

Research Article

Eye-Tracking Technology in Online Real Estate Rental

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In China in recent years, the rental housing market has boomed, but insufficient attention has been paid to microsubject tenants in the market, and there is a lack of research results on tenants' decision-making processes. In keeping with the characteristics of China's accommodation-renting population, this study takes as its research object graduating students, who form an important group in the housing rental market, and focuses on the information retrieval process underlying prospective tenants' rental decisions. First, it investigates tenants' concerns during the renting process by means of questionnaires. Second, using eye-tracking experiments, the real online renting process is simulated and tenants' web listings are analyzed qualitatively and quantitatively. In the process of information search, the characteristics and rules of browsing the entry search page, the listings page, and the details page are obtained, and the factors that prospective tenants pay attention to in their search for rental information are obtained. The research results show that initial alphabetical sorting of the term search page can improve the subjects' efficiency in locating the target keywords, the text information display area of the listings page receives more attention than others, and the real concern factors of the tenants on the page listing details are generally consistent with their selected factors but deviate slightly. Finally, the layout and display of web page information affect how subjects' attention is distributed, and web page information presents a significant difference in attention between upper and lower pages.

1. Introduction

Housing rental has become an important strand of housing consumption in big cities in China, where the house-sharing model has become the main form of renting for young people. In 2017, the latest survey conducted by Aipu Big Data found that corenting in the rental market in Beijing accounted for nearly 80 percent of all rentals. According to the 2020 China Youth Rental Life Blue Book, the bulk of the new generation of urban tenants is composed of people under the age of 30 and holding a bachelor's degree or higher educational qualification. At the same time, according to the 2018 China Housing Leasing Report, graduates are an important demand group in the current housing rental market, and this group is showing an upward trend year on year. Tenants in the rental market display behavior typical of their age bracket; accordingly, they mostly choose online rental platforms to search for accommodation information. To meet this demand, various online rental platforms have developed. However, at present, scholarly research on online rentals is scanty. Existing research investigates the current

situation and problems of the online rental market at the macrolevel. A comprehensive overview of this research is provided in the 2015–2020 Internet + Rental Industry Operation Mode Analysis Report. The report presents a detailed interpretation of the opportunities and challenges facing the rental industry in the online environment, the size of the rental industry market, a forecast of the future size of e-commerce, and an analysis of the rental industry's modus operandi in e-commerce. At the same time, some scholars have investigated the usability and optimization of online rental platforms, such as the usability analysis of the rental website based on website design [1], and designed the rental recommendation system [2]. A few scholars have attempted to set out from the Internet rental market main body of the behavior research on the level of micromain body, but the microscopic main body also contains more choice for real estate agents [3]. Therefore, from the perspective of the current research, the online rental field is less concerned with the behavior of microsubject tenants.

As the final decision-makers in the online rental process, renters play an important role. Their browsing and searching

behaviors will directly affect their final rental decisions. However, current research contains remarkably few results on renters' browsing and searching behaviors, which is largely due to the lack of technologies and tools that can quantify such behaviors. The process of searching for and selecting accommodation on the Internet is complex. However, at present, the evaluation of online Internet behavior is limited to website traffic and clicks and cannot record the subtle behavioral processes involved when people browse the web. In contrast, using human physiological data to study people's potential behavior processes provides more convincing data than traditional survey methods such as questionnaires and interviews. The research results of eye-movement technology in the field of print advertising and the Internet have laid a theoretical and practical foundation for its application to research on online renting behavior. However, there are very few applications of eye-tracking technology in the real estate field. Only a few scholars have optimized and explored online rental platform web pages according to design principles, and their research focus is only on the layout design [4]. Existing research has not explored the rationality of web page layout in combination with the needs of renters. The conclusions reached discuss only which parts of the page attract consumers' attention, but it is impossible to deduce from the research whether the items of information to which consumers pay attention match their actual needs. In short, existing research lacks an in-depth analysis of how consumer attention is distributed.

Accordingly, in terms of research content, this study first explores tenants' actual concerns and uses this information as a basis for a comparative analysis with the tenants' web-browsing focus to explore whether the existing rental web pages can reasonably display tenants' concerns, that is, whether the tenants' concern factors as revealed by the questionnaire match their concerns during web browsing. The research conclusions obtained could be used to facilitate rationalizing and optimizing the display and layout of information on online rental webpages.

In terms of research methods, this study is designed to simulate online renting behavior. It does this by means of eye-movement experimentation and recruitment of people who have rental experience or needs and then letting them carry out actions and make decisions in an experimental environment equivalent to the real online rental environment. Their potential behavior processes and characteristics are then mapped through an eye tracker so as to obtain a large number of indicators providing data on prospective tenant behavior. This study illustrates methods and conclusions for behavioral research into microsubjects on online rental platforms and promotes the in-depth exploration and practice of eye-movement technology in the real estate field.

2. Principles and Application of Eye-Movement Technology

Eye-movement technology, or in full, eye-movement tracking technology, refers to the tracking of eye movement by recording the position of the fixation point of the eyes or

the movement of the eyes relative to the head, to collect and analyze the behavior characteristics of the microsubject. In recent years, thanks to the continuous exploration and improvement of theoretical and experimental software and hardware, eye-movement technology has been fully applied in many research areas such as visual information processing, media communication, and human-computer interaction. Current eye-movement experiments have been able to gradually move the experimental scenario design as close as possible to real scenarios, thereby providing more accurate indicators and conclusions for microsubject behavioral research while making up for the deficiency that traditional methods cannot directly obtain information about the internal cognitive processes of research subjects.

