES in 10 typical urban parks within the central districts of Jinan via analyses of online comment data. The main findings of the study are as follows.

1) Aesthetics and leisure/ecotourism services were the most easily perceived CES categories in urban parks.

2) People's perception of each CES category in different urban parks varies. Aesthetics service in Baihua Park and Wulongtan Park, leisure/ecotourism service in Jinan Forest Park, and educational/knowledge service in Quancheng Park, Zhongshan Park, Huashan Lake Park, and Jinan Zoo can be better perceived by the public.

And 3) the perception of different CES categories in urban parks showed certain association rules. The strongest correlation was identified between aesthetics and leisure/ecotourism services, which were also often perceived by the public together with the services of cultural heritage, spiritual/religious value, and artistic inspiration.

4.1 Correlations Between the Perception of CES Categories in Urban Parks

It was found that the simultaneous perception of multiple CES categories occurred in urban parks, as root nodes or sub-nodes of a certain CES category, witnessing a number of association rules. This finding is consistent with the theory of "ecosystem services bundles," i.e., ecosystem services that repeatedly appear together across space and/or time[33] and can be perceived simultaneously[17]. This study found that aesthetics and leisure/ecotourism services were the most directly perceived CES categories by the public in urban parks and had the strongest correlation. This confirms the findings of the research by E. Seda Arslan et al., which proved that aesthetic service and recreational service can contribute to, influence, and spatially overlap with each other[34].

Previous studies have found that the public less perceive the service of the sense of place in parks[21], which is the same with the findings of this study. Although the perception frequency was relatively low, the public can perceive the sense of place service in the 10 urban parks in this study, which was respectively associated with the services of aesthetics, leisure/ecotourism, artistic inspiration, and cultural heritage in Daming Lake Park, Baotu Spring Park, Zhongshan Park, Baihua Park, Jinan Forest Park, and Jinan Zoo. This may be due to the prominent regional cultural identities or spiritual features of the above parks, which are easier to be perceived by the public[35][36]. In addition to strengthening the public sense of identity and belonging[24], the service of sense of place in urban parks can promote the improvement of landscape quality, encourage recreational activities, and enhance artistic inspiration service.

Moreover, the study found no association rules between the services of education/knowledge and social relations. This may be due to the lack of science/education facilities or the limited types of public activities in some parks, making these two CES categories difficult to be perceived. Another possible reason is that the public tend to make comments on the CES categories related with features of a greater visual attraction, such as aesthetics and artistic inspiration services.

4.2 The Influence of Urban Park Features on the Correlations Between the Perception of CES Categories

By analyzing the association rules among the 10 urban parks, it found that park features can influence the correlations among the perception of CES categories. The beautiful scenery, diverse historical sites and cultural facilities, and various cultural heritage activities in Daming Lake Park, Baotu Spring Park, Wulongtan Park, Huashan Lake Park, and Huancheng Park, as recreational destinations for both local residents and non-local tourists, manifest their significant historical and cultural values. In these parks, the public can have an intense perception of the services of cultural heritage and artistic inspiration. Furthermore, as a famous historical and cultural city, Jinan attaches great importance to the protection and construction of its historical and cultural heritages, and strengthens its tourism competence by improving the landscape quality of historical and cultural parks. Such measures help establish strong correlations between the services of aesthetics, leisure/ecotourism, cultural heritage, and artistic inspiration. Quancheng Park, Baihua Park, and Jinan Forest Park are well known for their appealing natural landscapes and rich plant biodiversity, where visitors are allowed to well interact with nature and have multi-sensory experience that are conducive to relieving mental pressure[37]. Therefore, the services of aesthetics, leisure/ecotourism, and spiritual/religious value would be closely associated with each other. Zhongshan Park and Jinan Zoo are both of science and educational functions with specially designed buildings and outdoor spaces. Zhongshan Park, as the main place for its surrounding residents to relax, read, study, and hold cultural activities, has seen a strong correlation between the services of leisure/ecotourism, cultural heritage, and education/knowledge; Jinan Zoo is a themed park with sound recreational facilities and a full interpretation and signage system, which strengthen the correlation between leisure/ecotourism and education/knowledge services.

Considering the correlations of the perception of varied CES categories, the service level of CES in different parks can be enhanced by highlighting park features, so as to promote people's CES perception[38]. Parks that focus on natural landscape experience should not only pay attention to the creation of plants and water landscape with natural aesthetic charms, but also strengthen the spiritual recovery value of the park, so that the public can get a restorative experience in the natural environment, satisfying their needs for mental relief. For the parks characterized for historical and cultural qualities, traditional and cultural resources can be translated into modern landscapes to activate its vitality in

contemporary life; the narrative structure of the cultural landscape in the park can be optimized to strengthen visitor's interactions with historical elements; in addition, the promotion of the park's leisure/ecotourism service should be also prioritized. For the parks with science and educational functions, interactive landscape devices and lively educational activities can be introduced to meet users' various needs in recreation, nature assess, historical and cultural education, and social interaction. Park planning and design need to maintain the landscape elements commonly mentioned in the high-frequency CES perception words, and should put more efforts in the improvement of the aspects widely criticized about the cultural ecosystem disservices.

