Evaluation of Store Layout Using Eye Tracking Data in Fashion Brand Store

Naoya Saijo[1(✉)], Taiki Tosu[2], Kei Morimura[2], Kohei Otake[3], and Takashi Namatame[2]

[1] Graduate School of Science and Engineering, Chuo University, 1-13-27, Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan
al3.rx7m@g.chuo-u.ac.jp
[2] Faculty of Science and Engineering, Chuo University, 1-13-27, Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan
{al4.cjbj,al4.ers7}@g.chuo-u.ac.jp, nama@indsys.chuo-u.ac.jp
[3] School of Information and Telecommunication Engineering, Tokai University, 2-3-23, Takanawa, Minato-ku, Tokyo 108-8619, Japan
otake@indsys.chuo-u.ac.jp

Abstract. In this study, we conducted purchasing simulation experiment using eye tracking device in fashion brand store. Using the gaze measurement data obtained through experiments, we conducted several analyses to evaluate the store layout. Firstly, we divided the inside of the store into several areas. We tried to identify the areas that can become areas that are easily visible (Golden Zone) by performing multiple comparison on visual time for each area. Through the result, we identify the area that could be Golden Zone. In addition, it became clarifying that the characteristics of the areas which can become Golden Zone. Secondly, we tried to clarify that relationship between good impression item and visual time. It is clarified that there had a positive correlation between "Purchasing time" and "The number of item held in hand." Moreover, "Purchasing time" and "The number of good impression item" also had a positive correlation. From the results, we proposed improvement plans for better store layout.

Keywords: Eye tracking · Gaze measurement · Purchasing behavior
Store layout · Shelf arrangement · Fashion brand store

1 Introduction

Improving store layout in a real store is still one of important issues. In a real store, there are areas that are most eye-catching and are easily accessible to hands to the customer. These areas are called "Golden Zone". Traditionally, by utilizing Golden Zone, sellers gathered customers' attention and sold items. However, it is thought that Golden Zone differs depending on the type and quantity of items to be handled, as well as the customer base. Therefore, it is necessary to grasp Golden Zone correctly in each store. To achieve that, it is important to clarify the customer's behavior within a store.

Eye tracking is one of the methods to capture the customer's in-store search and Purchase behavior. Eye tracking is a method of tracking the movement of a person's

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line of sight and measuring how much and which place that person gaze. Since it can analyze human behavior and unconscious need from the movement of the line of sight, it is used for the display method of products and the usability investigation on the website. In recent years, various studies of consumer behavior using eye tracking has been carried out [1]. By clarifying what kinds of gaze consumers are searching for items, it is thought that useful suggestions can be obtained in improving the store layout.

2 Purpose of This Study

In this study, in order to understand detail purchasing behavior, we conduct purchasing simulation experiment using eye tracking device in a fashion brand store. It aims to evaluate the store layout by using the purchasing behavior and characteristics of customers obtained from the gaze measurement data. Specifically, visual time for each area is measured, and we tried to identify Golden Zone through the analysis of multiple comparison. Also, with regard to the item that the participant replied that it was a good impression, we measure the visual time of good impression items and its surrounding items. From these results, we try to clarify the relationship between good impression items and visual time.

3 Previous Studies

In this chapter, we describe previous studies using eye tracking in the retail store. Kitazume et al. investigated the relation between staying or visual time and rate of purchase in a real shop by observing consumer's line of sight and view point by using the Eye-Mark Recorder and analyzing the decision-making process [2]. Chandon et al. evaluated the effect of getting gaze by POP (Point of Purchase) advertisement based on eye movement data in real store [3]. Van der Lans et al. proposed a methodology to determine the competitive salience of brands, based on a model of visual search and eye-movement recordings collected during a brand search experiment [4].

In addition, there are some studies focused on store layout and shelf arrangement of items. Tetsuoka et al. observed the consumer behavior in the retail store and clarified the relationship between the display method of goods in one display and the purchasing behavior by using bayesian network and belief propagation [5]. Shirai et al. revealed the position (Golden Zone) which is easy to select in the ice cream showcase [6]. However, from the aspect of consumer's eye tracking, there has not been adequately studied about store layout.

