Research on Control Areas of X-line Style women’s Suit Silhouette Based on Eye-tracking Technology

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Abstract. Up to now, the concept of classification basis that affects garment silhouette in pattern-making is still vague. This paper aims to analyze scientific basis for influence of pattern-making on silhouette classification by taking X-line style women’s suit as research object and using eye tracker as experimental way. Through data of TFD (total fixation duration), VC (visit count) and other indicators in four areas of interest of six X-line style women's suits, multivariate analysis of variance and average comparison were conducted for different styles and areas of interest. The study found that there was no significant difference in fixation duration and fixation count of different styles, but different areas of interest were, and it could be concluded that control areas affecting silhouette of X-line style women’s suit were mainly focused on waist, followed by chest. In this paper, the garment research connected with the machine recognition technology, which offers scientific reference significance for further research on influence of X-line style women’s suit pattern-making on silhouette.

Introduction

Silhouette and pattern-making play two important parts in women's suit. Silhouette design is basis of clothing style, pattern making is a key to pursue overall modeling aesthetic, plays a decisive role in silhouette. Pattern-making and silhouette complement with each other. On the one hand, silhouette of a garment can give vision the most intuitive feeling, but also a relatively subjective concept; on the other hand, definition of garment silhouette is usually a subjective evaluation, lacking corresponding relationship between subjective evaluation and objective indicators. In terms of relationship between pattern-making and silhouette, scholars at domestic and abroad have also conducted many researches. Liu Ruipu, in Serialized brand and pattern design of TPO for women's wear, divided silhouette of different X-line style women's suits by changing number of pattern pieces and position of separating line [1]. Fu Bailu has utilized human segmentation technique to determine key parts of profile influence silhouette, extracting measuring data from corresponding points on pieces to classify and define six kinds of basic silhouette like A, H, T, O, X and S, reflecting clothing curved line as well as identifying silhouette by obtaining basic size from database and calculating angles between main parts of pieces [2]. Tao Chen related body areas to height of head to divide body in dress into six regions through AdaBoost Algorithm, analyzing ratio change and extracting width of each region height, thus establishing ratio and formula of silhouette like A, T, H, X and O to quantify clothing profile [3]. Taking women's trousers as an example, Wu Huan built a sample database of five kinds of women's trousers' silhouettes, and proposed CaffeNet model based on convolution neural network, which automatically extracted silhouette features of
women's trousers by using algorithms and functions to realize classification of garment silhouettes [4]. Therefore this article will aim at quantitative analyzing relationship between pattern-making and silhouette more accurately by studying control areas influence X-line style women’s suits’ silhouette, offering next study of pattern-making impact on silhouette on X-line style women’s suit theory foreshadowing, simultaneously providing new theoretical basis and reference for clothing digital technology, has scientific significance.

With gradual popularization and improvement of eye-tracking technology, many scholars at domestic and abroad have carried out many researches on clothing in this field, aiming at defining and quantifying relevant clothing concepts. Zhou Huangli has finished a series of visual evaluation tests for correspondence between fabrics and garments from color, distribution and application of pattern by using eye movement tracking technology [5]. Tang Guanmin used eye-tracking technology to analyze designing style of JNBY female down jackets from aspects of separating lines and darts [6]. Wang Yizhou has analyzed style and features of custom in She nationality through eye-tracking technology [7]. Xu Juanfang has extracted six types of traditional phoenix patterns by using eye movement tracking technology, and ranked them through calculating their degree of typicality [8].

The above literatures mainly extract styles and features of clothing through eye movement experiments, tending to study fashion design. However, there are few quantitative studies on relationship between pattern-making and silhouette in garment through eye tracking technology. This paper will take X-line style women’s suit for example, use eye tracking technology, as well as statistical analysis software, to do multivariate analysis of variance in style and area of interest, gain whose impact on fixation duration and visit count, finally sums up main areas influence silhouette, has great significance for further study in relationship between pattern-making and silhouette in X-line style women’s suit.

**Experimental Scheme**

**Experimental Device**

Tobii Pro Glasses 2, produced by Tobii Company of Sweden, is the most portable eye-tracking system in nowadays market; it provides glasses of different degrees according to user's different vision level, ensuring experimenter to obtain the most natural and accurate behavior data to the greatest extent.

