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Enhancing Color Perception in Lipstick: The Synergistic Effects of Shade Range, Fragrance and Emotion

RUMOLO Jérôme¹; THEVENET Ludovic¹; KWON Gusang²; BONEMERE Thibault³; PEUVRIER Camille⁴

¹ Color Science, L'Oreal R&I, Chevilly-Larue, France; ² Cognitive Sensory Sciences, Evaluation Intelligence, Shanghai, China, ³ Cognitive Sensory Sciences, Evaluation Intelligence, Saint-Ouen, France, ⁴ Fragrance Métier, L'Oréal R&I, Chevilly-Laure, France

1. Introduction

Color, as a physical phenomenon, results from the interaction of light with matter. Its objective characterization relies on established optical and spectral measurements. However, the perception of color evokes a complex neurophysiological and social process, introducing a subjective dimension involving other senses and parameters that need to be considered, particularly in the cosmetic field. We will focus exclusively on the category of lux lipsticks. The present study will examine 1) quantify the impact of color, fragrance and emotions on lipstick perception; 2) identify the color-scent combinations that influence color perception; 3) determine whether these combinations are shade-dependent.

The influence of color on the perception of other sensory modalities, such as scent, has been highlighted in several studies. Color has influence on fragrance without proving the reciprocal [1]. Non-random and consistent cross-modal correspondences between color hues and fragrance families, suggesting that color can facilitate the identification of odor quality and influence the perception of its intensity [2]. The importance of the emotional dimension in cross-modal correspondences is a central element of Spence's (2011) work [3], which highlighted cross-modal associations at different levels of abstraction. Spence (2020) provides a comprehensive review of the literature on cross-modal correspondences between odors and colors, emphasizing the influence of color on odor perception, and vice versa [4]. Although the

bidirectionality of these correspondences is not systematically demonstrated, the colors that individuals intuitively associate with specific odors are consistent and non-random.

In the context of cosmetics, the multisensory impact, and particularly the influence of scent, has been extensively studied. Research has shown that adding a fragrance to a cosmetic product can enhance its appeal [5][6]. Barkat et al. (2003) highlighted the impact of color and fragrance on physiological parameters such as skin conductance and heart rate, indicating an influence on relaxation, excitement, perceived pleasure, and emotional arousal [5].

Diwoux et al. (2024), in a systematic review, analyzed the use of neurophysiological measurements to study emotional responses to cosmetics [7]. They highlight the complexity of the interactions and the need for a holistic approach combining several measures, including brain activity, cardiac activity (LF/HF ratio), and electrodermal activity. Some of these measures are used in our evaluations and will be discussed in the Materials and Methods section.

All these articles point to a relevant link between color and fragrance. However, none of them explores this relationship for make-up, and more specifically for lipstick. Moreover, by appropriately selecting emotional colors, we're trying to address a more complex target than a strict cross-modality. The choice was made to vary only the parameters related to fragrance, color and targeted emotions for our consumer in order to create synergy between these parameters.

2. Materials and methods

The objective is to identify trends and evidence within specific cases, thereby informing broader research. In this context, a number of parameters were pre-defined, particularly to align with the specific case of a lux lipstick. The proposed product is a reference shade range, comprising 20 shades, and a benchmark fragrance. This product is developed in a conventional manner within the cosmetics industry. It functions as a reference point for expanding the color shade range and fragrance options. These options are based on targeted emotional territories.

Samples

Two sample types were developed for the evaluations: physical and digital.

Therefore for physical evaluation, two representative colors (a red and a nude) were chosen. Red and nude shades were selected for the physical evaluation because they represent emblematic lipstick categories, enabling color-perfume synergies to be explored on contrasting shades relevant to the market. The red color is associated with tradition and history, while the fast-growing nude color is linked to contemporary trends and a natural aesthetic.

For each physical shade, a single batch was produced, to which the different fragrances were subsequently added.

The digital samples are intended to illustrate the relationship between the shade ranges of 20 shades each, presented linearly, and emotions. Digital shade ranges are presented on calibrated monitors [Eizo ColorEdge CG319X]. The monitor settings are consistent with the sRGB color space used in "Lip Makeup Color Emotions" [8] a recent poster presentation at the 2024 Society for Affective Science conference. A grey background (RGB: 221, 221, 219) was used for all images to standardize the viewing environment and minimize extraneous visual influences. The selection of this shade of gray is predicated on its relative lightness compared to the display's lightest color in "Lip Makeup Color Emotions" [8] study, and therefore our lightest lipstick color. It has been determined in this study that this option is less disturbing for the viewer.