4 Experiment Aimed at Gaze Measurement in Purchasing Behavior

4.1 Outline of Experiment

We conducted experiment of purchasing simulation in the fashion brand store to obtain gaze measurement data in purchasing behavior.

4.1.1 About Eye Tracking Device and Target Store

In this experiment, eye tracking device "Tobii Pro Glasses 2" and recording software "Tobii Pro Studio" are used to measure the gaze of participants [7]. These make it possible to accurately grasp the visual time of participants and the movement of eyes, and output the experiment result as numerical data. Eye tracking device is shown in Fig. 1.

Fig. 1. Eye tracking device (Tobii Pro Glasses 2)

The target store for this study is a downtown street shop in Tokyo. Main customers are women in their twenties and thirties. The store treat handling bags, wallets, accessories, clothes, shoes and the other fashion items. The present layout is shown in Fig. 2.

The number of items laid out in each area and the size (height, width, depth) of the area are shown in Table 1. Also, the composition of item categories in each area is shown in Table 2.

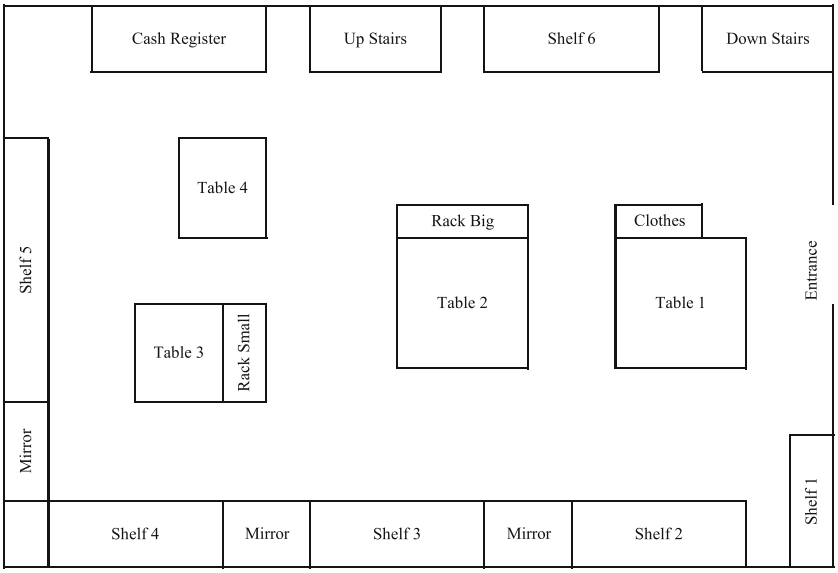

Fig. 2. In-store layout of the target store

Table 1. The number of items in each area and the size of each area

Area	The number of items	Height (cm)	Width (cm)	Depth (cm)
Shelf 1	9	231	117	
Shelf 2	26	280	280	
Shelf 3	31	280	280	
Shelf 4	60	250	200	
Shelf 5	22	220	220	
Shelf 6	29	291	312	
Table 1	14	63	122	304
Table 2	14	79	159	104
Table 3	26	92	44	150
Table 4	36	92	86	110
Rack Big	8	140	93	
Rack Small	5	140	80	
Cash Register	18	87	147	30
Clothes	8	117	150	

Table 2. The composition of item categories in each area

Area	Item categories
Shelf 1	Bag, key case, wallets, clothes, shoes (for men)
Shelf 2	Handbag, tote bags, shoes, wallet
Shelf 3	Handbag, tote bag, backpack, wallets, belt, pass case
Shelf 4	Handbags, wallets, pass case
Shelf 5	Handbag, shoes, wallet, key case
Shelf 6	Handbag, backpack, wallets, shoes, belt, pouch, pass case
Table 1	Handbag, shoes, belt, clothes, sunglasses
Table 2	Handbags, belt, bag charm
Table 3	Wallet, pass case
Table 4	Watch, bag charm
Rack Big	Tote bag
Rack Small	Shoulder bag
Cash Register	Earrings, bracelet, sunglasses, pouch
Clothes	Clothes

4.1.2 Experiment Participants

To gather the main target of this store, we selected 10 women in their twenties as participants. They are 4th grader at several university in Tokyo. First of all, we conducted questionnaire about sense of values in item purchasing and the target store. From the questionnaire, they have the following in common features.

