Thoughts and Tools for Crafting Colors: Implications from Designers' Behavior

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ABSTRACT
Despite the substantial changes made in the platforms to create graphic works, it is hard to clarify the improvement of authoring tools to manipulate design components such as colors, text, and images. In this regards, this paper presents empirical findings from designers' behavior and suggests preliminary ideas to develop graphic tools that support the visual design process. In particular, this paper focuses on the articulation of colors and images in the context of graphic design. Through experiments with designers, we investigated how designers perceive images and colors and how they create integrated aesthetics of images and color components. Based on the findings, we characterized a general color design process and derived implications for graphic tools to support image comprehension, color craft, and archiving design changes. As a primitive attempt, we expect this study can provide insights to advance the way of manipulating a variety of design components.

Author Keywords
Graphic design; color design process; visual content; image-color combinations.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

INTRODUCTION
Due to the rapid growth in its popularity and importance, the use of the visual content is now prevalent throughout media and platforms. A variety of visual contents such as images and videos are now engaged in the communication process to convey informative and/or emotional messages. Accordingly, a variety of services has been introduced in the market in order to support users who want to create personalized and aesthetic visual contents.

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For instance, Canva [1] is a platform that enables users to generate a wide range of two-dimensional graphic works utilizing pre-designed templates. Similarly, Magisto [10] and Shakr [9] provide automatic video editing services based on video templates and editing algorithms. Wix [7] and WordPress [5] are well-known platforms to publish a website, and these platforms significantly reduce the barrier that has obstructed novice users who do not own sufficient knowledge and skills to design and build a website. In general, these services are characterized by a large body of pre-designed templates and automation of a certain part of design tasks. Due to the aid of these services, the design activities of novices now become proliferated throughout various domains including web publishing, application development, and multimedia production.

There have been considerable changes in the tools and interfaces for experts as well. One of the distinctive trends is the embodiment of crowdsourcing technology. Sharing design resources in the crowdsourced platform is now prevailing among professional designers. Such platforms also function as a public archive and portfolios of professional designers to promote themselves [6, 8].

Although significant development has been made in the macroscopic systems to generate visual content, it is hard to notice changes in microscopic tools to manipulate design components including text, colors, and visual content. In particular, the authoring tool to manipulate colors is rarely changed or improved despite its prevalence and importance on the design process. Figure 1 compares the color picker of Adobe Photoshop version 1.0 (released in 1990) and version CS 6 (released in 2012). Except for the Lab color values, the interfaces almost remains constant for more than 20 years.

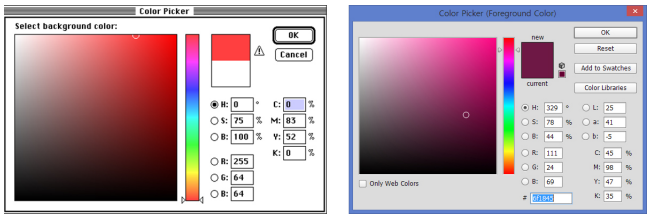

Figure 1. Comparison of color pickers of Adobe Photoshop version 1.0 (left, released in 1990) and version CS6 (2012).

In this regard, this paper aims at investigating the way that people uses graphic tools and suggesting implications for visual design tools in particular interest of color manipulation. In a more detail, the goal of this study is understanding the creative nature of color design process and presenting implications for a graphic tool to promote creative and reflective authoring activities of general users. To achieve the goal, we conducted experiments with designers to understand their color design process. Along with their design outcomes, we analyzed verbal protocols in order to understand their latent thoughts. Note that this study explores the designers' process not because we target the expert group, but because the trained people are more fluent and familiar to demonstrate their thoughts and intention regarding design creation explicitly. Thus, the implications proposed in this paper are not restrained to tools for a professional usage. It rather argues its implication to ease the visual design process of general users in a wide range of tools and interfaces.

The rest of the paper is structured as follows. We first overview the related research that deals with color design. We then introduce experiments with designers to understand their color design process in the context of visual content creation. Based on the findings from qualitative analysis, we present practical implications for color manipulation tools and suggest prospective topics to be investigated further. The paper concludes with a broad discussion and limitation of the study.

RELATED WORK

In relation to the aim of this study, we have identified two fundamental topics that have been widely investigated by researchers. One topic is related to the perception of color and the other introduces tools that support the color design process.

Perception of Colors

Color is one of the most important factors that have a strong influence on human perception. Hence understanding the perception of colors was long been an interest of researchers. For instance, Osgood et al. [1, 23] revealed the cross-cultural similarities in the affective perception of colors. They associated colors with perceptual aspects including as evaluation, activity, and potency, and specify the emotions each color is related. The study of Valdez and Mehrabian [35] reported the strong and consistent effects of saturation and brightness on emotions. A more recent of study by Suk & Irtel [38] also supported the major influence of tone upon the emotion.