Emotionnal territories and emotion selection

The lipstick developed for this study is a full-coverage matte formula, a category that has been observed to have a tendency to cause lips dryness. This formulation incorporates a novel technique, utilizing a high concentration of glycerin among other ingredients, to enhance comfort sensation and provide a caring benefit while maintaining the desired optical and color properties. The selection of emotions is based on previous study [8] who established correlations between specific colors and emotions elicited by lip makeup.

"Lip Makeup Color Emotions" study [8] involved a sample of 123 American women representing four ethnicities (Asian, African American, Caucasian, and Hispanic), varying in age and skin tone. Participants viewed 168 color patches and virtual try-on simulations on calibrated monitors while completing a questionnaire and undergoing simultaneous measurements of skin conductance (GSR), heart rate (ECG), brain activity (EEG), and visual attention (eye tracking). Generally, for each emotion, approximately fifteen colors were consistently identified across participants, along with some ethnicity-specific variations.

For our study, two emotional territories, "Secure" and "Self-Confident", are selected for further investigation. The "Secure" territory is characterised by the lipstick formulation's inherent comfort. The second emotion is "Self-Confident", for contrasting emotional profile, aligning with a more empowering femininity and the expression of luxury.

Color selection for emotionnal shade range

Since our cognitive evaluation is in China, we focus emotional color selection on this ethnicity in the poster "Lip Makeup Color Emotions" to limit cultural differences.

Two strategies were considered: (1) replacing each individual color with its closest "emotional color" counterpart and (2) a more selective approach, modifying only certain colors of interest. The second strategy, adopted for this study, offered several advantages in the current context. Due to the limited number of available "emotional colors," the first strategy risked creating color

redundancy or incorporating colors that deviated significantly from the reference palette. The objective was to enhance specific color propositions within the existing range, rather than develop entirely new color palettes. Twelve of the twenty shades in the reference range were adjusted to create the "Self-Confident" range, while thirteen shades were adjusted for the "Secure" range. The modified colors are not necessarily the same between the two ranges.

Shade range organisation

While individual colors can be analyzed for their inherent properties, color perception is subject to contrast effects from neighboring colors, particularly within a shade range. Therefore, shade range organization became a key methodological consideration. Given the lack of research on the impact of shade range organization on associated emotions, expert consultants (independent from the project) were engaged to organize the 3 shades range, minimizing contrast effects and creating a neutral presentation (figure 1). This methodological choice, while prioritizing neutrality, introduces a significant variable for future research.



Figure 1: Shade ranges corresponding to 1. Reference, 2. Self-Confident, 3. Secure.

Fragrance selection

The fragrance selection was the result of a collaborative effort between experts in the fields of fragrance and colour, with the objective of ensuring congruence with targeted emotional territories and complementing the nuanced colour selections. Three fragrances were selected for the study. Fragrance 1 was utilised as the benchmark fragrance, while Fragrances 2 and 3 were specifically selected on the basis of their congruence with the selected colour palettes and targeted emotional territories.

- Reference fragrance is structured around a white floral accord, combining peony with red fruit notes. Vanilla adds warmth and roundness. This fragrance evokes luxury with creamy, powdery and delicate scents.
- Fragrance 2, a composition built around mandarin, sandalwood, and orange blossom, was formulated to feature a comforting vanilla base and a subtler orange blossom note. The emotional profile associated with this fragrance emphasizes comfort and voluptuousness.
- Fragrance 3, a more complex composition, features delicate white floral notes, dominated by peony, with a touch of red berries, enhanced by the warmth of vanilla. This fragrance evokes emotional profile associated with luxury, seduction, and self-confidence.

Cognitive evaluation

This study investigated the multi-sensory experience and cognitive responses of Chinese female consumers to matte lipsticks. Forty-two participants (N=42), all regular users of luxury brand matte lipsticks aged between 20 and 40 years, were recruited for this study. Informed consent was obtained from all participants prior to their involvement in the cognitive evaluation. Participants were divided into two equal groups (n=21 per group): one group used red matte lipsticks and the other used nude shades for the multi-sensory experience portion of the study.

