The Story of a Color Advisor

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Abstract

The average person has little or no experience with color work nor the time or desire to be trained in its use. This is one of the big color computing problems that our profession has to face: because even though the computer brings to the average individual powerful color capabilities, it is unlikely that such a person will know how to use or will learn how to use color wisely. One of the original charters of Canon Information Systems was to develop a better way to do computer based color work. In our attempt to fulfill this charter we started by doing some basic research. Based on this research we developed some concepts, performed a number of experiments, and from the gathered data developed the Canon Color Advisor. The Color Advisor was included in every Canon Bubble Jet Printer Driver for over two years.

Our fundamental research explored how people in various fields using non-computerized methods select and use colors in their work. From this study we isolated the idea that color selection and use was based on a projects' context, its' intended audience, and its' expected outcome. In other words, colors are not chosen and used in some random, ambiguous fashion but with a method and a goal. The method was to analyze the nature and goals of the current project and from that develop a small palette of colors.

From these empirical results of our research we developed a two-stage experiment geared at gathering data about potential relationships between color and descriptive terminology. The results of this study identified a list of 31 terms that were at once descriptive of a document project and colorful. Then in order to associate each of those 31 terms to a number of defined colors we ran a trial experiment on a group of subjects. In it a test subject rank a defined set of 75 colors according to each of our 31 terms.

By averaging the results from these trial tests we created a set of "color relevancy curves" for each term. Then the 31 terms were grouped into four categories: audience, occasion, style and setting. The idea was that by picking one term per category a user could define the nature and goals of their project and from that point, using the color relevancy curves, our software could create a small palette of colors for them. From our original research we had determined a useful palette to be made up of one dominant color, two coexisting colors, two each supporting colors for each of the dominant and coexisting colors, three highlight colors and black.

We formulated a simple algorithm: from the curve of one descriptive term the dominant color could be chosen as the color with the highest relevancy value. From that dominant color two coexisting colors were determined. Supporting colors, two for each of the dominant and coexisting colors were calculated from the color that they were to support—basically one lower in value and one higher in value and lower in chroma than the color that they were supporting. Highlight colors were determined using the dominant color as a starting point. This basic algorithm was expanded so that if more than one term was selected then the relevancy curves were averaged together and the resulting composite curve was used to determine the dominant, coexisting, supporting and highlight colors.

The results of this work were productized as the Canon Color Advisor. Unfortunately it was buried into the BJ drivers and most users never saw or used it. We believe that that there are further color use technologies that could be developed from our investigations and work. Among them are, Color Agents, Color Use Profiles, color palette resources, system wide color work management and color work management tools.

Introduction

For most of those who develop color technology for the computer, color fidelity between devices is the big problem and much effort and progress has been made towards solving it. But there are other problems with color work on the computer.

One of these other problems is that, even though the computer brings to the average individual powerful color capabilities, it is unlikely that such a person will know how to use or will learn how to use color wisely. Why is this? Because, the average person has little or no experience with color work nor the time or desire to be trained in its use. Most people rely on intuition, blind luck, or their grade school color education in their decisions about color, often with the result that their color work is not satisfactory. As a result, many people are frustrated with their own color work and do not want to deal personally with color decisions.

With this as our premise we were charged with the task of developing a better way to do computer based color work. We asked ourselves, "How can we make working

with color less of an effort and more enjoyable for computer users?", "What are the obstacles preventing computer developers from doing this?", and "How do we really empower computer color users?"

Basic Research Crystallizes a Theory

In our attempt to find answers to these questions we did some basic research. Based on this research we developed some concepts, performed a number of experiments, and from the gathered data developed the Canon Color Advisor. The Color Advisor was included in every Canon Bubble Jet Printer Driver for over two years.

In our basic research, we explored how people in various fields, using non-computerized methods, select and use colors in their work. We divided humanity into four color use type categories.

First, "The Common Human". The common human is most likely to interact with color as it affects their immediate environment. Making a personal decision about the color of a car, clothing, house, furniture and decor, even choosing pencil or paper clip.

