

# Color Match: An Imaging Based Mobile Cosmetics Advisory Service

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## ABSTRACT

In this paper we describe an exploratory study of a mobile cosmetic advisory system that enables women to select appropriate colors of cosmetics. This system is intended for commercial use to address the problem of foundation color selection. Although women are primarily responsible for making most purchasing decisions in the US, we found very few studies to assess the adoption of retail related mobile services by women. Based on surveys, semi-structured interviews, and focus groups, we have identified a number of design factors that should be considered when designing mobile services for women consumers. The results of our study indicate that while usefulness is an important factor, other design aspects such as mobile vs. kiosk, installed vs. existing software, technical comfort vs. social comfort, social vs. individual, privacy and trust should also be accounted for.

## Categories and Subject Descriptors

H.1.2. [User/Machine Systems]: *Human factors*. H.5.2 [User Interfaces]: *User-centered design*.

## General Terms

Design, Experimentation, Human Factors.

## Keywords

Retail; mobile service; image processing, cosmetics; women

## 1. INTRODUCTION

Women make 85-90% of consumer buying decisions each year [12] not only for the traditional consumer packaged goods items, but also for durable goods such as consumer electronics, automobiles, home improvement, etc. [1, 12]. Even when women aren't directly responsible for the purchase they are strong influencers, which make women a critical part of understanding overall consumer behavior.

Past research has well documented evidence that women tend to

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make buying decisions differently than men. Their sense of observation, discovery and values also differs from men [1, 7]. We wanted to keep all of these aspects in mind to test the design, perception, adoption, and usage of a mobile service that is specifically designed for women consumers. In this study we focus on the selection and purchase of personal care products, specifically, cosmetics which are selected to enhance the woman's appearance.

The initial application design provides women with cosmetics advice through their mobile phone. We know that camera phone usage by women is greater than by men [11]. This may make women ideal users of camera phone based mobile consumer services. Kindberg et al. [8] in a camera usage study found that images are usually taken for the purpose of personal reflection and to complete remote and personal tasks.

## 2. RESEARCH OBJECTIVES

One of the areas of highest "personal" female consumer spending is the beauty and cosmetics industry, which is a \$160 billion-dollar market. This industry includes makeup, skin and hair care, fragrances, cosmetic surgery etc. [12]. The US color cosmetics industry alone is a USD \$29 billion market [4]. Research shows that foundation makeup is the second most popular product in the color cosmetics category. Foundation is a tinted liquid, cream or powder substance that is applied to the face before other color cosmetics. Its main purpose is to even the skin tone, hide flaws and provide a base for further cosmetic application. For this product to work effectively it must be selected to match the skin tone of the user. This requires the accurate perception of the consumer's skin tone. Our study confirms what the cosmetics advertisements claim – it is a hard problem for women to select a foundation that best matches their skin tone thus resulting in dissatisfaction.

Women deal with this issue in typically one of three ways: high-end brands sold at attended cosmetic counters, mass market drug store brands with self selection, and direct sales brands with a home-based consultant. Each high-end brand's beauty counters at department stores offer free cosmetics consulting services, but consumers face issues such as sales pressure, high cost of products, lack of privacy, and dependency on one individual counter sales person. Alternatively, for low-end drug store products, personal beauty advice is not available; also samples and testers are typically not available due to concerns about hygiene. Finally, the home-based consultant is also tied to a

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specific brand and products are often selected only through printed brochures.

Thus the goals of the system were to provide: a) expert makeup advice; b) the ability to choose foundation without relying on inaccurate printed brochures or visual inspection of shades in a product bottle (visual inspection tends to be problematic since the shade of the foundation differs from what is seen in a bottle to what it appears like after it dries down on application, also the product is typically packed in layers of packaging material); c) the ability to get advice anytime and anywhere since shopping is typically a collaborative and social activity [6].

