VISUAL ATTENTION IN RETAIL ENVIRONMENTS

Design Analysis using HMD based VR System Integrated Eye-Tracking

NAYEON KIM[1] and HYUNSOO LEE[2]
[1,2] *Yonsei University, Seoul, South Korea*
[1,2] *{ny.kim|hyunsl}@yonsei.ac.kr*

Abstract. The goal of this study is to understand the spatial experience of users in retail environments in an immersive virtual reality setting. This study measures the visual attention and visual merchandising cognition of users via a quantitative method. The study was conducted to assess users' visual perception arising from the visual merchandising in-store environment during virtual reality experiences. The experiment was conducted using eye-tracking methodology in a virtual reality environment. After the experiment, participants responded to questionnaire surveys to assess visual merchandising cognition in retail environments. The experiment stimuli were provided in the virtual simulation of a retail store. During the experiment, each participant wearing a head-mounted display device was asked to experience the virtual retail space. The result shows the quantitative analysis of user behavior in the retail space and which design elements attract their attention. Unlike the precedent eye-tracking studies, this research analyzes visual attention during the spatial experience of retailing in its use of virtual reality technology. The approach and findings of this research provide useful information and practical guidelines to retailers and designers who are interested in improving the retail environment in consideration of customer visual attention and spatial elements.

Keywords. Visual Attention; Retail Environment; Eye-tracking; Virtual Reality; HMD (Head-Mounted Display).

1. Introduction

Today's retail market is changing more rapidly than ever before. The global e-commerce market has experienced accelerated growth in recent years. The rise of online shopping has caused offline stores to close and retail companies to go bankrupt. The speed and magnitude of this paradigm shift present challenges for the survival of traditional retailers. However, the opportunity exists for retailers to undergo a digital transformation. Offline retail stores have traditionally focused on driving sales but are now becoming centers which provide experiential value that customers cannot get online. Offline stores should be more than physical environments for the placing and selling of products; they should be more

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oriented toward the customer experience. Retailers need to increase their efforts to attract the attention of customers and to optimize the in-store environment such that consumers can be better exposed to the visual perspective (Jang et al., 2018). It is important to add experiential value and understand the behavior and visual attention of consumers while they shop in a physical store. Contemporary shopping spaces are required to reflect customer interests and visual attention patterns. In the retail experience, visual merchandising creates the in-store environment to visually communicate with customers as well as to contribute toward driving sales. The physical retail spaces of evolved brands, such as flagship stores, are viewed as part of a marketing strategy for brand building.

There has been enormous growth in recent years in the use of neuromarketing methods to understand the customer experience at the point of sale. Previous studies were limited to measure visual attention on products by employing eye-tracking methodology to determine influences on consumer behavior and decision making (Kim and Lee, 2020). Eye-tracking methodology has been employed for evaluating marketing stimuli, such as packaging, or for evaluation of point-of-purchase marketing (P. Huddleston, Behe, Minahan, & Fernandez, 2015). However, there is a lack of research which evaluates visual attention on spatial design elements in retail environments. With the increased demand for experiential retail in physical stores amidst today's rise of online shopping, it is necessary to understand the in-store customer experience in retail environments.

This study aims to investigate where customers focus their attention and how they perceive visual merchandising in the in-store environment. The objective of this study is to measure visual attention and visual merchandising cognition in quantitative method. Using state-of-the-art technology, the experiment was conducted to assess users' spatial cognition arising from visual merchandising in a virtual reality (VR) environment. An eye-tracking method has been developed to take advantage of VR headsets to perceive a high level of realism in a VR setting. Head-mounted display (HMD) VR systems offer a high-quality immersive environment and interactive tools. They have the benefit of allowing control over the study environment in a VR setting for multiple tests, regardless of geographical location. We can observe exactly where the user's attention is focused, at all times, in real time. Scientific evaluation of various types of VR simulation design has a high potential for architectural research, but it is still in its infancy. For this reason, this study explores a novel approach to measure spatial behaviors and visual attention in naturalistic perception while providing a sense of presence via an immersive VR experience under full experimental control.