Second, "The Technician". This is a person who works with color in strictly a mechanical or analytical way. This group would include house painters, printers, body shop technicians, paint manufacturers and retailers. These people are particularly concerned with the physical and visual consistency and the overall quality of the color that is used and produced by them. The body shop worker needs to match the paint on a smashed 83' Buick, a printing professional has to faithfully reproduce a color proof, and the paint manufacturer must consistently produce a color mix.

Third, "The Creative Professional". These are professionals whose endeavors are predominantly creative and externally directed and motivated. Almost all creative professionals perform tasks that are both advisory and compositional. Color advisors are predominantly concerned with choosing between items of different colors. Their advice may be given directly or indirectly to others. A retail buyer chooses the several colors of jackets or sweaters that will be offered to their customers, indirectly advising the customer on what colors to buy. A sales person may act as a direct color advisor, helping a customer choose a color of paint, lipstick or tie. Compositional workers are graphic designers, illustrators, decorators, clothing designers, architects, theater set and exhibit designers, product designers, makeup designers, craft persons, florists, etc... These professionals choose colors and design compositions with them. A color composition may be a print piece, logo, automobile, product package, fabric, shirt or whole outfit, makeup style, theater set or exhibit, lighting design and so on.

Lastly, "The Artist". Artists are categorized by what they produce: paintings, sculptures, murals, mixed-media, conceptual creations, performances, and etc. The distinction between how an artist and other creative professionals work is subtle. The characteristic differences are in orientation, motivation and direction. Artists maybe subject to outside influences and constraints but are ultimately self-directed and motivated. Techniques used for color selection and composition are a reflection of the individual artist's way of working and the needs and constraints of the current project.

Admittedly these are somewhat artificial categories and many people operate at one time or another in all of these categories and no one spends all their time in just one. Data collection was conducted informally—based on four sources. First, a number of informal direct observation studies were conducted. These of color professionals like graphic artists, fine artists, house painters, auto body shop workers and paint sales persons as they performed their color work. Observations and anecdotal evidence was collected from friends and associates about common everyday color use. Second, interviews with color experts, who while not working directly in any of those professions that were targeted for study, had knowledge of the accepted standards and practices of those professions. Third, since we, the researchers, had extensive training and work experience in the photographic and graphic arts fields, our accumulated personal experience and knowledge became a source of anecdotal evidence. The last source of research data was published accounts, and analysis of color work and color workbooks used by the targeted professionals.[1,2,3,4]

From this collection of data we isolated the idea that color selection and use was based on the nature and the goals of the project in which the color is to be used. In other words, colors were not chosen and used in some random, ambiguous fashion but with a method and a goal. The method was to analyze the nature and goals of the current project and from that develop a small palette of colors tuned to the specific context, audience, and desired outcome of the project. For example, developing a flyer for the company picnic at the beach. The colors to be used would be dictated by the audience (Employees), the event (Games, Outdoors and Food), the location (Ocean and Beach), and the goals (Fun, Socializing and Relaxation). In deciding what clothing to wear the color decision is based on factors such as the activities planned for the day, who will be encountered, what impression is to be made and the time of the year.

Other factors that influenced the decisions were basic artistic color theory, individual, corporate, and cultural color preferences and the past habits of color use.

Other ideas gained from this research involved the mechanics of color usage. Functional color palettes or schemes are limited to very few hues, usually two or three. Colors are organized and applied according to a hierarchy of functionality in the design: dominant, coexisting, supporting, and highlight colors. Application of colors to a design is iterative and based on intuition, individual aesthetic judgment, and information design theory.

A New Kind of Color Tool

The idea for the Canon Color Advisor came directly from the conclusions derived from our basic research. The simple idea was to create a color selection tool that based on the input of a description of a project's context and goals would present a small functionally organized palette of colors for use in coloring documents. Specifically, by selecting terms from a number of categorized lists the user would define the project context and goals. Based on the

terms chosen, the program would algorithmically calculate the optimal palette of colors to match them.

We began by defining the number of colors in the palette that the Color Advisor would create and establishing the functional relationships that would exist between them. The result of the users term selection would be a palette of 13 colors. One dominant color with one each associated lighter and darker shade supporting colors. Two coexisting, each with their own associated lighter and darker shade supporting colors, and three highlight colors plus black. Still we had the difficult task to determine what would be the most useful and relevant categories and terms, how would colors be associated with them and more importantly associated to an arbitrary group of them?