2.1. Working Principles and Eye-Movement Indices. In 1924, Nixon positioned himself in a box behind a curtain and observed the eye movements of subjects when they read magazines with print advertisements. This was a sort of prelude to eye-movement research [5]. Since then, eye-movement research has developed through the stages of the afterimage method, the mechanical recording method, the optical recording method, the image recording method, and various other methods [6]. Since the 1960s, microelectronics technology, video technology, infrared technology, and the development of computer technology have fostered the development of new high-precision eye trackers and greatly promoted innovation in and popularization of eye-tracking technology. At present, eye-movement technology is widely used in many academic fields related to psychology and cognitive behavior, such as interface information acquisition and decision-making process tracking [7].

Eye-tracking based on the video recording of the pupil and corneal reflexes is the main tool used in eye trackers; it can provide greater accuracy and a greater number of evaluation indices and is portable with a higher sampling rate. The most commonly used eye tracker can record eye-movement indices including fixation duration, fixation point number (fixation times), and visit times. The area of the image designated by the researcher according to the research purpose is called the area of interest (AOI). In addition, there are visual analysis results that vividly reveal eye-movement characteristics, namely, fixation track graphs, hotspot graphs, and cluster graphs. A single eye-movement index is of little research value, so it is necessary to conduct an in-depth analysis of different indicators according to specific research needs in such a way as to support the experimental hypothesis.

2.2. Application Status. Since the 1970s, given the maturity and popularization of eye trackers, much research on the application of eye-tracker technology has been published. In 1978, Russo recognized the outstanding advantages conferred by eye-movement research in reflecting people's potential behavior and decision-making processes and thereby providing effective tracking data when studying the processes involved when consumers browse print advertisements to obtain relevant information. At present,

academic research based on eye-movement technology is largely divided into research on information acquisition behavior in human-computer interfaces and research on tracking decision-making processes [5].

The experimental information sources for information acquisition behavior are mainly print advertisements and the Internet, and the most widely used eye-movement indicators are average fixation duration, fixation times in the target area, fixation saliency map, saccade durations, and average amplitudes [8]. Many studies have demonstrated that the process of obtaining information from print advertisements and the Internet can be a direct reflection of the effectiveness of the presentation of the information and the availability of the platform that is the source of that information.

In the field of print advertising, researchers have established that the spatial layout of each element or partition in the advertisement determines the degree of attention and information processing that subjects give to each part [9] and also explained how advertising proposal, brands, pictures, and other elements affect data about subjects' eye movement and how subjects browse text, pictures, and other elements. In recent years, with the widespread introduction of eye-movement technology and equipment, some scholars have further deepened this kind of research, detecting the eye-movement indices of print advertisements such as automobile advertisements [10], travel advertisements [11], recruitment advertisements [12], real estate advertisements [5], and enterprise advertisements [13], and put forward targeted optimization suggestions for print advertisement content planning and module design.

In the field of Internet studies, relevant research further confirms the powerful role of eye-movement tracking technology in accurately collecting information about users' eye movements, determining users' focus and browsing pathway, and then accurately determining users' AOI and behavior. Related pieces of research include the browsing behavior involved with web advertisements of different layouts and forms [10, 14], layout rationality research [15], and research on plane visual elements in web interface design [16]. A wealth of eye-movement behavior observation experiments have been carried out at multiple levels, such as software interface operation efficiency [17], digital library interface design [18], network education system interface design [19], social software [20], and mobile apps [21].

Because eye-movement technology can quantify and analyze the process of information acquisition, many studies have also applied it to psychology [22], education [23], and even medicine [24]. The scope of application for eye-movement technology has continuously expanded, and its mode of application has been continuously improved. The present study applied an experimental design based on the quantitative analysis of the characteristics of human search behavior as recorded by eye-movement technology to explore the application of eye-movement technology to online renting. Summarizing the indicators selected in the study, it was found that fixation duration, fixation times, and visit times are mostly used to measure the degree of attention,

while time to first fixation (TTFF) and fixation before are mostly used to test retrieval efficiency.

3. Materials and Methods

3.1. Questionnaire. The research used questionnaires to investigate the tenants' concerns. According to the 2020 China Youth Rental Life Blue Book, the bulk of the new generation of urban tenants is composed of people under the age of 30 and holding a bachelor's degree or higher educational qualification and the tenant group in the rental market is showing behavior typical of a younger age group. And the form of co-leasing in Beijing has become the main choice for the younger generation [25]. At the same time, according to the 2018 China Housing Leasing Report, college graduates are an important demand group in the current housing rental market, and this group is showing an upward trend year on year. In accordance with the characteristics of tenants in Beijing, the questionnaire investigated the concerns of tenants in the rental market. It was mainly distributed to the graduation classes of colleges in Beijing and universities and was administered and collected through online questionnaires. A total of 345 valid questionnaires were issued and recovered during the period from November 2020 to December 2020. After the questionnaires were retrieved, the data was screened according to whether there was a willingness to rent. The questionnaires containing no rental plan and no rental experience were discarded, in total ten examples.

In investigating the influencing factors to which tenants pay attention in online corenting, this research divides them into five major categories based on the results of the literature review [26–28]: general information, community information, surroundings, roommate information, others (see Table 1). It then inserts a total of 33 subdivision factors under the five categories. The average value of each subdivision index was obtained through rating the results of a 5-point Likert scale, and then the relative ranking was established using the average value as a reference. The table assignment situation is 1 = very unimportant, 2 = not important, 3 = normal, 4 = important, and 5 = very important.

