# Snap and Match: A Case Study of Virtual Color Cosmetics Consultation

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## Abstract
In this paper we describe an imaging based virtual color consultation system that automatically recommends cosmetics appropriate for users' skin tone based on user's photograph. This system is intended for commercial use to address the problem of color selection of cosmetic foundation. Based on surveys and semi-structured interviews we have verified that visual selection of color foundation cosmetics by consumers is error prone, and the results of our study indicate that both mobile and kiosk touch points are essential to cover the entire target population (women of all ages) since we identified technical vs. social comfort, accuracy vs. convenience and social vs. individual parameters that play a huge role in the usage and adoption of such personal services for women.

## Keywords
Advisory service, surveys, interviews, mobile, kiosk, women, design, user studies, shopping, imaging, cosmetics, virtual consultation

## ACM Classification Keywords
H.5.1 [Information interfaces and presentation (e.g., HCI)]: Multimedia; H.5.2 [User Interfaces]: User-centered design and Evaluation/methodology.

## General Terms
Experimentation, Human Factors

## Introduction

*"Tactics that help customers accomplish their tasks more effectively and provide personal recognition are the most effective in engendering customer loyalty"* [2].

Personalized services in the retail environment have great potential for increasing customer satisfaction. Research shows that consumers are more likely to become loyal to a retailer or a brand if they believe that their individualized needs are being met [4, 10].

One of the areas of highest "personal" female consumer spending is the beauty and cosmetics industry, a USD $160 billion-dollar market. This industry includes makeup, skin and hair care, fragrances, cosmetic surgery etc. [3]. The US color cosmetics industry alone is a USD $29B market and it is projected to grow exponentially [11]. In the US, there exist multiple ethnicities thus various shades of skin tones. As the product options provided by brands continue to grow, customers are frustrated by the lack of personalized services. The sales associates at drugstores often cannot provide customized help since beauty product training is typically not provided. Additionally, retail employee turn over rate is over 80% [10]. On the other hand, while the sales associates at department stores receive training on the brands they represent, and are able to offer better service, the brands that are offered in department stores are typically too expensive for many consumers. Therefore these consumers turn to mass market brands sold in drug stores with no sales associate.

The beauty and cosmetics industry is a highly segmented market. Brands are categorized by their product attributes such as natural, urban, young, cruelty free, organic, scientific etc., and they tend to attract a wide variety of women with different characteristics. In literature today we do not find parameters that can be used determine how to align a technological solution offering with the need of a customer segment.

## Color match service

Estée Lauder conducted an online foundation study in June 2006 where they surveyed a panel of over 5,200 Oprah magazine [13] readers to find out exactly how difficult it is to choose the right foundation [1]. They found that 70% of women can't find their exact shade, and 94% of women are wearing the wrong foundation. (Note, we verified this problem in our study, and present these findings in the Results section) To address the issue of makeup selection, we have developed an imaging based solution that allows a consumer to photograph herself using a camera while holding a specially designed color chart. When the image is taken from a phone, it is sent by the consumer via multimedia messaging service (MMS) to an advisory service. The user interface (UI) for an MMS service varies by mobile handset, and is completely defined by the handset vendor such as Nokia and Motorola. When the image is taken at a kiosk (figure 1), it is sent to a web services back-end system for processing. We created a customer UI for the kiosk that walks the user through the steps of taking the picture and requesting the analysis. In both cases, the same backend system uses color science to correct the image color, image processing algorithms to locate and extract the face from the image, and statistical classifiers to determine the user's foundation makeup color with accuracy close to that of a makeup expert.

