Original Article
A Study of the Color Features Related to the Feeling of "Han-nari" in Women's Kimonos

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Abstract

Purpose: By using ten different types of kimono images, we investigated the physical quantities that constitute the feeling of "Han-nari", a term used for expressing a certain kind of beauty specific to kimonos.

Participants and methods: Thirty students (22 males and 8 females) participated the experiment. Ten kimono images were shown on a screen, and the participants evaluated them based on their degree of "Han-nari". The images were analyzed with RGB histograms and with u', v' chromaticity diagrams that were converted from RGB values. The brightness of the images was measured with brightness-meter.

Result: We found that the kimonos with "white" and "whitish yellow" colors strongly influenced the degree of "Han-nari" reported, and as the brightness of the kimono image increased, it showed a clear correlation with an increase in the reported degree of "Han-nari".

Conclusions: Quantifying the feeling of "Han-nari" makes it possible to extract one factor of the beauty of kimono. Until now, the sense of "Han-nari" that a kimono might have depended entirely on the tacit knowledge of craftsmen. However, in order to clarify the definition of "Han-nari" by utilizing numerical values, kimonos that evoke a sense of "Han-nari" could be created by industrial production. This could eventually help to revive the kimono industry and is useful in passing kimono culture on to future generations. We were able to quantify the color and brightness associated with a sense of "Han-nari" in this research. This method is not limited to kimonos and could be applied to other industrial products.

Keywords: Kansei, Color, Brightness, Kimono; Obi.

INTRODUCTION

In today's Japan, the kimono is only worn on special occasions such as coming-of-age and graduation ceremonies. It is a problem that people no longer wear kimono in their daily life. The annual output of Kyoto Yuzen peaked in 1972. After that it decreased every year, and in 2016, it was 49.8%, the same level as in 2005(Ikeda, 1964). Also, a sash is needed when wearing a kimono, but even the representative kimono sash made of Nishijin weave reached peak production in 1990, and fell to 16.3% of the peak in 2014 (Watanabe, 2016) . However, most Japanese people still long for the beauty of kimono. According to a survey on Japanese women's concerns about kimonos, more than 90% of people in their teens to their 80s answered that they "like kimonos", and over 75% want to "wear kimonos more often" (Komizo, 2014).

Clarifying the attractiveness of the kimono is considered an important effort for the kimono industry to find new ways to add to the sense of value of a kimono and may provide a clue as to how to encourage people to wear kimonos more often. Therefore, it is thought to be necessary to scientifically clarify the beauty of the kimonos are widely admired by women. Kimono is a tradition that embodies Japan's cultural sense of beauty and the word "Han-nari", meaning "elegant or graceful", has been used from ancient times to express the beauty of a kimono. This word is described in "Rakuyoshu", a Japanese dictionary of Kanji Chinese characters in the first year of the Houei period (1704) (Maeda, 1964). "Han-nari" has the sense of "cheerful and gorgeous", and is often used for expression of colors and the like. Etymologically, "Han-nari" comes from "Hana" or flower, adding the suffix "ri" to represent a state to a noun (flower) and is pronounced so as to enhance that meaning (Maeda, 1965). The word "Han-nari"

originated in Kyoto and is now known throughout Japan. Kyoto was the center of the medieval dynasty culture, and this tradition still can be seen in seasonal events and other occasions.　It is due to this historical background that the kimono industry is still concentrated in Kyoto today. Therefore, we think it is meaningful to reveal our study of the word "Han-nari" in Kyoto, both the birthplace of this word as well as a place where people bring traditions into their life and touch traditional beauty on a daily basis. Although the etymology might suggest a particular meaning, knowing how the word is currently taken by the people in Kyoto, where the word was born, is something we consider important for expressing the beauty of the kimono in modern times.

from which the background has been removed, was analyzed. In this study, we aimed to clarify the relationship between the feeling of "Han-nari" and color, and to quantify the factors contributing to a sense of "Han-nari" more clearly.

