

Correlation Between Library Reading Area Layout Characteristics and User Reading States: Postprint

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Date: 2023-08-27T00:00:00+00:00

Abstract

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Full Text

Preamble

Vol. 62 No. 24 December 2018

ChinaXiv Cooperative Journal

Research on the Relationship Between Library Reading Area Layout Characteristics and User Reading Status

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Abstract

[Purpose/Significance] Various features of indoor layout exhibit personalized associations with different reading types, which can lead to differences in users' reading states. Inducing optimal reading states in users represents an important objective of library interior layout, embodies the intelligent delivery of library environmental services, and can substantially enhance the quality of reading services. **[Method/Process]** Based on literature review, this study analyzes user reading status indicators according to psychophysiology and self-efficacy theory, and extracts five categories of layout characteristics including geometric shape unity from Chinese and foreign literature. Experiments combining these layout features with natural sciences, social sciences, planned, and unplanned reading were conducted to measure reading efficacy, attention, and emotional tendency data. SPSS analysis was used to identify correlations between layout characteristics and reading themes. **[Result/Conclusion]** The study found that different reading areas have corresponding layout characteristics that enable users to achieve better reading states. The research results can serve as a reference for the layout of various library reading areas and can be extended to environmental layouts for nationwide reading initiatives.

Classification Number: G250

Keywords: layout characteristics, user reading status, correlation study

DOI: 10.13266/j.issn.0252-3116.2018.24.007

Reading behavior constitutes a systematic intellectual cognition in which readers think and absorb information based on existing knowledge and experience. It represents a high-level neural system psychological activity and a linguistic communication process between readers and authors [1]. American psychologist Lewin proposed the function $B = f(P, E)$, where B represents behavioral performance, P represents individual state, and E represents environment [2]. Environmental psychology theory posits that when individuals are in various environments, the environmental atmosphere acts upon them, potentially intervening in their psychological and physiological states [3]. Individual reading states are considered closely related to physical environmental layout [4]. Therefore, physical environmental layout correlates with individual reading states, which are limited to the psychological and physiological level and can be com-

posed of individual reading efficacy psychological perception combined with reading attention and emotional tendency [5-6]. Indoor physical layout characteristics include analysis objects such as architectural structure, decoration, and furniture facilities. From the perspective of daily library activities, layout characteristics refer to the placement features of movable objects such as office furniture and bookshelves. Most library reading areas can be divided into social science reading areas, natural science reading areas, unplanned leisure reading areas, and planned target reading areas (study rooms) based on cognitive and task differences. Different reading areas should have personalized associations with the layout characteristics of office furniture and facilities.

The researcher conducted a literature review using search terms related to reading area layout, user reading status, and reading tasks in the CNKI database, with results imported into CiteSpace for knowledge graph analysis (see Figure 1 [Figure 1: see original paper]). The knowledge graph study reveals: The main nodes in the graph are university libraries, public libraries, reading promotion, and service innovation, indicating that this research topic is closely related to library work; Numerous studies discuss the creation of aesthetically pleasing reading environments, but few extract layout characteristics, and none involve the correlation changes between different reading tasks, user states, and layout;

Existing research primarily relies on subjective qualitative descriptions, with no objective quantitative verification of user experience. Therefore, the authors extracted reading area layout characteristics, explored the correlation changes between different reading tasks, user states, and layout characteristics in reading areas, and combined them with objective quantitative analysis through experiments to provide references for library management.

2 User Reading Status

The influencing factors of reading status comprise multiple elements including readers' physiological, psychological, and cognitive levels. The foundation is the brain as the basic physiological organ for reading [7], whose reading operation and reaction are primarily manifested as concentration, namely reading attention. The middle layer is mainly emotional tendency, which affects the physiological efficacy state of human reading. The upper layer primarily involves psychological judgment, evaluation, and expectation of reading behavior efficacy [8]. The highest level is the knowledge resource state required for reading cognition, which is rarely affected by environmental psychology and therefore not included in this experimental analysis. In summary, the classification of user reading status for this research topic is shown in Table 1 :