Not only the perception of single color, but also the color combinations have been studied by several authors. Ou and Luo [25] developed a three dimensional color-emotion space defined by activity, weight, and heat of colors. By positioning single colors and color combinations on the same space, they revealed that emotion of two-color combinations can be estimated by the mean of single color emotions. Addition to emotion of color combinations, color harmony has long been an interest of researchers. The early studies [13, 16, 28] has suggested universal and global principles, while more recent studies [32, 34] have differed the emotions that colors can convey. Like Goethe [13], Munsell [28] viewed balance as a key to creating harmony among colors. Matsuda [22] suggested a hue template that defines harmony among colors. Similar to the Matsuda's study, various color harmony principles were suggested, and a quantitative measure developed by Moon and Spencer [25] was one of them. A more recent study of Ou and Luo [33] also emphasized the great influence of hue on color harmony.

Although these studies have supported a better understanding of the perception of colors and color combinations, there is little information available on how the knowledge engages in the design practice. In this manner, we believe that this study can contribute to the understanding of the knowledge and tactics embedded in the color design process.

Tools for Color Design

Inspired by the findings of color harmony research, a number of tools have been suggested to support the generation of harmonious color combinations and its applications to certain design contexts [15, 23, 27]. For instance, Meier et al. [23] developed a toolset, Interactive Palette Tools (IPTs) that enables various activities including browsing, breeding, displaying of color palettes. Hu et al. [15] presented a tool that helps users to generate color themes based on the principles of familiarity and rhythmic span. Studies by Hsiao et al.[14] and Jahanian et al. [17] both utilized the image colors to construct a color theme and applied the theme for graphic and product design. Compared to the tools that only generate color schemes, the tools developed by Hu et al., Hsiao et al. and Jahanian et al. provide a more situated and extensive ability by allowing a direct utilization of a color theme in design practice [14, 15, 17]. A recent study by Jalal et al. [18] suggested a color interaction tool based on five key color manipulation activities they identified. Among commercial tools, Adobe Color CC [3] and Colourlovers [4] are well-known services due to the academic contribution of their database [19, 29]. Both services provide a tool to generate color themes and a platform to share the color resources. Adobe Capture CC [2] is another notable applications that support the color design process. In addition to color theme generation, it covers a wide range of design applications based on the platform of Adobe systems.

Although these tools have assisted an easier way of tailoring colors, their applications are limited to color combinations instead of the integration of colors and visual contents. In the present study, we thus tried to provide a novel and practical insights by investigating implications for graphic tools used in the integrated color design process.

EXPERIMENT WITH DESIGNERS

We performed experiments with designers to understand the process of manipulating colors in the context of visual content generation.

Method

Participants

A total of 15 designers participated in the individual experiment. All of them hold a bachelor's degree in an industrial or graphic design major and are currently enrolled in a graduate school of industrial design. The participants' mean age was 28.6, ranging from 26 to 31.

Materials: Images and Keywords

For the experiment, we prepared a set of 1000 by 1000 images and style keywords that deliver a certain emotion or affective image. Images were pictures that portray various topics including people, objects, animals, plants, and landscapes. Although the main objective of this study was understanding how designers create an aesthetic image-color combinations, we have specified the desired style of each image-color combination to observe multifaceted tactics and strategies of designers. The style keywords have been adopted from both of PAD theory [36] that suggested three dimensions of emotion and Color Image Scale [20] which investigated the emotion that colors can deliver.

Table 1 summarizes the information of stimuli of all three experiments. Instead of providing the same stimuli to every participant, we prepared three different set of images and style keywords. As a result, five designers received the same stimuli. In the stimuli, some images were presented more than once with different style keywords. This experimental design allowed us to investigate how designers' color choice could be differed according to the changes of design contexts.

Set	Style keywords	No. of images / keyword
1	4 keywords: Active, Afraid, Depressed, Relaxed	30
	120 image-color combinations / designer	
2	10 keywords: Chic, Clean, Enjoyable, Intellectual, Modern, Pastoral, Peaceful, Placid, Sporty, Youthful	5
	50 image-color combinations / designer	
3	10 keywords: Cheerful, Fresh, Friendly, Graceful, Healthy, Polished, Restful, Simple, Tender, Wholesome	5
	50 image-color combinations / designer	

Table 1. Stimuli for three experiments. Each experiment utilizes a distinctive set of keywords and images.

Procedure

The experiment was conducted individually in an isolated room that disguised as an office environment with a desk, a chair, and a desktop computer. Figure 2 shows a brief look of the experimental setting. When the experiment began, one of the images was presented with a style keyword. The designers were instructed to decide a color that is harmonious with the image as well as delivers the style suggested by the keyword. As a design outcome, they asked to present an image-color combination by filling the selected color into a rectangle located under the images (Figure 2). The size of the rectangle was 1000 pixels wide and 350 pixels tall, and the entire design process was performed with Adobe Photoshop® CS6. The color-selection task was described as a part of graphic design, but we did not specify its use in order to explore general and unbiased behaviors of designers that could be applied to a wider range of applications.