METHOD

1. Evaluation of "Han-nari" in Kimono Images Experiment

　　Ten images as shown in Figure 1 were projected on a screen using a projector (Epson EB-W 12, Seiko Epson Corp.) in a dark room with a brightness of 3 lx. This projected image was shown to the experimental collaborators, consisting of 30 students (22 males and 8 females) without color vision
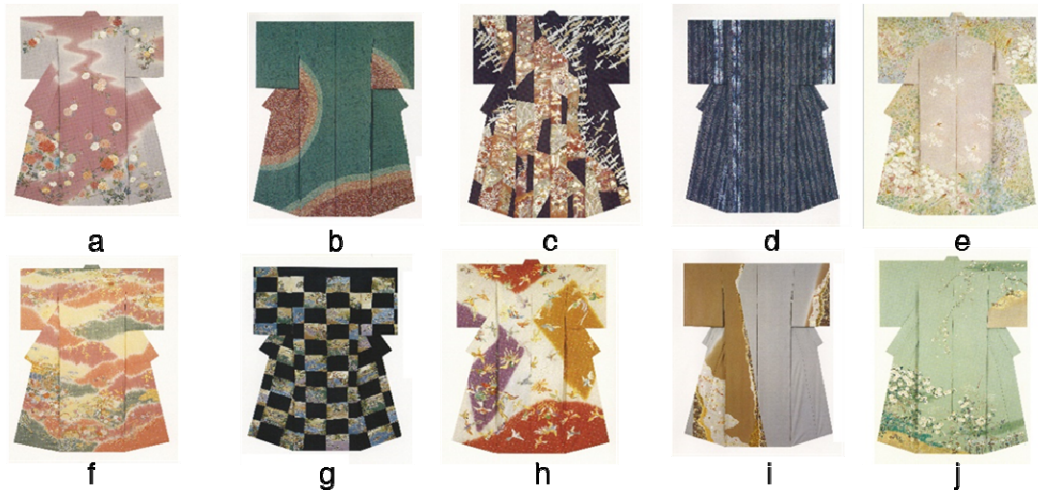

Figure 1: Ten Kimono Images for Evaluations

　　In our previous study, we quantified the factors that contribute to a sense of "Han-nari" from kimono images with the use of less color. The feeling of "Han-nari" increased more in kimonos using whitish yellow than those with white, and more in those using whitish yellow than those with blue. Further it was clear that kimono images with higher brightness also showed an increased sense of "Han-nari" (Komizo, 2015). However, in this previous study, the number of samples was small and the influence of the background image could not be ignored, thus the threshold for feeling "Han-nari" was not clearly shown. Therefore, in the present research, the number of sample kimono images has been increased, and the RGB values of each pixel in the kimono image,

abnormality as shown in Figure 2. They were asked to mark the degree of "Han-nari" from 1 to 5.

Figure 2: Experimental Setting

Five kimono images were selected out of 114 design images from Kyoto Yuzen's semi-formal women's kimono line by eight experts studying the material history of kimono (resource: Kyoto Yuzen Cooperative Association Liaison Committee), and another five kimono images were added according to the results of previous study (f through j) (Komizo, 2015)

The experts selected a and e as images evoking a strong sense of "Han-nari", while they selected kimono images b and d as evoking less "Han-nari", and chose image c as neither. The kimono images f and j evoked a strong sense of "Han-nari", while the images g and i produced less "Han-nari" in the experts, and image h was neither. The evaluation experiment was conducted using these 10 images.

2 Relationship between Sense of "Han-nari" and Color

In this study, we assumed that the three-dimensional values that made up the color of the kimono image were expressed in 1 pixel unit. If it can be represented by the chromaticity diagram, we can accurately extract the physical characteristics of the color of the kimono image. All kimono images were 1718 × 1417 pixels. In this research, physical characteristics are extracted using RGB, which expresses colors using the three primary colors of light and u', v' chromaticity diagram based on CIELUV color system. We examined the relationship between the sense of "Han-nari" produced by an image and its color.

