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# *"Lip color diversity and makeup strategies"*

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## 1. Introduction

The lips have played a significant role in cosmetic techniques since approximately 3500 B.C., evidenced by Queen Schub-ad of Ur in the Sumerian area, who applied a lip tint created from white lead and pulverized red stones [1,2]. Lip makeup, a particularly symbolic beauty product, has been both vilified and celebrated throughout history. Exclusively worn by prostitutes in the Greek Empire and then viewed as a sin by the Church during the Middle Ages in Europe [1], the use of lip makeup became popular again in England in the second half of the 1500s. In the early twentieth century, Suffragettes applied lip makeup as a symbol of female emancipation [3]. It was at this time that the first modern tubes of lipstick were developed [1]. Since then, its popularity has constantly increased, symbolizing in turn glamour during the 1950s, and social rebellion in the 1970s when it was adopted by both genders [1].

A 2019 market research report indicated that 62% women over 18 years of age across various ethnicities used lipstick [4]. They often applied it as the final touch of their makeup routine, and most of them reapplied it 3 to 4 times a day [2,5]. Many consumers consider lipstick an empowering and feel-good beauty product. Indeed, lip makeup seems to have a transformative effect on some consumers, its application associated with self-enhancement and self-

indulgence [2,5]. In addition, some users have reported that their choice of lipstick color reflects their mood [2].

The global lipstick market reached 9.2 billion US dollars in 2023 with an increase forecast over the next 10 years. This can be explained by the fact that lip makeup is highly diversified in terms of color (such as red, pink, black, blue and nude) as well as texture (including matte, shimmery, metallic and glossy) [1,6,7]. This is in contrast to skin foundation, which tends to match the natural skin color and texture.

Paradoxically, little is known about natural lip color compared to skin color, probably due to the challenges inherent to their difficult measurement caused by the heterogeneity in lip size and relief. Given the significance of lips in makeup strategies and their crucial role in social interactions [8,9], our team in a previous study tested different devices in order to identify the most appropriate for measuring lip color [10].

Our present research focuses on better understanding lip make-up strategies according to preferred lipstick's shade, given the color diversity of bare lips of four ethnic groups in three different countries.

## 2. Materials and Methods

### *2.1. Panel*

A panel of 514 women participated in the present study undertaken in France, the USA and China. The panel consisted of 100 Caucasian French, 107 Caucasian American, 103 African American, 100 Hispanic American and 104 Asian Chinese women. The participants ranged from 19 to 68 years (mean = 42.5; standard deviation = 12.8), including 87 women aged 18-28 years, 126 women aged 29-38 years, 121 women aged 39-48 years, 107 women aged 49-58 years, and 73 women aged 59-68 years.

The use of selective lipsticks at least twice a week was a criterion for volunteer selection in this study. Women who had previously undergone facial surgical procedures and/or any lip tattooing for the French volunteers were excluded. From the evening before their appointment,

participants were instructed to refrain from applying any lip products, whether moisturizer or make-up.

Upon arrival at their appointment for the study, the participants were instructed about the study objectives and provided signed informed consent, inclusive of image rights. As an incentive for their participation, the volunteers received a gift in France and China and monetary compensation in the USA.

### *2.2. Measurement*

Inferior lip color measurement was performed using the SpectraFace® device (Newtone Technologies, Lyon, France), a full-face hyperspectral imaging system. The SpectraFace® device consists of a high-resolution monochrome camera (2048 x 2048 pixels) and a liquid crystal tunable filter (LCTF), allowing for the selection of 30 wavelengths ranging from 410 nm to 700 nm with a 10 nm interval. To homogeneously illuminate the subject's face, two lighting pods are located on either side. The system is equipped with polarization filters in cross-position to discard specular reflection and ensure relevant color analysis. Thirty images were captured sequentially within 3 seconds for each panelist, thereby limiting subject movement during the acquisition. The stack of these 30 two-dimensional monochrome images acquired at different wavelengths resulted in a hyperspectral image, with spectral information available in each pixel. This allowed for computation of RGB color coordinates given a specific illuminant and observer, resulting in a standardized RGB color image. For this research, the D65 illuminant and 10° observer were used as standard conditions for color computation. The D65 illuminant corresponds to the average midday light and is often used as a reference illuminant for colorimetric measurement and analysis. The 10° observer matches a standard human observer with a view angle of 10°. The resulting image is a strict conversion of the spectral reflectance without any post-treatment or color enhancement applied, as opposed to most commercial devices. As it requires no contact that could potentially alter the blood flow and therefore the color of the area of interest, the SpectraFace® results are more representative of the natural color of the lips.