3.2. Eye-Movement Experiment

3.2.1. Experimental Design. The combination of eye-tracking technology with the experimental scenario method can realistically simulate the real rental information retrieval process and can collect data about information retrieval and browsing processes that cannot be obtained by the traditional questionnaire method. This study uses eye-tracking technology to determine the difference between tenants' actual concerns and expected concerns (as revealed by the questionnaire), tries to explore the reasons for discrepancies, and then proposes suggestions for the optimization of the rental company's website information.

This study was conducted in the Behavior and Human Factors Engineering Laboratory of Beijing University of Aeronautics and Astronautics. The experimental instrument used is the Sweden Tobii T120 Desktop Eye Tracker. The experimental procedures and data collection were completed

TABLE 1: Index for measurement.

Classification	Variable
General information	Geographical location (close to/far from the workplace)
	The number of floors
	Accommodation type
	Accommodation location
	Accommodation area
	Room orientation
	Room design and decoration style
	Functions (kitchen, etc.)
	Facilities (air conditioner, heating, washing machines, Internet, etc.)
	Vacancy and roommates
Community information	Existence time and accommodation age
	Reputation and popularity
	Property management level (greening, security, etc.)
Surroundings	Level of convenience in transportation
	Fast-food restaurants, convenience stores, take-out services, etc.
	Shopping malls
	Education institutions
	Public green spaces, parks, etc.
	Fitness centers
	In a busy area or not
Roommate information	Gender
	Age
	Education
	Occupation
	Marital and family status
	Living habits
	Interests and hobbies
Financial situation	
Other	Rental price
	Payment methods (monthly payment, quarterly payment, etc.)
	Guarantee deposit
	Trends in rental prices in the future
	Period of the contract

using the built-in Tobii Studio 2.3.2.0 software of the eye tracker. The standard procedure, questionnaire, and consent protocols were drawn up. The subjects were recruited, and the requirements for participants were strictly checked to ensure smooth coordination in the early stages of the experiment, on-site organization, and feedback in the later stages.

The formal computer experiment consists of three parts and eight tasks (as Table 2 shows), which are the web page familiarization experiment, the entry retrieval experiment, and the renting behavior simulation experiment. Tasks are linked by a bootstrap. The experimental materials are mainly pictures. A well-known accommodation rental website was selected for participants to download pictures and screenshots of web pages and edit them. The format is JPEG and the resolution is 1280×1024 . The material is presented and the results are analyzed by the experimental software. The subjects only needed to complete simple tasks of browsing and mouse operation under the guidance of prompts, and each subject's computer use lasted about 20 minutes.

3.2.2. Experiment Implementation. According to the 2018 China Housing Leasing Report, college graduates are an important demand group in the current accommodation

rental market, and this group is showing an upward trend year on year. Accordingly, in the experiment, we mainly selected college graduates as experimental subjects. Before the experiment, we screened the subjects, and all the subjects had either experience in renting accommodation or a concrete plan to rent in the future, so the results of the subject sample guarantee the validity of the experiment. For this study, 20 subjects were randomly recruited from graduating students, consisting of 8 men and 12 women aged 18–25, with a bachelor's or master's degree, and original or corrected visual acuity of 1.0 or above. All participants were proficient in using a computer network and had some understanding of or familiarity with the currently popular online rental platforms. Due to the high expenditure of time and money in eye-movement experiments, some scholars in the past have also used fewer than 30 samples for decision-making research [29–31], and the research results are stable. Accordingly, we consider that the sample size selected this time is acceptable. After entering the laboratory, the subjects first had to familiarize themselves with the laboratory environment and understand the experimental procedures under the guidance of the experimental observer and fill in the informed consent form. Then, participants sat in front of the eye-tracker computer under the guidance of the observer, adjusted the

TABLE 2: Experimental task content and purpose.

Task number	Content of the task	Task goal
Part one: familiarize yourself with the experiment		
Task 1	Limited time to browse the rental website search page, list page, and details page.	To stabilize the emotions of the subjects and make them enter the experimental state; make the participants familiar with the basic information on the rental website, the instrument, and operation.
The second part: the entry retrieval experiment		
Task 2-4	Freely browse the combination of three groups of accommodation location terms (each group has about 50 terms), look for “key terms,” and gaze for a long time (gaze lasts longer than 2 s); all the three groups of entries are arranged in a horizontal and random order (phrase a, b, c).	1. Simulate the browsing behavior of tenants on the accommodation search page to obtain relevant eye-movement indicators 2. Discussion hypothesis: when the tenant searches and screens the accommodation location, it is more efficient to browse the accommodation location entry in alphabetical order than to browse it in random order.
Task 5-7	Freely browse the combination of three groups of accommodation location terms (each group has about 50 terms), look for “key terms,” and gaze for a long time (gaze lasts longer than 2 s); all three sets of entries are arranged in horizontal, alphabetical order (phrase a', b', c').	
The third part: renting behavior simulation experiment		
The last task of 8	Freely browse the accommodation listings page and accommodation details page.	1. Simulate the browsing behavior of tenants on the accommodation listings page and details page, and obtain relevant visual analysis results and eye-movement indicators 2. Explore the general rules for tenants to browse the accommodation information page.

sitting distance and sitting position as required, and followed the eye-tracker software to correct the body posture and calibrate the eyes. Once the head and eye correction process was passed, the screen displayed the message “Welcome, participants in the eye-movement research experiment on online renting behavior,” and the subjects then entered the formal experiment. In the formal experiment, each participant followed the instructions of the program to complete all the web-browsing tasks mentioned above. There was no aural or tactile interference in the experimental environment. At the end of the experiment, the collection rate of eye-movement indicators for the 20 subjects was all higher than 90 percent, so all of them could be used as valid data for the next step, namely, experimental results analysis.