(1) Color Measurement

To analyze RGB values, there were three values used to express the color on the display at each pixel of a kimono image (1718 × 1417), histograms of each color were calculated. Also, in order to express the color distribution of each kimono image in a more concise and visually easy-to-understand manner, the u' and v' values for each pixel were calculated from the RGB values of each pixel, and each u', v' chromaticity diagram was created for each kimono image. The RGB values of each kimono image with the background removed were analyzed pixel-by-pixel, and data processing was performed by the histograms. The conversions were performed in the order from RGB → XYZ → xyz → u'v'. The RGB values obtained from each pixel, were converted to a u', v' chromaticity diagram for each kimono image. We did no analyze the actual kimono image, but rather analyzed the kimono images shown on the display using computer software, so the monitor sRGB (sRGB) was first determined by CIE I; converted to linear RGB (CIERGB). In this research, we analyzed in the Windows environment, so it was necessary to consider the correction amount when creating the accurate u', v' chromaticity diagram. After converting the sRGB value (RGB) originally indicated in the range of 0 to 255 from real number (R'G'B') of 0 to 1, the inverse conversion of gamma correction was performed by the following equations. Linear RGB (R"G"B") was calculated by using Eq. (1). Then linear RGB was converted to XYZ by Eq. (2). Finally, after calculating x and y using X, Y and Z in Eq. (2), u' and v ' were calculated using x and y by using Eq. (3).

$$R'' = R'^{2.2} \quad G'' = G'^{2.2} \quad B'' = B'^{2.2} \tag{1}$$

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 2.76883 & 1.75171 & 1.13014 \\ 1.00000 & 4.59061 & 0.06007 \\ 0.00000 & 0.05651 & 5.59417 \end{pmatrix} \begin{pmatrix} R'' \\ G'' \\ B'' \end{pmatrix} \tag{2}$$

$$x = \frac{X}{X+Y+Z} \quad y = \frac{Y}{X+Y+Z}$$
$$u' = \frac{4x}{-2x+12y+3} \quad v' = \frac{9y}{-2x+12y+3} \tag{3}$$

(2) Creation of u', v' Chromaticity Diagram

For the removal of the background area, we used image processing software GIMP and R ver.3.2.2. The RGB value measurement of all the pixels and processing after measurement were performed with only R. The histograms of kimono images a through j in RGB values are shown in Figure 5. Then, the u', v' chromaticity diagram of each kimono image created by RGB values of each pixel were prepared. The average values and standard deviations of u' and v' values of each kimono image were calculated, and the relation to the average evaluation scale value of "Han-nari" was calculated. The regression lines are shown in Figures 8 to 12 along with their coefficients of determination.

3 Relationship between the Sense of "Han-nari" and Brightness

Each kimono image was projected on by a projector (EMP-1815 manufactured, Seiko Epson Corp.) in a darkroom, and its brightness was measured with a brightness meter (CS-100A, Konica Minolta Inc.). The brightness meter made measurements from about 80 cm away from the screen on which the image was shown. The measurement was performed in a dark room with 3 lx or less brightness, so as to avoid interference. The brightness meter was CS-100A manufactured by Konica Minolta, and the projector was EMP-1815 manufactured by Epson.

RESULTS

1. Evaluation of "Han-nari" in Kimono Images Experiment

The average scale value of the sense of "Han-nari" in kimonos is shown in Figure 3. The larger the average evaluation scale value of "Han-nari", the greater the sense of "Han-nari" reported. According to the results, the subjects felt stronger sense of "Han-nari" in the ascending order of e, j, h, f, a, c, d, b, i, g. The result was the same as the result obtained in the average evaluation scale value of "Han-nari" in kimono images a) through e) in our previous experiment (Komizo, 2013).

The selection criteria evaluated by experts are as follows: a) strong, b) weak, c) neither strong nor weak, d) weak, e) strong, f) strong, g) weak, h) neither strong nor weak, i) weak, j) strong. However, the present subjects felt a greater sense of "Han-nari" from image h), which was evaluated as "neither strong nor weak" by experts, whereas image f), which was selected as evoking a strong sense of "Han-nari" by experts only produced a moderate "Han-nari" response. A significant difference between each kimono image is shown in Figure 4. Considering the results, ten kimono images were classified as strong, moderate and weak in their sense of "Han-nari".