### 3. COLOR MATCH MOBILE SERVICE

To address the issue of makeup selection, we have invented a mobile phone based solution that allows a consumer to photograph herself using a phone camera while holding a specially designed color chart (fig. 1a). The image is then sent by the consumer via multimedia messaging service (MMS) to an advisory service host at a backend server. The system uses color science to correct the image color, image processing algorithms to locate and extract the face from the image (fig. 1b), and statistical classifiers to determine the user's foundation makeup color with accuracy close to that of a makeup expert (fig. 1c). The photo analysis works regardless of the image quality, camera specifications and lighting conditions. Within seconds of sending the MMS, the consumer receives a SMS (Short Message Service) text message containing the foundation shade recommendation that best matches her complexion (fig. 1d).

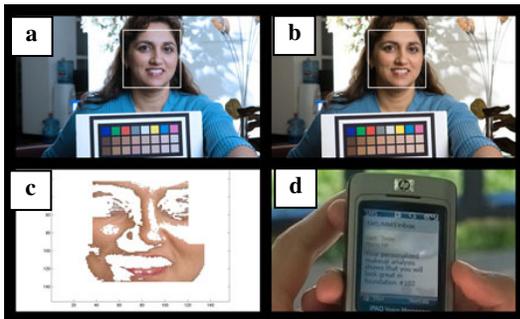


Figure 1. (a, b) face detection, (c) color correction, and (d) SMS recommendation

#### 3.1 Imaging pipeline

To make recommendations the system has to process the image and then deliver the response to the user. Since the imaging technology is computationally intensive, for the results to be computed within a matter of seconds, the computation is executed at the server-end and not on the mobile device. The cosmetic recommendation system is a pipeline containing imaging processing, color correction, and finally an expert system that evaluates the subject's facial skin coloring and makes a synthesized expert opinion.

The image processing pipeline 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.

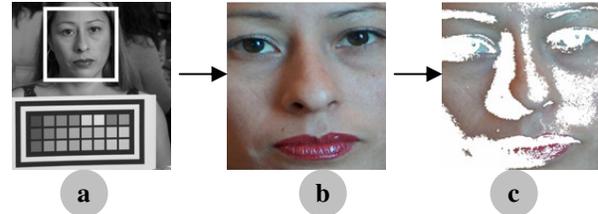


Figure 2. a) face detection using enhanced Viola and Jones method; b) apply face mask template; c) exclude pixels with luminance outside bounds

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 [9, 10].

A robust fast skin detector finds the face region placing a bounding box around the area, figure 1b. 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.

#### 3.2 Expert ground truth

The statistical classifiers are used as the basis of the cosmetic recommendation. The system locates an exemplar whose skin color distribution closely matches the test subject. Note that the statistical system simply replicates the opinion of the beauty expert contained in the database. This is significant because the beauty expert builds the database on her experience of application makeup on exemplars; she observes how a foundation dries, blends, and lies on the skin. This can vary significantly from formulation to formulation. The database contains the beauty experts' techniques and judgments which are more sophisticated than simply matching the color. For example she may select a foundation that does not "match" the color of a sunburn, rather a shade that helps the sunburn be less noticeable. This makes our system like the attended counter experience because we allow for the artistry of the expert. When we collect the database of exemplars and cosmetic mapping we conduct checks of the RGB values of subject's and cosmetic expert's selections to confirm the consistency of recommendation of our cosmetic experts.

Our studies 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 [9, 10]. The system can be configured to plug in any expert opinion that the consumers like, or the brand wants, or the public respects, etc.

### 4. SOLUTION DESIGN FACTORS

We conducted a number of paper-based surveys, focus groups and semi-structured interviews with over 200 female participants in California, USA. The age range was as follows: 25%: 18-27 years;

20%: 28 to 37 years; 30%: 38 to 47 years; 20%: 48-57 years; and 10% over 57 years of age. Participants were offered \$50 as compensation. 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%).