**Experimental Participant**

A total of 20 teachers and students of this major were randomly invited as experimental participants to study differences in perception and cognition of silhouette of X-line style women's suits within different styles and areas of interest. In order to exclude potential influence of objective factors such as participant's vision and eyeglasses on experimental results, it is necessary to ensure normal naked eye vision of each participant. For myopic participants, they can wear contact lenses or choose lenses suitable for themselves according to myopia lens provided by eye tracker. Ensure that there are no other visual diseases other than myopia.

**Experimental Picture**

Six representative pictures of X-line style women’s suit, positive style, were collected according to their length, separating lines, number of pattern pieces, through famous clothing brand's official website, such as Christian Dior, George Armani, also ranking them from loose to fit [9], as experiment material (as shown in figure 1). In order to eliminate interference caused by background in pictures to participants, all background was removed to present a unified format, as shown in figure. Meanwhile, 6 sorted pictures are numbered, such as S1 for the first style (S1-S6 stands for different style numbers).
Experimental Operation

Before the start of experiment, each participant is explained rules and purpose, then experimental device also calibrated. After that, test started and each one takes turns to watch pictures presented on computer screen. In order to allow participants to have enough time to do it, and not to lose interest in picture area because of long staring time, it is stipulated that each picture is presented 6s randomly; eye tracker will automatically record data of eye balls. In order to minimize experimental errors, each participant should avoid seeing pictures before test and keep his head still during experimental process to ensure that distance between people and screen does not change significantly.

![Figure 1. Six representative styles of X-line style women’s suits.](image)

Division of Area of Interest

Area of interest (AOI) is a term of eye tracking technology, it means a part of separate division or one image is divided into several regions, each region as an independent factor to be analyzed, namely comparing fixation duration and visit count in each suit’s different region. Based on reference and consideration of bust line and waist line in top’s prototype and suit’s pattern, thus area of interest is divided into four parts: shoulder (P1), chest (P2), waist (P3) and hip-hem (P4) [10], as shown in figure 2.

![Figure 2. Division of area of interest.](image)

Selection of Eye-tracking Indicators

There are many data generated during eye-tracking experiment, whose indicators mainly include: first fixation duration, average pupil size, total fixation duration, visit count, share of total time and
so on. According to research purpose of this paper, fixation duration of AOI, visit count and total fixation duration were finally selected for data analysis. Wherein, fixation duration of AOI refers to time spent to keep fixation point in different AOI. Visit count means total number of fixation points produced in specified area. Total fixation duration refers to total time after excluding eye saps when each participant watched each picture.

Analysis of Experiment

Analysis of Eye-tracking Data

It is SPSS 23 statistical software combined with eye movement tracking technology was used to obtain fixation duration and visit under different styles and different areas of interest of suits, which two indicators were mixed to conduct multivariate analysis of variance and average comparison.

Multivariate Analysis of Variance and Average Comparison

Average value and variance of each eye movement indicators were obtained according to fixation duration, visit count and total fixation duration of different styles and areas of interest, and then summarized to attain table of multivariate analysis of variance and table of average, so as to analyze control areas affecting silhouette. As shown in table 1 and table 2.

Table 1. Table of multivariate analysis of variance.

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of squares</th>
<th>DOF</th>
<th>Mean square error</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixation Duration/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Style</td>
<td>1.355</td>
<td>5</td>
<td>0.271</td>
<td>0.259</td>
<td>0.935</td>
</tr>
<tr>
<td>AOI</td>
<td>39.610</td>
<td>3</td>
<td>13.203</td>
<td>12.599</td>
<td>0.000</td>
</tr>
<tr>
<td>Style*AOI</td>
<td>19.300</td>
<td>15</td>
<td>1.287</td>
<td>1.228</td>
<td>0.252</td>
</tr>
<tr>
<td>Visit Count</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Style</td>
<td>10.421</td>
<td>5</td>
<td>2.084</td>
<td>1.255</td>
<td>0.285</td>
</tr>
<tr>
<td>AOI</td>
<td>58.479</td>
<td>3</td>
<td>19.493</td>
<td>11.738</td>
<td>0.000</td>
</tr>
<tr>
<td>Style*AOI</td>
<td>39.396</td>
<td>15</td>
<td>2.626</td>
<td>1.582</td>
<td>0.080</td>
</tr>
</tbody>
</table>

