

A Computational Study of Empty Space Ratios in Chinese Landscape Painting, 618–2011

GUOYAN WANG, JIAFEI SHEN, MENG MENG YUE,
YENA MA AND SHUYANG WU

ABSTRACT

The use of empty space (ES) is ubiquitous in Asian art. The authors use a computational method to quantitatively assess the amount of ES in Chinese landscape painting (CLP). The data show that 56.8% of ancient CLPs contain mostly ES, while only 9.4% from modern times do. ES reached its peak during the Yuan dynasty (1271–1368) and its lowest point in the 1960s. Chan culture, literati ink play, the “exhibition hall effect,” and Maoist politics, as well as other social factors, may have had an impact on this shift. This empirical study indicates that art keeps abreast of current developments: The philosophy, culture, politics and general education of a specific era influence artists’ perception, aesthetics and creative output.

CHINESE LANDSCAPE PAINTING AND EMPTY SPACES

Chinese landscape paintings (CLPs), which are “one of the most typical types in Chinese painting” [1], constitute “one of the oldest traditional arts in the world” [2]. CLPs consist of two elements: ink and blank, or empty, space (ES). Whether black or colored, ink of different shades is used to depict different sceneries. ES is not disregarded space; rather these spaces are left deliberately by the artist and increase the appeal of the composition.

The style of landscape painting has gradually changed over time. Broadly, periods of CLP can be characterized by picto-

rial representation (from the Han to the Song dynasty), calligraphic self-expression (Yuan dynasty), revivalism (early and middle Ming dynasty) and synthesis (late Ming to mid-Qing dynasty) [3]. In order to explore the statistical progression of Chinese arts, we conducted a quantitative analysis of ES in landscape paintings from ancient China to modern times. The computational method is based on pixel identification in artworks, as measured by computers. We comprehensively analyzed all the recognizable samples in the collection of the Palace Museum and the National Art Museum of China, as well as in the monograph *The History of Chinese Landscape Painting* [4], for a total of 933 CLPs. The Palace Museum is the most influential museum of ancient art and culture in China; the National Art Museum of China is the largest gallery of modern art in China; and the book is an influential, classic monograph that gathers a large number of ancient CLPs. The author, Chen Chuanxi, has conducted highly significant art history research in China.

An ES does not necessarily mean nothingness. An ES often represents clouds, mist and waterfalls in harmony with the inked parts of the painting. As an important element in Asian art, ESs play a vital role in spatial relationships. CLP is a dynamic reflection of objective reality in the manifestation of “spaces,” not an absolute copy of real spaces [5]. In other words, it “doesn’t organize or establish precise spatial relationships by developing mathematical laws” [6]. The “artistic conception” formed is “one of the important standards in judging whether a Chinese traditional painting is good or not” [7]. As to what ES should show, painters’ philosophical positions differ slightly. However, on the whole, sky is the most important ES, followed by water and then smoke and clouds. There are also painters who believe that ES may appear in a part of the painting that does not need to be expressed but can nevertheless produce painterly conceptions, that is, “the technique of painting is not perfect, but the expressed artistic conception is satisfactory” [8]. In modern research, ES is explained as “the original white of the materials of paintings and calligraphy works such as paper, namely,

Guoyan Wang (researcher) (corresponding author),* Department of Digital Communication, Room 5146, Building 5, Dushu Lake Campus of Soochow University, Suzhou, Jiangsu, China. Email: gywang@ustc.edu.cn. ORCID: 0000-0002-3175-6025.

Jiafei Shen (doctoral candidate),* Department of Science and Technology Communication and Policy, University of Science and Technology of China, Hefei, Anhui, China. Email: jeff116@mail.ustc.edu.cn. ORCID: 000-0002-8819-4430.

Mengmeng Yue (media manager), Suning e-buy Group Co., Ltd., Building 2, Suning Zijin Jiayue, Xuanwu District, Nanjing, Jiangsu, China. Email: ymmdj@qq.com. ORCID: 0000-0002-6831-1468.