Throughout the experiment, we also asked them to think-out-loud their thoughts and concerns as much as they can. However, we did not strongly enforce them to keep speaking in order to minimize its influence upon the design activities. Instead, we conducted a thorough posthoc interview to retrieve the details of their thoughts by reviewing the design outcomes together.

Data Analysis

Through the experiments, we obtained design outcomes - 1,100 image-color combinations - and verbal protocols from think-aloud and posthoc interviews. To understand the designers' latent thoughts, we began with the analysis of the protocols and utilized the design outcomes as supplementary quantitative data.

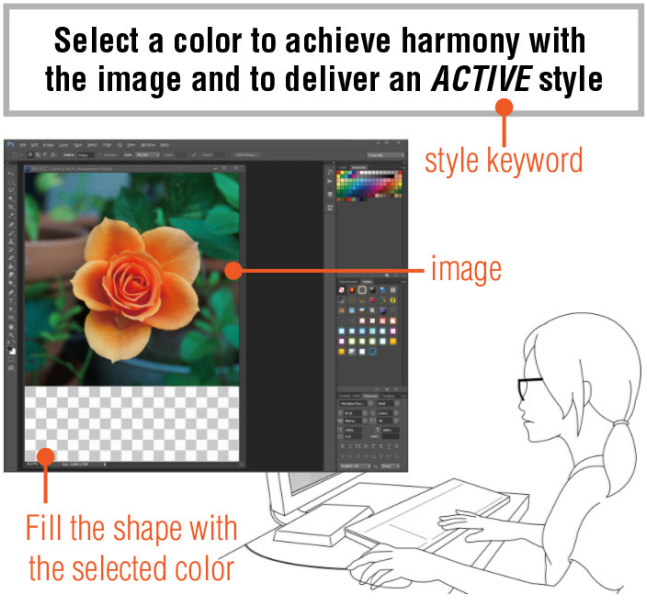

Figure 2. Settings and exemplary task of the experiment

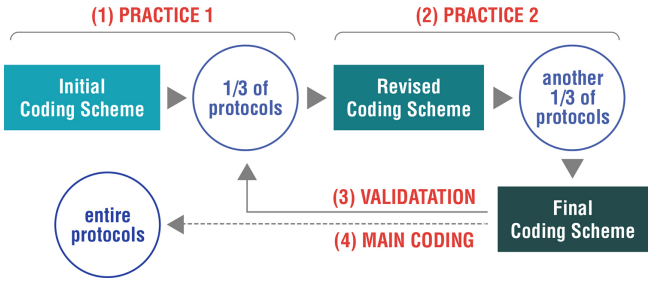

Figure 3. The entire coding procedure

The protocols were transcribed verbatim, and the transcripts were used for the analysis. Since we had a sound perspective on the objects of investigation, we conducted a closed coding with a predefined coding scheme. The initial coding scheme was developed based on our research question as suggested by Miles and Huberman [24] and had revised and confirmed during the two repetitive pre-coding practices. Figure 3 shows the entire coding procedure. The pre-analysis consists of two phases of coding practices to develop a solid and comprehensive coding scheme. With an initial coding scheme, one of the researchers analyzed one-third of the protocols and revised the coding scheme. During the first practice (Figure 3, (1)), a code that comprehends image, color and style were added to the scheme. In the second practice, the researcher coded another one-third of protocols using the revised scheme (Figure 3, (2)), and developed layers of the final coding scheme by specifying the subcategories of Image code. At last, the final coding scheme was validated by revisiting the protocols that have analyzed in the first practice (Figure 3, (3)). In the validation process, an external coder, who has more than three years of experience in qualitative studies, was invited to review the final coding scheme along with the protocols.

Figure 4 shows the structure of the final coding scheme. According to the factor that designers mainly considered, we classified the segments of protocols into one of the seven codes (A~G). The categories from A to C include verbal expressions that participants solely designate an individual factor such as Style keyword (A), Image (B) or Color, respectively. In the cases of Image (B) and Color (D), subcategories were utilized in order to discern the intricate changes in designers' perspective. The rest of four categories encompasses designers' cognitive activities regarding interactions between Style-Image, Style-Color and Image-Color as well as the holistic view of Style-Image-Color.

The qualitative analysis enables us to understand cognitive process of designers to create integrated aesthetics using images and colors. The results were interwove with the design outcomes which visualize the last decision of designers. In the following sections, we will discuss the findings that have been revealed and confirmed by both qualitative and quantitative analysis.