2. Color Measurements of kimono images correlated with "Han-nari" responses

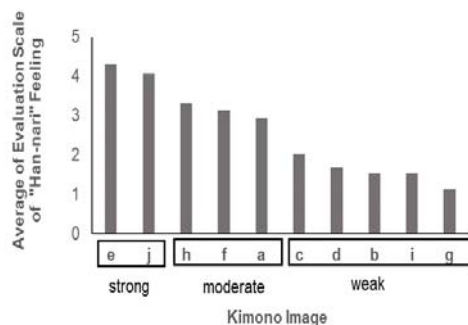(1) RGB Value

We showed the histograms of RGB

Figure 3: Average Degree of **"Han-nari"** Reported for Each Kimono Image
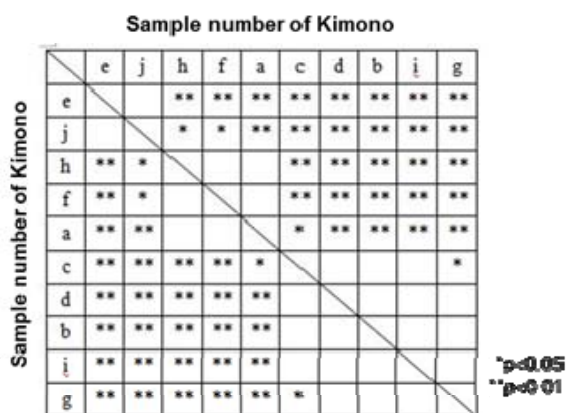

Figure 4: Significant Difference between Each Kimono Image

values for the 10 kimono images and categorized them into groups based on whether they produced strong, moderate and weak "Han-nari" responses, the groupings are shown in Figure 5. In kimono images producing strong "Han-nari" responses in Figure 5, the frequencies were all in the high numerical value bands around 200 for RGB values, and the graph showed bell shape distribution, located on the right side. The kimono images producing moderate "Han-nari" responses in Figure 5 have peaks in the high numerical value range of 150 or more in the R value, and large frequencies. Also, they are characterized by having more than two peaks in their G and B histograms. The kimono images producing weak "Han-nari" responses in Figure 5 has the peaks distributed in the lower R value range. Also, it heavily used black color, displaying a peak in the value range around 50 in all RGB values.
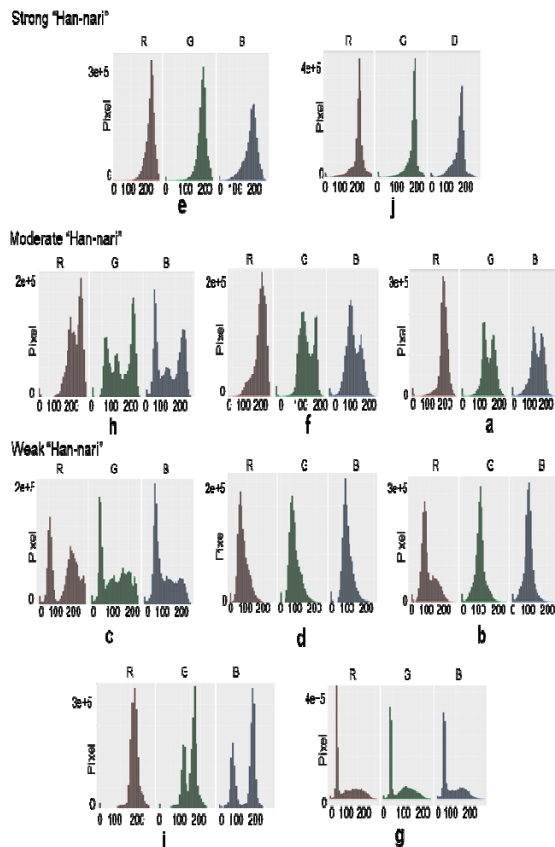
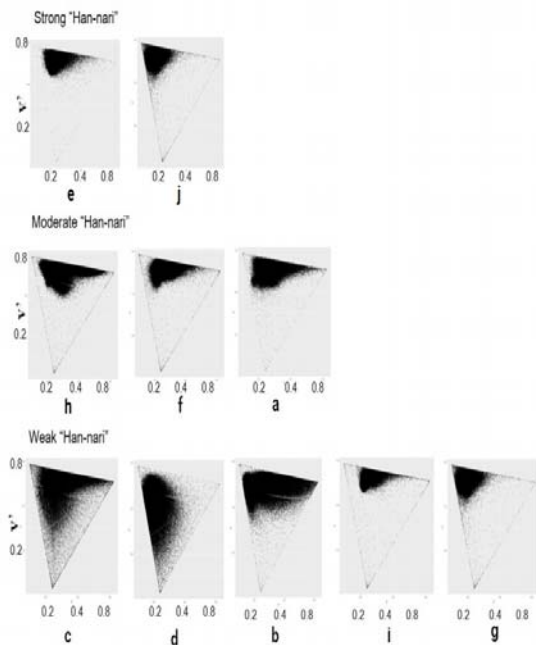Figure 5: RGB Pixel Histogram for All 10 Kimono Images