- They purchase inexpensive items for themselves.
- They knew this shop from before.
- They rarely purchase items from this store.
- They rarely visit the EC site of this store.

4.2 Experiment Procedure

The specific procedure of the experiment is described.

1. Make participants gather in the room different from the store and explain the purpose and flow of the experiment.
2. Call the participant one by one outside the store, and the participant is attached the eye tracking device.
3. Calibrate the eye tracking device, and make it be accurate to collect recording data.
4. Record instore purchasing behavior of each participants from outside the store. At that time, 5 participants enter from the right side of the store, and the remained 5 participants enter from the left side of the store.
5. During the experiment, they can freely turn around the first floor of the store and pick up the items which they interest. Moreover, we observed the behavior of the participant and keep a brief note on the state of purchasing behavior. Expected time for purchasing behavior is about 5 min. When you finish watching them all, raise your hands and ask them to signal the end of the experiment.

6. After the purchasing behavior of the participant, we asked impressive items and items that they want as the after-questionnaire.

These experiments were repeated for 10 participants and gaze measurement data was acquired.

4.3 Measurement of the Visual Time Using AOI

We measure the visual time of each area and item from recorded data of purchasing simulation obtained by the experiment. To measure visual time, AOI (Aria Of Interest) installed in the recording software "Tobii Pro Studio" is used. By using AOI, it is possible to measure how much participants are viewing a certain areas or items. First, we specify the area to measure gaze time. Next, the recorded data is reproduced. If the area where we want to specify is shifted, move AOI or change its shape. When measurement is performed, the staying time of the line of sight is counted as 1 every 200 ms. By converting the measurement result at AOI to seconds, the visual time of each participant is clarified. The state of AOI is shown in Fig. 3.

Fig. 3. The state of AOI

5 Analysis of the Visual Time of Each Shelf and Item

5.1 Multiple Comparison

In order to evaluate the difference in visual time in each area, we try to find dominant area by performing multiple comparison. In this case, since the sample size is small and a normal distribution cannot be assumed, the Steel-Dwass method is used [8]. The Steel-Dwass method is a multiple comparison using a rank order to simultaneously test all paired comparisons between groups for parameters representing the position of the distribution. The procedure of the Steel-Dwass method is as follows.

1. Make a combination of i and j $(i > j)$ for all groups.
2. Let the number of samples in both groups be $n_i, n_i(N = n_i + n_j)$.
3. The order of the i-th group and the j-th group is ranked, and the order of the k-th data of the i-th group is r_{ik}. Let the rank sum of the i-th group be $R_{ij} = r_{i1} + r_{i2} + \cdots + r_{in_i}$.
4. Calculate the expected value $E(R_{ij})$ and variance $V(R_{ij})$ under the null hypothesis.

$$E(R_{ij}) = \frac{n_i(N+1)}{2} \tag{1}$$

$$V(R_{ij}) = \frac{n_i n_j}{N(N-1)} \left\{ \sum_{k=1}^{n_i} r_{ik}^2 + \sum_{k=1}^{n_j} r_{jk}^2 - \frac{N(n_{ij}+1)^2}{4} \right\} \tag{2}$$

5. Calculate the test statistic t_{ij}.

$$t_{ij} = \frac{R_{ij} - E(R_{ij})}{\sqrt{V(R_{ij})}} \tag{3}$$

6. The p-value is calculated from the distribution of the studentized range of degrees of freedom ∞.

5.2 Identification of Golden Zone by Analyzing Visual Time

Firstly, the visual time of each area was measured from the recorded data using AOI. The visual time of each area for each participant is shown in Table 3. However, it is counted only when the line of sight stays for more than 1 s.

