The application of eye tracking technology in the evaluation of shoulder fit of male suit

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Abstract. With the development of science and technology, intelligent production of clothing has become a major trend, and male suit, as a kind of clothing with stable style and subtle changes, is undoubtedly one of the goals of intelligent production. In fact, in the intelligent production of men's suits, fitness evaluation has certain research significance for both the early pattern design and the later quality evaluation. However, up to now, the evaluation system for the fitness of men's suits is not perfect, and most of them lack a certain objectivity. Therefore, this paper will analyze and solve this problem by using eye tracker experiment to evaluate the fitness of men's suits' shoulders. By dividing the interest area of men's suit style and selecting the eye movement index of the tester, the eye movement data of four views and five interest areas of men's suit were analyzed and compared, and finally the evaluation standard of the fit of men's suit shoulder was obtained.

1. Introduction

Eye-movement tracking is usually a technique used to record and measure eye movements. With the gradual maturity of this technology, its application research in the field of clothing is also becoming more and more common[1~3]. At present, most studies on the fitness evaluation of men's suits are subjective, and previous studies on the fitness evaluation of men's suits mainly focus on the amount of relaxation of chest, waist and hip, while there is still a certain gap in the fitness evaluation of shoulders[4~7]. Therefore, with the help of eye-movement tracking technology and its image processing and analysis function, this experiment conducted image collection and data analysis on the factors affecting the fit of the shoulders of men's suits, which to some extent made up the blank of the evaluation research on the fit of the shoulders of men's suits. In addition, this result will be of practical significance to the design of men's suit pattern and the later quality inspection evaluation in the intelligent production of clothing.
2. Experimental scheme design

2.1. Experiment preparation

The equipment used in this experiment is Tobii Pro Glasses 2 portable eye tracker and eye movement tracking system produced by Tobii Company in Sweden. A total of 30 participants were investigated, all of whom had a clothing professional background of more than 7 years. Besides, it was ensured that each participant had normal naked eye vision, and short-sighted people could replace the nearsighted lens provided by the experimental instrument. The experimental pictures are 12 men's suits from four views, including front, side, back and top, randomly collected from the official websites of Clothing brands such as Giorgio Armani(Figure 1). As the focus of this research is the fitness of the clothing, the colors, backgrounds and decorations in the experimental pictures are uniformly processed, so as not to interfere with the line of sight of the research object and affect the experimental effect.

![Figure 1. The style of a man's suit: front, side, back and top view](image)

The experiment used the area of interest (AOI) analysis method, which is the term of eye movement tracking technology. It means to separate a part of an experimental image or divide an image into several regions, each of which is an independent factor to be analyzed. Since human eyes naturally select different areas within the visual field, in order to reduce the interference to the experimental results, after the experiment, AOI will be divided into front, side, back and top views of men's suits respectively. Based on the research of domestic and foreign experts and scholars on the shoulder shape of men's bodies and the shoulder pattern of men's suits, this experiment divides AOI into five parts: collar (P1), shoulder (P2), armhole (P3), chest (P4) and back (P5)(Figure 2)[8–11].

![Figure 2. Division of AOI](image)

2.2. Experimental operation

Make sure that the tester understands the procedure and purpose of the experiment before the experiment begins, and that each tester will perform line of sight calibration with the experimental apparatus before
the experiment begins. After the beginning of the experiment, participants sat in front of the computer screen and adjusted an optimal distance of 50–70cm from the screen according to their height[12]. During the experiment, they kept their heads as still as possible to ensure that their eyes were always parallel to the computer screen. In addition, in order to allow participants enough time to observe the images and not lose interest in the image area due to prolonged staring, the playing time of each image was set at 8s[13]. In addition, each participant should avoid seeing pictures before the test to reduce the accuracy of the experiment.

3. Analysis of experimental data
Fit in order to suit the shoulder of the evaluation of all-round, multi-angle analysis research, experiment of different styles of men's suit is, side, back, look down at the four angles of images in the collection of samples, and then extract the fixation duration and visited the two eye movement index data, using SPSS software to multivariate analysis of variance and average comparison, finally according to the analysis conclusion summed up a set of men's suits shoulder fit evaluation standard.