4.3 Relations Between CES Perception and Maslow's Hierarchy of Needs

Abraham Harold Maslow's Hierarchy of Needs divides human needs into five levels—physiological needs, security and safety needs, love and belonging needs, esteems needs, and self-actualization needs—which progress from basic to complex, the higher levels the rare to satisfy[39]. This study verified the relations between CES perception in urban parks and the needs for love and belonging, esteems, and self-actualization. This is in line with existing research findings that CES can satisfy higher-level Maslow's needs[40]. Through further recursive mining of association rules, this study found that aesthetics and leisure/ecotourism services often appear as root nodes, and they are the most frequently perceived CES categories related to needs for love and belonging and self-actualization; the services of cultural heritage, artistic inspiration, spiritual/religious value, and education/knowledge are moderately perceived CES categories, which is related to the esteems need; the services of the sense of place and social relations are perceived the least, relating to the needs for love and belonging and esteems. A possible reason is that most of the 10 urban parks are traditional parks built years ago, the creation of which focused more on visual and spatial design but lacked attention to public participation, user interaction, and the sense of belonging. Responding strategies for the renovation and improvement of the parks include enhancing users' experience and participation by strengthening interactive facilities and activities, inviting the public to engage with the park and have a sense of place and belonging.

4.4 Research Significance and Limitations

CES has always been difficult to conduct quantitative evaluations due to the subjective and non-consumptive nature of its generation, performance, and accessibility[41][42]. Traditional research methods often require a great amount of time and manual effort, and data acquisition suffers from collection difficulties, insufficient sample size, and weak randomness, limiting the accuracy and precision of research outcome. Online comment data from social networks has advantages of easy collection, large sample size, and high randomness[43]. This greatly enriches the data sources for CES perception research, reduces the cost for data acquisition, and improves research efficiency, which can be applied to further studies on CES perception identification and assessment.

This study illustrates the characteristics of public CES perception in urban parks, and applies the FP-Growth algorithm association rules to recursively mine frequent itemsets for the correlations established between different CES categories, to explore the ones that occur simultaneously in a higher frequency and are of a more closer association among the parks. This approach allows to cluster CES categories without identifying the exact spatial distribution of CES. In contrast to mathematical analyses, analyses of association rules can clearly show the specific frequency of high co-occurrence CES categories. The findings of this study suggests a likelihood of synergy between CES categories, i.e., the presence of the perception of one CES category is likely to facilitate the perception of other CES category/categories. Such CES synergies can enhance the efficiency of closely-related CES categories, which is important for improving the CES supply and spatial quality of urban parks.

There are also some limitations in this study. First, park users' demographic information (such as gender, age, occupation, education level, and income) is difficult to obtain for privacy reasons, which limits the possibility to conduct research on the influence of these factors on the perception of CES. Second, a further analysis on the disparity of CES perception of local residents and non-local visitors was not conducted, because the collected online comment data did not distinguish the two user groups. Third, considering the fact that the online comments are largely posted by the young and the middle-aged, the findings of this study might less cover the CES perception of elderly people, children, or other infrequent online commenters[44].

In the future, online comment data (especially demographic information) can be further mined to create accurate user profiles, which would support target research on users' perception in different environmental settings and their behavioral preferences, and inform in-depth exploration of the influence of demographic characteristics on CES perception in urban parks[45]. Integrating

multiple sources of data and methods, such as combining online comment data with questionnaire methods[46], will supplement perception data of the elderly, children, and the ones who are not online commenters. In addition, statistical analysis can be used to further explore the landscape characteristics of urban parks that affect how the public perceive CES.