2. Theoretical Background

2.1. EYE-TRACKING METHODOLOGY IN RETAIL ENVIRONMENT

Eye-tracking methodology has been widely used in cognitive science, consumer behavior, psychology, and design analysis research and in evaluating design, visibility, usability, and advertisements. Since the 1990s, the eye-tracking method has been utilized in the field of human computer interaction in usability researches conducted on information sharing interfaces (Tonbuloğlu, 2013). Through

tracking the user's gaze and eye movements, eye-tracking data can demonstrate what attracts a person's interest and where they get information. New VR technology offers new opportunities to research brand interaction and customer experience in retail environments. Recently, eye-tracking technology combined with a VR system has been used for the experimental study of an historical street design (Jeng & Zhang, 2018). However, advanced study in VR systems integrated with eye-tracking technology is still in the early stage of application to the built environment. Much synergy from the combination is expected to further experimental research to expose users to realistic visual stimuli, promoting a sense of presence in immersive settings. Eye-tracking has an intrinsic relation with VR, and the integrated system can provide more potential for eye-tracking research in VR environments (Jacob and Karn, 2003).

In this study, eye-tracking methodology is utilized in order to understand visual attention evoked from visual merchandising cognition in physical retail environments. Visual perception includes the various physiological components that give rise to the experience of vision. Recently, eye-tracking technology has also been used to examine the visual attention of consumers in online retailer environments. A recent study investigated the impact of various product photo features on the attention of online users through an eye-tracking experiment (Shin, 2019). In relation to retailing, the following literatures show the precedent studies which include search-choice process in the retail environment (P. T. Huddleston, Behe, Driesener, & Minahan, 2018). However, most of the literature in this area has been focused on the visual elements of product and package design. Unlike previous retailing studies, this study tackles the spatial experience and visual merchandising cognition perceived in in-store environments.

2.2. VISUAL MERCHANDISING COGNITION

Visual merchandising is both making merchandise attractive and selling merchandise through a visual medium (Pegler, 2012). Visual merchandising is a powerful tool for communicating visually with consumers and driving sales. Visual merchandising contributes to a brand's image and increases the likelihood that a customer will make a purchase. Many retailers utilize visual merchandising to maximize brand experiences in physical store environments. Visual merchandising is an important part of strategic product development planning and product sales methods for meeting consumer needs and driving them towards purchases.

Visual merchandising cognition is the visual perception of store characteristics associated with a brand image (Matthews, Hancock, Joseph, & Gu, 2013; Park, Jeon, & Sullivan, 2015). Research on how visual merchandising cognition affects brand attitudes and consumer purchase intentions has been limited (Park, Jeon, & Sullivan, 2015). Jeon & Park (2005) developed an instrument to measure visual merchandising cognition according to the dimensions of harmony, attractiveness, compatibility, trendiness, and functionality. Visual merchandising affects customer affective responses (Law, Wong, & Yip, 2012). According to Park et al. (2015), visual merchandising trendiness and attractiveness encompass a brand's aesthetic attributes and functionality describes a brand's utilitarian

attributes. The result shows that positive responses to visual merchandising are directly related to purchase intention (Park, Jeon, & Sullivan, 2015).

3. Methods

3.1. EXPERIMENTAL PROCEDURES

This study was mainly conducted in two phases: an experiment and a post survey. The experiment was implemented using eye-tracking methodology in a VR setting and was conducted in a laboratory setting. After the experiment, participants were asked to respond to a survey regarding personal information, the sense of presence in the VR environment, and visual merchandising cognition in the in-store retail environment. The experiment protocol was reviewed and approved by the university's IRB for the protection of human subjects. The subjects were recruited on the university campus and randomly selected on a first-come basis. The condition is to fairly provide all subjects a first-time VR spatial experience of retail environment via headset display.

The visual stimuli were shown as the in-store environment of a global automobile retail company located in Seoul, South Korea. It is a standalone flagship brand showroom, which features a newly curated retail and cultural experiences, as well as exhibits. To create the interior and exterior architecture, 'Suh Architects' used 36,000 meters of steel pipes and anodized panels supplied by H motor group. The experiment stimuli were presented in the 360˚ virtual simulation of a retail space. The architectural images were modeled from a camera which can record 360˚ panoramic images with high-resolution. Ten architectural images from different perspectives were nominated initially, but after review with professionals, only two types of representative space were selected. The final selected images were modified using Adobe Photoshop CC properly for experimental stimuli use. For this study, we developed two types of 360˚ panoramic images for virtual simulation. Two spaces were distinguished by the price range of merchandise: high versus low. The one is a sales area for premium vehicles on the 3rd floor and the other is for economy compact vehicles on the 4th floor.