4. Results

4.1. Questionnaire Results. 335 valid questionnaires were input for data analysis. All the respondents displayed the willingness to rent accommodation, and their detailed characteristics are shown in Table 3. The characteristics of the selected subjects are consistent with the characteristics of the larger renting group in Beijing, and the sample is thus representative.

The questionnaire surveyed the factors that tenants value in sharing and sorted them according to the average score.

The top ten factors that tenants are most concerned about in sharing were found to be transportation convenience, vacancy and roommates, rental price, basic accommodation facilities, the location of the accommodation, the living habit of the roommate, the gender of the cotenant, the rental period of the accommodation, the distribution of nearby fast-food stores, convenience stores, and takeouts, and rent trends and forecasts. The detailed scores are listed in Table 4.

4.2. Experimental Results. The eye-movement experiment software can automatically record the eye movements of the subjects and generate a visual graph of the data results and an analysis of the eye-movement index. The visualized data results are presented as a saliency map graph and a hotspot graph, which are mainly used for preliminary qualitative analysis. Based on the delineation of the AOI, eye-movement indicators are mainly used for quantitative analysis to consider such indicators as fixation duration, number of fixation points, and number of visits.

SPSS 25.0 software was used in this study to conduct a one-way analysis of variance (ANOVA) to test whether major demographic variables such as gender, age, and education background have any influence on eye-movement indicators such as fixation duration and fixation times. The AOI of eye-movement indicators was collected by taking

TABLE 3: Characteristics of respondents.

Basic characteristics		Frequency	%	Effective (%)	Cumulative (%)
Gender	Male	119	35.5	35.5	119
	Female	216	64.5	64.5	216
Age (years old)	<20	68	20.3	20.3	68
	20–30	255	76.1	76.1	255
	30–40	7	2.1	2.1	7
	40–50	5	1.5	1.5	5
Education	College degree or below	9	2.7	2.7	9
	Bachelor's degree	173	51.6	51.6	173
	Master's degree	60	17.9	17.9	60
	Doctoral degree or above	63	18.8	18.8	63
Marital and Family Status	Single	316	94.3	94.3	316
	Married without children	7	2.1	2.1	7
Renting Experience	Married with children	11	3.3	3.3	11
	Yes	104	31.0	31.0	104
Preferences	No	231	69.0	69.0	231
	With roommates	116	34.6	34.6	116
Entire house	Entire house	63	18.8	18.8	63
	It depends	156	46.6	46.6	156

TABLE 4: Factors of concern to sharing tenants.

Affecting factors	Number of cases	Min	Max	Mean	Standard deviation	Relative ranking
Level of convenience in transportation	335	1.00	5.00	0.82190	4.2806	1
Vacancy and roommates	335	1.00	5.00	0.92986	4.2060	2
Rental price	335	1.00	5.00	0.84749	4.1821	3
Room facilities	335	1.00	5.00	0.90562	4.1552	4
Accommodation location	335	1.00	5.00	0.84986	4.1522	5
Living habits (roommate)	335	1.00	5.00	0.87151	4.1373	6
Gender (roommate)	335	1.00	5.00	1.10113	4.0090	7
Period of the rent	335	1.00	5.00	0.86309	3.9403	8
Nearby fast-food restaurants, convenience stores, takeout services, etc.	335	1.00	5.00	0.93088	3.9313	9
Trends of rental price in the future	335	1.00	5.00	0.89467	3.8955	10
Accommodation functions	335	1.00	5.00	0.86240	3.8597	11
Property management level	335	1.00	5.00	0.95399	3.8358	12
Guarantee deposit	335	1.00	5.00	0.90102	3.8119	13
Occupation (roommate)	335	1.00	5.00	0.90138	3.7910	14
Marital and family status (roommate)	335	1.00	5.00	0.98403	3.7582	15
Shopping malls nearby	335	1.00	5.00	0.91467	3.7463	16
Age (roommate)	335	1.00	5.00	0.97181	3.7463	17
Room orientation	335	1.00	5.00	0.97618	3.7284	18
Payment methods	335	1.00	5.00	0.96920	3.7045	19
Room location	335	1.00	5.00	0.94161	3.6507	20
Accommodation type	335	1.00	5.00	0.99152	3.6269	21
Education (roommate)	335	1.00	5.00	0.94455	3.6060	22
Room area	335	1.00	5.00	0.90490	3.5821	23
In busy area or not	335	1.00	5.00	0.90363	3.5552	24
Public green spaces, parks, etc.	335	1.00	5.00	0.94026	3.5373	25
Room design and decoration style	335	1.00	5.00	0.89525	3.5134	26
Reputation and popularity (community)	335	1.00	5.00	0.91477	3.4179	27
Financial situation (roommate)	335	1.00	5.00	0.94386	3.3881	28
Interests and hobbies (roommate)	335	1.00	5.00	1.02492	3.3791	29
Fitness centers nearby	335	1.00	5.00	0.99792	3.3761	30
Existence time and accommodation age	335	1.00	5.00	0.92552	3.3701	31
Education institutions nearby	335	1.00	5.00	1.03070	3.3194	32
The number of floors	335	1.00	5.00	0.95293	3.1612	33

“accommodation information” in the accommodation listings page as an example (see the shaded section in Figure 1). The results showed that the gender of subjects had no significant influence on fixation duration ($F=0.121$, $p=0.732$), the number of fixation points ($F=0.031$, $p=0.863$), or the number of visits ($F=0.041$, $p=0.843$) at the significance level of 0.05. The age of the subjects had no significant effect on fixation duration ($F=0.288$, $p=0.932$), the number of fixation points ($F=0.323$, $p=0.913$), or the number of visits ($F=0.256$, $p=0.948$). The educational background of the subjects had no significant influence on fixation duration ($F=2.317$, $p=0.145$), the number of fixation points ($F=2.446$, $p=0.135$), or the number of visits ($F=2.306$, $p=0.146$). Therefore, all subjects participating in the experiment can be regarded as undifferentiated.