3.1. Multivariate analysis of variance for men's suits from different views
Anova, also known as F test, is used to test the significance of the difference between the mean of two or more samples. The basic idea is to determine the influence of controllable factors on the research results by analyzing and studying the contribution of variations from different sources to the total variation. Multivariate analysis of variance is a statistical analysis method used to study whether two or more control variables have significant effects on observed variables. In this experiment, style and AOI were used as control variables to analyze whether they had significant influences on fixation duration and visit count respectively. SPSS gives the corresponding associated probability value P according to the F distribution table. If the P value is less than or equal to the significance level of 0.05, it is considered that the population mean at different levels of control variables has significant differences; otherwise, it is not the case[14].

The summary table of multivariate anova of male suits from different angles is shown in Table 1. According to the test of the analysis of fixation duration and visit count, whether it is front, side, back, or top view style of P values were greater than 0.05 significant level, that style number at time of testers and visits had no significant influence, so the selection experiment at duration and visits as a reference index is feasible. On the contrary, the P values of AOI were all lower than the significant level of 0.05, indicating that the division of AOI from different views had a significant impact on the fixation duration and visit count.

| Indicator | Fixation Duration | Visit Count |
|-----------|-------------------|-------------|
|           | Source            | Sum of squares | DOF | Mean square error | F  | P  | Source | Sum of squares | Mean square error | F  | P  |
| Front view| Style             | 0.206         | 2   | 0.103           | 1.192 | 0.367 | Style | 2.259         | 26.407          | 1.13 | 8.802 | 1.852 | 0.236 |
|           | AOI               | 1.467         | 3   | 0.489           | 5.654 | 0.035 | AOI    | 2.259         | 26.407          | 1.13 | 8.802 | 1.852 | 0.236 |
|           | AOI               | 20.332        | 4   | 0.023           | 0.566 | 0.589 | AOI    | 157.718       | 239.315         | 1.844 | 0.219 | 1.852 | 0.236 |
| Side view | Style             | 0.046         | 3   | 0.023           | 0.566 | 0.589 | Style | 0.61          | 157.718       | 0.305 | 39.43 | 1.844 | 0.219 |
|           | AOI               | 0.046         | 4   | 0.508           | 126.116 | 0    | AOI    | 157.718       | 239.315         | 0.305 | 39.43 | 1.844 | 0.219 |
|           | Style             | 0.043         | 2   | 0.021           | 0.133 | 0.878 | Style | 7.743         | 75.092         | 3.871 | 25.031 | 3.866 | 0.083 |
|           | AOI               | 0.763         | 3   | 1.254           | 7.779 | 0.017 | AOI    | 75.092         | 24.993         | 25.031 | 24.993 | 25.031 | 0.001 |
| Back view | Style             | 0.044         | 2   | 0.022           | 0.133 | 0.878 | Style | 0.378         | 26.474         | 0.189 | 8.825 | 1.021 | 0.415 |
|           | AOI               | 10.269        | 3   | 3.423           | 78.211 | 0    | AOI    | 26.474         | 47.728         | 0.189 | 8.825 | 1.021 | 0.415 |

3.2. Analysis of relevant factors affecting shoulder fit of men's suits

3.2.1. Average comparison. As Table 2 shown for the average summary of the eye movement data of the subjects. Through the comparison and analysis of the four angle views and the mean values of the five AOI of different styles of men's suits, the comprehensive ranking of the fixation duration of the five AOI from most to less is P3>P1>P5>P2=P4, and the comprehensive ranking of the visit count to the
five AOI is P3>P5>P4>P2>P1. Whether it is the fixation duration or the visit count, the higher the value is, the more attention the subjects pay to this area of interest, which also indicates that the subjects think this area has a greater influence on the fit of the shoulders of men's suits. However, due to the inconsistency in the order of the two eye movement indicators, the between-subjects effect of the two will be further examined and analyzed, so as to obtain the final order of the degree of influence of different regions of interest on the shoulder fit of men's Suits.