Figure 6: u' v' Scatter plot on CIE 1976 UCS Chromaticity Diagram for Kimono Image

(2) u', v' Chromaticity Diagram

Figure 6 showed u', v' chromaticity diagrams, which were calculated from the same images as those in Figure 5, by using Eqs. (1) to (3). The u', v' chromaticity diagram showed distinct triangle-type scatter diagrams. All the points corresponding to the sides and vertexes of the triangle were black portions that were slightly present at the boundary between the image and the background. Since this research was a measurement of each pixel, the black parts were also reflected. By superimposing the u' and v' values of Figure 6 on the CIE 1976 UCS chromaticity diagram, shown in Figure 7, it was possible to determine what kind of colors each kimono image used. Further, the size of the distribution area shows the amount of color used, the wider the distribution, the more variations of colors were used. This suggests that the kimono images evoking a strong sense of "Han-nari" had small distribution areas, meaning that they used few colors. The distribution area of the image evoking a weak "Han-nari" response were more widely distributed.
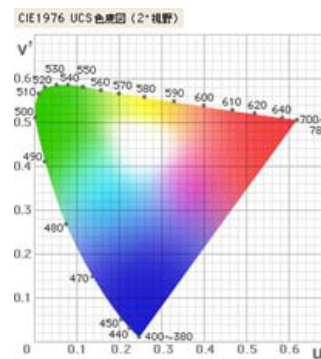

Figure 7: CIE 1976 UCS Chromaticity Diagram

(3) Relationship between u' value v' value and Sense of "Han-nari"

The relationship between average value of u' and degree of "Han-nari" is shown in Figure 8. The coefficient of determination was $R^2 = 0.0414$, and the correlation coefficient was 0.2032, which suggested that a weak correlation exists between the average value of u 'and the degree of "Han-nari" reported. The relationship between the average value of v 'and the degree of "Han-nari" for each image is shown in Figure 9.
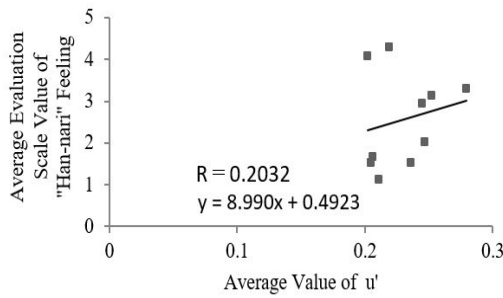
Figure 8: Relationship between Average Value of u' and the Degree of "Han-nari" Reported
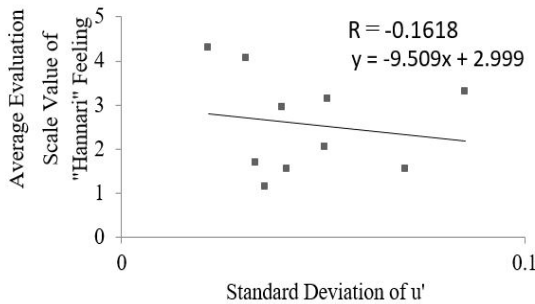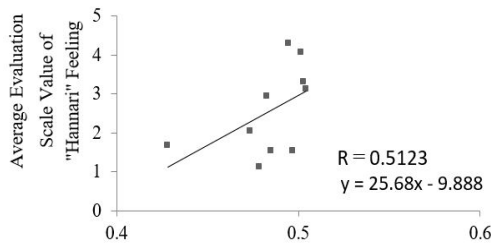

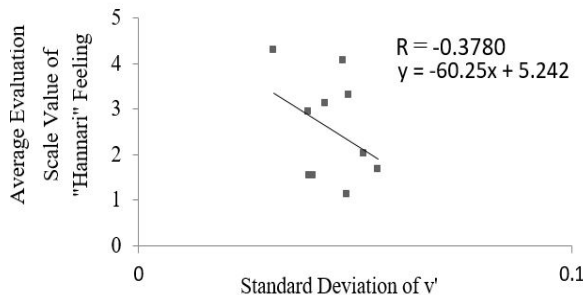Figure 10: Relationship between Standard Deviation Value of u' and the Degree of "Han-nari" Reported

Figure 11: Relationship between Standard Deviation Value of v' and the Degree of "Han-nari" Reported

The coefficient of determination was R^2 = 0.2624. Since the correlation coefficient was 0.5123, it became clear that there was a moderate correlation between the average value of v' and the degree of "Han-nari" reported.