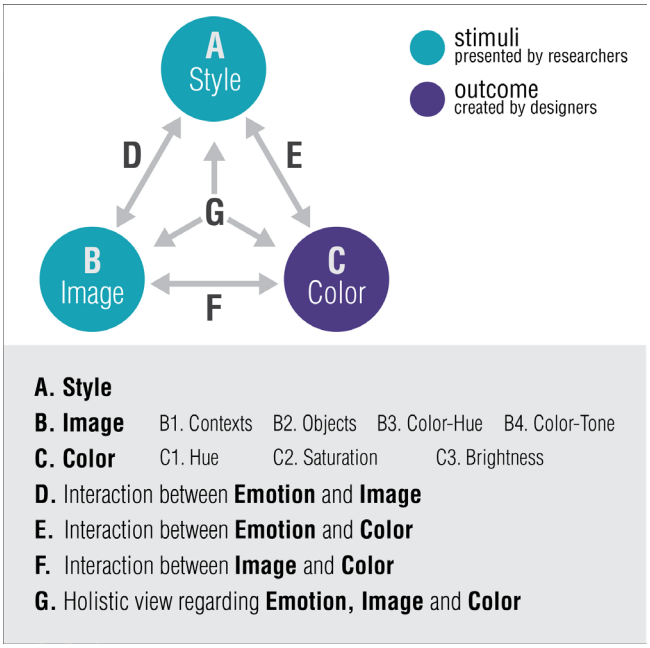

Figure 4. Structure of the final coding scheme

FINDINGS FROM DESIGNERS

Through the observations during the experiments, we noticed that the procedures of generating desired colors are much alike among designers. In short, it consisted of three activities. They have started the practice by identifying representative one from a mass of colors in an image. In most cases, designers employed the Eyedropper tool for the sorting-out activity. Once they identified a good starting point to proceed, they moved to articulating the initial color. In this step, the Color Picker has been mainly explored to identify better alternatives. While selecting a proper color for the image, they also considered the integrated visual effect generated by the combination of the image and the color they selected. Figure 5 (next page) is a diagram that summarizes the color design process by locating principal cognitive activities in parallel with the use of design tools. We visualized the process as a linear flow for its clarity though the reality was a mixture of parallel and synchronous activities.

How designers perceive images

The analysis of the protocols revealed two different perspectives that designers perceive and understand given images. The first perspective was color-focused perspective and the second one was semantic-focused. When a new image was presented to them, designers tended to deploy one of the perspectives predominantly, while both engaged in the perception of images mutually in most cases. Following sections provides the descriptions of each perspective with supportive instances from both verbal protocols and design outcomes.

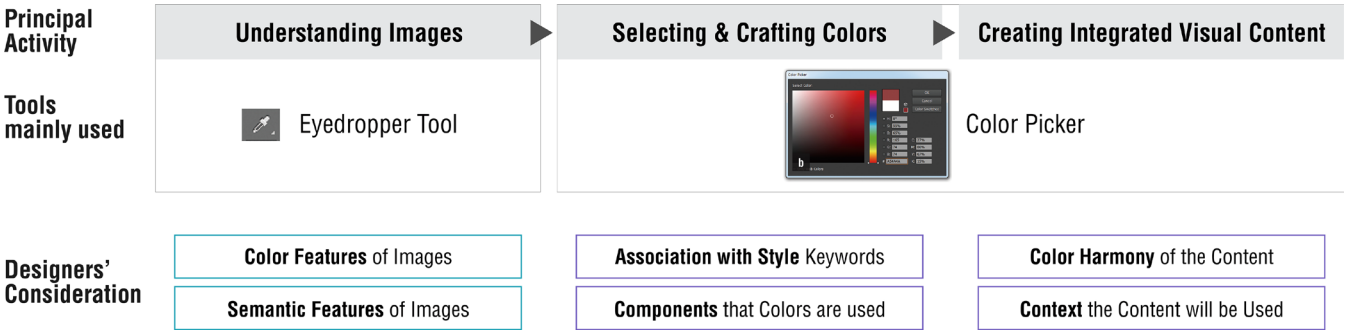

Figure 5. Color design process in general. It comprises three principal activities, of which has distinctive considerations.

Color-focused: Image as a Collection of Hues

Since the design task was generating a color for an image-color combination, designers naturally exhibited a primary focus on the color features of images. A majority of descriptions of a new stimulus – an image and a keyword - has begun with stating noticeable color features that an image possesses. We compiled the descriptions of images and unfolded two characteristics in relation to designers' perception of colors in an image.