A total of six subjects went through calibration tests wearing an HMD VR integrated eye-tracking device, but only one subject failed. Finally, five subjects whose eye-tracking ratios were above 90% participated in this experiment. This is a preliminary study to observe and investigate individual user behavior and visual patterns in-depth. Nielson (2000) found that usability tests produce the best results when they are conducted with no more than five participants and that as many small such tests as can be afforded should be conducted. The subjects were aged in their 20s or 30s. Three were male and two were female. Two were students and three were office workers. They responded that they had previous experience using VR systems for games or entertainment only. All subjects were familiar with a global automobile brand, but they had not actually visited an automobile retail store. During the VR experience, all subjects responded that the immersive sense of presence caused them to feel as if they were in the physical store.

To benefit from eye tracking technology within the VR environment, there

are three main components that must be in place: VR content as visual stimuli, an eye-tracking enabled VR headset, and analysis software. For the experiment setup, it is required to create a setting for a VR environment. Cubical devices called 'base stations' set the extent of the implementation of a virtual space in the laboratory. The hardware used in this experiment was the 'HTC-Vive', manufactured by SMI (Senso Motoric Instruments, Germany). Integration of eye-tracking in the 'HTC-Vive' device enables controlled environments for naturalistic eye-tracking studies. Next, in order to collect the data from all subjects during the experiment, SMI experiment suite software for stimulus analysis, such as software development kit 'SDK (C/C++)', 'Experiment Center', 'BeGaze', 'Steam VR', 'Unity 3D', were installed an a laptop.

The HMD VR device enables collection of the user's gaze data simultaneously with the VR experience in real time. In particular, by simply setting start and end times for experiments, the user's raw eye data are synchronized with the time when the actual stimuli are presented. During the experiments, eye data transmitted from the HMD device is displayed on the laptop screen in real time, so that it is feasible for a researcher to check and manage the user's eye-tracking status as well as the progress of the experiments. Eye-tracking data is collected at 250 Hz binocular. Data include point of regard on the display (left and right eye, binocular), gaze base point, gaze vector, and inter-pupillary distance (pupil to pupil distance). Eye-tracking metrics including first fixation, total duration of fixation, and time to first fixation. In this study, participants were exposed to visual stimuli for 120 seconds and a total of 30,000 raw gaze data points from individual eye-tracking were collected. For all five participants' tracking, 150,000 raw data points in total were collected for analysis.

Each experiment was conducted individually with the researcher for a total time of approximately 30 minutes. As soon as a participant arrived at the experiment lab, the researcher explained the overall research procedure in person. All subjects were carefully informed of the step-by-step precautions of the experiment. In the experiment lab, the subject wore an HMD device with integrated eye-tracking. Each participant was taken through a calibration procedure prior to the experiment, then the experiment was conducted under researcher control. During the experiment, each participant wearing the HMD device was asked to look at two images of 360° virtual retail space for 120 seconds in total. Each image was shown for 60 seconds to collect eye-tracking data and visual attention patterns on each. After the experiment was complete, the participants were asked to answer survey questionnaires regarding demographics, the sense of presence of the VR experience, and visual merchandising cognition.

3.2. MEASURES

3.2.1. Eye-tracking measures

In this study, the researcher defined and classified the main spatial design elements as areas of interest in each image. Area of interest (AOI) means regions of a display that researchers define and classify by shape for which quantitative data can be calculated (Bergstrom & Schall, 2014). In this study, a researcher determined the

AOIs in each still image according to the spatial element composing the retail environment. The following introduces the basic AOI events that connect the data to stimulus space and key performance indicators (Bergstrom & Schall, 2014; Holmqvist, 2011). The details of key performance indicators of AOIs include: sequence, entry time, dwell time, hit ratio, revisits, revisitors, average fixation, first fixation and fixation count.