Data were acquired in standardized rooms with a constant temperature of 21°C (+/- 3°C). In France, the study was conducted in Neuilly-sur-Seine from January to mid-February 2021. In the USA, the study was conducted in Teaneck, New Jersey, from November 2021 to February 2022. In China, the study was conducted in Shanghai from the end of October 2022 to January 2023.

At the beginning of the appointment, women eliminated any potential residual makeup on their face and lips using makeup remover, toner, and thermal water. To ensure that the natural color of bare lips was measured, the volunteers were then asked to wait for 15 minutes before any measurement was taken. Data were recorded on the darker part of the lower lip, considered to reflect lip color more accurately, particularly for voluminous and heterogeneous lips, within defined areas of an 8.2 mm² diameter (Figure 1), on both bare lips and made-up with the preferred lipstick according to consumer's own gesture.

**Figure 1**: Regions of interest of the inferior lip defined on SpectraFace® images for homogeneous (left) and heterogeneous (right) lip color.

SpectraFace® allowed to extract standard colorimetric parameters of lightness (L*), chroma (C*) and hue (h), and data were expressed in the CIE 1976 standard colorimetric space: L*, a*, b*, C*, h.

*2.3. Statistics*

Clusters of women were made for both bare and make-up colorimetric data (on the lightness (L*), chroma (C*), and hue (h)) according to CAH « two-step clustering » method (Euclidean distance and Ward's method), to identify bare lips and makeup results typologies. To

determine which groups had statistically significant differences, Tukey's post-hoc tests were applied following the ANOVA. The threshold for statistical significance was set at $p \leq 0.05$, meaning that differences with a probability of error below 5% were considered significant. Data were analyzed with JMP®, Version 17. SAS Institute Inc., Cary, Caroline du Nord, 1989–2023.

## 3. Results

### *3.1. Bare lip color diversity*

Our results highlights 12 clusters of lip colors, with some specificities according to ethnicities. In fact, Groups 1, 2 and 3 are solely constituted of African women, groups 10 and 11 exclusively of Caucasian women, group 12 solely of Hispanic women, and group 6 exclusively of Asian women. However, we also observe overlaps between ethnic groups, as there are 5 out of 12 groups with at least 2 ethnic groups (Table 1).

| **Group** | **Ethnic groups concerned** | | | | **Mean L*** | **Mean C*** | **Mean h** | **Color of the lower lip of the group** |
|---|---|---|---|---|---|---|---|---|
| | African | Caucasian | Hispanic | Asian | | | | |
| Group 1 (AF1) | 37 | | | | 28.5 f | 10.1 g | 37.1 bc | |
| Group 2 (AF2) | 12 | | | | 30.3 f | 13.2 f | 33.6 de | |
| Group 3 (AF3) | 17 | | | | 33.5 e | 17.0 e | 38.0 b | |
| Group 4 (AF4+AS1+H2) | 17 | | 25 | 18 | 42.9 c | 23.2 c | 40.8 a | |
| Group 5 (AF5 + AS3) | 20 | | | 35 | 38.2 d | 22.7 c | 33.5 de | |
| Group 6 (AS2) | | | | 20 | 43.4 c | 25.1 b | 37.5 bc | |
| Group 7 (AS4 + C4 + H1) | | 62 | 25 | 11 | 47.9 a | 26.3 b | 36.5 bc | |
| Group 8 (AS5 + C2 + H3) | | 41 | 17 | 20 | 42.5 c | 26.9 b | 31.9 ef | |
| Group 9 (C1 + H4) | | 35 | 17 | | 42.9 c | 28.8 a | 27.4 g | |
| Group 10 (C3) | | 37 | | | 47.9 a | 29.6 a | 30.7 f | |
| Group 11 (C5) | | 32 | | | 45.6 b | 22.3 cd | 30.4 f | |
| Group 12 (H5) | | | 16 | | 35.9 e | 20.2 d | 35.5 cd | |
| F | | | | | 287.0 | 252.7 | 102.3 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pr > F | | | | | < 0.0001 | < 0.0001 | < 0.0001 | |

**Table 1.** Summary of colorimetric means and standard deviation by HAC-group from 1-factor Anova (Group) and Tuckey post hoc tests. Two different letters indicate a significant difference for the same variable at the 5% level. (AF: African American, C: Caucasian, H: Hispanic American and AS: Asian Chinese)