Table 3. The visual time of each area for each participant (s)

Area	Participant									
	A	B	C	D	E	F	G	H	I	J
Shelf 1	2	0	2	21	1	18	0	3	1	3
Shelf 2	25	33	70	53	18	7	4	9	96	53
Shelf 3	9	15	12	60	37	11	13	18	96	38
Shelf 4	19	74	26	77	14	4	65	77	110	8
Shelf 5	5	3	8	49	8	2	25	7	36	9
Shelf 6	32	0	10	4	42	81	0	24	7	6
Table 1	1	3	3	9	10	0	2	2	13	0

(*continued*)

Table 3. (*continued*)

Area	Participant									
	A	B	C	D	E	F	G	H	I	J
Table 2	0	14	0	3	24	10	0	3	32	0
Table 3	5	27	8	25	21	9	3	75	73	0
Table 4	16	38	25	16	36	27	8	31	23	0
Rack Big	25	15	4	0	0	0	0	99	0	0
Rack Small	0	15	0	5	14	0	2	29	48	0
Cash Register	0	0	0	5	0	0	8	0	0	2
Clothes	0	0	12	0	0	0	0	0	0	0

Secondly, a hypothesis test is performed by the Steel-Dwass method for the result of Table 3. By dividing by the visual time of all areas of each participant and the number of products in each area, the visual time for each area in "Table 3" is standardized. Visual time of "Shelf 1 to 4", "Table 3" and "Rack Small" is defined as "viewing time on the left side of the store as seen from the entrance" S_L. Visual time of "Table 4", "Rack Big", "Cash Register", "Shelf 6" and "Clothes" is defined as "viewing time on the right side of the store as seen from the entrance" S_R. How to divide the area is shown in Fig. 4.

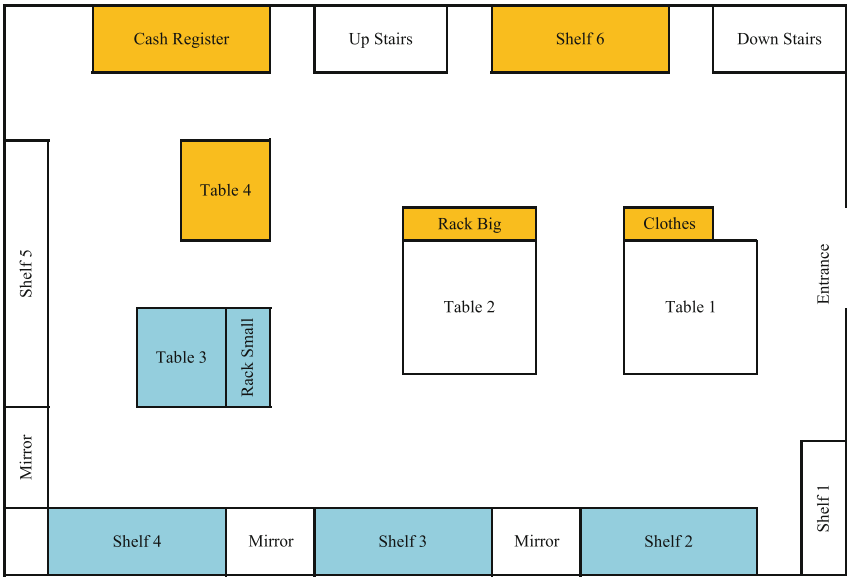

Fig. 4. How to divide the area

The hypothesis test at the significance level of 5% is performed with the following hypothesis.

$$H_0 : S_L = S_R$$

$$H_1 : S_L \neq S_R$$

As the result of the hypothesis test, the p-value is 0.00040. At the significance level of 5%, the null hypothesis is rejected and the alternative hypothesis is adopted. That is, the left side is seen more significantly from the right side.

Finally, the visual time of each area is standardized as $R_a(\text{Shelf } 1), \cdots,$ $R_n(\text{Clothes})$. We make the following hypothesis for all combinations and perform a hypothesis test at a significance level of 5%.

$$\left.\begin{array}{l} H_0 : R_x = R_y \\ H_1 : R_x \neq R_y \end{array}\right\} (x, y) \in \{a, \ldots, n\}$$

The combination that became significant and its p-value is shown in Table 4.