The analysis of participants' eye-tracking data and visual attention include fixation count, fixation duration, coordinates, gaze path, gaze pursuit and others. In addition, we analyzed AOIs of the in-store retail environment, including spatial components such as architectural elements and interior objects: floor, wall, ceiling, furniture, lighting fixture, and display object. Heatmaps were generated from eye movement data of average of all participants.

3.2.2. Visual merchandising cognition measures

Visual merchandising cognition is the visual perception of store characteristics associated with a brand image (Matthews, Hancock, Joseph, & Gu, 2013; Park, Jeon, & Sullivan, 2015). Jeon & Park (2005) developed an instrument that measures visual merchandising cognition according to the elements of harmony, attractiveness, compatibility trendiness, and functionality. In the study, the survey questionnaires shown in Table 1 were developed based on the literature review.

Table 1. Instrument of Visual merchandising cognition .

Variables	item	Scale
Harmony	• Harmonized floors, walls, ceilings in interior space • Harmonized with your brand image with art display. fixtures, POPs etc.	5 point Likert scale from "Strongly disagree"=1 to "Strongly agree"=5
Attractiveness	• Creative image creation in display • Make your products attractive through eye-catching techniques.	
Trendiness	• Introducing new trend through color display and design technique • Delivering new trend using effective visual merchandising	
compatibility	• Visual merchandising elements are displayed in a consistent to communicate brand image. • Use fixture, display objects, props that match the brand image.	
Functionality	• Consideration of sufficient corridor in the store layout • Consider the functionality of spatial design	

4. Results and Discussion

4.1. ANALYSIS AND FINDINGS FROM EYE-TRACKING

During the VR experiment, all participants' behaviors were observed during the spatial experience in the retail environment. As an analysis of general spatial cognition, the following attention maps generated from eye-tracking show all participants' visual interest within the space. Red indicates a high intensity of visual attention. As shown in Figure 1, two attention maps represent the average data of all participants for two stimuli. In the first sales space for premium cars, people paid more attention to the premium lounge and the unique structural elements of the ceiling. In the lounge area, various components for the manufacture of premium cars are displayed to visually provide specific product information and brand communication to customers. In contrast, the economy

sales space has more efficient placement of different types of cars; participants paid more attention to the cars than the environment.

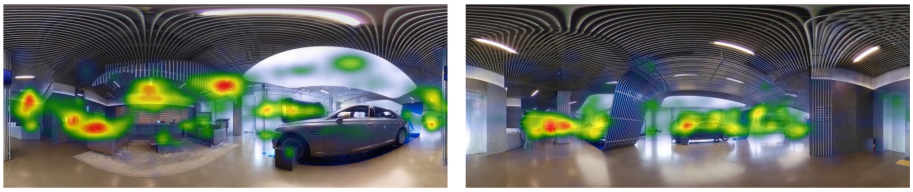


Figure 1. Heatmap of retail environment for premium cars(left) and for economy cars(right).

The following data represent an individual's spatial experience sequence. As an example, one participant (P04), who recorded the highest tracking ratio at 97%, is selected. Figure 2 shows how this individual behaved and look around the spatial element in sequence. The number of each spotted area indicates its position in the sequence.

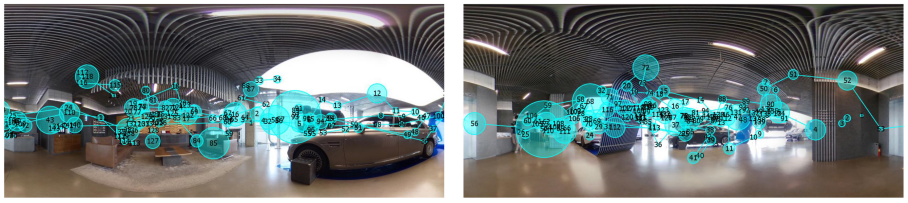
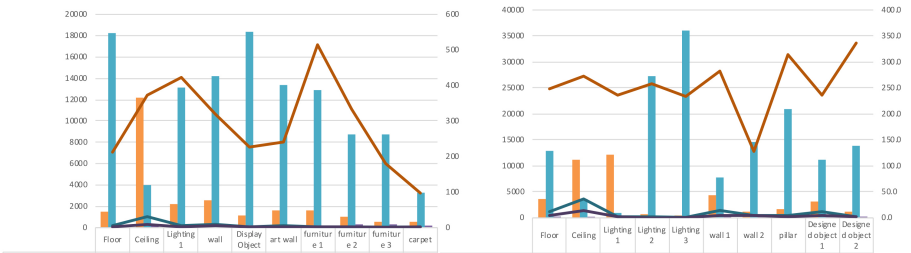


Figure 2. Scan path in retail environment for premium cars (left) and for economy cars (right).