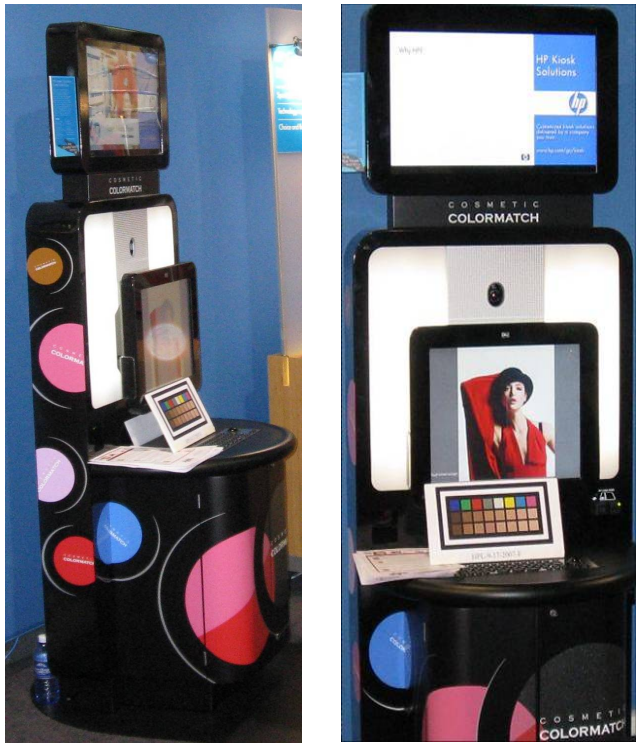


**figure 1:** Custom built kiosk that was designed for the color match service

The analysis works regardless of the image quality, camera specifications and lighting conditions. Within seconds of sending the image, the consumer receives the foundation shade recommendation that best matches her complexion (if the image was sent from a phone a SMS text message is sent, see figure 2).

*Imaging pipeline*

To make recommendations the system processes the image and delivers the response to the user (figure 3). Since the imaging technology is computationally intensive, and the goal is to provide a result in a few seconds, the computation is executed at the server-end not on the mobile device.

This also allows for easy updates of cosmetics shades and new product introductions as the client application does not require modification for seasonal product offerings. The cosmetic recommendation system is composed of image processing, color correction, and statistical classification of skin color matched to a database of expert opinions of cosmetics selection. The system can be customized to process multiple brands and with multiple beauty experts.


**figure 2**: (a) Customer takes photo holding a color chart and send via MMS; and (b) after back end processing customer receives SMS with foundation shade recommendation