Table 1 Classification of User Reading Status in This Study

Reading Status Classification	Layout Environment Influence
Brain Reading Attention	Affects reading efficacy
Emotional Tendency	Affects reading efficacy
Reading Efficacy Perception	
Knowledge Resource State	Not included

2.1 Reading Attention and Emotional Tendency Physiological Status

The foundation of reading is human brain physiological function. Text signals are transmitted to the brain and converted into concepts for reception, with old and new information combined in brain activities to internalize knowledge into individual resources [9]. Attention is the brain's direction, retention, and concentration on specific objects, representing an important physiological element of user reading status. The generation, scope, and duration of reading attention are related to external environmental stimuli. Human brain reading attention can be measured by brain waves, as emotional physiology has shifted from qualitative analysis to computational analysis of spontaneous EEG [10]. Brain waves can be divided into δ waves (0.3Hz-3Hz), θ waves (4Hz-7Hz), α waves (8Hz-13Hz), and β waves (14Hz-30Hz). α waves are further divided into slow, medium, and fast waves [11]. The 12Hz-15Hz range represents the sensorimotor rhythm (SMR) [12]. From slow to fast brain wave frequencies, human states gradually transition from sleep to drowsiness, alertness, tension, and excitement. α wave and SMR signal measurements have been applied to medium-low intensity attention training [13, 14], while β wave signals are used for high-intensity attention training such as flight simulation [15]. Reading attention represents medium-low intensity, hence SMR waves were selected for measurement.

In the 19th century, American psychologist W. James explored emotional mechanisms, proposing that emotions originate from organism physiological reactions [16]. When emotions shift, the nervous system regulates, accompanied by physiological signal changes in the organism with psychological experiences. Skin conductivity increases with excitement and tension, and decreases with calmness and relaxation [17]. Skin conductance measurement for emotional analysis has been widely applied in human-computer interaction, driving, and lie detection fields [18-20]. Skin conductance level can quantitatively analyze the fluctuation degree of reading emotions. In summary, researchers measured the mean SMR value of brain waves and the relative increase/decrease amplitude of skin conductance mean value during a certain reading period, recorded as reading attention and emotional tendency values.

2.2 Reading Efficacy Psychological Perception

The renowned American psychologist Bandura proposed in social learning theory that self-efficacy is an individual's perception or belief in their ability to

effectively control various aspects of their life [21]. Reading efficacy perception is the embodiment of self-efficacy in the reading domain, representing a psychological evaluation of controlling reading behavior and a judgment of confidence in one's ability to use reading skills to complete established tasks. Reading efficacy perception directly affects reading outcomes, which has been widely confirmed and applied in various fields, such as reading object matching research [22][23], reading efficacy strategy research [24], and concept mapping strategy research [25]. Centered on Bandura's efficacy theory and the connotation of reading, combined with literature research, reading efficacy perception can include six items: sense of capability, sense of control, sense of benefit, sense of confidence, planning, and anti-interference. Capability perception is the user's psychological recognition of their own reading efficiency; confidence perception is the user's psychological confidence when facing reading difficulties; control perception is the psychological assessment of one's own reading behavior control; benefit perception is the psychological expectation of one's own reading gains; planning is the user's psychological determination to adhere to reading processes; anti-interference is the user's psychological persistence in excluding external influences. Confidence perception and benefit perception are formed through long-term self-evaluation of reading confidence and benefit cognition, and are less affected by the on-site environment, thus not included in this study. The researcher analyzed and designed a library user reading efficacy perception questionnaire, with each item containing five self-evaluation statements. The average score of the five statements was calculated as the score for that item, and the total average score of the four items was calculated as the reading efficacy score. The questionnaire used a 7-point Likert scale with scores from 1 to 7. For example: "During reading, I can choose reading content that is difficult but allows me to learn knowledge, and maintain good efficiency to complete it." Options range from "completely agree" to "completely disagree." To prevent response bias, two items can be reverse-scored, such as: "During reading, I failed to make specific plans based on today's actual situation; reading has no goal, just casual browsing."