First, the nomenclatures appeared in the descriptions attested designers' intent and delicate views on the hue rather than the brightness or saturation of an image. To be specific, terms related to hues were identified far more than those of saturation or brightness. Table 2 provides the average percentage of the terms used per designer, and representative expressions for each category. Throughout the transcripts of 15 designers, 87.10 % of denotations were selected in consideration of hues, while the terms regarding tones only took 12.90 %. Since the hue feature has more definitive nomenclatures to describe its condition than tone, it is difficult to directly compare the quantity of comments. Despite the difficulties of the direct comparison, it is considered that the frequent mentions of hue features implies the rich and exquisite capacities of designers in hue perception.

Then, we moved to a profound analysis to understand how designers comprehend an image and incorporating its features into design process selectively. By discerning the color features involved in the color generation process, we identified two distinctive measures which are devised by designers, that is, **color-dominance** and **color-saliency.** Figure 6 shows images and all colors selected by designers in consideration of different style keywords. Depending on the color distribution of images, designers tended to selectively devise one of the two measure in the perception of images.

The measure of **color-dominance** was typically devised when an image is perceived as a single color feature that holds the global tone or hue of the image. The upper part of Figure 6 is an exemplary that illustrates the apparent color-dominance and its impact upon the color selection of a designer. As shown, the images are recognized in relation to blue or yellow respectively, and the majority of designers' colors follows the dominant hue in general. The verbal protocol of designers supported the involvement of color-dominance measure. Words such as *'Bluish Gray', 'Light Blue' 'Blue tone'* were utilized to depict the left picture while *'Yellowish'* and *'Lemon'* were repetitively appeared in the comments regarding the right one.

	Expressions of Hue	Expressions of Tone
Examples	Yellow, Red, Brown, Blue.. (color names), Warm, Cool, Blu*ish*, Green*ish*, *Nuance* or *Hint* of ~, *Shades* of ~…	Monotone, Neutral, Pastel, Vivid, Dark, Dull, Lightness…
Average % of its Frequency	87.10 %	12.90 %

Table 2. Expressions used to describe color features of images. The average proportion is calculated based on frequency.

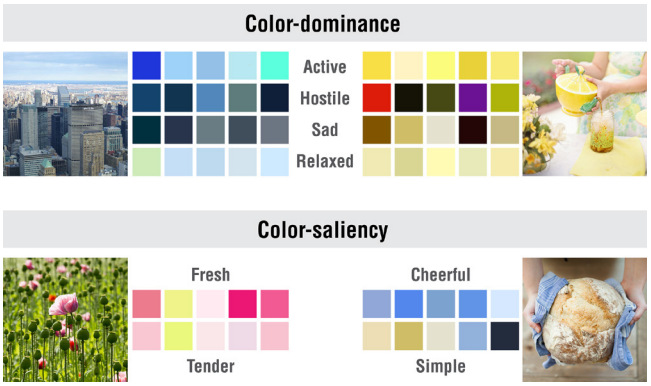

Figure 6. Images and selected colors demonstrating the semantic-focused perspective in perception of images

Contrary to such decision-making process, participants also utilized the measure of **color-saliency** to grasp representative colors. Like the lower cases of Figure 6, several images had salient color segments that are much more distinctive and noticeable than the rest. In these cases, participants tended to refer the salient colors by using specific color names. Opposite to the salient region, the rest often described as a background. Regarding color selection, however, designers exhibited a comparable use of background color depending on their intention or desired styles.

Semantic-focused: Meanings of Objects

The *semantic-focused* perspective is related to the **object-semantics** that describe the properties and/or sentiments of objects in given images. The focus of object-semantics is local and individual instead of embracing the entire features of an image, and exhibits interactivity with the color features of the object.

Figure 7 shows four image-color combinations that have been mentioned by designers with the view of object-semantics. The first image was presented with keyword *Cheerful* in experiment 3, and D11 described, *"In this image, yellow-green or the color of the rail load is dominant, but I'd like to use the red from the train. Somehow I can feel cheerfulness from the train, such as an excitement of a journey."* The designer related the perceived semantic of the train with cheerfulness. In the case of second images, D8 thought of the sunshine as the most *Pastoral* thing of the image. Hence she utilized the color of the sunlight to represent Pastoral mood in her image-color combination.

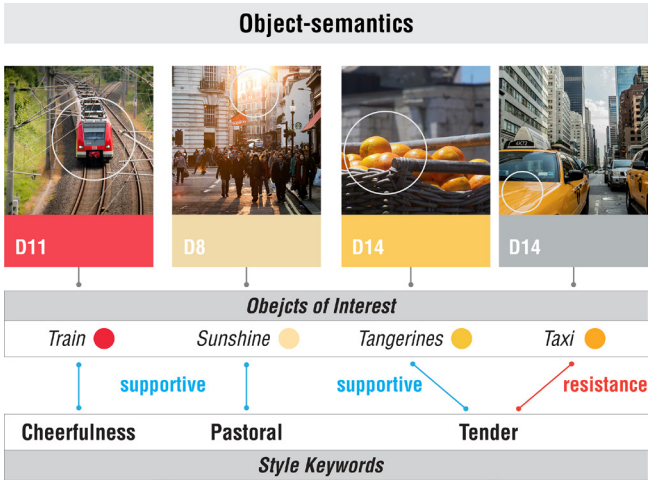

Figure 7. Examples that demonstrate the engagement of object-semantics in color design process. Three examples from the left shows that colors of the objects of interest support the style keywords. The right case is conflicting case that the object-semantic does not match with the style keyword.