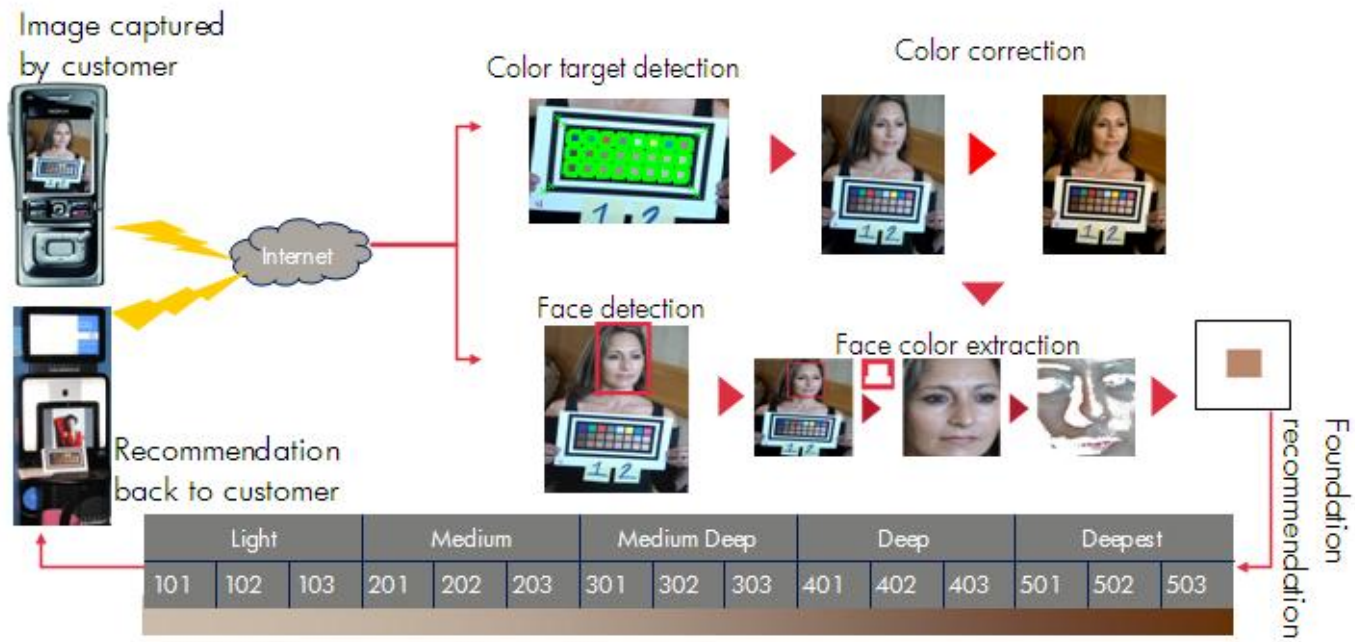


Figure 3 shows the image processing pipeline that completes several stages to produce cosmetics recommendation [5]. First the image must be color corrected. Images are transmitted in RGB format but the sensor capabilities of the camera, camera imaging pipeline, and illuminant conditions all affect the RGB values of the image.

These values are used to judge the complexion color and therefore must represent the "true color" of the face. To compensate for the unknowns of illuminant, sensors, and processing, the color chart is employed to color correct the image. Computer vision algorithms locate the chart regardless of its position in the image. Once located, the color square's RGB values are sampled and compared to their original calibrated values. Once the comparisons are made a transformation matrix is calculated.

This matrix fixes the alteration of the image and maps it closer to the "true color". This means that pixels from the face can be relied on to accurately represent the subject's skin color [8, 9]. A robust fast skin detector finds the face region placing a bounding box around the area. Skin pixels are extracted from the bounding box

and sorted by their brightness. A set of filters are applied to remove skin that it likely to be shiny or in shadow. We then have only well illuminated skin suitable for analysis. The well illuminated pixels are then analyzed and statistically compared to exemplars (previously studied female subjects) that have been classified *a priori* by beauty experts.

Our experiments showed that our system gives a comparable distribution of predictions as that found between two cosmetic experts under different lighting conditions and different consumer imaging devices and different cosmetic product lines [8, 9]. The system can be configured to plug in any expert opinion preferred by consumers, desired by the brand, or that the public respects, etc.

*Reference color chart*

Color calibration is achieved through the use of the reference color chart which has been specifically designed to calibrate for the color range of skin tones of all races. This allows the system to perform an approximation of a spectral analysis. Using robust computer vision algorithms the color chart is located in the image regardless of orientation or placement of the image. No special positioning is required. However, results are best when the illuminant falling on the face falls on the chart. Therefore, the chart is often held in front of the user's chest area. The chart can take many forms. The simplest is a collection of blocks as shown in figure 1. But we have created several charts more in keeping with the esthetics of consumer brands (figure 4). We have found through our studies that we require a minimum of 5 skin-tone colored sampling areas, at least 1 inch in diameter. The appearance of the color values in the chart is used to correct for illuminant conditions and camera differences.

**figure 4:** Example color chart designs: incorporated into a butterfly brand symbol, or as a necklace

## The study

We conducted a number of paper-based surveys and semi-structured interviews with 200 female participants in the western USA (California, Washington, Oregon). Participants were offered $50 (in gift cards) as compensation.

## Participants

We did not obtain a statistically representative sample of US women. However, our sample holds similar attitudes about makeup usage as the subjects in the Estée Lauder study [1]. Thus we prove that it is a recognized industrial problem. The subjects in our sample tend towards being slightly more technically advanced than average. Specifically, 70% of our participants and 79% of the Estee Lauder participants had trouble selecting the right foundation shade. However, 95% of our participants owned a computer, 90% owned a cell phone, and the average time spent on the internet was 7.5 hrs as compared to 80% (owning computers), 72% (owning cell phone), and 5.5

hrs (average time spent on the internet) as reported by Forrester research in 2007 [4].

The age range of our sample was as follows: 20%: 18-27 years; 25%: 28 to 37 years; 25%: 38 to 47 years; 20%: 48-57 years; and 10% over 57 years of age.

## Methodology

One-on-one interviews were conducted with all the participants. We communicated the usage of both the mobile and kiosk solutions and probed issues related to privacy, social and technical comfort etc. We used a between-group design, and it was counter-balanced. 50% were randomly chosen and were described the mobile solution first, followed by the kiosk. Similarly, the other 50% (randomly chosen) were described the kiosk solution first, followed by the mobile.

Next, all the participants completed a survey. In the survey, they answered questions such as methods currently used by them to select the right foundation shade; difficulties and pain points associated with foundation color matching; preferred choices for gathering beauty advice etc. In this survey, participants also rated technical and social comfort of using mobile-based and kiosk-based solutions in various settings (in store, at home or at the counter; in a public and private setting etc).

