COLOR, ALGORITHMS AND EXPRESSIONS

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ABSTRACT

Computational color methods are changing the way artists and designers work and interact with color. My main focus as a new media artist and scholar has been to explore aspects of creating expressions based on digital color processes, whether by manipulation of RGB (red-green-blue) values, projection, or the use of computer vision to generate visual patterns. In order to better understand the visual structure of the RGB system, I have also devised taxonomy and methods of mapping RGB color relationships, which I use to create both printed (in which colors are adapted into CMYK) and digital artworks. In this presentation I discuss theoretical, technical and symbolic aspects of my work and collaborations.

INTRODUCTION

Imagine the world in black & white and you will quickly notice that a major component of its beauty is lost. Color not only embellishes our surroundings, it also imparts meaning to things via symbolic associations. It helps to categorize information and define spaces. Color influences our well being and even purchasing decisions. Our sense of taste is also impacted by color and it even plays tricks with our eyes. Color, when used effectively, is one of the most powerful tools used to build the overall image of a product or a work of art.

Through my work I examine digitally manipulated color and the expressions that they create. It is my vision that the colorful works that I produce add a splash of freshness and consequently new meanings to the environments in which they inhabit. I want the viewers encounter to be as uplifting as inspiring. Dr. Phoebe Farris, professor emeritus of art and design at Purdue University, once told me that my work is a kind of visual optimism. In retrospect, I can see that.

VISUALIZATION AND NOTATION: IMPACT ON ART AND TEACHING

The Munsell Color Notation system has played a major role in my understanding of color and has informed my research on color design. It was through Munsell that I started to question my creative practice with digital color, and consequently the juxtaposition of intuitive and rational color design methods. The questions led me to investigate computational color in its most fundamental level: the RGB color system (Figure 1, left), a fundamental model used both to generate as well to select digital color using a Graphical User Interfaces or GUI (Figure 1, right).
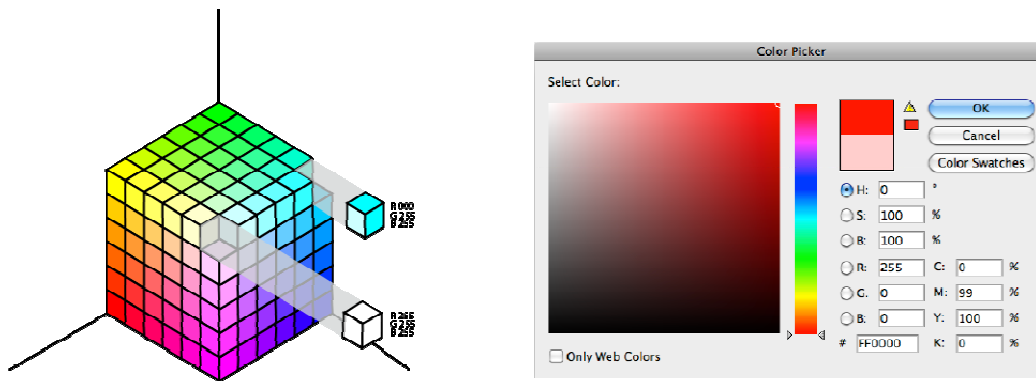

Figure 1. The RGB Color Cube model (left) illustration shows the displaced location of white and cyan and their respective RGB values (Copyright © Petronio A. Bendito). The RGB color selection method shown in the right is available in Adobe Photoshop.

Artists have for a long time used tools to inform their design decisions. For example, chemist Eugene Chevreul created a color wheel that inspired artists to make color selection based on a system of order. His studies, published in 1839, impacted artists color design processes (Crispino, 2008). During that period, Van Gogh used his knowledge of color theory to paint striking color combinations. As I worked with digital colors, I wondered how color design could be affected by digital color perceptual organization. Mostly, what I found out about digital colors were technical.