Multi-Sensory Experience Evaluation

Participants applied the physical lipstick stimuli to their own lips and were provided with a mirror to fully appreciate the multi-sensory effects. After one minute of wear, participants were given 30 seconds to reflect on their experience and then provided subjective responses on a 10-point Likert scale (1 = strongly disagree, 10 = strongly agree) to the following statements: (1) I feel comfortable on the back of my lips. (2) I can feel moisturizing on my lips after applying it. (3) This lipstick smoothes the lip lines. (4) I like the color intensity of this lipstick. (5) I like the color of this lipstick.

Shade Range Presentation and Cognitive Evaluation

Following the multi-sensory evaluation, participants underwent a cognitive evaluation using digital stimuli presented on a screen. Three different shade ranges were presented individually: Reference, Self-Confident, and Secure (Figure 1). Each stimulus was displayed for 15 seconds while galvanic skin response (GSR) and eye-tracking data were collected. Shimmer3 GSR sensors were placed on participants' non-dominant hands, which were kept still throughout the data collection period, to monitor skin conductivity as a measure of emotional arousal. Eye-tracking data, used to assess attentional focus, was collected using a Smart Eye AI-X system.

Prior to the evaluation, participants underwent a calibration procedure while seated in front of the screen. Immediately after viewing each digital stimulus, participants were presented with a list of 22 emotions (see Table I) and asked to select the one that best represented their feeling towards the presented shade range. Finally, participants rated their overall liking of each shade range on a 10-point scale (1 = I don't like it very much, 10 = I like it very much).

POSITIVE EMOTION			NEGATIVE EMOTION	
Happy	Sexy	Invigorated	Irritated	Bored
Relaxed	Reassured	Focused	Stressed	Frustrated
Energized	Calm	Serene	Disgusted	Depressed
Surprised	Nostalgic	Secured	Sad	Sleepy
Self-confident	Intrigued			

Table I. Emotion List

3. Results

Sensory Synergies and Fragrance Influence:

This section presents the results of the multi-sensory experience evaluation, focusing on the interaction between scent and color perception in matte lipsticks. The study revealed a notable interaction between lipstick color and added fragrance, suggesting sensory synergies where scent influenced color perception. While red shades generally received higher ratings overall, the impact of fragrance was more pronounced in the nude shades. Specifically, Fragrance 2 appeared to enhance the perceived color intensity and overall liking of the nude lipstick, as evidenced by the higher mean scores (Figure 2). Conversely, Fragrance 1 was associated with lower scores for color attributes (Color Intensity and Overall Color Liking; Figure 2) and some functional benefits (Moisturizing and Smoothness; Figure 2), particularly in the nude shade. This finding highlights the potential of fragrance to modulate the perception of cosmetic product attributes, even within the same color shade.

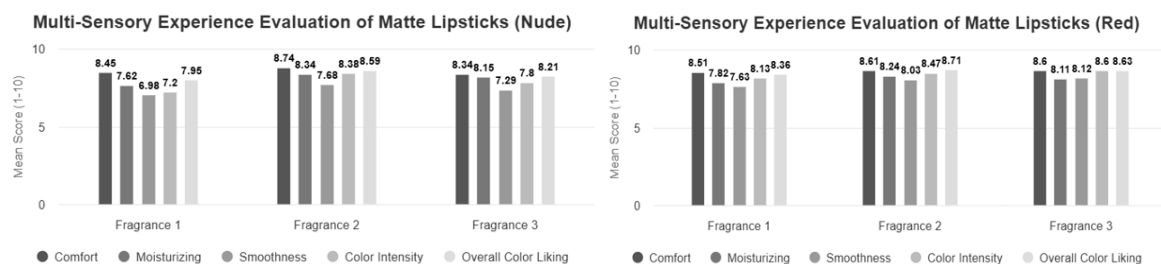


Figure 2: Mean scores for each attribute across the different fragrance and color combinations

Although the observed differences did not reach statistical significance, the trends provide valuable insights for product development. The data suggest that Fragrances 2 and 3 are promising candidates for enhancing color perception, particularly in nude shades. Further investigation is warranted to optimize these synergies and confirm these preliminary findings.