3 Reading Area Layout Characteristics

Reading areas are specific places for reading. Indoor movable object layout characteristics can influence human spiritual perception and psychological states, such as the narrow and deep layout of cabinets and bookcases in ancient libraries creating mystery, or the rigorous symmetrical layout of tables, chairs, and corner tables in the Imperial Academy's conference hall generating solemnity. Layout characteristics and corresponding psychological suggestions are reflected in all layout art forms, and despite individual differences, universal patterns exist.

From the perspective of researching user reading behavior in libraries, universal patterns should be comprehensively analyzed from three dimensions: human,

architecture, and reading. Based on artistic aesthetic theory, the researcher proposes layout proportion and scale; based on architectural theory, layout balance and stability, and primary-secondary and emphasis; based on reading theory differences between arts and sciences, layout geometric shape unity, rhythm and cadence.

3.1 Proportion and Scale

The numerical relationships of length, width, and height of layout elements within library buildings are the research objects of proportion and scale. The Greek Pythagorean school proposed that universal laws govern nature, and all relationships have numerical proportions, including humanities such as painting, music, and sculpture. Viollet-le-Duc proposed in the *General Dictionary of French Architecture* that proportion is the numerical relationship between whole and parts, which is logical and satisfies both intellectual and visual requirements. All architecturally psychologically infectious works contain rational proportions. The length, height, and tapering proportions of library reading area layouts should be simple and conform to modulus, making them easily resonant. The 1:1.618 golden ratio can be applied in length-width ratios and object placement positions. Scale is the relationship between perceived size impression and reality. All things have scale, and reasonable scale generates intimacy. Excessively long horizontal or vertical dimensions in library reading areas cause discomfort, and local scales that are too large or too small also produce opposite effects. Functional impact on scale cannot be ignored, such as the spacing between seats and aisles in library reading areas, where aisles should accommodate three people. Hall classified social distances: within 0.45 meters is intimate, within 1.2 meters is personal [28]. Considering differences between Chinese and Western cultures, the distance between the centers of two reading seats can be 1.3 meters.

3.2 Rhythm and Cadence

Rhythm and cadence originally refer to tonal undulation and rhythmic sense in music and poetry. Psychologists believe that the origin of poetry and music is closely related to human love for rhythm and cadence. Aristotle considered the love for rhythm, cadence, and similar forms as an innate human tendency. Many natural phenomena stimulate psychological responses through regular repetition or orderly changes, such as the rhythmic ripples created by stones thrown into water. In indoor architectural layout, humans consciously create rhythm and cadence beauty with organization, repetition, and continuity through imitation and application. Rhythm and cadence can be formed by continuous repeated arrangement of one or several object elements, maintaining constant distance and relationships between elements, creating continuous extension. For example, reading area tables, chairs, and potted plants can be arranged in alternating repetition, constraining each other, appearing and disappearing alternately. Elements within an area can also change progressively in height, shape, and color

levels, demonstrating organized variation.

3.3 Balance and Stability

Overcoming Earth's gravity is one of the starting points of human activity. In architecture, the form and result of overcoming gravity are balance and stability. In indoor layout, humans also form positive psychological perceptions of ease and comfort toward balance and stability. Library reading area balance and stability can have symmetrical and asymmetrical forms. Symmetrical forms are relatively mechanical, while asymmetrical balance and stability appear more lightweight. Gropius emphasized in *The New Architecture and the Bauhaus* that the bold lightweight of modern layout methods has eliminated mechanical oppression of humans, and the superficial axial symmetry that has been difficult to escape since ancient times is yielding to vivid, relaxed balance and stability. Modern architectural theory emphasizes time and movement as two elements. Human psychological approval of layout is not at a single point but is obtained in continuous movement over time. The shape and contour lines of balanced and stable layouts in library reading areas are precisely the vivid and interesting changes of time and movement, giving users relaxation suggestions.