Then, we showed the relationship between the standard deviation of u' and v' values, and degree of "Han-nari", shown in Figures 10 and 11, respectively. The correlation coefficients of standard deviation of u' and v' with "Han-nari" reports were -0.1618 and -0.3780, respectively, both of which suggest the existence of a weak correlation. The larger the u' values were, the greater the degree of "Han-nari" reported, suggesting that using "white" increased the "Han-nari" experienced. When looking at the average of the v', it became clear that the use of "white" or "whitish yellow" increased the degree of "Han-nari" reported.

3 Relationship between Brightness and Sense of "Han-nari"

The relationship between the brightness of kimono images and the degree of "Han-nari" reported is shown in Figure 12. The coefficient of determination was R^2= 0.7792, and the correlation coefficient was 0.8827. As the brightness value of the kimono image increased, the degree of "Han-nari" reported increased. Therefore, the brighter the kimono image was, the "stronger the sense of Han-nari" was.
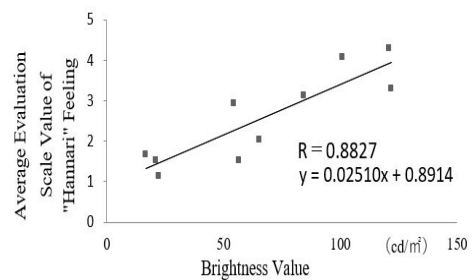

Figure 12: Relationship between the Brightness Value of Each Image and the

Discussion

In this research, we increased the number of samples from our previous study, calculated the color of the kimono images from the RGB, u' and v' values, and

examined the relationship between the "Han-nari" feeling and the colors. It was revealed that the kimono images that evoked a strong "Han-nari" response had peaks in the high numerical value range around 200 in the R value histogram, and the frequencies were large. As for the kimono images evoking moderate "Han-nari" responses, the peaks of R, G and B values appeared around 150, suggesting that the R value was related to the degree of "Han-nari" reported in RGB values. We removed the background area of the kimono images and analyzed it considering the color of the kimono body. As a result, it became clear that "white" or "whitish yellow" made, the sense of "Han-nari" increase. In the previous study where the test subjects felt more "Han-nari" for "whitish yellow" rather than "light green" or "blue". Therefore, the use of "whitish yellow" raised the reliability that the kimono would evoke stronger "Han-nari" responses, which supported the previous study (Komizo, 2015). Moreover, both in the present and the previous research, it was found that kimono using fewer colors evoked reports of a stronger sense of "Han-nari". As a result, there was a high correlation between the brightness and the "Han-nari" feeling, and it became clear that the brightness of the kimono image is directly correlated with the feeling of "Han-nari" reported, which also supported the previous study and increased the credibility of those findings.

In this research, we have demonstrated how quantifying the feeling of "Han-nari" makes it possible to extract one factor of the beauty of a kimono. Kimonos that evoke a sense of "Han-nari" have been created through the tacit knowledge of craftsmen until now. However, in order to create kimonos with a sense of "Han-nari" by industrial production, it is important to clarify the definition of "Han-nari" by using numerical values. This will eventually help to revive the kimono industry and will be helpful to pass kimono culture on to the next generation. We successfully quantified the relationship between color and brightness and the degree of "Han-nari" evoked by a kimono image in this research. This method need not be limited to the kimono; it could be applied to other industrial products.

Future Works

There was a relationship between the distribution of RGB values and the average degree of "Han-nari" reported. If the color of the kimono image is changed by image editing software and the graph of the RGB value distribution is changed, we believe that the average degree of "Han-nari" reported will also fluctuate. We will verify this hypothesis in future research.

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