Applied Research and Data Gathering

We developed a two-stage experiment geared at gathering data about potential relationships between color and descriptive terminology. In the first stage we developed a list of 184 terms that we targeted as potential color relevant words. That is, words that could be used to describe a document project and would also be associated with colors. Words like fun, party, Christmas, boys, girls, engineers, mangers, ocean and so on. The terms were selected by the researchers from resource texts, primarily the *Random House Word Menu* book.

The terms did not include color-related terms such as "brighter" or "vivid". The terms were randomized, printed out as lists and a number of randomly chosen individuals were asked to review them. The test subjects represented a mix of the four types of color users. There were some color professionals, some color technicians, some artists, and some common humans. Each individual was given two word list printouts, both with the same words each in a different order. On the first, they were asked to indicate on the list, words that were, to them, descriptive of a document project. On the second they were asked to pick the words that were colorful—those that brought a set of colors to mind or could be descriptive of some set of colors.

We performed a correlation analysis on the data generated in this experiment. Based on the analysis, the list of terms was narrowed from the 184 word list down to 31 terms that were used to conduct the final experiment. The analysis removed terms that were either non-descriptive of document projects or non-descriptive of color. What remained were terms that had a high likelihood to be at once descriptive of a document project and at the same time "colorful"—at least for the cultural sample that was chosen. It had been decided not to take in to account any cultural/social biases in our subject pool for this first cut at developing the technology. We instead concentrated on establishing a repeatable procedure of collecting and analyzing data, that could be applied to different market demographics later. The final list of 31 terms in four categories were selected then categories were chosen based on the terms generated. The categories were: Occasion, audience, setting, and style.