### *3.2. Lip makeup results*

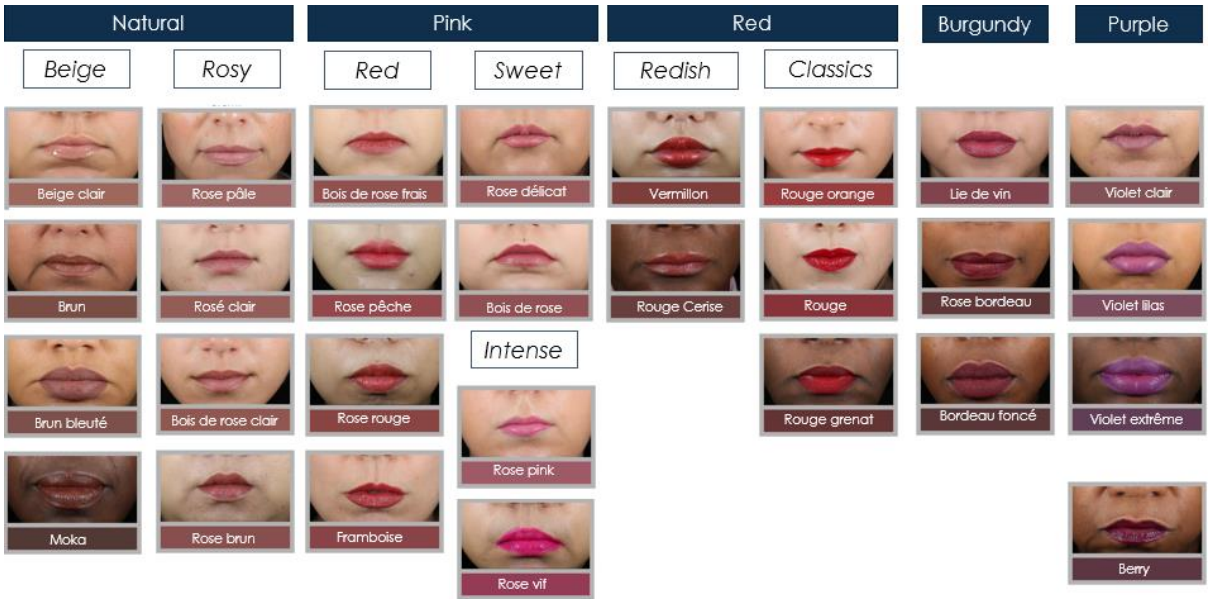


**Figure 2**: The 28 worldwide lip make-up typologies illustrated with barycentre VISIA pictures and RGB color shade, from two-step clurstering k-means and HAC.

Made-up lips colors revealed a wide color range, highlighting 28 make-up typologies with 5 dominant color families with some nuances of lightness and hues: natural makeup results (close to the natural color of the lips), pink, red, buergundy and purple (Figure 2).

Figure 3 shows that pink makeup results are the most represented (38%), followed by natural (30%) and red (20%) makeup results. Burgundy (7%) and purple (5%) families are in the minority. Moreover, differences were observed between ethnic groups. African women mostly obtained red and natural results, but they also are the most numerous of the burgundy and purple families. Asian are clearly represented by pink makeup results, as there is 63% of the population in this group. Caucasian women obtained mostly natural and red make-up results, and we observe a tendency of over-representation of French women in the red results compared to American women in the natural results. Hispanics women are more equally distributed in each group, meaning that they have the greatest diversity of makeup results.