3.4 Primary-Secondary and Emphasis

The ancient Greek materialist philosopher Heraclitus believed that nature tends toward difference and opposition, and harmony arises from difference and opposition rather than similarity [27]. There are many types of differences, but the primary-secondary difference is the most significant to the whole, widely existing in nature and human society. In organic unities, there are primary and secondary elements. Conversely, it gives a loose perception. For example, library reading area internal layout can place large-volume main elements in central prominent positions, with subordinate elements placed around to form emphasis and assistance. Library internal layout can also use left-right symmetrical composition, typically showing a one-primary-two-secondary relationship, with the main body in the center in a prominent position and secondary elements on both wings forming foils, creating primary-secondary and sequential perception. Western modern library building internal symmetrical forms have many variations, also evolving into one-primary-one-secondary asymmetrical forms. Primary-secondary and emphasis can also utilize functional characteristics of area elements to consciously highlight certain elements, placing them in primary positions, such as interest centers in foreign library buildings.

3.5 Geometric Shape Unity

Ancient architects recognized that simple, definite geometric architectural shapes and indoor element layouts can cause positive psychological resonance. For example, any element on a circumference is equidistant from the center, and the circumference length is always 3.14 times the diameter. Palace study rooms are square or rectangular, with all side lengths and angles that cannot

be changed arbitrarily, possessing strictness. Modern architectural master Le Corbusier emphasized that primitive forms are psychological beauty that enables clear recognition [26]. Primitive forms refer to library indoor elements that can compose circles, spheres, squares, and equilateral triangles. Easy recognition means library indoor layout geometric shapes are simple and clear. Geometric shape layout theory has been verified in examples throughout history and across cultures. Outstanding ancient buildings such as the Roman Pantheon and St. Peter's Basilica all used simple, regular geometric shapes to achieve highly rational and authoritative states. Modern indoor layout also widely uses circles, squares, triangles, and other geometric compositions. For example, public venues like the Brussels International Exposition Hall use geometric shapes for both function and form, providing psychological suggestions to visitors.

4 Experiential Experiment and Correlation Analysis

4.1 Experiential Experiment

The experiment was conducted at Jiangsu University Library. Movable objects such as reading tables, chairs, bookshelves, potted plants, decorative cabinets, and service desks in the experimental area were arranged according to five categories of layout characteristics sequentially. For geometric shape unity, reading seat areas and bookshelf areas were laid out as several small square zones, with service desks and potted plant areas forming several dotted circles and triangles, with these two types collectively constructing a rectangular shape overall. For primary-secondary and emphasis, large reading seat areas were placed in the main central axis zone, with bookshelves, potted plants, and service desks arranged on both wings to form secondary embellishments. The final layout was a control group that avoided the five layout characteristics. As shown in Figure 2 [Figure 2: see original paper]:

Figure 2 [Figure 2: see original paper] Example of Single Characteristic Layout with Geometric Shape Unity

Participants completed four reading tasks: natural sciences, social sciences, unplanned leisure reading, and planned target reading, simulating the main scenarios of four types of library reading areas. Participants were library volunteers, totaling 81 people, with data selected from 68 person-times, meeting the sample size requirement for reading psychology, including teachers, staff, students, and citizens. Participants were introduced to the tasks and, after resting and calming down, entered a reading area with a specific layout to experience a task for approximately 30 minutes. Within one day, participants' experiences of four tasks needed to be spaced and non-continuous. Experiences of different layout characteristics were spaced at least one day apart. Reading materials were limited to identical or homogeneous book chapters to avoid content differences affecting results.

For each task, participants completed a 25-item Likert-type reading efficacy questionnaire, with average scores calculated. During the experience, participants' data were synchronously observed remotely using physiological instruments. Fast Fourier Transform was used for power spectrum analysis of reading brain wave SMR and skin conductance values, calculating and recording the increase/decrease amplitude values, as shown in Figure 3 [Figure 3: see original paper]:

Figure 3 [Figure 3: see original paper] Physiological Measurement Data

4.2 Data Statistics and Correlation Analysis

Reading status data were constructed, and SPSS was used for statistical analysis. For normally distributed data, means were used; for non-normally distributed data, medians were used. Data underwent Cronbach's alpha reliability coefficient analysis, all above 0.8, indicating good internal consistency. The final correlation between user reading status and four tasks under six layouts is shown in Table 2.