## Results

The interviews were analyzed inductively using the grounded theory approach [12]. We first discovered the key components and identified a number of concepts, and found interrelations between them using coding and sorting. These results were coupled with the quantitative survey data to identify the following key findings:

*Self selection of foundation color is difficult*
The three most popular mechanisms of choosing a foundation shade were – visual selection (33%), help at a cosmetic counter at a high-end store (30%), and testers at a high-end store (25%) [6].

We conducted an experiment where we asked all the women to visually select and submit their preferred shade of foundation (we provided them with all the shades from a popular cosmetics brand). Next, two independent cosmetics experts determined the correct foundation choice by first visually selecting the shade and then applying the foundation of each participant's face to confirm the correct shade. Often makeup will "dry down" to a slightly different shade. We then asked the participants to rate the shade chosen for them by the experts. Of the 80% of women that liked the shade chosen by the experts, only 16% had visually selected it correctly. This experimental finding was also confirmed qualitatively in our interviews where women in all age ranges and ethnicities conveyed that foundation selection was a frustrating problem for them. Note that the participants were asked if she liked the makeup with only foundation applied, in general this is only one component of a professional "makeover" (which always includes color cosmetics such as blush, eye shadow and lipsticks) so expectations were high.

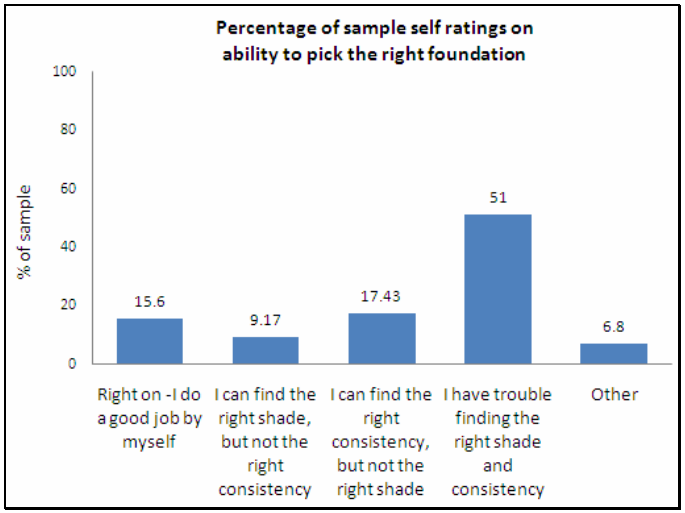


**figure 5**: Ability to pick the right foundation shade

*Women are unhappy with the ability to select the right shade*

Based on our study we found that 85% of women had bought foundation more than once, and 70% self-reported that were still unable to find a perfect shade that matched their skin tone. Figure 5 shows that almost 50.45% have trouble finding the right shade and consistency, and 17.4% have trouble finding the right shade.

*Important to get the shade right*

In our sample, 75% of the women self-reported that they use a foundation almost everyday and of these 61.5% have not yet been able to find the right shade.

Women reported (77.97%) that they have tried approximately five foundations in the last 5 years, with almost always being unable to find the exact shade match. This makes them very frustrated, because unmatched foundation equals to money wasted on products.

*Both mobile and kiosk touch points are essential*

We demonstrated both the mobile and kiosk prototypes to all the participants. There were two variants of the kiosk – a public kiosk (e.g. like airport check-in) and a private kiosk (a semi-closed kiosk). There were three variants of the mobile solution usage – at home, at the store (in the cosmetics aisle), at the cosmetics counter.

TECHNICAL COMFORT VERSUS SOCIAL COMFORT

We asked the participants to rate each touch point variant using a 5 point Likert scale, where 0 was not comfortable and 5 was very comfortable.

Figure 6 shows that participants below the age of 40 years did not rate all the touch point variants equivalently for technical comfort (Friedman Chi sq= 48.69, (df=4), $p<0.0001$) and social comfort (Friedman Chi sq= 99.90, (df=4), $p<0.0001$).

Figure 7 shows that for participants above 40 years the technical (Friedman Chi sq= 41.61, (df=4), $p<0.0001$) and social comfort (Friedman Chi sq= 38.11, (df=4), $p<0.0001$) were also not equivalent.