### Table 2. Average summary of eye movement data of subjects

| Indicator | Fixation Duration | Visit Count |
|-----------|-------------------|-------------|
| **View**  | **Front view**    | **Side view** | **Back view** | **Top view** | **Average** | **Front view** | **Side view** | **Back view** | **Top view** | **Average** |
| P1(Collar)| 1.25              | 0.71        | 0.26         | 3.01         | 1.31        | 4.03        | 2.6          | 1.59          | 7.58         | 3.95        |
| P2(Shoulder)| 0.59             | 0.31        | 1.41         | 1.7          | 1.00        | 3.54        | 2.27         | 6.21          | 6.59         | 4.65        |
| P3(Armhole)| 0.95             | 3.43        | 1.68         | 0.66         | 1.68        | 5.33        | 10.89       | 7.73          | 3.56         | 6.88        |
| P4(Breasts)| 1.53             | 0.62        | 0.86         | 1.00         | 0.65        | 7.38        | 3.09         | 5.65          | 5.37         | 5.37        |
| P5(Back)  | 0.53              | 1.52        | 1.03         |              | 5.33        | 3.41        | 7.64         |              | 5.53         |            |

### 3.2.2. The test of Between-Subjects effect

As Table 3 shown for the test of Between-Subjects effects of the two eye movement indicators. Under the premise that P value reaches significant effect, that is, P is greater than or equal to 0.05, the greater the F value of the index is, the more significant the difference will be, which also indicates that the data of this index is more in line with the influence degree of various factors on the fit of shoulders of men's suits. According to the data in the table, the P values of fixation duration and visit count of P1 to P5 are both less than 0.05, indicating that significant effects have been achieved. However, the F value of visit count is significantly larger than that of fixation duration, indicating that the difference of visit count is more significant than that of fixation duration, and the data of visit count is more representative.

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### Table 3. Test of Between-Subjects effect of fixation duration and number of visits

| Source     | Dependent Variable | Sum of Squares | df  | Mean Square | F    | P    |
|------------|--------------------|----------------|-----|-------------|------|------|
| P1(Collar)| Fixation Duration | 20.489         | 1   | 20.489      | 16.818| 0.002|
| P1(Collar)| Visit Count       | 187.151        | 1   | 187.151     | 31.834| 0    |
| P2(Shoulder)| Fixation Duration | 12.1           | 1   | 12.1        | 30.452| 0    |
| P2(Shoulder)| Visit Count       | 259.842        | 1   | 259.842     | 58.572| 0    |
| P3(Armhole)| Fixation Duration | 33.835         | 1   | 33.835      | 25.1  | 0    |
| P3(Armhole)| Visit Count       | 567.738        | 1   | 567.738     | 63.219| 0    |
| P4(Breasts)| Fixation Duration | 9.08           | 1   | 9.08        | 46.238| 0    |
| P4(Breasts)| Visit Count       | 259.64         | 1   | 259.64      | 68.485| 0    |
| P5(Back)  | Fixation Duration | 6.283          | 1   | 6.283       | 15.954| 0.01 |
| P5(Back)  | Visit Count       | 183.375        | 1   | 183.375     | 34.095| 0.002|
4. Conclusion
First of all, through eye movement experiment, the correlative factors affecting shoulder fit of male suit were analyzed. Next, the fixation duration and visit count to the AOI were extracted. Then, SPSS was used to conduct multivariate analysis of variance, mean comparison and inter-subject effect test. It is concluded that armhole is the main factor affecting the fit of male suit shoulders, followed by back, chest and shoulders, and finally collar. Therefore, when evaluating the fit of the shoulders of men's suits, the fit of armhole is the primary reference factor, including whether the armhole line is round and beautiful and whether there are wrinkles under the armpit. The second is the fitness of the back, that is, whether the back is wide flat, shoulder blade around whether redundant plaits; the third is the fitness of the chest, namely whether the chest is flat, and whether fits the human chest; the fourth is the degree of shoulder fit, mainly reflecting whether the shoulder line is round, there is no drag; finally is the fitting degree evaluation of collar, the main performance is whether the collar fits neck or chest. The above five evaluation factors constitute the evaluation standard for the fit of the shoulders of men's suits.

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