In this study, we analyzed AOIs of the in-store retail environment including spatial components such as architectural elements and interior objects: floor, wall, ceiling, furniture, lighting fixture, and display object. The first experiment stimulus is the sales area for premium cars. As a result of averaging the eye-tracking of all participants, the fixation sequence of AOIs shows: (1) carpet- (2) ceiling- (3) furniture 2 - (4) furniture 3 -(5) furniture 1 - (6) lighting1 - (7) art wall - (8)wall - (9) floor - (10) display object. The first object in the fixation sequence shows 'carpet', and 'ceiling' is next. The carpet is in the premium lounge area where customers can consult with a salesperson. In addition, participants showed little interest in the display object. The second experiment stimulus is the sales area for economy cars. As a result of averaging the eye-tracking of all participants, the fixation sequence of AOIs shows: (1) ceiling - (2) wall 1 - (3) display object 1 -(4) lighting 1 - (5) floor - (6) display object 2 - (7) wall 2 - (8) pillar -(9) lighting 2 - (10) lighting 3. In this space, participants paid more visual attention to 'ceiling' and 'wall 1'. The last sequence of fixation shows 'lighting 3'. From all analysis of the two types of space, users show the least visual attention on the lighting fixtures, are the linear fluorescent light.

In addition, the total fixation time on each AOI events were measured. It is total amount of time that participants have spent looking at particular elements during entire experiment. Thus, if the dwell time on particular area is higher, the

interest of that element is higher. In the sales area for premium car, total fixation time shows from the longest to shortest: (1) ceiling- (2) wall - (3) lighting 1 - (4) furniture - (5)art wall - (6)floor - (7)display object - (8) furniture 2- (8) furniture 3- (9)carpet. In the sales area for economy cars, the result of total fixation time shows from the longest to shortest: (1) ceiling - (2)wall 1 - (3) floor - (4) display object 1 -(5) pillar - (6) wall 2 - (7)display object 2- (8)lighting 1 - (9) lighting 2 -(10) lighting 3. Figure 3 describes data from the key performance indicator analysis of AOI events: total dwell time, entry time, first fixation, average fixation, revisits, and fixation count.



	Floor	Ceiling	Lighting 1	wall	Display Object	art wall	furniture 1	furniture 2	furniture 3	carpet
Total dwell time	1490.4	1220.4	2251.1	2626.4	1112	1670.5	1675.2	1045.6	543.2	521.5
Entry Time	18240.7	3991.4	13151.4	14154.6	18341.5	13404.2	12929.8	8689.8	8756	3317
First fixation	140	248.8	359.2	204.8	188	216.8	188.8	306.4	258.4	138.4
Average fixation	211.7	371.3	423.4	319.2	227.8	241.4	514.5	331.9	180.5	97.3
Fixation count	5.2	3.1	6	7.8	3.8	6.2	3.2	3.6	1.6	2
Revisits	2.8	9	1.6	4	2.3	3	1.2	2	1	1.5

	Floor	Ceiling	Lighting 1	Lighting 2	Lighting 3	wall 1	wall 2	pillar	Designed object 1	Designed object 2
Total dwell time	3552.9	11248.2	12109.6	744	373.6	4408	1234.4	1775.2	3206.4	1099.2
Entry Time	12979.6	3732.4	852	27254.8	36019.3	7808.4	14649.5	21044.3	11121.2	13977.2
First fixation	212.8	306.4	224	255.2	215.2	260	138.4	230.4	178.4	214.4
Average fixation	247.5	272	235.1	258	232.8	282.5	127.9	314.8	235.4	336.4
Fixation count	11.4	36.4	3	2.2	1	14.6	5	4.2	1.1	3.2
Revisits	4.2	14.0	1.8	0.8	0.7	4.8	4	2.3	5.4	1.6

Figure 3. KPI analysis: retail environment for premium cars (left) and economy cars (right).