Findings from paired comparisons (Wilcoxon signed-rank test, $p<=0.05$) of participant ratings between touch point variants demonstrate that younger participants were technically more comfortable with mobile solutions as compared to the older participants. We also see that older participants (40+) were more socially comfortable with in-store solutions.

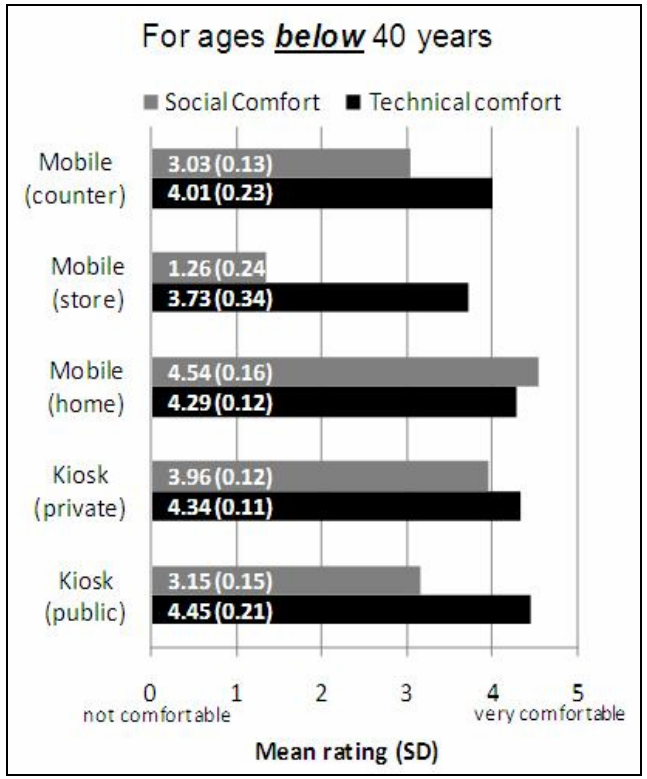


**figure 6**: Mean participant ratings of technical and social comfort of touch point usage variants for ages below 40 yrs

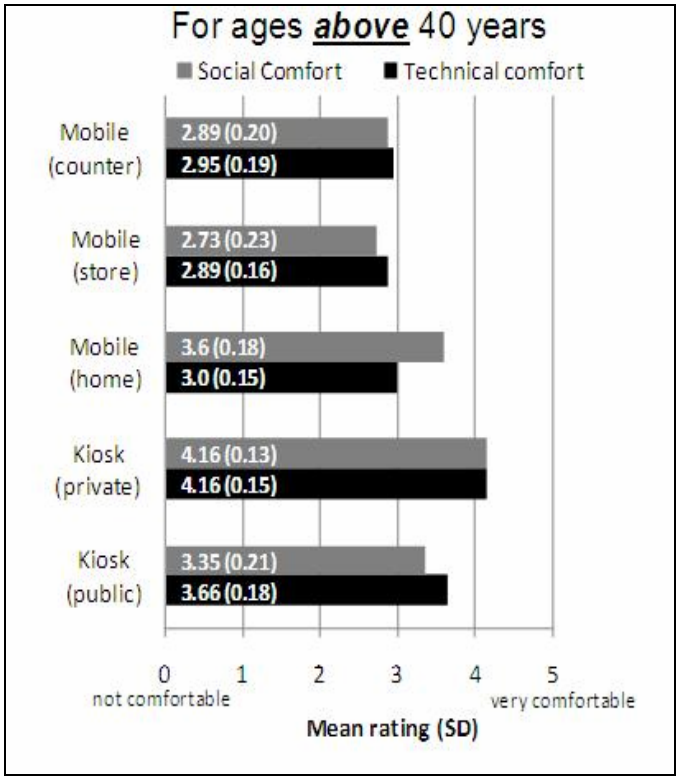


**figure 7**: Mean participant ratings of technical and social comfort of touch point usage variants for ages above 40 yrs

A Spearman correlation test was carried out on technical and social comfort for both the older and the younger participants (refer Table 1).