The main focus of the initial phase of my color research was to examine the RGB color cube from a visual standpoint. I tried to understand the perceptual organization of the RGB cube and studied its inside and outside. I produced diagrams and a computer animation to foster the understanding of how digital color is produced. I realized that the RGB cube provides not only a mathematical answer to how digital colors are created but also it is a potential cognitive tool to aid in the process of creating digital color palettes for art and design. I questioned if the RGB color cube would become a critical a tool to

inform color selection in the new millennium. I believe that the RGB color cube is a thinking tool for the skilled new media artist and designer.

One aspect of my research was to slice the RGB cube in several different ways. Each slice has allowed me to better understand how digital colors are created (Figure 2, right) and consequently, I applied this knowledge to the design of artworks. *Color Digits* (Figure 2, left), a collaboration with musician Didier Guigue, is based on a single 'slice' of the RGB cube from which I selected colors and narrowed down my choices by selecting the ones that appealed to me for their expressiveness.

Color Digits features gentle movements of expanding and contracting rectangles and colors that blend together. Guigue used the RGB value of each color to create sounds that could be performed independently or played back with the video. Essentially we merged both objective and subjective process to create the work. Conceptually, *Color Digits* examines the aesthetic of digital colors using a hybrid process of creation, both rational and intuitive. It invites the viewer to enter a state of awareness and relaxation and abandon the fast paced nature of a technologically augmented world.
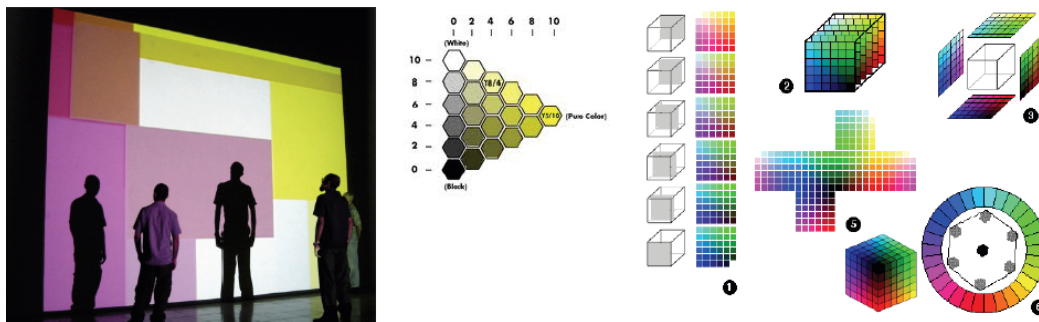

Figure 2. *Color Digits* is a video and audio installation by Petronio Bendito and Didier Guigue. Installation view from an exhibition at Usina Cultural, Brazil (left, photo by Adriano Franco.) The RGB cube diagrams by Petronio Bendito show possible ways to visualize the rig cube (right).

The 'slices' of the RGB color cube led me to new possible logical configurations, such as the planar view of the cube (also shown in Figure 2, right). In a later phase, I expanded, Influenced by Musell and Birren I developed a notation system to map digital colors (Bendito, 2005). I also produced a RGB color wheel with a notation (Figure 3). Finally I produced RGB hue palettes (not pictured). This allowed me to work with digital color more systematically.

Figure 3: Bendito's RGB color wheel with notation. Copyright © Petronio A. Bendito.

It was by studying Munsell that I realized the implications of being able to map RGB colors in a way that allowed me to examine them purely from a perceptual standpoint. Unfortunately, the exact appearance or reproduction of RGB colors is compromised by hardware dependency (e.g. usually RGB color varies from monitor to monitor). Maybe in the future, technology will advance enough to reproduce RGB colors consistently. When that happens, this notation system will fulfill its full potential as an artistic tool. For now, it can be effectively used in context-specific scenarios. For example, by selecting color based on its location in the RGB cube, I can assure that I can numerically select the most vivid red that the device can or could produce. For my works, I capitalize on this understanding to make theoretically sound color design decisions.