The last two images of Figure 7 demonstrates how object-semantics can vary the perceived meanings of colors. Both images have similar color distribution – main objects with yellow color and grayish background. When the two images presented individually with the same keyword *Tender*, D14 made different choices. Yellow was selected for the picture of tangerines while light gray was picked for the street picture. During the posthoc interview, the designer plainly mentioned the influence of object-semantics: *"I think.. it relates to impressions of each object. I recognized the similarity in color features, but it was hard to associate the tenderness with a car, I mean a taxi. However, I can sense soft and warm feelings from fruits."*

The evidence of object-semantics was observed frequently and commonly among designers throughout diverse stimuli. Though its influence was strong enough to overwhelm other factors, it broadly interacted with the given keywords and colors of the object during the color selection process. In qualitative analysis, the view of object-semantics was mainly identified in concordance with the code G (Figure 4) which encompasses the holistic view regarding image, style, and color. This result suggests that object-semantics have supported the integration of image, style, and color. Thus it contributes to a semantic structure among them which provides a persuasive rationale for designers' selection.

In addition to the role of object-semantics, we identified another interesting trait originated from individual designers. Even with the same image and keyword, sometimes the perceived semantic upon an object was highly personal and idiosyncratic. Figure 8 highlights the outcomes of two designers who made unique interpretations on meanings and relationships between objects and the given keyword. As shown, the mood of presented picture is quite distant from the desired style *Enjoyable*. The perceptual distance made the task fastidious, and all designers commented its difficulty. As a result, three designers did not deploy any of semantic-focused perspectives, but D7 and D10 brought their personal impressions into the design process. For instance, D7 mentioned about a warm and delectable tea time to support his color choice from the golden teacup. On the other hand, D10 related the *Enjoyable* feeling with books: *"I wanted to convey the pleasures of reading since there are books in the image."*

Figure 8. Personalized interpretation of object-semantics regarding the style keyword.

As mentioned previously, we did not make a minute observation on the results of the code A (Figure 4) which is solely related to given style keywords. A preliminary analysis suggested characteristic differences of designers in the perceiving and interpreting the style keywords. This indicates the possibility of other factors that encourage designers to disclose their distinct characteristics. Hence it is hard to argue that object-semantics is a major factor that enforces the expression of personal identities during the design process. Considering the role of object-semantics, however, we believe that understanding the view of object-semantics has a significant relationship with the understanding of the way that designers express their identity. Designers constantly endeavor to provide meanings and values toward their design. Throughout the endeavoring, object-semantics offer opportunities to build compelling narratives behind the design by integrating multiple design components. Although there have been attempts to utilize the outcomes of designers [21, 30], the tactics and strategies embodied in the color selection process are still veiled. As an initial step, investigating the utilization and implication of object-semantics could contribute to understanding a hidden facet of designers' tacit knowledge.

Furthermore, the view of object-semantics also implies design-oriented potential of advanced techniques in other disciplines, for instance, an object detection technology which identifies objects in images. Due to the continuous efforts made in computer vision domain, the technology is now capable of detecting objects rapidly with a high detection rate [12, 39, 41]. However, the technology has yet been applied to construct a meaningful narrative that delivers a sentiment and intent. By incorporating these techniques in further studies, we expect novel insights that trigger prospective applications are suggested and demonstrated.

To summarize, examining the color features of images seems the prior and major perspective of designers to perceive an image (color-focused perspective). Specifically, designers selectively focus on either of the dominant colors or salient colors depending on the color distribution of an image. In addition to color features, designers also perceive semantics from the image (semantic-focused perspective). In general, object-semantics broadly engages in the interpretation and configuration of the entire design components – image, color and a keyword.

How designers craft a color

In the earlier stage of color design, designers exhibited a tendency to discover colors that represent given images. Once a satisfactory color is identified, designers moved to craft the color to make it aesthetically and purposefully proper for design usage. In such crafting activities, we identified two distinctive factors that designers considered. The first factor is the style keyword we provided in the experiment, and the second one is a design component designers assumed that the color would be applied.