**Table 1:** Correlation between technical and social comfort

| | ***Tech vs. Social Age < 40 yrs (n = 90)*** | ***Tech vs. Social Age > 40 yrs (n = 110)*** |
|---|---|---|
| Kiosk (public) | 0.44 * | 0.53 ** |
| Kiosk (private) | 0.47 * | 0.51 ** |
| Mobile (home) | 0.34 * | 0.56 ** |
| Mobile (store) | -0.62 ** | 0.57 ** |
| Mobile (counter) | -0.52 ** | 0.57 ** |

* $p<0.01$, ** $p<0.0001$

For younger participants, Table 1 shows an interesting negative correlation between the technical and social comfort of users in terms of the mobile solution in stores. This means that young US women were technically comfortable using mobile solutions, but not socially comfortable in an in-store setting, and they wanted privacy.

For both age groups, we see that while they are technically comfortable using the mobile solution at home, the ratings drop when they are asked to use the same in the store or at a counter.

When probed further, the younger group reported social anxiety as a factor affecting their rating, and the older group reported that at home they could ask friends and family to help using the mobile solution, but in stores this help would not be available. Thus we find that both mobile and kiosk touch points must be provided for various age groups and usage locations.

### Accuracy versus Convenience

Not surprisingly, clean makeup free faces give more accurate results as the face is imaged and not the makeup surface. The mobile solutions supports this in the comfort of consumer's home but then color charts must be distributed in magazines, online, etc. Other women preferred the convenience of the store, since they could test the product and purchase immediately. 75-80% of participants reported shopping alone and preferred the convenience of in-store shopping. Thus, again we see the need to provide both the mobile and kiosk solution.

### Social versus Individual

70% of our participants said that they wanted the ability to share recommendations and advice provided by the advisory solution. Participants did not want a one transaction system, preferring a continuing relationship. The service could continue by sending information on related products (other types of cosmetics that compliments her skin tone), new products, makeup trends and how-to advice. This capability can be provided by the kiosk solution, but we deliberately did not want to provide this on the mobile devices since past research shows that two main factors that hinder the widespread usage of mobile services is: a) requiring additional software to be downloaded and installed on mobile devices, and b)

steep learning curve associated with the new applications. To avoid these issues, the mobile solution is designed such that consumers can use the existing MMS/SMS software on their phones to send the image and to receive the recommendation. In future user studies we will test if the conversion rate tends to be high if the incentive provide by the mobile solution is also high.

## Conclusions

In this study, we confirmed that comfort with technology has more than one aspect. Technical comfort and social comfort should be considered separately, especially when we design products for use in social situations. Based on the user study with over 200 women from three locations in USA, we were able to show that: a) older women were more socially comfortable with in-store solutions than younger women; b) younger women were more technically comfortable with mobile solutions than older women; c) younger women were socially uncomfortable with in-store solutions even though they were comfortable with the technology.

The mobile and kiosk instantiation of the system each address the different needs of women (older vs. younger); their desire for privacy or technical comfort. User interface designers should consider how age affects users' social and technical comfort, and can take this finding into account when designing products.

Since the cosmetics industry is highly segmented, and each brand's customers have certain unique characteristics, it is important to identify the parameters that should be considered before deploying a technology. Based on the user study, we have uncovered a number of factors and trade-offs that should be considered to segment the population when deploying a solution for women (especially in a social setting), these were not apparent until we did the study.

## Future work

We are in the process of creating a perceptual map of product attributes where select brands fall in the three-dimensional space of technology vs. social comfort, accuracy vs. convenience, and social vs. individual, and are planning on conducting a follow on user study to validate the mapping, and further enhancing the attribute space.

We started exploring the mobile and kiosk touch points since these two channels were highly requested by our commercial partners. As we move forward, we recognize that a web-based application where the customer has a webcam and wants to buy online might be the ideal touch point, especially for online e-tailer brands that primarily use the Internet as a medium for customers to shop for the goods. We are also considering an iPhone application which would provide easy distribution of the mobile application. Both the web and iPhone application channels would be useful in maintaining continued relationships with the customer.

## Acknowledgements

This system incorporated several technologies: color science, computer vision, mobile networking, and statistical analysis. The work was done by a cross-disciplinary team that combined their talents to create a new system that was larger than the sum of its parts; Harlyn Baker, Sabine Susstrunk, Mike Harville, John

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