4.2.1. Entry Retrieval Experiment. The hypothesis underlying the entry search experiment: when the (prospective) tenant searches and screens the location of accommodation, it is more efficient to browse the entry about the location of the accommodation in order (in alphabetical order) than to browse it at random. Six browsing tasks were designed in the experiment; that is, subjects could freely browse the combination of six groups of terms of accommodation source location, find the key terms of the target, and continuously stare at the above for 2 s. Experimental tasks and materials are shown in Table 5. The experimental results were analyzed qualitatively and quantitatively from the perspective of visual results and eye-movement indicators.

(1) Visual Results Analysis. This paper takes the experimental task “finding *Sanyuanqiao* among the major landmark phrases in the Chaoyang district, Beijing” as an example, and uses the Gaze Plots and Heat Map generated by the experiment to analyze the visual results. Among them, the target keyword *Sanyuanqiao* is the AOI in the eye-movement experiment.

(a) Gaze Plots. The Gaze Plots are used to present the order and position of fixation points in the whole eye-movement process of a single subject viewing a certain experimental material. The size of the dot represents the fixation duration, and the number in the dot represents the order of fixation points. Figure 2 shows two sets of track maps produced by a single subject when browsing the “main landmarks of the Chaoyang district, Beijing” in this experiment. As shown in Figure 2, in the state of unordered presentation of the phrase, the subject spent 10.148 seconds from task start to fixation on *Sanyuanqiao*, and more than 30 fixation points were generated in the browsing process. In Figure 3, the subject spent 4.518 seconds from task start to fixation on *Sanyuanqiao*, and only 11 fixation points were generated in the browsing process. The fixation points were few and concise, and the fixation saliency map was relatively orderly, showing obvious guided path characteristics. The initial letter guidance and sequence of the phrase can guide the eye-movement behavior of individual subjects to a certain extent and shorten their time in finding the target keywords.



FIGURE 1: Area of interest (AOI): accommodation information.

(b) Heat Map. The Heat Map uses different colors to show the focus area used by one or more subjects to an image or to show the dwell time of one or more subjects in a certain area. In hotspots, red is usually the area with the longest gaze, followed by green, with many transitional layers. Figure 3 shows two groups of hotspots generated by all effective subjects in this experiment when browsing the “main landmarks of the Chaoyang district, Beijing.” In Figure 4, when the subject browses the unordered terms, several dark-colored hotspots appear, and the hotspots deviate from the target keyword. However, in Figure 5, subjects’ fixation points tend to be centralized and unified in an alphabetical ordering of terms, showing a better visual search effect. The initial letter guidance and sequence of the phrases exercise a certain guiding effect on the eye-movement behaviors of all the subjects.

(2) Eye-Movement Index Analysis. Compared with visual pictures, the quantitative analysis of eye-movement indicators is more statistically convincing. This study proposes target keywords “*Shiliuzhuang*,” “*Wudaokou*,” and “*Sanyuanqiao*” for the AOI and focuses on the eye-movement index for the TTF (time to first fixation, unit: second) and the FB (fixation before, unit: a). Among them, TTF refers to how long it takes the user to stare at an AOI for the first time, that is, to enter the AOI for the first time. FB refers to the number of fixation points before the first entry into the AOI. The unordered and ordered arrangement of phrases were taken as independent variables, and TTF and the FB were taken as dependent variables for ANOVA, and the results are shown in Table 6. The results of the percentage comparison of two eye-movement indicators in three AOIs, namely, “*Shiliuzhuang*,” “*Wudaokou*,” and “*Sanyuanqiao*,” are shown in Figure 6.

It can be seen from Table 6 that there is a significant difference between the two eye-movement indicators generated when subjects browse unordered and ordered

TABLE 5: Experimental tasks and materials of entry retrieval.

Task number	Material	Target keywords (AOI)	Material characteristics
Task 2	A: Beijing metro line 10 (45 stations)	Shijiazhuang	Horizontal random order
Task 3	B: major landmarks of the Haidian district, Beijing (48 in total)	Wudaokou	
Task 4	C: major landmarks of the Chaoyang district, Beijing (58 in total)	Sanyuanqiao	
Task 5	Beijing metro line 10 (45 stations)	Shijiazhuang	Horizontal, alphabetical order
Task 6	Major landmarks of the Haidian district, Beijing (48 in total)	Wudaokou	
Task 7	Major landmarks in the Beijing Chaoyang district (58 in total)	Sanyuanqiao	

Target keywords stand for a place name.



FIGURE 2: Results of unordered term browsing: saliency map diagram.

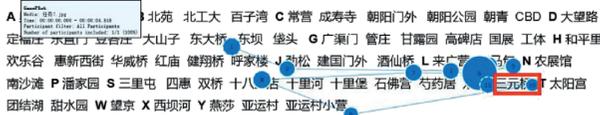


FIGURE 3: Results of orderly term browsing: saliency map diagram.

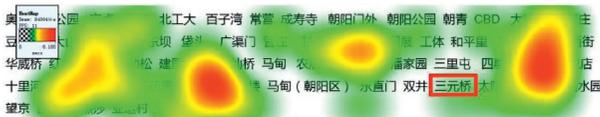


FIGURE 4: Results of unordered term browsing: hotspot graph.