The qualitative data was analyzed inductively using the grounded theory approach. Using this approach, we identified a number of categories and concepts, as well as interrelations between each of them using coding and sorting. The key findings are as follows:

#### **4.1 Usefulness of the solution**

The first factor that we evaluated was usefulness – is the service addressing a real need of the consumers. Estee Lauder is one of the largest beauty brands, and in an independent study they found that 94% of women wear the wrong foundation shade [3]. Our discussion with cosmetics companies also confirms that shade selection is a massive unsolved problem that they have wrestled with for years. But in this study we sought to determine if consumers themselves recognized this issue.

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. 40% of the women regularly used visual inspection in the store to select a foundation of choice. We conducted an experiment where we asked all the women to visually select their shade, followed by determining the right foundation shade by two independent cosmetics experts. We then asked the participants to rate the shade chosen for them by the experts. Of the 80% of the women that liked the shade chosen by the experts, only 16% had visually selected it correctly. This shows that there is a need for automated beauty service that can aid foundation makeup color selection.

#### **4.2 Mobile vs. Kiosk**

We were approached by a large cosmetics company to create a commercial solution that would be a new way of buying makeup. The reason for the request is because the use of “old-media” like newspapers, radio and broadcast television networks is slowing decreasing in the younger generations, and is being replaced by “new-media”, like the Internet, mobile services, etc. They wanted to use mobile services to lead the adoption by the teenage market, and also since kiosk installation in stores is expensive and difficult to scale. Many kiosk implementations were tried in the 1980’s and in fact did produce a positive effect on sales and consumer satisfaction. However, these required trained attendants and proved to be expensive to staff and maintain.

The mobile cell phone based solution has its own challenges. The use of MMS and mobile internet in the US is limited - only 25% of users subscribe to a data plan, and about 50-55% subscribe to MMS in the US [8, 11]. Though 90% of our participants owned a cell phone, only 14% used mobile internet and 22% used MMS. Also, while selecting a foundation, correct shade matching is the number one criterion, but this is often coupled with other factors, two main ones being: a) formulation of the foundation (i.e. liquid, cream or powder) which is typically based on the skin type of the user (i.e. dry, oily or normal); and b) coverage provided (i.e. heavy, natural, light etc.) which is typically based on the skin condition (i.e. acne scars, mature skin etc.). Thus, we quickly concluded that we needed to provide other touch-points such as access from the Web and kiosk-based access in stores, as well as

additional techniques (without the use of installed software) on the mobile phone to input parameters such as skin type and condition in order to choose a customized product for the consumer. One of the options that we are exploring is SMS based “voting-style” input. When the user receives a foundation shade recommendation, she also receives instructions on replying to the SMS with certain “keywords” to personalize the results. E.g. enter “D” if your skin is dry, “O” if you skin is oily, etc.

#### **4.3 Installed software vs. Existing software**

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 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.

Consumer focused mobile services are very different from the most prevalent form of mobile applications, games – since the level of engagement is much low. Mobile services that are implemented to sell physical products must be designed such that there is the lowest form of commitment on the consumer’s part in terms of technology (no installation of the application), finance (no payment to download the application), and time (no learning period before being able to use the service). We observed that by eliminating the dependency on carriers or cell phone models we provide an easy on-ramp to the broadest range of consumers for widest adoption.

#### **4.4 Attended vs. Unattended**

We observed two varying views of the “automated” nature of the recommendation system. Some participants seemed to be more accepting of the science behind the technology and viewed it as “unbiased”, and did not feel pressured to buy a product that the system recommended. On the other hand, some participants were concerned that the human element required to make a judgment regarding a color- match is essential since the skin tone can get complex consisting of various undertones, etc. Our system database in fact comprises of expert advice by beauty consultants on various complexions. But this aspect was not clear and was a concern to some users. In future studies, we would like to understand if there is a distinct type of customer segment that falls in this category. We are also revising the user interface to reflect the “human element”.