In general, designers identified multiple representative colors. Thus they had to select one among them since a single color was the solution we asked. We found that style keywords are frequently used to prioritize the representative colors according to their perceptual congruity with the given style. Figure 9 shows two sets of a design outcome along with representative colors that have been discovered during the design process. The left set of Figure 9 derived from outcomes and verbal protocols of D11, the participant of experiment 3. He said, *"This image is quite complicated. There are several salient colors - yellow, red, and purple... Among them, I think, yellow fits to the Fresh feeling."* His description explicitly displays the role of style keyword to select the most suitable color from the representatives.

Through prioritization, designers were able to narrow down their choices into a single color feature. Thus it was one of the most significant decision-making activities throughout the color selection process. In addition to the selection, the style keywords were also highly engaged in the articulating process. D8 who designed the right set of Figure 9 said, *"Ugh... this was a truly knotty case. For me, this image is something opposite to Chic mood. Among yellow, red and green, I looked for a color that is likely to be Chic. Green was chosen and I deliberately change its tone to the dark one."* This partial protocol clearly demonstrates the act of color selection and the further elaboration of the selected color according to the style keyword.

The other factor that designers considered in the articulation stage is the component that the color will be used. Even we did not specify the usage of the color selected, designers frequently assume or imagine its usage by themselves to assist their decision making. The most notable consideration is whether the color will be used for text or not. Seven designers have considered the text component when they design the color, and articulate the color in order to make it more proper to be used for a text color. It is highly related to the functional aspect of the design outcome that determines its readability and clarity.

Figure 9. Engagement of style keywords in selecting and crafting colors. The left example demonstrates the role of the style keyword in the selection of colors and the right one demonstrates both selection and crafting of a color.

Additionally, there were instances that a color is considered as a background or a dominant color of the design. Since we asked designers to fill a rectangle, it is somehow natural to assume a background color to present an image or texts. In this case, designers often exhibit their prior knowledge about the area effect, which means that a larger area makes the color looks more saturated [26].

How designers create integrated aesthetics

At last, we observed two viewpoints that help us to envisage the designers' perception upon image-color combinations. The findings were mainly extracted from the segments belong to the code F (Figure 4) which signify the interaction between an image and a color. In terms of their properties, the viewpoints are not compatible with each other, but each provides valuable insights and implications towards potential applications.

The first viewpoint is considering the image-color combination as a two-color combination. We observed multiple cases that designers devised their prior knowledge upon the color harmony and emotion. Words such as *'contrast' 'rhythm'* and *'balance'* frequently appeared in their descriptions. They also referred to the general emotion and perception they had obtained from various color combinations. For instance, D6 commented, "For me, a strong contrast between complementary colors looks dynamic and active." D7 also mentioned that the use of analogous colors looks not only harmonious but also calm and *Peaceful*. In relation to this viewpoint, we identified that designers considered the color as a liberal design component that is not subsidiary, but equivalent to the image. Especially when designers had a clear intention or design direction, the color often became a leverage to steer the look and feel of the entire image-color combination. They strived for unified and synergetic visual impressions by manipulating the color.

The second finding covers a wider and practical view of designers. Although the use of image-color combination was not prescribed purposely, nine out of 15 designers mentioned a specific use of the image-color combination more than once. For example, D11 said, *"If I'm gonna use this for a perfume package…"* The comments of D12 indicates a possibility of different color selection criteria depending on the purpose: *"If this is for a calendar, I think this color can be a good alternative, but for a book… I'd rather use a heavier color."* Throughout the protocols, *a book cover, a calendar, a package* and *a poster* were mentioned, and *a perfume package* and *a travel guide* were specific cases with the detailed application.

DISCUSSION: IMPLICATIONS FOR TOOLS

Based on the insights and thoughts identified through the experiment, we explored their implications upon the development of tools and further studies to support visual design process of both novices and experts. The implications are classified into three categories: how to support the utilization of images, how to improve the ways of color manipulation, and how to provide a better way to explore alternatives.

Supporting Comprehension of Image Colors

Although an image has a bunch of color features, only a few attracted designers' attention and involved in the design process. In general, dominant or salient color features were mainly considered, and hues received more interests than the features of tone. The Eyedropper tool was the one and only tool that designers utilized to explore and simulate the color of an image.

Considering the repetitious actions of designers using the Eyedropper tool, it seems like that there is a disagreement between the purpose of the task and the capacity of the tool. The Eyedropper tool is suitable to extract a single color from few pixels but does not fit to extract multiple colors from a broader range. In the perspective of color perception, designers' main interest was the distribution of the color in order to identify dominant or salient colors. Instead of the eyedropper tool, an instrument that displays the distribution of colors or summarizes the color features of a broader space could be an alternative.

A function that automatically extracts several colors and presents them along the image could be one of the solutions that minimize the designers' effort to identify representative colors. Fortunately, Adobe Capture CC [2] provides the function that allows users to extract five-color themes and utilize the theme throughout the Adobe platform. However, the prime features of the service are not sufficient to aid the perception and utilization of image colors. To better represent an image, the number of colors in a theme could be flexible. In addition, the size of color swatches can be differed depending on their dominance or saliency in order to represent the importance of each color.