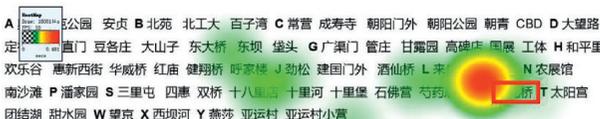


FIGURE 5: Results of orderly term browsing: hotspot graph.

terms—TTFF ($F=6.777, p \leq 0.001$) and FB ($F=3.717, p \leq 0.001$). Figure 4 illustrates the eye movements of subjects when browsing for target keywords among unordered terms: compared with browsing unordered terms, TTFF and FB are reduced when browsing alphabetical terms.

By combining the visual results and eye-movement index analysis, it can be concluded that in the task of “entry retrieval” the order of entries can guide eye-movement behavior, and the first alphabetical order of entries can improve the participants’ efficiency in finding the target keywords. This is manifested in (1) clear path, (2) unified search target, (3) shortened search time, and (4) a decrease in the number of fixation points during the search. To sum up, it is more efficient for tenants to browse the terms of accommodation location in an orderly alphabetical order than to browse the terms of housing location in an unordered order when they search and screen the accommodation location. Many landmark terms on the search page are arranged in a certain order and clearly guided, which can

improve the efficiency of tenants in searching for target keywords, and thus improve their efficiency in finding and selecting accommodation.

4.2.2. Renting Behavior Simulation Experiment

(1) *Accommodation Listings Page.* Figure 7 shows the eye-movement hotspots of the participants when they browse the accommodation listings page. Vertically, the listings page is divided into three areas from left to right: pictures (PIC.), information (Info.), and monthly price (Price). The hotspots of accommodation information cover the largest area and have the deepest color, covering almost all the key information. Monthly rent is next in intensity, mainly covering the amount of rent, while real pictures of accommodation display relatively fewer and weaker hotspots.

From another perspective, the statistical results of the eye-movement index reveal the eye movement of the participants when they browse the accommodation listings page. This experiment chose live-action accommodation pictures, accommodation information, and rent as three AOIs and selected fixation duration (unit: second), fixation count (unit: a), and visit (unit: s) as eye-movement indices. The results in Figure 8 show that the distribution of the mean values of the three indicators in the three AOI is accommodation source information (info) > monthly rent (price) > real picture (PIC.), which is consistent with the distribution rule of the Heat Map. The participants tended to pay attention to specific accommodation information (including community name and room details) in the form of text when browsing the accommodation listings page, followed by the specific amount of monthly rent, while the real picture of accommodation resources was of less concern.

(2) *Accommodation Information Page.* Compared with the listings page, the accommodation information page concentrates more on multifarious information, and the display methods tend to be diversified. For rental platforms, the disclosed real estate information can reflect the professional level of the platform. The quantity and quality of information reflect the effectiveness and usability of the platform. The platforms hope to attract network users (that is, potential tenants) by means of richer content and a web layout with a rich sense of design and put the most effective information, or the information that tenants pay the most attention to, in the position where the website can attract the most attention. For tenants, browsing for detailed web page

TABLE 6: Significance analysis of eye-movement indicators of subjects in the case of the unordered and orderly arrangement of items.

The dependent variable		Sum of squares	The mean square	F	Significance
First gaze time (in seconds)	Between groups	69.653	1.181	6.777	000.
	Within the group	3.484	0.174		
	The total number	73.137			
Number of fixation points before the first entry (unit: 1)	Between groups	2, 848.377	178.624	3.717	000.
	Within the group	3, 070.010	47.889		
	The total number	5, 865.387			

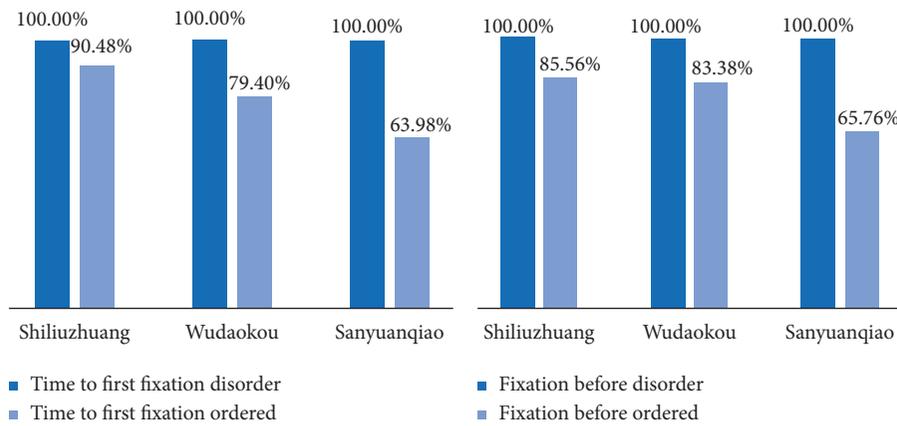


FIGURE 6: Comparison of the percentages of two eye-movement indicators under the condition of the unordered and orderly arrangement of phrases.