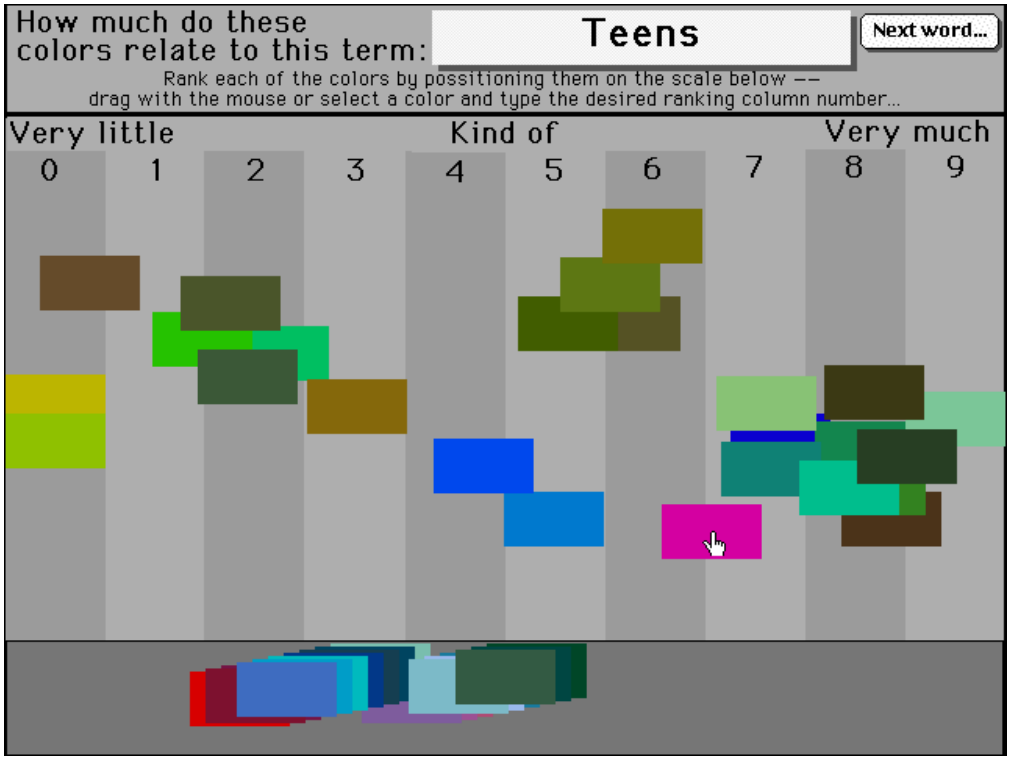

Figure 1. A screen shot from the color ranking program

In our final experiment we needed to associate actual colors or ranges of color to each of the finalized terms. A test subject would rank a defined set of colors according to each of our terms. The first question was what color set or color space should that should we use to select those test colors? At a minimum the colors that we needed should present a perceptually uniform range of colors that spanned the whole hue range and that also presented some variation in value and chroma. In addition they should represent colors that fall within both a typical CRT gamut and the gamut of a typical desktop printer. We chose to use the Munsell color patches since they were convenient and met all of our criteria. From this space we chose a distinct set of 75 colors. Colors were selected at regular intervals in the Munsell space across the whole range of hue, chroma and value. Then we hand-tuned the selection to produce a wide palette of colors.

For the final test a program was written that presented one term at a time and the user was tasked with dragging the 75 color swatches one at a time across the screen and positioning them on a visual scale from zero to ten. Where zero meant that the color is not relevant to the term and ten meant that the color was very descriptive of the term. A screen shot of the test is shown in Figure 1. By the end of the test a subject would have ranked each of the 75 colors for each of the 31 terms. Within the experiment, the terms were randomized for each subject and the colors were randomized for each term. The ranking data from this test was normalized and averaged.

A Simple Algorithm for Goal Based Color Selection

The original idea[5,6] was for an algorithm based on a three-dimensional mapping of color relevancy into some appropriate perceptual color space. For a single term, the region with the highest relevancy would produce the dominant color and its two supporting colors. Areas with relevance's that were a bit lower, but still relatively high, would give the coexisting colors and their supporting colors. Highlight colors would be contrasting to those chosen as dominant and coexisting. To determine the color palette for multiple terms the color space relevancy mappings would be averaged, perhaps with a weighting for the importance of each term or category of term. Then the same process would be used to select the colors but using the composite relevancy mapping.

To limit the complexity of the implementation, the algorithm was simplified. By averaging the results of all the color ranking tests, we created a set of "color relevancy curves" for each term. These curves were two-dimensional: one axis was the relevancy of a color to the term and the other shows the 75 discrete colors that were included in the original test.

From the curve of one descriptive term the dominant color could be chosen as the color with the highest relevancy value for that term. From that dominant color, two coexisting colors were determined. We used the artist color wheel as opposed to the CRT or graphic artist's color wheel and the theory of a triadic color scheme to choose them. The basic idea was to start from the dominant color and go ±120° in hue and then find the nearest color in our set of colors that had a relevance of 50% or greater. Supporting colors, two for each of the dominant and coexisting colors were calculated from the color that they were to support. One lower in value and chroma and one higher in value and lower in chroma than the color that they were supporting. Highlight colors were determined using the three colors that were 90° and 180° in hue from dominant color and a fixed value and chroma based on the value and chroma of the dominant color. If the Dominant color had a high chroma and low value, fixed low chromas and high values were assigned to them.

Figure 2. Color Palette

If more than one term was selected then the relevancy curves were averaged together and the resulting composite curve was used to determine the dominant, coexisting, supporting and highlight colors as described above. Each of the categories, audience, occasion, style and setting had an associated weight that was applied to the curves when they were averaged together could be adjusted to have more or less of an effect on the results.

Conclusions: The Color Advisor in the Field

The results of this work were productized as the Canon Color Advisor. The real power of the tool was to create palettes of colors and apply them during the creation of documents. Unfortunately, it is difficult for a peripheral vendor to make a user choose their authoring tool for their device. Given that, it was decided to build the Color Advisor into the printer driver. The idea was to provide the ability to color a document just before it was printed. The benefit of this approach was that the tool could be used across applications, any document could be colored independent of what program created it. Also Canon could provide the tool without creating and marketing its own document creation application or convincing third parties to include the tool in their applications.