In addition to the color features of images, designers frequently devised semantic-focused perspectives. Advanced technologies related to object detection may replace a part of designers' ability within an automatic design system. However, the semantics that designers reflect upon an object or a context is significantly complicated and yet fully investigated. Further research is required to understand the way that designers deploy the semantic perspective and the tactics utilizing the semantics to construct a compelling narrative. Moreover, its relevance and values should be investigated more profoundly in prior to introducing such technology into the graphic tools for designers.

Providing Flexibility to Color Manipulation Interfaces

Regarding the tool used, the crafting of a color was mainly performed on the plane of Color Picker. When designers explore the multiple colors and try to prioritize them, it seems the Color Picker provides an adequate amount of usability. It has a hue slider that alters the hue value only and this offers easy transitions among distant hues. Since designers depicted a greater interest on hue features rather than the brightness or saturation, providing an independent instrument seems like a good strategy. As design process proceeds, designers rarely made a huge movement on color features. Instead, they kept simulating alternatives with minimal differences and tried to identify the most satisfactory color. In this stage, the Color Picker has shown limitations on assisting the delicate manipulation of colors. The easy transition benefited from a hue slider shifts to a limitation which discourages a further elaboration of the hue feature. Few designers made attempts to adjust the numerical values of a color, but a majority of designers prefers to utilize the graphical user interfaces. Even a designer (D15) who used the numeric values commented that manipulating numbers do not provide any sense of perceiving and elaborating a color. He also mentioned that it is almost impossible to correlate the changes in color values with the ones in the appearance of a color.

Considering these issues, GUI (Graphic User Interface)-based color tools seem to be preferred by designers, because of its conceptual coherence as well as its usability. On the basis of the current interface, providing a zoom-in or magnifying ability would be a good strategy to flexibly respond to designers' needs upon color manipulation.

In a more radical way, providing a three-dimensional representation of a color space could be a significant change that breaks the limits of two-dimensional space. In general, colors are designated by three-dimensional color spaces such as RGB, HSB, and Lab. Thus, a three-dimensional representation could be more natural and intuitive to understand the relationship among color features and the distance between two colors. By granting a controllability over the entire features of a color, the final elaboration color could be largely smooth and fluent.

Archiving Design Moves for Alternative Exploration

In general, we also identified that there is no sufficient space to review the changes made and compare several alternatives generated from such changes. In particular, there was a limitation to compare multiple image-color combinations together in the middle of the design process. Because of this limitations, designers inevitably chose to narrow down their alternatives into two, and compare them by switching between two colors. This caused repetitive operations since designers were not able to compare even two alternatives together.

Considering the iterative nature of design process, providing a repository to save and retrieve their design movements can aid designers to effectively manage the entire design process. Even in the Color Picker, designers made a number of trials to pick a color. However, none of the trials are recorded or successively displayed during their actions. By recording the traces and presenting them properly, the tool can promote the reflection of designers that increases the design-driven activities and brings new insights [35, 37].

It also would be useful to provide a space to juxtapose several alternatives to compare and evaluate the integrated design outcomes. In the case of our experiment, an image-color combination was a design outcome for each of the task. Thus, it was important for designers to view the image and the color together. In general, graphic design practice often incorporates different types of resources and elements. Enabling parallel comparison among various combinations of multiple resources could improve the compatibility of a graphic tool and enlarge the design space of designers. There also have been several studies related to the benefits and advantages of providing alternatives in parallel [11, 31, 40]. Based on the knowledge from these studies, a future study can be advanced further in order to suggest a novel tool for graphic design practice.

CONCLUSION

The present study has conducted to understand the intricate aspects of color and image manipulation in the context of visual design and to provide practical implications for the development of graphic tools. Through the experiments with designers, we investigated how designers perceive images and colors and how they create integrated aesthetics of colors and images based on the capacity of current graphic tools. The findings revealed a comprehensive color design process which comprises three activities – understanding images, crafting colors, and creating integrated visual of an image and a color. For each activity, we also identified factors that influence the decision making of designers. In particular, the engagement of object-semantics and personal interpretation regarding the object-semantics provided a probable explanation about how designers make their design distinctive and idiosyncratic. Based on the findings, implications for graphic tools were suggested to support image utilization, color manipulation, and alternative comparison during the design process. Although it provides relevant findings, this study has limitations including its context confined to a color selection task. The suggested ideas for graphic tools are also needed to be implemented and verified. As a primitive attempt, we expect this study brings forth in-depth studies to understand constituent characteristics of the design process and inspires further investigation to develop better tools for the creation of creative aesthetics.

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