RESEARCH FUNDS

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基于网络评论数据分析的城市公园生态系统文化服务感知研究

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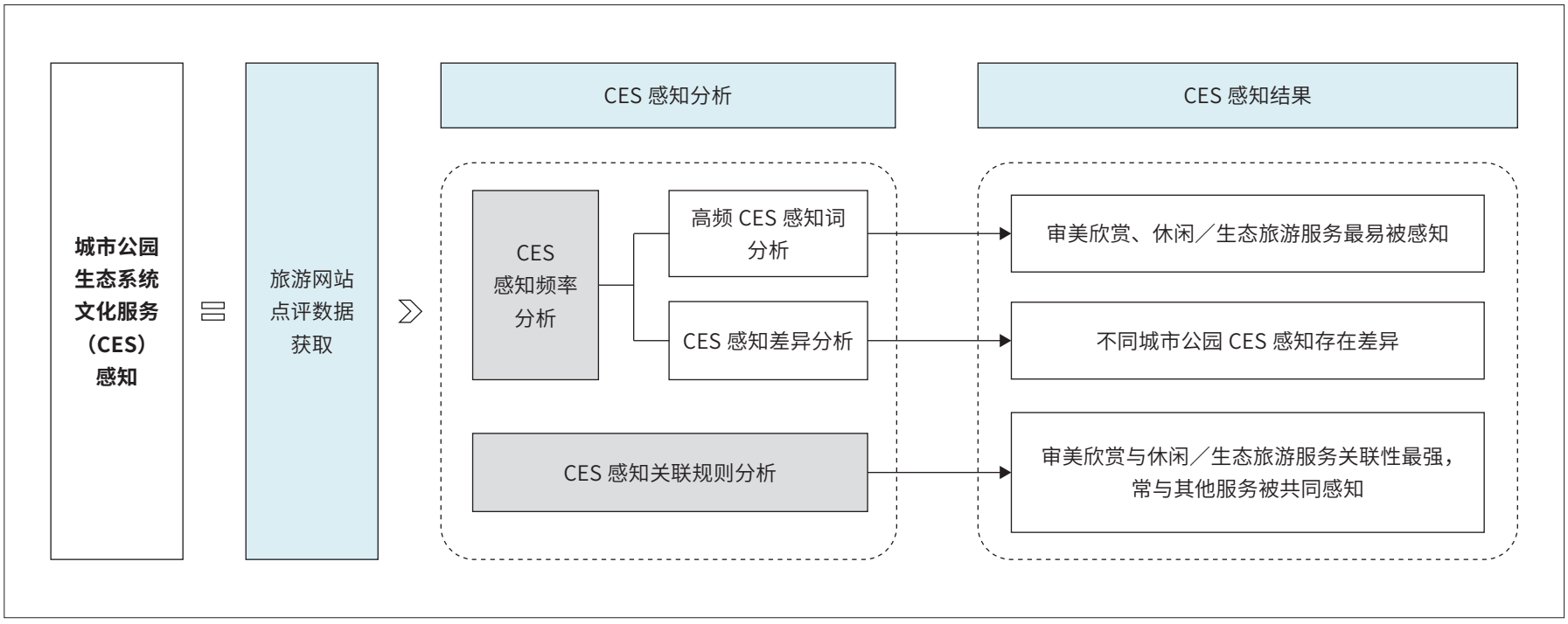
图文摘要



文章亮点

- 城市公园的审美欣赏服务与休闲 / 生态旅游服务最易被感知且关联性最强
- 不同城市公园生态系统文化服务感知存在差异
- 城市公园的文化遗产、精神 / 宗教价值、艺术灵感启发等服务常与审美欣赏、休闲 / 生态旅游服务共同被感知

关键词

城市公园；
生态系统文化服务；
景观感知；
网络点评数据；
FP – 关联规则；
济南

摘要

公园绿地是城市生态系统的重要组成部分，能够为城市居民提供有益的生态系统文化服务（CES）。地理空间与网络点评数据的融合与挖掘已成为CES感知研究的重要方法，但目前研究多聚焦CES感知类别识别与空间分布，较少关注不同CES类别感知间的关联性。研究以济南市主城区10个典型城市公园为例，爬取旅

游网站上用户的公开评论数据，基于内容分析法获取高频CES感知词和感知频率，分析不同城市公园的CES感知异同，并应用FP－关联规则揭示CES感知间的关联性。研究表明：1）审美欣赏、休闲／生态旅游是最易被公众感知到的城市公园CES类别。2）不同城市公园中公众对CES类别的感知存在差异。百花公园与五龙潭中的审美欣赏服务，济南森林公园中的休闲／生态旅游服务，泉城公园、中山公园、华山湖公园与动物园中的教育／知识服务可被公众较好感知。3）城市公园CES感知具有关联性：审美欣赏和休闲／生态旅游服务关联性最强，常与文化遗产、精神／宗教价值、艺术灵感启发等服务被共同感知。研究充实了基于网络评论数据的CES感知实证研究，阐明了城市公园CES公众感知特征，有助于为公园绿地规划设计与管理提供科学依据，对于提升城市公园CES供给与空间品质具有重要意义。

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1 引言

生态系统文化服务（Cultural Ecosystem Services，以下简称CES）是指“人类通过精神生活、认知发展、教育思考、娱乐休闲及审美体验等方式从生态系统中获取的非物质收益”[1][2]。城市公园具有美学、游憩、教育和精神体验等价值，因而能够为城市居民提供有益的CES，对于缓解压力、促进身心健康具有重要作用[3]；与此同时，公众也对城市公园绿地的服务品质、空间设计与管理提出了相应的高需求[4]。从公众的实际需求出发，探索城市公园CES感知特征，不仅有助于提高居民福祉，也能为公园绿地的规划设计与管理提供科学依据[5]。