Yena Ma (researcher), Anhui Renhe Data Technology Co., Ltd., Guangming Beibu Gulf, Hefei, Anhui, China. Email: 1092036764@qq.com. ORCID: 0000-0002-6927-2624.

Shuyang Wu (researcher), Department of Science and Technology Communication and Policy, University of Science and Technology of China, Hefei, Anhui, China. Email: wshuyang@mail.ustc.edu.cn. ORCID: 0000-0002-0319-3050.

*Guoyan Wang and Jiafei Shen contributed equally to this article.

See <https://direct.mit.edu/leon/issue/55/1> for supplemental files associated with this issue.

TABLE 1. Time Distribution According to Creation

Times/ Dynasty	Tang	Five	Song	Yuan	Ming	Qing	Modern Era									Total
Year	618– 907	907– 960	960– 1279	1271– 1368	1368– 1644	1636– 1912	1915– 1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000– 2011	618– 2011
Sample number	6	24	60	61	151	198	22	55	56	104	75	34	37	29	21	933

the place without ink” [9]. For the purposes of this study, we define ES as areas without ink or paint, based on current studies and the identification ability of computers.

SAMPLE PROCESSING AND ANALYSIS

We selected samples between 2017 and 2019. A collection of 1,140 CLPs with a rectangular shape was collected, with 342 from the Palace Museum, 446 from the National Art Museum and 352 from the book. After we screened out paintings that were severely damaged or whose date could not be verified, 500 ancient and 433 modern paintings remained. The time distribution is shown in Table 1.

The ratio of empty spaces can be obtained by calculating the pixels occupied by empty space compared to the painting’s total pixels. All samples were analyzed and processed using Photoshop. The magic wand tool was used to select pixels of ES. The inked area differs substantially in tone, while the area without ink remains the original color of the paper or canvas. Therefore, we selected the blank area instead of the inked parts.

Figure 1, *Rooftop of Jiuhua Mountain*, shown with a section in detail (right), exemplifies how we selected areas of ES in ink paintings. Considering that the edges of the brushstrokes

are often soft and graded, we endeavored to select blank areas matching the recognition of the naked eye at a normal distance for a full screen reading.

Figure 2 demonstrates the changing trends of ES in CLPs. The darker histogram represents the average of the ratio of ES in each painting, while the lighter represents the proportion of paintings dominated by ES (in which the amount of ES is over half). The upper right linear figure shows the changes on the uniform timeline. The results show that the composition style of CLPs has undergone significant changes.

Generally, ES is a typical feature of CLPs and has been used from ancient times to the present. Both average ES and dominant ES show significant differences between the compositions of ancient and modern CLPs. Ancient paintings feature large amounts of ES, while modern ones largely consist of ink. The average amount of ES in all ancient paintings is 53.4%, and in modern paintings 32.6%. Additionally, 56.8% of ancient paintings contain dominant amounts of ES, in sharp contrast to modern landscape paintings, with only 9.4% ES. The use of ES progressed from a lower ratio in earlier times to a higher ratio, reaching its peak during the Yuan dynasty, with an average of 61.7% ES in paintings, with 80.3% of all paintings of this period being dominated