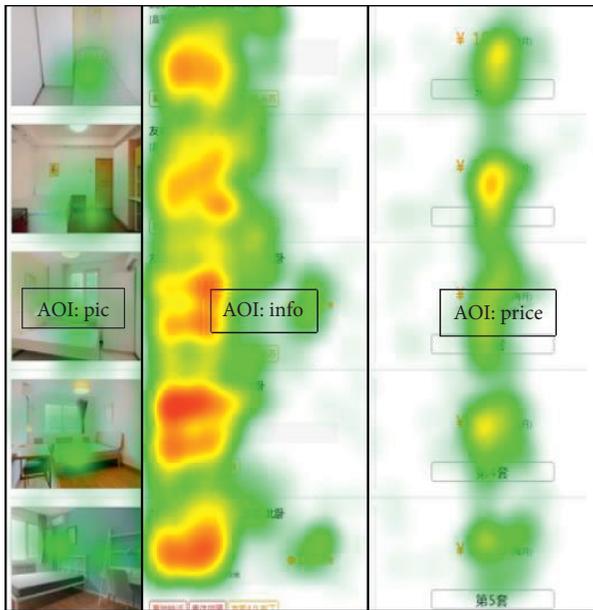


FIGURE 7: Eye-movement hotspots of the participants when they browse the accommodation listings page.

information enables them to appreciate all the information about the accommodation inside and outside without leaving their own home. Prospective tenants will process and analyze the information about the accommodation while browsing the website, and the eye-movement index consequently

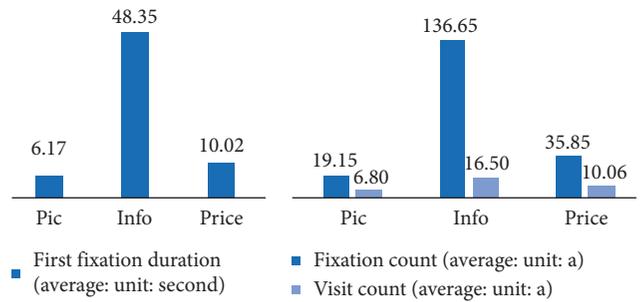


FIGURE 8: Eye-movement indicators of the participants when browsing the accommodation listings page.

generated will reflect the intensity and order of the attention they give to each part of the information presented to them.

Figure 9 illustrates the eye-movement hotspots of participants when they browse the accommodation information page. In this experiment, all the valid information contained on the accommodation information page is divided into 17 interest areas. The fixation points of the upper half of the page (above the dividing line) are more than those of the lower half. Each interest area is covered with hotspots. The area with the darkest color is “details” in the upper right corner of the page, which contains information such as accommodation name, area, orientation, type of accommodation, floor (which floor the accommodation is on), and traffic. Detailed introductory text, roommate situations, and monthly rent received more attention than other parts. In the roommate situation area,

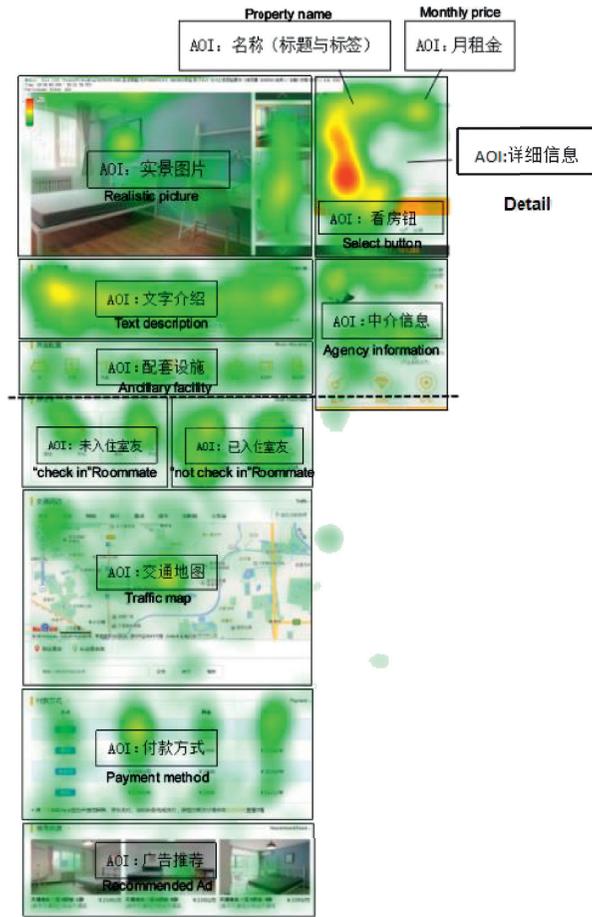


FIGURE 9: Eye-movement hotspots of the participants when browsing the accommodation information page.

TABLE 7: Duration of fixation points and the number of fixation points on AOI per unit area.

The serial number	AOI	Unit area of interest (percentage)	Duration of fixation on AOI (unit: seconds)	The number of fixation points in the AOI per unit area (unit: PCS)
1	Floor	0.1	211.20	490.00
2	The traffic	0.19	149.26	373.68
3	Door model	0.1	133.40	360.00
4	Orientation	0.1	118.20	300.92
5	Area	0.1	106.60	300.00
6	Name (title and label)	0.72	74.79	258.33
7	Introductory text	3.25	56.10	189.23
8	The monthly rent	0.22	52.23	200.00
9	Roommate in residence	2.21	33.81	109.95
10	The checking button	1.38	28.07	82.61
11	Supporting facilities	1.8	24.99	81.11
12	Mediation information	4.97	21.19	72.64
13	Absent roommate	2.22	16.18	50.45
14	Live-action pictures	10.35	13.57	48.12
15	Terms of payment	6.16	13.12	45.29
16	The traffic map	8.09	9.49	27.94
17	Recommended advertisement	4.85	7.05	25.36

“checked in” information is covered by more hotspots than “not checked in” information. Limited by experimental materials and software, the real scene pictures and traffic

maps on the page fail to achieve dynamic page turning and link effects, so the eye-movement results of the two parts need to be further tested and improved.