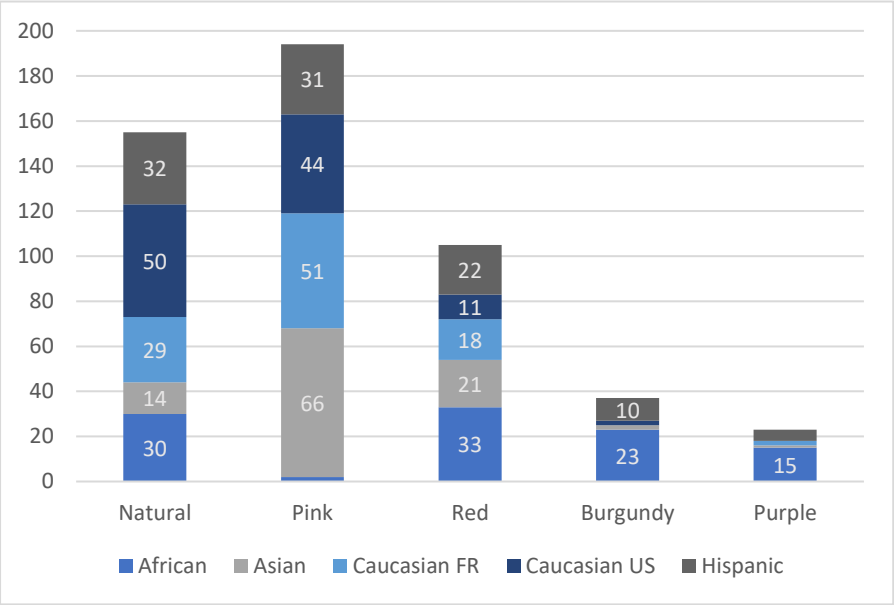


**Figure 3**: Ethnic distribution by number of women (N=514) according to makeup result families.

To investigate relationship between bare and made-up lips colors, an illustrative exemple is presented in Figure 4. While the bare lips color can influence the makeup result, our observations indicate that very different bare lip colors can yield similar makeup result, even across diverse ethnicities. Specifically, a Caucasian woman with the lightest lips (group 7), an Asian woman with lips of low saturation and redness (group 4), and a Hispanic woman with highly saturated and red lips were all able to achieve a comparable "Rosy Red" makeup result. These participants share similar expectations regarding lipstick, expressing a desire to project an image of “confidence”, “politeness”, or “high social standing”.


**Figure 4**: Example of different bare lip colors from 3 different ethnicities (on top) leading to a similar ‘Rosy Red’ make-up result (bottom) (VISIA-CR pictures)

## 4. Discussion

The aim of our study was to explore lip makeup strategies according to preferred lipstck's shade, taking in consideration color of bare lips, with four different ethnicities (Caucasian, African, Hispanic and Asian) living in three different countries (France, USA and China). Our data highlighted an important diversity of lips color with overlaps between ethnicities: 12 groups of lips color have been identified, including 5 with at least 2 different ethnicities. These findings are consistent with previous published data that showed overlaps between several ethnicities [11]. Not surprisingly, the 2 studies showed that African women were the population with the darkest lips, and Caucasians the lightest and reddest lips. However, the study by Baras and Caisey showed no difference in lip lightness between Caucasians and Asians, whereas we show that Caucasian lip color tends to be lighter than that of Asians. The latter even share 3 groups in common with Africans. This may be explained by the fact that our Asian population consists only of Chinese women, whereas the previous study's Asian population consisted of women from China, Japan, Korea and Thailand. Overall, the same conclusions are drawn regarding skin colors [12].

Makeup strategies are predominantly described in the literature on complexion, as demonstrated by the study of Baras and Caisey [11] which describes four different strategies according to countries and ethnicities. This present study offers a complementary view on lip makeup strategies, which are highly diverse, as 28 different color results were identified, ranging from natural to very colorful results. This diversity can be explained by different consumer motivations, notably driven by self-esteem. Indeed, women with lower self-esteem tend to want to conceal their imperfections, while women with high self-esteem seek to seduce by highlighting a part of their face [13]. Makeup, therefore, mainly serves to convey a good self-image and facilitate relationships with others. Primarily based on appearance, the perception of others influences social interactions [14]. It is as a modulator of appearance that makeup has interactional consequences. Thus, appearance contributes in the choice of a partner and is linked to physical and mental health, but also well-being [15].

Therefore, it would be interesting for future investigations to compare complexion and lip makeup strategies by analyzing the contrast. A previous study has investigated the perceived color of facial skin according to the color of the lip [16]: 21 observers were exposed to the images of 40 Japanese women with their natural lip color or with artificially colored lips (darker and paler than the natural tone). The authors showed that redder lips made the perceived tone of facial skin appear lighter whereas darker lips made it darker. Furthermore, the skin/lip color contrast is associated with the perception of age, attractiveness and health in different ethnic

groups: the higher the contrast between lip and skin tones in women, the higher the perception of youth, health and beauty.

## 5. Conclusion

This study highlighted that lip color should not be neglected in comparison with skin color, as there is a wide range of colors to consider. These lip tones could serve as target shades for the development of a more diverse and inclusive range of lipsticks, such as nude. Clusterization analysis has provided an exhaustive representation of lip color make-up diversity across four ethnic groups and three different countries. The differences obtained by country can help to promote different lipstick shades in the different cosmetics markets.

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