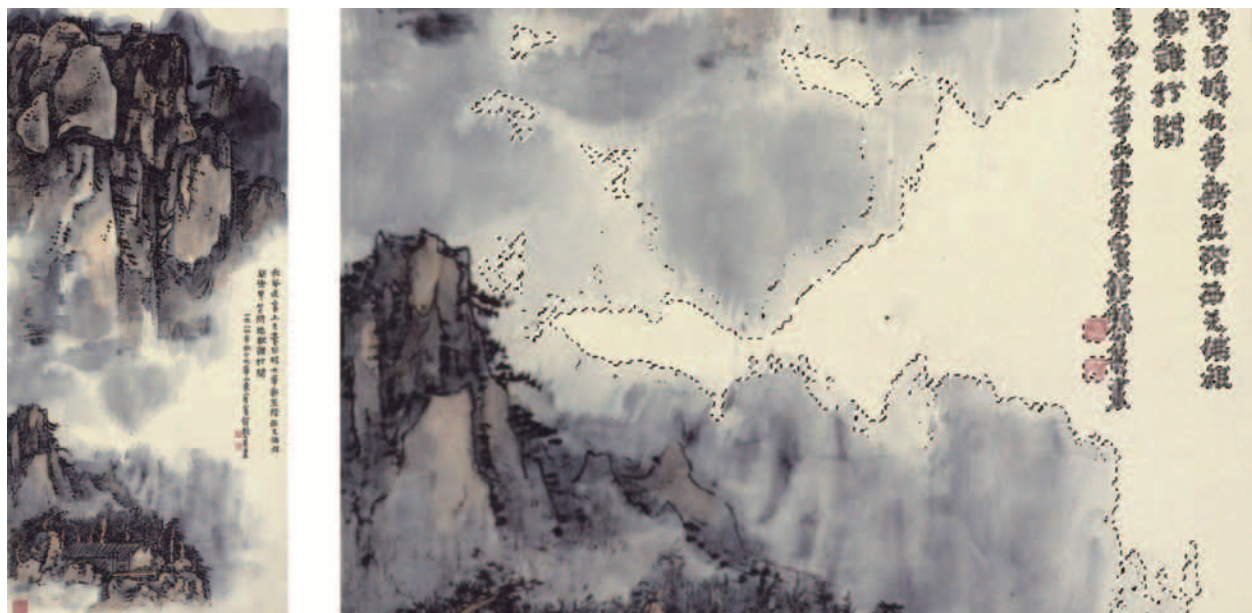


Fig. 1. Lai Shaoqi, *Rooftop of Jiuhua Mountain*, 1985. (© Xiaofeng Lai)

by ES. There occurs a clear downward trend after the Yuan dynasty, reaching a low point around 1960, with an average ES rate of 27.1%. Only two paintings out of 75 in this decade are dominated by ES.

In addition, the standard deviation of each time period can be seen to be relatively stable, at around 15%, indicating the consistent reliability of the data.

DISCUSSION AND LIMITATIONS

Changes in philosophy, politics, education, culture and other factors enter into artistic aesthetics and painting outputs. In particular, the Chan culture, literati ink play, the exhibition hall effect, Maoist politics, and other factors may have had an impact on the shift away from ES.

CLP originates from the profound impact on artistic aesthetics of Confucianism, Daoism and Chan Chinese ideology, which tend to hold that the part exists in the whole, thus placing emphasis on the part's relationship with the whole [10]. Moreover, ancient artists stress spiritual literacy in their paintings, as well as the ability to reveal the inner harmony between humanity and nature [11,12]. It is held that the "heart" is the basic organ of aesthetic appreciation [13]. Thus, aesthetic appreciation goes beyond the physical boundary of objects and encourages free will and emotion. In this way, the unification of subjective perception and objective appearance in the process of landscape painting creation is realized. Before the Tang dynasty, painters paid more attention to neat, realistic paintings and preferred to use bright color. From the middle of the Tang dynasty, the development of Chinese literature and art, including painting, has had an indissoluble bond with Chan Buddhism.

Under Chan influence, literati ink painting was conceived. "Literati ink play" was an improvisation created by scholar-bureaucrat literati in communication with friends, emphasizing "playfulness" and "subjective expression" with simple strokes. For literati, painting was not a means of making a living or obtaining official positions but an artistic activity through which they freely expressed their inner interests and personalities. Literati painting originated in the Tang and Song dynasties, was refined during the Song and Yuan dynasties and reached its peak during the Yuan dynasty. Su Shi (1037–1101) of the Song dynasty was the most powerful advocate of literati painting [14], promoting the notion of "painting in poetry, poetry in painting" [15]. Such works gradually achieved the blending of painting with poetry and even calligraphy. The imperial examination system of selecting officials through countrywide assessments enabled talented literati from lower classes to enter the government arena. The literati thus gained the rights to evaluate paintings, and paintings that did not conform to the creative interests of the literati were considered to be inferior [16]. The literati thus wielded power over social discourse, and their aesthetic