Table 4. The combination that became significant and its p-value

Area		p-value
Shelf 2	Cash Register	0.034
Shelf 3	Cash Register	0.043

By combining the analysis results of both obtained above, it can be seen that "Shelf 2" and "Shelf 3", particularly on the left side of the store, can be candidates for Golden Zone.

5.3 Relationship Between Good Impression Item and Visual Time

Firstly, we summarize the results of purchasing simulation experiments of each participant. Specific value of each participant is shown in Table 5. "Purchasing time" represents the purchase simulation experiment time of each participant. Regarding "Enter position", it was defined as that 1 was entered from the left side of the store and 0 was entered from the right side. "View outside store" was set to 1 when the out-of-store window was visually observed, and to 0 when the out-of-store window was not visually observed. Also, "The number of good impression item" is counted from the after-questionnaire.

We clarify details about "The number of good impression item". The results of "The number of good impression item" for each area is shown in Table 6.

Table 5. Specific value of each participant

Participant	Purchasing time (sec)	Enter position (0: left, 1: right)	View outside store (0: No, 1: Yes)	The number of item held in hand	The number of good impression item
A	368	0	0	7	2
B	312	1	0	5	4
C	461	0	0	14	5
D	640	1	1	16	6
E	359	0	1	5	6
F	316	1	1	5	2
G	273	0	0	8	2
H	488	1	0	9	6
I	604	0	0	9	5
J	269	1	1	5	4

Table 6. The number of good impression items by area of each participant

Area	Participant									
	A	B	C	D	E	F	G	H	I	J
Shelf 1	0	0	0	0	0	0	0	0	0	1
Shelf 2	1	0	0	0	0	0	0	0	0	0
Shelf 3	0	0	1	0	2	0	1	0	1	1
Shelf 4	0	0	0	1	0	1	1	1	1	0
Shelf 5	0	1	1	2	0	0	0	0	0	0
Shelf 6	1	0	0	0	1	1	0	0	0	0
Table 1	0	0	0	1	0	0	0	0	1	0
Table 2	0	1	1	0	1	0	0	0	1	0
Table 3	0	1	0	0	1	0	0	3	1	0
Table 4	0	0	1	0	1	0	0	0	0	0
Rack big	0	0	0	2	0	0	0	2	0	0
Rack small	0	1	1	0	0	0	0	0	0	2
Cash register	0	0	0	0	0	0	0	0	0	0
Clothes	0	0	0	0	0	0	0	0	0	0
Outside store	0	0	0	0	0	0	0	0	0	2

Secondly, the visual time of each good impression item and surrounding items it can be measured from the recorded data using AOI. By comparing each visual time, it is possible to clarify the relationship between good impression item and visual time. For example, visual items and times of participant C on the area of “Rack small” is shown in Figs. 5 and 6.