The result shows that they paid little attention to carpet in the sales for premium car and lighting 3 in the sales of economy car. However, in both areas participants paid significant amount of attention to the architectural elements of unique industrial steel pipes on ceiling for the longest. It means people are interested in what is a common architectural element that conveys brand identity associated with automobile manufacture. Every detail within architectural elements should be designed to create synergy toward providing holistic brand experience. The physical retail environment should be utilized as part of a marketing strategy for brand building.

4.2. ANALYSIS AND FINDINGS FROM VISUAL MERCHANDISING COGNITION

The survey of visual merchandising cognition is analyzed with the statistical software SPSS 24. Five instruments are measured to assess visual merchandising cognition: harmony, attractiveness, trendiness, compatibility, and functionality. Among the five variables of visual merchandising cognition, the average of participants' responses ranks them from highest to lowest as: 'attractiveness', 'harmony', 'trendiness', 'compatibility', 'functionality'. As a result, users generally felt the attractiveness of this space makes products appealing since it creates interesting spatial impression with eye-catching display. However, they perceived lower compatibility and functionality from visual merchandising cognitions. It means retailers and designers need to improve brand communication with customers in-store retail environment. For example, using fixtures, display

objects, and props which match the brand identity can help to enhance the brand image. Retailers also need to properly provide product information in each sales zone so that customers can easily find the information they want. In addition, the store layout also needs to be reconsidered to provide sufficient corridor for customer convenience.

From the findings of the eye-tracking experiment and the survey, in order to enhance the in-store retail environment, the brand image or product information that the retailer wants to deliver should be reflected and integrated into the particular spatial elements that the users looked at the most and the first time in sequence during the VR experiment. User experience-oriented design is required to reflect the user's interest and convenience by observing the user's behavior within the architectural space. The results of this study suggest that design communication between retailers and consumers should be further enhanced when creating spatial environments. In order for users to become familiar with products and brand images more quickly and easily, it is necessary to communicate brand identities through spatial elements with priority on areas to which consumers pay attention. Thus, the spatial experience eventually contributes to enhance brand image so customers can maintain a positive purchasing intention. This integrative study of eye-tracking analysis and survey on visual merchandising cognition can be the basis for building an evidence-based design to create a user-oriented retail environments.

5. Conclusion

In this study scientific methods were used to quantitatively analyze the spatial design elements in which users are interested and to which they pay attention. The results show the quantitative analysis of where customers look in the in-store environment, how they behave with the space, and where they pay attention in AOIs. The approach and findings of this research provide useful information and practical guidelines to retailers and designers who are interested in improving retail environmental design in consideration of customer visual attention and spatial elements. This research assists designers in architectural design processes to engage user-oriented experiences. In addition, for retailers, this research can provide useful guidelines for applying visual merchandising related to the in-store environment.

Unlike precedent eye-tracking studies, this study uses a state-of-the art technological system for a scientific approach to observe the user experience in real time within a VR setting. However, this study has a limitation in that it is a very basic preliminary study applied to one retail case with a small number of participants. Although the study needs further development, it has significance in demonstrating the protocol of experimental methodology using VR combined with eye-tracking technology. In future research, in addition to focusing on visual attention, pupillary response will also be studied and measured to investigate how users respond emotionally to the spatial experience. Further study may be extended to compare and analyze differences in user behavior patterns among different groups according to individual characteristics (e.g., gender, age, job status, product involvement).

Eye-tracking within VR creates more immersive research scenarios by enabling integrations based on gaze. It also opens up many opportunity apply to the evaluation of virtual simulation. VR experiments allow pre-evaluation of spatial simulations prior to construction in the real world. From the results of pre-testing the user experience, the final architectural design can be modified to fit customer needs and contribute to optimization of the design. Use of eye-tracking methodology within a VR environment contributes to a better understanding of how users navigate a space, what they actually look at, and how their attention is drawn to design elements. This is more powerful than relying on the intuition of designers or architects to optimize designed spaces. The implications of this study show many possibilities to enhance architectural design and its process in the future.

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