Table 2 Correlation Data of Different Reading Tasks, Layout Characteristics, and User Status

Layout Characteristic	Natural Science Reading (Physiological Measurement %)	Social Science Reading (Physiological Measurement %)	Planned Target Reading (Physiological Measurement %)	Unplanned Leisure Reading (Physiological Measurement %)
Control (Eliminated Characteristics)	-3.21	-3.77	-9.78	-4.79
Geometric Shape Unity Rhythm and Cadence	-5.54	-7.18	-0.13	-5.76
	-0.34	-2.11	-1.98	-3.89

Layout Characteristic	Natural Science Reading (Physiological Measurement %)	Social Science Reading (Physiological Measurement %)	Planned Target Reading (Physiological Measurement %)	Unplanned Leisure Reading (Physiological Measurement %)
Primary and Emphasis Balance and Stability Proportion and Scale	-4.75	-5.92	-6.06	-7.79
Secondary and Emphasis Balance and Stability Proportion and Scale	-4.99	-7.23	-6.21	-8.16
Proportion and Scale	-5.92	-6.96	-9.79	-9.87

From Table 2, higher reading efficacy scores indicate better effects (4+ points is positive). Larger reading attention values indicate higher concentration. Smaller emotional tendency values indicate more stable and calm user emotions, representing better status [29]. The correlation relationships between various reading task layouts and user reading states become prominent (see Table 3). For natural science reading, geometric shape unity best induces good reading status. Except for the control group, rhythm and cadence is least suitable for natural science reading, even weaker than the control group in emotional tendency values. For social science reading, rhythm and cadence performs best. Although its reading attention value is slightly lower than the second-place proportion and scale, SPSS independent samples t-test shows $P > 0.05$, indicating no statistical difference. Except for the control group, geometric shape unity shows weaker effects. For planned target reading, primary-secondary and emphasis performs better, with all values significantly superior to other layouts. Except for the control group, balance and stability is relatively unsuitable for planned target reading. Although its attention value exceeds rhythm and cadence and approaches geometric shape unity, with no statistical differences among the three, both reading efficacy and emotional tendency values are weaker than other layouts. For unplanned leisure reading, balance and stability performs best. Although its emotional tendency value is slightly lower than the second-place proportion and scale, t-test shows $P > 0.05$, indicating no difference. Except for the control group, primary-secondary and emphasis shows weaker effects.

Table 3 Suitability Ranking of Layout Characteristics for Various Reading Tasks

Reading Task	Optimal Layout	Secondary Layout	Tertiary Layout	Quaternary Layout	Least Suitable
Natural Science	Geometric Shape Unity	Proportion and Scale	Balance and Stability	Primary-Secondary and Emphasis	Rhythm and Cadence
Social Science	Rhythm and Cadence	Proportion and Scale	Balance and Stability	Geometric Shape Unity	Primary-Secondary and Emphasis
Planned Target	Primary-Secondary and Emphasis	Proportion and Scale	Rhythm and Cadence / Geometric Shape Unity	—	Balance and Stability
Unplanned Leisure	Balance and Stability	Proportion and Scale	Rhythm and Cadence / Geometric Shape Unity	—	Primary-Secondary and Emphasis

5 Experimental Conclusions and Library Layout Recommendations

5.1 Experimental Conclusions

The five layout types show varying effectiveness across four reading tasks, but all demonstrate positive effects. Geometric shape unity possesses strong mathematical and geometric attributes, closely associated with natural science thinking patterns, providing positive psychological suggestions for abstract content reading, but showing poor influence on social science reading and average influence on unplanned and planned reading. Rhythm and cadence primarily reflect rhythm, meter, and harmony, aligning with the connotation characteristics of social science reading, thus assisting users in achieving better reading status. It shows poor influence on natural science reading and average influence on unplanned and planned reading, with no significant difference between the latter two. Primary-secondary and emphasis layout's main-secondary and emphasis-non-emphasis characteristics match the psychological suggestions of planned reading, showing optimal influence on planned target reading but poor performance in unplanned reading, with average performance in social and natural science reading. Balance and stability primarily reflect perception of no

prominence or lag, balance, and uniformity, aligning with the purposeless and universal nature of unplanned leisure reading, thus showing optimal effectiveness but weak influence on planned target reading. Proportion and scale show the best universality. As previously mentioned, all natural things should have good proportion and scale, and the demand for this layout is relatively consistent across various reading tasks, with influence ranking second and showing good effects.