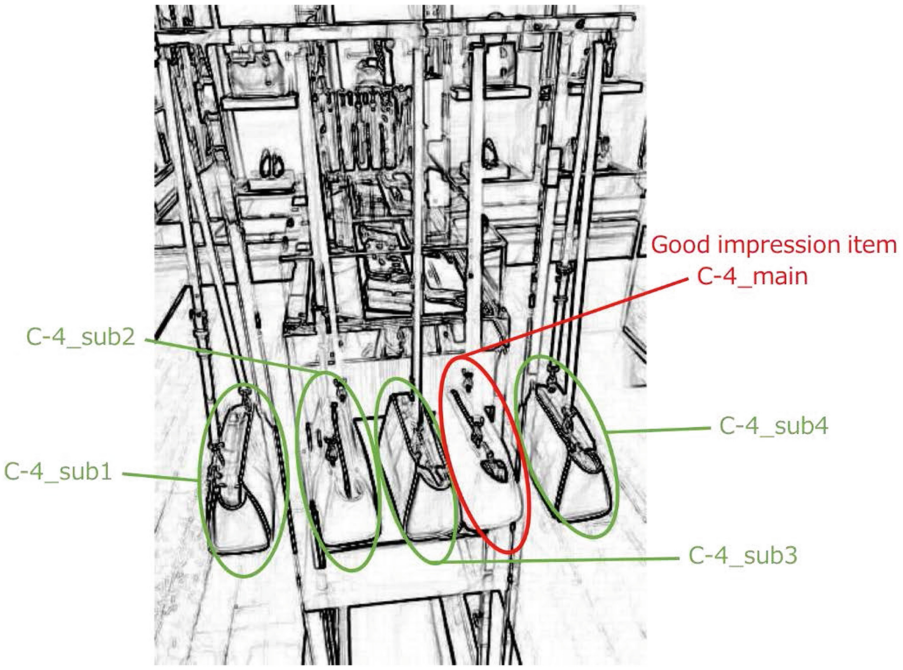

Fig. 5. Visual items of participant C on "Rack small"

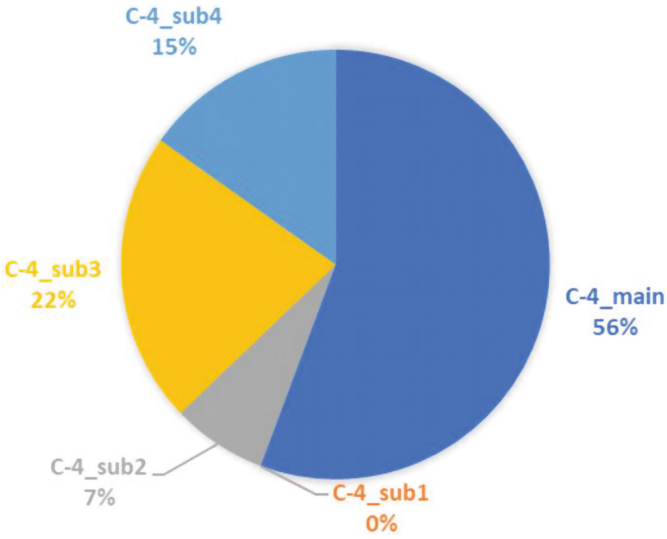

Fig. 6. Visual times of participant C on "Rack Small"

These results for each participant are shown in Table 7. Among the good impression items, the number of items with the longest visual time in the same area of the good impression items is defined as "The number of the longest visual time" in Table 7. Match ratio is defined as the ratio of "The number of the longest visual time" among "The number of good impression item" in Table 7.

Table 7. Relationship between good impression item and visual time

Participant	The number of good impression item	The number of the longest visual time	Match ratio
A	2	2	1.000
B	4	2	0.500
C	5	4	0.800
D	6	5	0.833
E	6	5	0.833
F	2	1	0.500
G	2	1	0.500
H	6	6	1.000
I	5	4	0.800
J	4	3	0.750

It clarifies that the items that remain in the good impression are seen long from the index of match ratio. Therefore, it is suggested that there is a relationship between good impression items and visual time.

Thirdly, we perform correlation analysis using each purchasing specific value. For correlation analysis, Pearson product-moment correlation coefficient is used. Pearson product-moment correlation coefficient is shown below.

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}} \tag{4}$$

Pearson's correlation coefficient of each purchasing specific value is shown in Table 8.

The bold letters in Table 8 are the correlation coefficients of $-1.0 < r < -0.6$ or $0.6 < r < 1.0$. This is a value that is generally thought to be a strong correlation. It can be seen that there is a positive correlation between "Purchasing time" and "The number of item held in hand" and between "Purchasing time" and "The number of good impression item".