#### **4.5 Use at home vs. Use at store**

For our system to work most accurately, one of the requirements is to have a clean face without any foundation. Women can have eye makeup and lipstick on if required. This requirement can be a problem for some women as they do not leave the house without any makeup on. Thus, the convenience of using a mobile service anytime and anywhere is very attractive. The distribution of the charts can be made through tear-outs in magazines, in the Sunday newspapers, or in shipment purchased online. On the other hand, some women prefer the convenience of using the kiosk version at the store, since they can make the buying decisions immediately based on the recommendations.

#### **4.6 Technical comfort vs. Social comfort**

Based on socio-economic segmentation (such as age, past technological background, income level, marital status, etc.) of the

research data, we discovered that young women were technically comfortable with using an MMS based service, but they are not socially comfortable using the system in an in-store based setting. The mobile based service is ideal for this customer segment. On the other hand, women older than 35 years of age were socially comfortable using the system in the store-setting. This segment was not as comfortable using MMS or web access on the mobile phone. For this customer segment, it would be ideal to create another touch-point (i.e. a kiosk) that is available in the store.

#### 4.7 Social vs. Individual

Mobile services usually have a social aspect that should not be ignored [2]. A majority of our participants said that they usually recommend a cosmetic product to their friends and family if it works for them, and they would like to see similar features in our system. Approximately 70% of the participants said that they would be willing to try a service only based on their friend's recommendation. Based on these observations, we are planning on extending the mobile service to incorporate social networking features. For example, if a customer is satisfied with the foundation recommendation made by our system, they will have the ability to share the application with multiple friends instantly.

Participants also expressed interest in a social beauty related website, where they can share their favorite products with friends; explore and discuss the products used by others with similar skin tone and skin type. They would like a personalized system that allows them to continue the shopping experience from home to store so that they can immediately access the products that were recommended for their skin tone.

#### 4.8 Privacy and trust

Privacy turned out to be quite an important factor for women consumers. Also, we observed that it would be harder to get customers to continue using the mobile service that was the state-of-the-art and ground breaking in nature, thus it is important to explore aspects that build trust.

##### 4.8.1 Provide control over collected data

Since our system is taking a photograph of their faces in order to make recommendations, a number of women were concerned about the location where their image will be stored, how it will be used, will they have an opportunity to delete the image, will it be used for marketing purposes, etc. The user interface should be designed to address all of these concerns. Initially, the SMS message was only sending back the shade recommendation. We modified the message to reflect that the photograph was used for image processing purposes only and was promptly deleted after the analysis was completed.

##### 4.8.2 Trust of personal information

One of the features that we wanted to evaluate was the ability to create a profile on a website (owned by a brand or a retailer) and view and keep track of products recommended by the system. To be able to do so, the customers would have to create an account and save their photograph along with profile preferences (such as skin type, condition, foundation formulation preference etc.). In our studies we discovered that the trust of personal information was driven more by *who* was providing the service as compared to the user interface itself. Most users said that they would be more willing to provide their personal information to a brand or retailer that they trust.

## 5. CONCLUSIONS AND FUTURE WORK

In this paper we discussed the solution design factors that affect the adoption and usage of mobile services by women consumers. We observed that while usefulness is an important factor, other solution design aspects such as mobile vs. kiosk, installed vs. existing software, unattended vs. attended, technical comfort vs. social comfort, home use vs. store use, social vs. individual, privacy and trust should also be considered.

We are incorporating changes in the user interface based on the findings in each of the above factors. In the next study, we will be using regression analysis to explore how these factors are weighted and find possible relationships between them in order to develop a model for accessing adoption of mobile services by women consumers. We are also planning on repeating the studies in various geographical locations to further enhance the model. We will also conduct in-situ user studies to explore how the social and technical aspects; and the physicality of holding the color chart affect the usage of the system.

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