Cognitive Evaluation of Shade Ranges

This section presents the results of the cognitive evaluation, integrating findings from eye-tracking, emotional response matching, and GSR measurements. The analysis focuses on comparing participant responses to three different shade ranges: Reference, Secure, and Self-Confident.

Reference Shade Range:

Eye-tracking data revealed a concentrated focus of attention on the four reddish shades within the Reference range (Figure 3(a)). This suggests a preferential visual attention towards these specific colors. However, the emotional responses elicited by this range differed notably from the others, characterized by a prevalence of lower-energy emotions, including some negative affect (Figure 4). This contrasts with the emotional profiles of the other shade ranges. Furthermore, the Reference range evoked the lowest GSR responses compared to the Secure and Self-Confident ranges (Figure 5), indicating a lower level of emotional arousal.

Secure Shade Range:

The Secure shade range elicited strong and broadly distributed visual attention across almost all lipsticks, as shown in the eye-tracking heatmap (Figure 3(b)). This suggests a harmonious perception of the range, with no single shade dominating visual attention. The most frequently selected emotions associated with this range were "intrigued" ($n = 12$) and "invigorated" ($n = 6$) (Figure 4), indicating a high level of emotional energy and engagement. This observation is further supported by the GSR data, which showed higher peak amplitudes for the Secure range compared to the others (Figure 5). These higher GSR peaks suggest a greater intensity of emotional arousal.

Self-Confident Shade Range:

Similar to the Secure range, the Self-Confident range also attracted strong visual attention (Figure 3(c)), but with a more focused distribution towards the reddish shades. "Self-confident" was the most frequently chosen emotion ($n = 8$), aligning with the intended emotional association of the range. Other frequently selected emotions included "intrigued" ($n = 7$) and lower-energy emotions like "calm" ($n = 4$) (Figure 4). Overall, the emotional profile of the Self-Confident range, while positive, exhibited lower energy compared to the Secure range. This is

consistent with the GSR findings, which revealed lower peak amplitudes for the Self-Confident range compared to the Secure range (Figure 5).

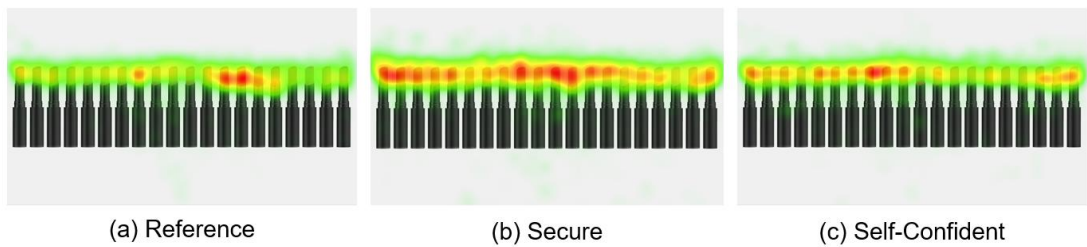


Figure 3. Eye-Tracking Heatmap results

The results suggest a complex interplay between visual attention, emotional response, and physiological arousal in the perception of lipstick shade ranges. The Secure range stands out for its ability to capture broad visual attention and evoke high-energy positive emotions, coupled with increased physiological arousal.