In this experiment, the fixation duration and fixation count in the per unit AOI were further calculated, and the statistical results show the fixation status and ordering of the detailed information for each AOI (as Table 7 shows). In the 17 AOIs of the accommodation information page, the top six interest areas are floor (which floor the accommodation is on), traffic, accommodation type, orientation, area information, and accommodation name information. These pieces of information summarize all the key facts about accommodation resources with concise keywords and phrases. They are the information modules with the highest density and quality on the accommodation information page. They are located at the top of the page. The traffic map, payment method, and advertising recommendation area at the bottom of the page have smaller index values due to scattered information, which is also consistent with the eye-movement visualization results shown in the Heat Map. The above results suggest that the accommodation information published by the rental platform is accepted by the tenants, and the degree of attention paid falls into a relatively obvious primary and secondary category. These results are capable of helping the rental platform to better plan the quantity, quality, and website layout of detailed accommodation information and further optimize the efficiency and experience of tenants in online renting.

5. Conclusions

This study focuses on (prospective) tenant behavior in the online corenting market and uses a combination of methods, namely, questionnaire survey and eye-movement scenario experiment, to study the process of tenants retrieving information from web listings. The research explores whether there are divergences, and, if so, the reasons for those divergences, between expectations about tenants' concerns as revealed by the survey and their actual concerns. The study found that there is a discrepancy between what tenants were predicted to pay attention to and what they actually did pay attention to, and there are two main reasons for this. First, the information displayed on the web page is not sufficient to meet the tenants' expectations, especially the introductory information about the cotenant and the surroundings. Second, the display and layout of web page information are unreasonable to a certain extent, which increases the cost and difficulty for tenants to quickly satisfy their expectations.

The questionnaire survey found that the top ten factors that tenants are most concerned about in shared rentals are transportation convenience, roommate occupancy, rental price, basic accommodation facilities, geographic location of the accommodation, living habits of the cotenant, gender of the cotenant, length of rental, the distribution of surrounding fast-food restaurants, convenience stores, and takeouts, and rent trends and forecasts. In the eye-tracking experiment, the top ten factors that tenants actually pay attention to are floor (which floor the accommodation is on), traffic, accommodation type, orientation, area, accommodation name (location), introductory text (including surroundings and traffic information), rent, the status of existing roommates, and the viewing room button. During

the corenting process, tenants expect and will actually pay attention to transportation convenience, roommates' occupancy, rental prices, and geographic location of the accommodation. However, some factors also cause discrepancies between expected and actual concerns.

Regarding the information about roommates, the prospective tenant expects to obtain more information about the cotenant's living habits, the gender of the cotenant, and other information about the cotenant. Therefore, tenants cannot obtain the desired information from the web page, which increases the cost and difficulty of obtaining tenant information.

As regards the distribution of nearby fast-food restaurants, convenience stores, and takeouts that renters want to obtain, although the surrounding environment is mentioned in the introductory text, it mainly focuses on presenting traditional supermarkets, banks, and hospitals. However, with the rise of the Internet shopping model, young consumers mainly rely on it to purchase daily food and daily necessities. Therefore, the delivery of various products in the surrounding area has become the focus of the new generation of young tenants. There is an insufficient presentation of surrounding takeouts in the introductory information on the existing web pages, which leads to tenants being unable to obtain the expected information.

Regarding accommodation facilities, although tenants expect to receive relevant information, they pay relatively little attention to the investment in facilities during the actual information browsing process. Based on the information on the renting web pages, the research leads us to believe that the use of pictures allowed tenants to invest less cognitive processing effort [32, 33] and therefore pay less attention to them. However, they are still ranked eleventh, which proves that tenants are concerned about and can obtain the accommodation facilities and equipment they want from the current rental website.

Regarding rental trends and length of the rental period, the relevant information is placed at the bottom of the web page, which causes tenants to pay insufficient attention to the relevant information and increases the time cost of information retrieval. Renting companies might be wise to consider displaying the requirements on the length of rental and brief information about rent trends in the information-intensive area in the upper right corner, and then tenants could quickly find the information they expect.

When renting accommodation, prospective tenants focus their attention on the basic conditions of the accommodation such as the floor, accommodation type, orientation, and area, as well as the viewing button, which is mainly due to their location in the information-intensive area of the picture of the accommodation. Studies have shown that the information on the right side of a picture will receive more attention from consumers, and the information-intensive areas will receive more attention from tenants [34–36]. Compared with the surrounding information, the information-intensive area in the upper right corner is the area that receives high-frequency attention during web page display. There is an unreasonable layout in the information display on the rental platform, and the display cannot meet

the tenants' requirements to quickly obtain the desired information, thus causing tenants to pay too much attention to information that was not predicted (according to the questionnaire results) and they would pay attention to.

The results obtained from processing and analyzing the results of the eye-movement experiment provide a useful quantity of effective data for research into Internet rental behavior, which, in turn, will open the way for the study of eye movement in the microsubject behavior of the real estate market. Through eye-movement research, we can find that the initial alphabetical guidance method on the search page can greatly improve the efficiency of tenants' information searching. On the information browsing page, the tenant will pay closer attention to the information-listing text and then make the decision to enter the details page. On the decision-making page, the attention paid by tenants when browsing information shows a clear hierarchy of upper and lower pages. Comparison of the tenants' actual concerns with their expected concerns as derived from the questionnaire data can help the rental platform to better plan its website design and information quality. That would improve the effectiveness and availability of the platform and consequently optimize the efficiency and experience of tenants in online rentals, promote the establishment of rental relations, and ensure the smooth operation and virtuous cycle of the Internet rental market. At the same time, this study innovatively introduces the eye-movement experimental method into the study of market microsubject behavior in the real estate field, thereby enriching research both on eye-tracking technology and in the real estate field.

Data Availability

The data used to support the findings of this study are included in the article and supplementary information files.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Experimental data from Tobii Studio are included. (*Supplementary Materials*)

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