5.2 Recommendations

Natural Science Reading Rooms can prioritize geometric shape unity layout, assisted by proportion and scale, also considering primary-secondary and emphasis and balance and stability, without considering rhythm and cadence. For example, reading rooms can first form several small square zones with a certain number of reading seats and potted plants, filling the indoor overall space; second, the length-width ratios of small zones and overall macro zones can follow the golden ratio, with seat spacing referring to the 1.3-meter scale; third, redundant spaces can be arranged with lightweight independent small bookcases or green embellishments as secondary items to set off the reading area focus, with geometric small zones considering left-right volume symmetry to assist overall balance; finally, the indoor space highlights rigor, logic, and rationality.

Social Science Reading Rooms can prioritize rhythm and cadence layout, assisted by proportion and scale, also considering primary-secondary and emphasis and balance and stability, without considering geometric shape unity. For example, reading rooms can first arrange traditional reading seats, green plants, and leisure sofas in horizontal or vertical, rhythmic alternating interspersed layouts to display different charms and highlight freehand style; second, each reading seat combination and each zone divided by rhythmic changes can follow the golden ratio in length-width ratio, with seat spacing referring to the 1.3-meter scale; third, the reading area volume in each zone divided by rhythm can be enlarged to highlight emphasis, with consistent total numbers of each zone to maintain balanced stability; finally, the indoor space reflects humanistic and artistic atmosphere.

Study Rooms for Planned Target Reading can prioritize primary-secondary and emphasis layout, assisted by proportion and scale, also considering rhythm and cadence and geometric shape unity, without considering balance and stability. For example, reading rooms can first arrange reading seats throughout the entire room along the central area to form the main emphasis zone, with plant shelves, service desks, and transfer bookcases placed on both sides of the zone as secondary items to form subordinate zones; second, the plane length-width ratios of each reading seat combination, main zone, and secondary zone can follow the golden ratio, with seat spacing referring to the 1.3-meter scale; third, the shapes of main and secondary zones can refer to rectangles or squares, with various objects in secondary zones alternating with

rhythm and cadence; finally, the indoor space highlights primary-secondary, sequence, and planning, avoiding balanced and purposeless psychological suggestions.

Leisure Reading Areas for Unplanned Reading can prioritize balance and stability layout, assisted by proportion and scale, also considering rhythm and cadence and geometric shape unity, without considering primary-secondary and emphasis. For example, reading areas can first arrange reading seats, bookshelves, and plant shelves with full coverage according to area and shape, with left-right front-back symmetrical and balanced layout of object quantities and types at both local and macro levels. For asymmetrical cases, tall or heavy objects can be placed in small-area ends to correspond with large-area zones, forming balance and stability; second, the plane length-width ratios of each reading seat combination and zone can follow the golden ratio, with seat spacing referring to the 1.3-meter scale; third, reading areas can be divided into two sections according to rhythm and cadence and geometric shapes, reflected separately in details but separated symmetrically to form balance, meeting the needs of different reading types; finally, the indoor space highlights natural relaxation and comfort, avoiding primary-secondary, difference, and planning psychological suggestions.

Exploring the relationship between reading area layout characteristics and user reading status helps grasp the potential impacts of various reading area layouts on user reading efficacy, attention, and emotional levels. This contributes to improving user reading quality, creating personalized, humanized, and intelligent ecological environments for library users, and reflecting the intelligent characteristics of architectural layout [30]. Managers can choose single layout characteristics for application or make composite selections, depending on the specific positioning concept of the reading area. Experimental results can be extended to socialized reading services, providing environmental layout references for nationwide reading initiatives. Future research will continue to deepen in dimensions such as data quality, object differences, and reading categories to benefit related industry work.

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