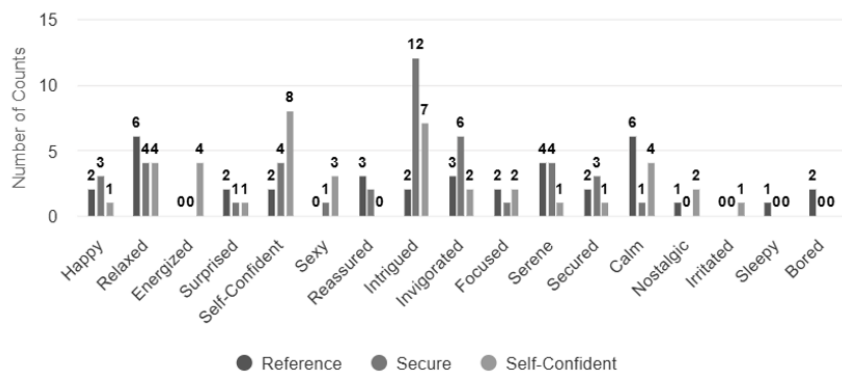


Figure 4. Subjective Emotional Responses to Lipstick Shade Ranges

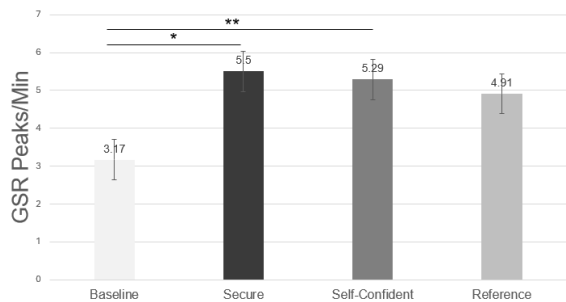


Figure 5. Objective Emotional Responses from GSR measurement. (*: $p<0.05$, **: $p<0.01$).

GSR Peaks per Minute indicate, on average, how many emotional events occurred every 60 seconds

The Self-Confident range, while also attracting visual attention and eliciting positive emotions, generated a comparatively lower level of emotional energy and arousal. The Reference range, despite attracting focused visual attention, elicited a distinct emotional profile characterized by lower energy and some negative affect. Further research is needed to explore the underlying

mechanisms driving these differences and to investigate the relative contributions of color, visual presentation, and individual differences in shaping consumer responses to cosmetic products.

4. Discussion

Analysis of the emotional color ranges, using GSR and eye-tracking data, revealed that coherent shade arrangements can elicit specific emotional responses. The "Secure" range, in particular, generated perceptible emotional engagement and sustained visual attention. This suggests a novel approach to cosmetic design based on the synergistic analysis of color, fragrance, and emotional impact, rather than individual parameter optimization.

This study, while contributing valuable insights, faces methodological challenges. For the time being, however, these results should only be seen as trends, for a number of reasons.

Firstly, the sample size is relatively small. A larger study should be carried out to statistically confirm these trends.

Secondly, we've only looked at two colours, which are certainly representative, whereas the perceptible nuances of lip make-up are numerous.

With regard to multisensoriality, we chose to study only the relationship between perceived colour and fragrance. However, multisensoriality implies the simultaneous activation of all the senses. By choosing to exclude some of them, we may lose a correlation, positive or negative, with the perception of our colour. In the case of lipstick, taste and touch have a definite impact, but what about their cross-influences on the perception of colour components?

In addition, environmental and social parameters can make the data slightly variable. The influence of factors such as age, skin type and personal experience with beauty products could also be investigated in future studies. In addition, the cultural nature of the colour/emotion pair is an interesting parameter. This highlights the need to include a social or at least cultural dimension in these studies.

5. Conclusion

This study offers innovative insights into the subtle interactions between color, fragrance and emotions in lipstick perception. It also contributes to the understanding of multisensory perception mechanisms in the field of cosmetics. These interactions support and extend previous work on cross-modal correspondences in the perception of cosmetic products.

The findings demonstrate that sensory synergies between fragrance and color perception are shade-dependent, with fragrance exerting a more pronounced influence on nude shades compared to reds. Specifically, Fragrance 2 enhanced perceived color intensity and liking in nude lipsticks, highlighting the potential of targeted scent formulations to modulate cosmetic product attributes. While differences did not reach statistical significance, these trends

underscore the value of cross-modal optimization in product development.

The cognitive evaluation of shade ranges, using eye-tracking, emotional response matching, and galvanic skin response (GSR) measurements, revealed distinct patterns of visual attention, emotional engagement, and physiological arousal. The "Secure" shade range elicited broad visual attention, high-energy positive emotions, and increased physiological arousal, while the "Self-Confident" range, though eliciting its intended association, showed a lower energy profile. The "Reference" range, despite attracting focused attention, evoked lower-energy emotions and some negative affect, differentiating it from the other ranges.

These results emphasize the importance of holistic, multi-sensory approaches in cosmetic design, integrating color, fragrance, and emotional territories to create resonant consumer experiences. Future research should explore the mechanisms driving these cross-modal effects, investigate cultural differences in sensory integration, and refine neurophysiological measures to enhance understanding of consumer emotional responses in the cosmetics domain.

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