Table 8. Correlation coefficient of each purchasing specific value

	Purchasing time	Enter position	View outside store	The number of item held in hand	The number of good impression item
Purchasing time	1.00				
Enter position	−0.03	1.00			
View outside store	−0.08	0.41	1.00		
The number of item held in hand	**0.77**	−0.08	−0.12	1.00	
The number of good impression item	**0.64**	0.13	0.15	0.44	1.00

6 Discussions and Evaluation of Store Layout Using Sales Ranking of Items

Based on the above analysis, we plan a better store layout. Firstly, we consider Golden Zone in the retail store. In this study, we divided the inside of the store into several areas and tried to identify Golden Zone by performing multiple comparisons. As the result, "Shelf 2" and "Shelf 3" are considered to be Golden Zone. Traditionally, it has been said that easiness for customers to see and to take in hand have a connection with Golden Zone. Therefore, it was assumed that the inner part of the store where customers can see the items slowly could be Golden Zone. That is, if utilizing existing knowledge at the target store, the areas such as "Shelf 4", "Shelf 5", "Table 3" and "Table 4" is defined as a Golden Zone. However, conventional studies are targeting daily necessities such as supermarkets.

In this experiment, there were store clerks and experiment record members at the "Cash Register" and "Down Stairs". In addition, the target store was a fashion brand store, which is expensive for supermarkets. As a result of after-questionnaire to participants, it was the first time that they visited this time, so they often checked the price. At that time, participants answered that they were concerned with the store clerk's gaze. Such a feeling is thought to be more likely to occur with higher price items. Due to these influences, in this study, it is considered that "Shelf 2" and "Shelf 3" were located away from the store clerk and the items can be seen slowly. Actually, in this store, store clerks often stay near the cash register during business hours, so "Shelf 2" and "Shelf 3" are considered to be Golden Zone.

Secondly, we consider relationship between good impression item and visual time. In this study, in many participants, the match rate between good impression items and the longest visual items in each area was high. Therefore, it is conceivable that the longer the viewing time of the item, the easier it is to have a good impression. As the result of correlation analysis, it was clarified that there is a positive correlation between "Purchasing time" and "The number of item held in hand" and between "Purchasing time" and "The number of good impression item". Therefore, it is considered that

increasing the purchasing time and increasing the number of items to be taken by hand will lead to an increase in the number of good impression.

Thirdly, based on the sales ranking of the store targeted for this study, we compare visual time of popular items. Also, the popularity ranking is a ranking that integrates the qualitative evaluation based on the sales of the store and the subjective evaluation that the store clerks got through the customer service. The relationship between popular items and visual time is shown in Table 9.

Table 9. Relationship between popular items and visual time

Area	Item	The number of staying participants	Ratio of visual time in area
Shelf 3	Tote bag (black)	4	**0.15**
Shelf 6	Bag (black)	3	0.31
Rack Big	Tote bag (Upper right)	2	0.30
	Tote bag (Bottom right)	2	**0.14**
Rack Small	Bag (black)	2	0.26

As shown in "Ratio of visual time in area" in Table 9, tote bag which located in "Shelf 3" and bottom right of "Rack Big" are not seen much. Therefore, it is considered effective to place these items in a position more attracting attention.

Finally, we propose about store layout from these considerations. First of all, items that the store want to sell is arranged on "Shelf 2" and "Shelf 3". To make it stay longer in the store, the popular items is arranged in distributed fashion. Also, to get more items to be picked up, place the item in a position that is easy to pick up, or put the distance between the items wider. Considering the above proposal, it is thought that store layout can be more improved.

7 Conclusion and Future Works

In this study, purchasing simulation experiment was conducted to evaluate the store layout using eye tracking device in fashion brand store. By analyzing the gaze measurement data obtained in the experiment, we could identify the area that could be Golden Zone. Also, we analyzed relationship between good impression item and visual time, it was clarified that there is a positive correlation between "Purchasing time" and "The number of item held in hand" and between "Purchasing time" and "The number of good impression item".

As future works, the following can be considered. First of all, in this experiment, the number of participants was 10 and insufficient. In addition, all 10 participants were women in their twenties. By conducting experiments with participants in a wide range of age groups, it is thought that it is possible to clarify the difference in purchasing behavior by age. Also, in this experiment, we conducted experiments outside of

business hours. For this reason, we do not consider the influence of other customers and service of clerks. By conducting experiments under conditions closer to actual purchasing behavior, it is thought that more accurate purchasing behavior can be clarified.

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