Table 1 shows results of multivariate analysis of variance of experiment. According to analysis of variance of fixation duration, it can be found that main effect of style is not significant, among which \( F=0.259 \) and \( P=0.935>0.05 \), indicating that different styles of X-line style women's suits have no effect on fixation duration. Therefore, this experiment is feasible to take fixation duration as a reference indicator. The main effect of AOI was significant, \( F=12.599 \) and \( P=0.000<0.05 \), indicating that different parts of X-line style women’s suit affect fixation duration, so that control areas affecting silhouette could be extracted according to visit count. The main effect of interaction between style and AOI was not significant, \( F=1.228 \) and \( P=0.252>0.05 \), indicating that changes in style or areas of interest do not affect participant’s fixation duration.

According to analysis of variance of visit count, it can be found that main effect of style is not significant, among which \( F=1.255 \) and \( P=0.285>0.05 \), indicating that different styles of X-line style women's suits have no effect on visit count. Therefore, this experiment is feasible to take visit count as a reference indicator. The main effect of AOI was significant, \( F=11.738 \) and \( P=0.000<0.05 \), indicating that different parts of X-line style women’s suit affect visit count, so that control areas affecting silhouette could be extracted according to visit count. The main effect of interaction between style and AOI was not significant, \( F=1.582 \) and \( P=0.080>0.05 \), indicating that changes in style or areas of interest do not affect participant’s visit count.
Table 2. Summary table of average of participants’ eye tracking data.

<table>
<thead>
<tr>
<th>AOI</th>
<th>Style</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixation Duration/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1(Shoulder)</td>
<td>S1</td>
<td>0.814</td>
<td>0.502</td>
<td>0.284</td>
<td>0.968</td>
<td>0.368</td>
<td>0.222</td>
<td>0.526</td>
</tr>
<tr>
<td>P2(Chest)</td>
<td>S2</td>
<td>0.684</td>
<td>1.236</td>
<td>1.036</td>
<td>0.856</td>
<td>1.49</td>
<td>1.956</td>
<td>1.210</td>
</tr>
<tr>
<td>P3(Waist)</td>
<td>S3</td>
<td>1.454</td>
<td>1.514</td>
<td>1.958</td>
<td>1.944</td>
<td>1.618</td>
<td>1.136</td>
<td>1.604</td>
</tr>
<tr>
<td>P4(Hem)</td>
<td>S4</td>
<td>0.672</td>
<td>0.928</td>
<td>0.828</td>
<td>0.892</td>
<td>0.716</td>
<td>0.870</td>
<td>0.818</td>
</tr>
<tr>
<td>Visit Count</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1(Shoulder)</td>
<td>S5</td>
<td>1.0</td>
<td>1.2</td>
<td>0.7</td>
<td>2.0</td>
<td>0.6</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>P2(Chest)</td>
<td>S6</td>
<td>1.4</td>
<td>2.4</td>
<td>1.8</td>
<td>1.3</td>
<td>1.3</td>
<td>2.6</td>
<td>1.8</td>
</tr>
<tr>
<td>P3(Waist)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4(Hem)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Through above analysis of experimental data shows that there was no significant difference among fixation duration and visit count in different styles, but in different AOI. Different regions need to be taken into consideration when do research in control areas. It can be concluded from table 2 that, on the whole, value of P3 is significantly higher than others in terms of fixation duration, followed by P2, which is the same outcome in indicator of visit count. And it can be further confirmed that fixation duration of four regions is P3>P2>P4>P1, ranking from long to short in average column, so is in visit count. That is, control area is waist, chest, bottom and shoulder in turn.

Conclusion

This paper, taking X-line style women’s suit as an example, studies control areas influence clothing silhouette, obtaining indicators of TFD (total fixation duration) and VC (visit count) among four regions in six suits through eye-tracking experiment, then conducted multivariate analysis of variance and average comparison in different styles and areas of interest. It is found that different areas of interest have different attention degrees, among which body part is main factor affecting overall silhouette. The value of fixation duration and visit count of waist is significantly more than other areas, followed by chest. Therefore, control areas affecting silhouette of X-line style women’s suit is mainly focused on waist and chest. Thus waist measurement and chest measurement should be taken as two main reference indicators of body part in pattern design.

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