在研究对象上，目前国内外关于CES的感知研究主要聚焦于不同生态系统的感知差异[6][7]，不同利益相关者的感知比较[7]~[11]，以及生物物理、社会人口和制度因素对感知的影响[10][12]~[15]；或通过感知研究进行CES评估、制图与量化[13][16]，探讨利益相关者的社会文化偏好[17][18]，研究CES与景观特征的关系[19][20]等。然而，针对城市公园CES感知类别之间的关联性研究尚不多见，且少有学者探讨不同CES在特定空间中是如何被感知的。在研究方法上，除问卷与图片调查[17]、公众参与制图[21]及研讨会[22]等传统调研方法外，整合地理空间数据与网络点评数据进行CES的识别已成为主要趋势[23][24]——网络点评数据记录的大量个体使用信息（如地理坐标、语义文本、情绪信息等[25]）可通过筛选转译应用于景观感知研究，在一定程度上弥补了传统调研方式在数据获取方面的不足。相关研究多利用文本分析软件jiebaR[4]和Rost Content[6]进行原始评论数据的预处理，虽然关注到高频CES感知词的统计与分类[4][6]，但对于CES感知类别之间的关联性尚未充分挖掘。

基于此，本研究以中国山东省济南市主城区10个典型城市公园为例，爬取旅游点评网站上用户的公开评论数据，基于内容分析法获得高频CES感知词及其出现频率，分析使用者对不同城市公园CES的感知差异，而后应用关联规则揭示CES感知类别间的关联性，以期为城市公园CES提升提供科学依据。研究旨在探索以下问题：1）公众在城市公园中最容易感知到哪些CES？2）不同城市公园中，公众的CES感知存在何种差异？3）不同CES在特定空间中能否被同时感知？

2 数据获得与数据处理

2.1 研究对象选择

研究范围界定在济南市绕城高速路所围成的区域，涵盖历下区、市中区、历城区、槐荫区与天桥区5个行政区。研究首先根据《城市绿地分类标准》（CJJ/T85-2017）的相关规定，以2021年6月“开放街道地图”（Open Street Map）网站的开放绿地空间分布数据、高德地图的公园POI信息数据及《济南市城市绿地系统规划（2010—2020）》中的公园名录为基础，对研究区域内公园的规模和建成情况进行统计；其次，统计上述公园在旅游网站上的评论数量，将公园按评论数量的高低排序；最终结合公园面积、公园类型、评论数量、所属辖区等因素，筛选出10个具有代表性的城市公园（表1）[7]。

2.2 数据获得与处理

研究数据的获取和处理主要包括四个步骤（图1）。

1）数据获取和预处理：从旅游网站爬取评论，对非结构化的文字信息进行数据清洗、分词和文本信息向量化，使其结构化。

2）CES指标选择与编码标准制定：筛选适用于城市公园的CES指标，并构建编码分类标准。

3）CES感知词分类与编码：组建专家团队，运用德尔菲法，交叉分类完成所有评论内容的编码，并将具有CES感知意义的词语纳入感知词数据库，无意义词语纳入过滤词数据库。

表 1：样本公园基本信息

公园名称	公园面积（hm^2）	建成年份	公园类型	公园特色	行政区划	评论数量
趵突泉公园	10.5	1956	专类公园	以泉水、人文景观为主的文化名园	历下区	16 405
环城公园	26.3	1986	专类公园	连接多个泉群的环城带状公园		362
泉城公园	46.7	1986	综合公园	前身是植物园，现为兼具多种功能的城市中央公园		628
大明湖公园	86.0	1958	综合公园	因大明湖而得名的历史名胜旅游景区		7 650
中山公园	3.1	1904	综合公园	临近居住区的小型文化休闲公园	市中区	129
百花公园	18.0	1986	综合公园	以植物花卉景观为主的公园	历城区	192
华山湖公园	625.0	2018	综合公园	坐拥华阳宫古建筑群的近郊型山水旅游景区		88
济南森林公园	64.9	2010	综合公园	集游憩、科普、健身、避险等功能于一体的综合公园	槐荫区	166
五龙潭公园	5.4	1985	专类公园	以潭池溪港等景观构成，是四大泉群中水质最好的泉群	天桥区	2 789
济南动物园	60.0	1959	专类公园	动物科普教育性公园		15 490