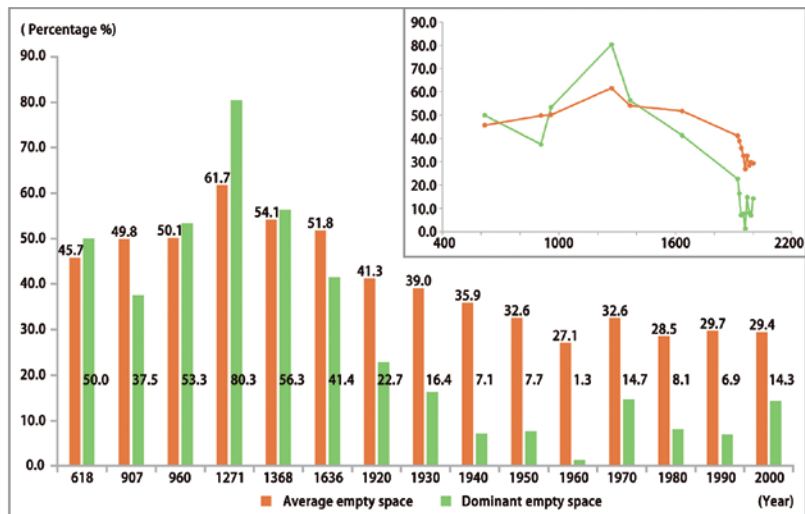


Fig. 2. The changing trends of empty space in Chinese landscape paintings (618–2011). (© Guoyan Wang and Jiafei Shen)

tastes deeply influenced the painting style of that time. As a result, their painting became part of the mainstream during the Song dynasty. Literati paintings reached the peak of their influence during the Yuan dynasty, when Zhao Mengfu (1271–1368) made an indispensable contribution [17].

The exhibition hall effect may also have affected the quantity of ES and modern painting styles. The modern landscape painting is generally hung in a magnificent exhibition hall in which one observes the work from a distance. The works that boasted a majestic style became preferred in exhibition halls. These works included such features as lofty mountains, steep hills and billowy waves. To increase the sense of a far-sighted exhibition hall setting, the pictures inevitably began to present the impression of being full, dense, complicated and complex [18]. Paintings in the Five Dynasties period and the early Song dynasty contained less ES; imperial court decorative painting, with ornate and delicate features, was the dominant style. Imperial court decorative paintings were initially used to decorate the palace and later became a popular painting style during the Song dynasty. With the prosperity of literati painting during the Song dynasty and afterward, the typical method of observing a painting became a close observation performed by opening the scroll little by little out of one's sleeve, in front of friends. Therefore, a style incorporating simplicity with elegant details may have been seen as more suitable for close observation. After 1935, when the National Art Museum was built in Nanjing, where the National Art Exhibition was held, art exhibitions gradually became the primary way to display and propagate Chinese paintings. This has fundamentally changed the function and style of Chinese paintings originating from the literati tradition [19]. The different modes of observation may also have affected the ratio of empty space in different periods.

A reference to European elements also promoted change in the style of modern landscape paintings. With the arrival of Western missionaries in the Ming dynasty, the skills of Western painters were also introduced to China. There were

also foreign painters in the imperial court in the Qing dynasty [20]. The incorporation of Western realistic painting theory was first implemented by Xu Beihong (1895–1953) in the early twentieth century. He introduced the Western academic teaching model and built up a realistic style of art education in China [21]. Afterward, Western art appreciation became a common course in Chinese art education. Additionally, due to frequent international exchanges, the exposure to worldwide art brought new elements to Chinese paintings; the lively integration of Chinese and Western art and culture contributed to the development of Chinese paintings in modern China [22].