Unfortunately, coloring documents in the print stream was klugy at best—technically difficult and limited in scope. It was also an unexpected and unnatural point in the document creation workflow to be applying color. In the end the Color Advisor was hidden so deep in the drivers that most users never saw or used it. Those reviewers or customers who did find it consistently had positive things to say about it's use. Under these conditions, the fact that the product lived and died unnoticed should not necessarily negate the merit of the idea of selecting colors by describing the context and goals of their intended use.

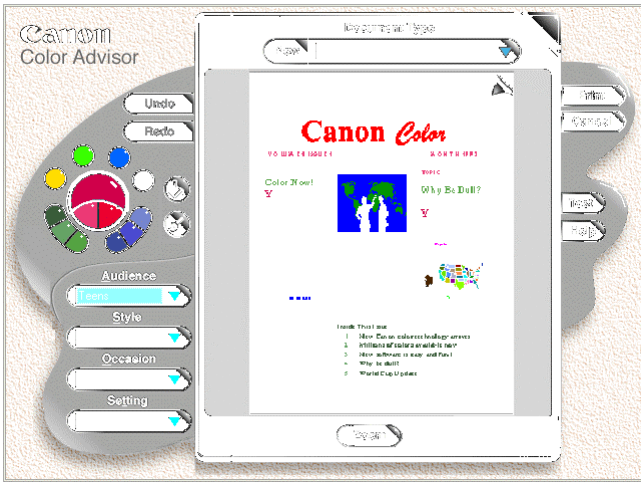

Figure 3. The Color Advisor Product

And Corollaries

Our hope is that description of the technology in this paper may spark some others to build something along similar lines and prove, or disprove, its usefulness under a broader and more objective public light. One of the basis's for our research endeavors has been the notion that the problem of color fidelity, though worthy of all the zeal, effort and persistence put to it is not the sole color problem to be solved. That in a certain sense, because it is a comfortable well-defined problem, one well suited to be attacked and solved by good solid science and engineering that other fuzzier color problems, those with no hard science/engineering solutions are ignored. We turned to one of those issues: making the creation end of color work easy, satisfying and manageable and with some basic research came up with one solution. We believe that that there are further color use technologies that could be developed from our investigations and work. Among them are, Color Agents, Color Use Profiles, color palette resources, system wide color work management and color work management tools.

The idea of a Color Agent is to have a piece of system software that monitors all of the color work done on an individual computer system. The agent would serve two functions. The first is to offer color advice and suggest or provide appropriate color work tools when the "need" or opportunity arises. For example, suggesting a good background color to accompany a block of colored text, directing the user to the appropriate tool for selecting web safe colors or informing them of newly installed color resources. The second function of the Color Agent would be to build Color Use Profiles. These would be data base records and analyses of the color work done on a particular computer system or for an identified user of that system. The agent will note things like the commonly used colors, colors that are avoided or never used, colors that are often replaced and how, how often and where color is used. This information will allow the agent to tune its advice, the behavior of the color tools at its' disposal and perhaps even system and application user interfaces to conform to the users likes, dislikes and work style.

The notion of color palette resources and color work management is that, like fonts, colors, color tools and the color palettes created by them should be controlled and managed by the operating system. If color work is to be easy and productive it is critical that color tools and resources be consistent, uniform and accessible by the user in all of the applications running on the system. In other words, a palette of colors, should be customizable, should be accessible and used in a consistent way in all of the applications that the user may choose to use during a specific the project. For example, a new custom palette of colors may be created for each user project, each new palette spawned from the previous projects' as the user's color preferences and projects change. To develop a verity of materials for the project—letters, announcements, web pages, brochures, reports, posters, logos and so on, the user will use that palette of colors in many applications. In the course of the project the user will collaborate and delegate some creative tasks to others who will use the palette in their applications on their own systems. That new palette needs to be available system wide to all applications and utilities on the original users system and transferable to others on different platforms and systems.

Color work management tools are need to create, modify, organize and distribute color palettes. Some examples of high-end tools like this exist today—from Equilibrium, Pantone and X-Rite but these are known and used by only the top of the graphic arts profession. If our goal is to make color work easy and reliable, distributed, easy to use tools like these are need for the everyday work of the average consumer. These people need to be able to select colors from real objects around them, to create and organize groups of colors, use them in all of their favorite applications and to make them available to their colleagues, families and friends.

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