4）CES感知类别关联性分析：通过计算公园各类CES感知的出现频率，分析不同公园CES感知类别间的关联规则。

2.2.1 网络点评数据获取及预处理

研究选择携程网、马蜂窝网、猫途鹰网和美团网作为数据来源。这些网站在国内较受欢迎，均展示用户名、评论内容与发布日期、评分（级）评价及图片等信息，数据结构相似，便于处理。研究者以“济南+公园名称”为关键词在各网站进行搜索，共得到46 181条数据，包括公园名称、评分（级）评价、评论内容、评论时间等信息字段，总计1 362 607字（中文）。研究数据于2021年6月24日开展信息采集，时间跨度为2009年2月9日至2021年6月23日。

网络评论数据通常具有碎片化、分类化和异质性等特征[26]，需剔除无关数据。现有的分词工具无法识别专业领域的新名词，会将文本强拆分——如“生态旅游”会被拆分成“生态”和“旅游”两个词——从而影响CES编码的准确度。因此，研究在剔除无关信息与除重后，引入Python的Jieba分词库工具，解决了专业名词的强拆分问题。随后对分词进行词频分析，综合考虑分词个数和词频数值，将词频大于2的分词定义为高频CES感知词[22]。最后，将各公园的高频CES感知词按词频排序，并使用词云工具“微词云”来描述这一结果。

2.2.2 CES指标选择与编码标准制定

根据前人相关研究[24][27]，筛选精神 / 宗教价值、审美欣赏、休闲 / 生态旅游、艺术灵感启发、场所感、文化遗产、教育 / 知识、社会关系及负面CES这9种服务类别（表2），对CES指标进行编码，并对指标内涵和编码标准进行阐释。

2.2.3 高频CES感知词分类与编码

研究首先组建了一支由5位专业人士组成的专家团队①，要求他们

① 专业人士的筛选标准是研究生态系统服务景观感知的教授及高年级研究生，部分成员为本研究团队成员。

表 2：CES 指标类别与编码标准

CES 指标类别	编码	指标内涵	编码标准
精神／宗教价值	C1	公园所提供的精神、宗教及与其他庄严活动相关的价值	宗教信仰或景观特征可以为人类提供精神层面的对象化情境
审美欣赏	C2	在公园观赏美丽景色而获得的，令人愉悦的视觉感受	欣赏公园的美丽景色
休闲／生态旅游	C3	在公园内进行休闲游憩活动	进行娱乐活动（如生态旅游、游钓和其他户外休闲活动）
艺术灵感启发	C4	公园景观所激起的艺术灵感	观景联想到诗词、绘画等艺术作品或文人名士
场所感	C5	公众对某一公园或公园内某一特定场所的感情	提及对场景的特殊体验或感情
文化遗产	C6	公园所蕴含的文化与历史价值	提及公园中的历史建筑、文化设施及地域文化
教育／知识	C7	公园为公众提供的知识科普与教育机会	从公园中获得知识或描述公园的科普设施
社会关系	C8	公园中发生的人与人之间的社会交往	提及与他人的互动或群体活动
负面 CES	ES-	公园中对人类福祉不利的生态服务功能	对公园的负面评价

按照编码标准将各公园的高频CES感知词归入上述9个类别中，完成第一轮编码。而后，让专业人士顺序交换手中的编码组，完成高频CES感知词的第二轮编码，同时研究者会对分类不一致的词语进行标注。这一交叉编码步骤重复若干次，直至专家团队对所有被标注的词语形成统一意见，将所有高频CES感知词分至某一特定类别中。研究者随后对编码完毕的高频CES感知词进行整理，将其以“词语—编码”的形式进行标记，形成高频CES感知词的编码词库；无意义的词语（即评论中除去高频CES感知词后剩下的词语）形成过滤词库。研究借助Excel VBA宏语言分别用编码词库与过滤词库对原高频CES感知词进行检验，以纠正错误、筛查重复编码项。最后，研究对各公园不同类别CES的感知频率进行统计，确定各公园的主要CES类别。CES感知频率计算公式计算如下：

$$F_{CESj} = \frac{n_{CES}}{n_j} \quad (1)$$

其中，F_{CESj}是第j个公园某一类CES的感知频率，n_{CES}是提到该类CES的高频感知词数量，n_j是第j个公园的高频感知词频总量。

2.2.4 CES关联性分析

数据挖掘能够揭示独立项集之间存在的某种潜在关系，研究以此来分析CES感知类别间的关联性。这种潜在关系被称为“关联规则”，可用$X \rightarrow Y$表示，其中X表示关联规则的条件，Y表示与X相关的一系列事务项的延续[28]。频繁项集是指某种关系下经常一同出现的事务的集合，是挖掘关联规则的常见先行步骤，频繁项集中某一事务的出现可能会导致其他事务的高频发生[29][30]。FP–Growth算法是韩家炜等人[31]提出的新型关联规则挖掘算法，该算法以频繁模式（frequent pattern，FP）树为基本形式挖掘频繁项集，可将数据集压缩存储、直接提取，提高了挖掘效率[32]。具体应用步骤如下。