The landscape paintings of the 1960s had the least amount of ES, which might be due to the political power dynamics at the time. Chinese political circles witnessed fluctuations in the twentieth century, particularly during the 17 years that followed the founding of the People's Republic of China (1949–1966), when paintings tended to revolutionary themes. The works of modern landscape painters such as Li Keran (1907–1989) and Fu Baoshi (1904–1965) mainly focused on depicting the holy land of the Chinese people's war of resistance, as well as the changing appearance of the mountains and rivers of the new China [23]. Since the 1950s, the poetry and lyrics of previous Chinese chairman Mao Zedong gradually became important themes in Chinese painting circles [24]. Mao's poetry and lyrics were famously bold and joyful, full of fighting spirit. During this period, the amount of ink used peaked. Of 179 paintings from the 1950s and 1960s, up to 170 belong to the category of paintings using a large amount of ink.

After China's Cultural Revolution (1966–1978), people's ideas and concepts developed diversely. From the late 1970s,

the style of painting is characterized by a transformation from a political theme to describing ordinary peoples' realities. After the 1980s, with the advent of social openness and compatibility of multiple cultures, landscape painters tried various forms such as local paintings and experimental ink paintings. In the 1990s, "new literati paintings" appeared with a return to the traditional antique landscape. By the early 21st century, new abstract ink paintings had joined the category of contemporary ink paintings. The promotion of new media technology has taken Chinese ink art from static to a state of animation and interaction. The development of landscape painting inherited the traditional style of ink painting but also is infused with modern elements.

With regard to computational studies on ES, by using eye tracker analysis, Fan [25] found that people's attention is indeed attracted by ES in ink paintings. Li Shijia [26] selected 60 paintings from the *Illustrated Handbook of Chinese Paintings* and tentatively analyzed the pixels of empty space using the same technology used for this study. Of course, there are other kinds of Chinese art than landscape paintings, and nature, figure and other paintings also play a role in Chinese painting. Additionally, the small number of early samples and the specific data selected from the mentioned two museums and book may have exerted a bias on the results.

To sum up, the historical trend of ES in CLPs is revealed through relatively systematic and credible data, which tell us that artists and their paintings correspond to the influences of the time, which impact their creation, aesthetics and perception. The injection of new elements continuously sparks new life into art. The vitality of the art of CLPs is reflected not only in classic inherited forms but also in the time it takes to realize continuous innovation and development.

Acknowledgments

This study was supported by the Key project of China National Social Science Fund (Grant 20FXWA003). We thank Keyong Chen, president of the Chinese Academy of Landscape Painting, for his valuable views on the analysis of changes in empty space. We thank the Palace Museum and the National Art Museum of China for their help in providing the sample catalog and the China Treasure Museum for providing part of the sample data. Thanks also to the editor and anonymous peer reviewers for their valuable comments.

References and Notes

- 1 F. van Briessen, *The Way of the Brush: Painting Techniques of China and Japan* (Boston: Tuttle Publishing, 1998) p. 48.
- 2 T. Wang et al., "An Investigation of the Neural Substrates of Mind Wandering Induced by Viewing Traditional Chinese Landscape Paintings," *Frontiers in Human Neuroscience* 8 (2014) p. 1018.
- 3 W.C. Fong, *Images of the Mind* (Princeton, NJ: Princeton University Art Museum, 1984) p. 121.
- 4 C. Chen, *中国山水画史* (History of Chinese Landscape Paintings) (Tianjing: People's Fine Arts Publishing House, 2001).
- 5 Q. Huang, "‘天人合一’与中国传统山水画图式" ("Theory That Man Is an Integral Part of Nature" and the Iconography of Traditional Chinese Landscape Paintings), *Jiangxi Social Sciences* 4 (2014) pp. 231–235.
- 6 H. Delahaye, "Du peu d'effet de la peinture occidentale en Chine aux XVIIe et XVIIIe siècles," *L'Europe en Chine* (Paris: De Boccard, 1993) p. 111.
- 7 Huang [5] p. 231.
- 8 Y. Zhang, *历代名画记* (Famous Paintings from Different Ages) (Changsha: Hunan Fine Arts Publishing House, 1997) p. 174.
- 9 Y. Tang, "中国画‘留白’浅析" (A Brief Analysis of "Empty Space" in Chinese Paintings), *National Arts* 3 (2014) pp. 160–161.
- 10 K. Nand et al., "Examining Cultural Drifts in Artworks through History and Development: Cultural Comparisons between Japanese and Western Landscape Paintings and Drawings," *Frontiers in Psychology* 5, No. 72, 1041 (2014).
- 11 J. Legge, *The Texts of Taoism: Sacred Books of China*, Vol. 2 (New York: Dover Publications, 1891) p. 15.
- 12 M. Sullivan, *The Arts of China* (Berkeley, CA: University of California Press, 1999) p. 19.