1）利用Excel VBA替换网络评论中的单个可编码高频CES感知词作为“频繁项”，并统计各频繁项的支持度（出现次数）。

2）将所有的频繁项按照支持度进行大小排序，形成频繁项索引表L。

3）利用Excel VBA逐条处理网络评论，每条评论经替换可编码高频感知词、剔除非感知词后对应形成一个由编码组成的，形如[C1, C2, C7,

C8]的频繁项集。

4）将各频繁项集中的频繁项按索引表L的次序重新排序，在Python中为频繁项集构建FP决策树并将计算出的节点链进行绘图，得到各公园的CES感知类别关联规则图集。

3 研究结果

3.1 高频CES感知词分析

经由词频统计分析发现，采集的网络评论中高频CES感知词的数量为1 185个，占分词总数23.7%，但其出现频率占所有分词的84.1%。其中，反映审美欣赏、休闲／生态旅游的高频CES感知词出现频率较高，表明这两类CES最易为公众所感知。在大明湖公园、泉城公园及五龙潭公园，“景色”“花卉”“风景”等描述审美偏好的CES感知词出现频率最高；在百花公园、济南动物园、济南森林公园与中山公园中，“散步”“旅游”“健身”等描述游憩活动的CES感知词占比最多；在环城公园中，“游船”的出现频率相对较高（图2）。

除此之外，文化遗产、教育／知识，以及负面CES也较易被公众感知。公众可以通过公园内的历史建筑、故居等感知到文化遗产服务，例如华山湖公园的高频CES感知词多体现公园的历史文化价值，包括“华阳宫”“历史”等。在具有解说系统、科普教育建筑的公园中，公众更易感知到教育／知识服务，例如中山公园设有书市，“看书”被提及的频率最高；济南动物园作为专类公园，配备相应的游憩设施与解说标识系统，“看动物”“科普”“指示牌”被提及的频率最高；泉城公园前身为济南植物园，设有植物游览区，“植物区”被提及的频率最高。公众感知到的负面CES主要体现在“失望”“不值”等感知词上，反映出公众需求与公园服务供给的差距。其中，公众对于大明湖公园、环城公园和五龙潭公园做出的“萧条”“单调”“光秃秃”等评价，反映出冬季公园景观审美欣赏服务不足的问题。环城公园与济南动物园内“臭味”“脏乱差”“淤泥”等CES感知词被多次提及，反映出公园在环境品质管理方向存在欠缺。

3.2 城市公园CES感知差异

根据数据统计，知名度较高且外地游客访问较多的公园高频感知词较多。如趵突泉公园、大明湖公园和济南动物园的CES高频感知词数量最多，分别为21 350个、12 379个和5 650个。相较而言，以服务于当地居民为主的百花公园、济南森林公园和中山公园，由于少有游客专程前往，高频感知词较少，各识别到586个、384个和215个CES感知词。

所有CES在各个城市公园中均可被感知到，但不同公园存在CES感知类别差异（图3）。总体而言，在10个公园中审美欣赏和休闲／生态旅游感知频率相对较高。百花公园与五龙潭公园的审美欣赏服务感知占比最高，分别为54.10%与49.33%；在大明湖公园、趵突泉公园与环城公园中的占比也均超过了40%。休闲／生态旅游服务的感知在各个公园中存在较大差异：在济南森林公园中最高，占比44.59%，趵突泉公园最低，仅为9.01%。文化遗产服务的感知词频在大明湖、中山公园和环城公园中最高，均超过了10%。泉城公园、中山公园、华山湖公园与济南动物园的教育／知识服务感知频率均超过了15%，百花公园最低，仅占0.68%。社会关系服务在泉城公园、华山湖公园与济南动物园的感知频率最高，说明游客在这三个公园中进行社交活动或建立社交关系的意愿更强。精神／宗教价值服务在各公园中的感知频率相近。只有极少数的游客（低于10%）可感知到艺术灵感启发服务或场所感服务——场所感是平均感知频率最低的服务，仅为3.50%。负面CES的感知频率不高，平均感知频率占比3.73%，济南动物园的负面CES感知频率最高（8.67%），泉城公园与华山湖公园次之（均为4.80%）。

3.3 CES感知类别间的关联性

关联规则分析结果显示，审美欣赏服务与休闲／生态旅游服务密切关联（图4），这两类服务在大明湖公园、五龙潭公园、百花公园、环城公园、泉城公园、济南森林公园这6个公园中均建立了最强的关联规则，分别被共同提及139、27、20、18、16、6次。审美欣赏服务与休闲／生态旅游服务又常与文化遗产服务、精神／宗教价值服务或艺术灵感启发服务一起被公众所感知。在大明湖公园、环城公园与华山湖公园中，这两类服务与文化遗产服务分别共同出现了44、8和7次；在百花公园与泉城公园中，这二者与精神／宗教价值服务被共同提及7次与5次；在五龙潭公园中，与艺术灵感启发服务被同时感知12次。场所感服务与审美欣赏服务、休闲／生态旅游服务、艺术灵感启发服务和文化遗产服务建立了一定的关联规则。负面CES在大明湖公园、趵突泉公园与济南动物园三个公园中与其他服务类别建立了关联规则。大明湖公园中文化遗产服务与负面CES常一同出现，趵突泉公园中游客对教育／知识服务与社会关系服务的负面评价较多，济南动物园的负面CES评论则多与审美欣赏服务、休闲生态旅游服务有关。此外，教育／知识服务和社会关系服务间并未建立关联规则。

4 结论与讨论

本文基于网络点评评论数据，研究了公众对济南市主城区内10个典型城市公园CES的感知情况，研究主要结论如下。

1）审美欣赏服务和休闲／生态旅游服务是最易被公众感知到的城市公园CES类别。

2）公众对不同城市公园存在CES感知类别差异。百花公园与五龙潭公园的审美欣赏服务，济南森林公园的休闲／生态旅游服务，泉城公

园、中山公园、华山湖公园与济南动物园的教育／知识服务可被公众较好地感知到。

3）城市公园CES感知类别具有关联性。审美欣赏服务和休闲／生态旅游服务关联性最强，并且常与文化遗产、精神／宗教价值、艺术灵感启发服务一起被公众所感知。

4.1 城市公园CES感知类别的关联性

研究发现，多种CES类别既可以作为根节点同时出现，也可作为某一服务的次级节点一同被感知，从而产生关联规则。这一结论符合“生态系统服务簇理论”，即不同生态系统服务在时间或空间上会反复、同时出现[33]且一同被感知到[17]。本研究表明，城市公园中，审美欣赏服务和休闲／生态旅游服务最易被公众直接感知，且关联性最强。这与E·塞达·阿尔斯兰等人的研究结果一致，该研究表明美学价值与娱乐价值密切相关，且空间分布高度重叠[34]。

以往的研究发现，公众感知到公园场所感服务的程度普遍较低[21]，这与本研究结论相同。尽管感知频率相对较低，但在本研究10个城市公园中，公众均能够感知到场所感服务，且场所感在大明湖公园、趵突泉公园、中山公园、百花公园、济南森林公园和济南动物园中分别与审美欣赏、休闲／生态旅游、艺术灵感启发和文化遗产等服务建立了关联规则。这可能是由于上述公园的地域文化或场所精神特征较为突出，更容易被公众感知[35][36]。城市公园的场所感服务除了可以强化公众的认同感和归属感之外[24]，还能促进景观提升、激发娱乐活动的开展，以及艺术灵感的感知。

此外，本研究还发现，教育／知识服务和社会关系服务间并未建立关联规则。这可能是由于部分公园内科普宣教设施匮乏，公共活动类别不够丰富，致使这两类服务不易被感知；也可能是因为公众更倾向于就审美欣赏和艺术灵感等更具视觉吸引力的服务发表观点。

4.2 城市公园特色对CES感知类别关联性的影响

分析10个典型城市公园的关联规则发现，公园特色能够对CES感知类别间的关联性产生影响。大明湖公园、趵突泉公园、五龙潭公园、华山湖公园和环城公园作为本地居民和外来游客的休闲游憩目的地，景色优美，且历史古迹、文化设施和非遗活动丰富，具有较高的历史文化价值，公众对其文化遗产服务与艺术灵感启发服务的感知较强。此外，济南作为历史文化名城，重视历史文化遗产的保护与建设，通过历史文化公园的景观营造加强城市旅游吸引力，因此审美欣赏、休闲／生态旅游、文化遗产与艺术灵感启发服务建立了较强的关联性。泉城公园、百花公园与济南森林公园以自然景观为特色，植物种类丰富，游客与自然的接触更为亲密，能获得良好的多感官体验，有助于缓解精神压力[37]，因而审美欣赏、休闲／生态旅游服务与精神／宗教价值服务之间的关联性较强。中山公园和济南动物园以文化科普教育为特色，具有专用于科普教育的建筑和户外空间：中山公园作为周边居民游憩休闲、阅读学习及举办文化活动的主要场所，其休闲／生态旅游、文化遗产和教育／知识服务之间建立了较强的关联性。济南动物园属于专类公园，园内有完备的游憩设施与解说标识系统，关联性主要体现在休闲／生态旅游和教育／知识服务之间。