- 13 Y. Guo, “儒道禅审美感官论—中国传统审美感知理论研究之一” (Aesthetic Sensory Theory of Confucianism, Taoism and Chan Culture—A Study of Traditional Chinese Aesthetic Perception Theory) *Journal of Northwest Minorities University (Social Sciences)*, No. 1 (1998) pp. 82–87.
- 14 M. Wei and H. Xu, “文人画最有力的提倡者—苏轼” (The Most Powerful Advocate of Literati Paintings—Su Shi), *Beauty & Times*, No. 7 (2019) pp. 54–55.
- 15 S. Su, *东坡题跋* (Preface and Postscript by Su Dongpo) (Hangzhou: Zhejiang People’s Art Publishing House, 2016) p. 236.
- 16 F. Li, “文人画传统与匠画传统的互动—马麟与‘宋元之变’艺术史分” (The Interaction between the Tradition of Literati Paintings and That of Artisan Paintings—Ma Lin and the Art History of “Changes in the Song and Yuan Dynasties”), *Literature & Art Studies*, No. 9 (2016) pp. 125–136.
- 17 B.M. Wang, *中国绘画史* (History of Chinese Paintings) (Beijing: Culture and Art Publishing House, 2009) p. 33.
- 18 M. Fan, “‘展厅效应’与山水画创作之弊” (The “Exhibition Hall Effect” and the Disadvantages of Creating Landscape Paintings) *Traditional Chinese Painter*, No. 1 (2015) pp. 12–13.
- 19 Q. Wan, “百年中国画展感言” (Reflections on the Centennial Chinese Painting Exhibition), *Art Magazine*, No. 1 (2001) p. 31.
- 20 S. Wei, “探微山水画中的‘道家虚实观’” (Exploring the “Taoist View of Reality and Emptiness” in Landscape Paintings), *Art and Literature for the Masses*, No. 3 (2016) pp. 111–112.
- 21 N. Zhang, “论徐悲鸿美术教育思想的推行” (On the Implementation of Xu Beihong’s Ideology of Art Education), *Art Research* No. 4 (2020) pp. 81–84.
- 22 J. Li, “浅析中国画笔墨与时代的关系” (An Analysis of the Relationship Between the Chinese Paintings and the Times), *Art Education* No. 3 (2018) pp. 180–181.
- 23 Li [22] p. 180.
- 24 Li [22] p. 180.
- 25 Z. Fan, 计算美学在水墨画的量化分析中的应用 (Application of Computational Aesthetics in the Quantitative Analysis of Ink Painting), master’s thesis (Tianjin University, 2018) p. 45.
- 26 S. Li, “一种新的审美方式—‘量化留白’在园林景观设计中的应用的可行性” (A New Aesthetic Approach—The Feasibility of Applying “Quantitative Empty Space” in Landscape Design), *Jiangsu Agricultural Sciences* 43, No. 11, 263–267 (2015).

Manuscript received 4 June 2020.

GUOYAN WANG is a full professor in the Department of Digital Communication, Soochow University. Her research interests include visual art, science communication and computational methods. Her recent research has been published in *Public Understanding of Science*, *Journal of Informetrics*, *Science Communication*, *Science as Culture* and other leading journals.

JIAFEI SHEN is a doctoral candidate in the Department of Science and Technology Communication, University of Science and Technology of China (USTC). His research interests include art design, aesthetics and technology communication.

MENGMENG YUE, **YENA MA** and **SHUYANG WU** are former master’s students in the Department of Science and Technology Communication, USTC. Their research interest is technology communication.