由于不同城市公园的CES感知类别关联性不同，可通过突出公园特色加强CES服务水平，促进相关的CES感知提升[38]。以自然景观体验为主的公园，除了注重自然美学下的植物和水体景观营造，也应加强公园的自然疗愈价值，使公众在自然环境中获得恢复性体验，满足精神放松的需求。以历史文化为特色的公园，可通过现代景观手法转译传统历史文化要素，激活其在现代生活中的活力与魅力；重构公园人文景观空间叙事结构，加强公众与历史的互动交流；并且在满足公众历史文化和艺术美学需求的同时，加强公园休闲／生态旅游服务。具有科普教育功能的公园可置入交互式景观装置、举办寓教于乐的教育活动等，满足公众在休闲游憩、自然与历史文化教育、增加社会交往等方面的多样化需求。此外，公园规划设计应重点关注高频CES感知词词云中反复提及的景观要素，着重改善负面CES中提及的景观要素。

4.3 CES感知与马斯洛需求层次理论的对应关系

马斯洛需求层次理论将人的需求划分为生理需求、安全需求、爱和归属的需求、尊重需求，以及自我实现需求5个层次，以金字塔式逐级上升，高层次的需求往往难以被满足[39]。本研究发现，城市公园CES与爱和归属、尊重、自我实现需求存在对应关系。这与已有研究结论一致，CES可以满足较高层级的马斯洛需求[40]。通过对关联规则的进一步递归挖掘，审美欣赏与休闲／生态旅游服务常作为根节点出现，是高频感知服务，既对应马斯洛需求层次理论中低层级的爱和归属的需求，也对应高层级的自我实现需求；文化遗产、艺术灵感启发、精神／宗教价值和教育／知识服务是中频感知服务，对应尊重需求；场所感和社会关系服务感知频率最低，对应爱和归属及尊重的需求。这可能是由于本研究所选取的10个城市公园多为建设年代较早的传统公园，多注重视觉感知与空间营造，缺少对公园中参与性、互动性及场所归属感的关注。由此，在城市公园改造提升时可将体验感和参与感提升作为重点目标，加强公众可参与、可互动的设施与活动，从而为公众营造场所感与归属感。

4.4 研究意义与局限

一直以来，CES因其产生及获取的主观性和非消耗性[41]，在量化评估时难以得到量化评价结果[42]。基于传统调研方法开展的研究耗时耗力，数据获取存在收集困难、数量少、随机性弱等问题，限制了相关研究的科学性与准确性。基于社交网络的在线评论数据具有收集方便、保

有量大、随机性强等优势[43]，为CES感知研究极大地扩充了数据来源，降低了数据获取成本，提高了研究效率，可应用于CES的感知识别与价值评估研究。

同时，本研究阐明了城市公园CES的公众感知特征，并针对不同服务类别间存在的关联关系，应用FP-Growth算法关联规则递归挖掘频繁项集，探究不同公园中一同出现频率较高、关联较密切的CES类别，这种方法无需明确CES的具体空间分布，即可完成服务类别间的聚类；相比于相关性数理分析，关联规则能够清晰展示共现频率高的服务类别间的具体频数。研究表明了CES类别之间很可能具有协同作用，即对某一CES类别感知的出现大概率会促进其他类别CES的感知，关注这种协同作用能够提升关联密切的CES效能，对于提升城市公园绿地的CES供给与空间品质具有重要意义。

本研究也存在一定的局限性：1）出于隐私保护机制，用户的社会特征信息（如性别、年龄、职业、受教育程度和收入等）难以获取，使得针对这些因素对于CES感知的影响研究难以开展；2）在线评论数据难以区分本地居民与外地游客，因此难以对二者的感知差异展开研究；3）尽管网络平台面向所有人开放，但发表网络评论的使用者以中青年为主，难以开展对老年人、儿童或其他不经常发表网络评论的使用者的感知研究[44]。

未来可进一步挖掘网络评论数据，通过社会特征信息创建用户画像[45]，更全面地剖析用户的环境认知、行为偏好，探索公众社会特征对城市公园CES感知的影响。同时，尽可能融合多源数据与方法，如将网络点评数据和问卷调查方法相结合[46]，补充老年人、儿童及其他不常发表网络评论的人群的感知数据。此外，未来可利用统计分析方法进一步探究影响公众CES感知的城市公园景观特征。

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- 教育部人文社会科学研究青年基金项目“基于水生态系统服务供给与需求的城市绿地评价及布局优化”（编号：18YJCZH066）
- 山东省高等学校青创团队计划“黄河流域下游绿色生态空间研究创新团队”（编号：2022KJ202）
- 山东省住房和城乡建设厅软科学研究项目“公园城市”背景下城市综合公园空间品质评价研究（编号：2021-R3-4）

图 1. 数据处理流程图
图 2. 典型城市公园的高频 CES 感知词词云分析图。其他几种 CES 类别由于高频感知词较少，难以制作词云，故未列出。
图 3. 典型城市公园 CES 感知频率
图 4. 典型城市公园 CES 感知关联规则