Mapping the RGB color cube allowed me to experiment with it in an educational setting. It led me to develop a curriculum and a software to teach color design methods in the RGB environment. The curriculum involved a set of visualization exercises with the RGB cube, color interaction (Albers), color coordination (Chevreull, Birren, Kobayashi and Itten), observing nature and transposing it to RGB values, etc. (Bendito 2002).

PAINTING WITH LIGHT

Another aspect of my color research is based on software I designed called Kinetic Traces which was developed in Processing, a derivative of Java. The software allows me

to paint and interact with dancers in real-time on the stage or in a gallery setting (Figure 4). Essentially Kinetic Traces is a drawing system in which RGB colors are projected as lines or shapes on the body of the performers and the environment.

Kinetic Traces requires that both the dancer and artist (the author) understand its realm of possibilities (e.g. how light travels in space; awareness of distance between dancer and the projector; how to paint in a Cartesian system while transposing it into a 3D space). My experience with Kinetic Traces gave me insights into a possible set of rules that could be learned by the dancer and used during improvisation. This led to the development of a dance vocabulary, which I further developed in collaboration with choreographers, movement designers, dancers and performers. This also led to a taxonomy of shadows in space (Bendito and Cunningham-Sigman, 2011).

Figure 4. *Dreamscape* performance (2010), and *Entropy* (2011) a video dance projected in collaboration with Carol Cunnigham-Sigman.

COMPUTER VISION AND ART

Most recently, I explored the relationship between computer vision, color and audience participation. Sound is also integrated in the work and responds to movements. *Action//Musique* (Figure 5) is a system in which a camera captures colors from the environment and turns them into painted RGB color splotches. The levels of brightness and saturation of colors captured can be adjusted to adapt to different light conditions. Because of such adjustments, the room does not have to be dark for the work to be experienced. By selecting colors located in specific areas of the RGB color cube, I was able to project in relatively bright environments. On a conceptual level, what could be commercially used for video surveillance became a tool for a techno-poetic experiences, a 'musical' instrument based on people's movements that are captured by the camera.
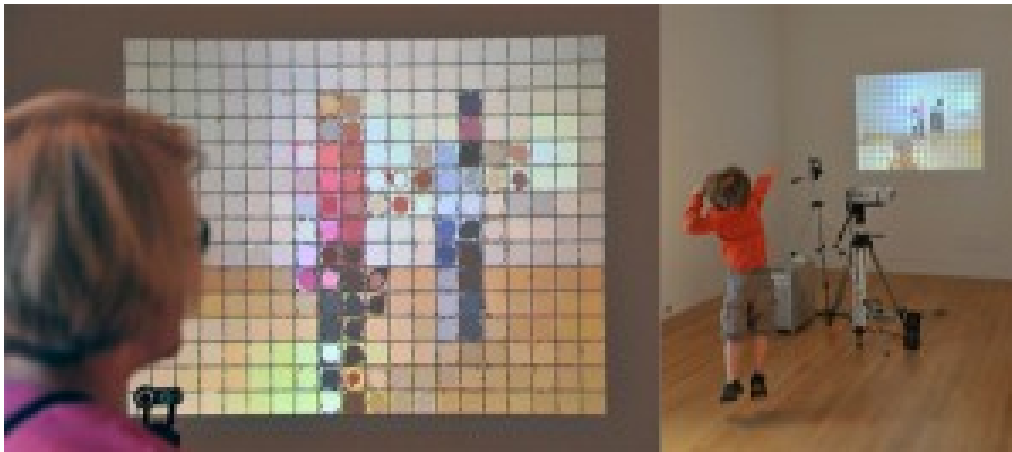
Figure 5: *Action//Musique,* 2010, by Petronio Bendito and Didier Guigue. Interactive relationship between movement, sound and color. Rueff Galleries, USA (Photos: Shannon McMullen).

COMPUTATIONAL COLOR DESIGN: COLOR CODE SERIES

In 2009 and 2010, I developed algorithmic digital drawings in association with my computational color design research. The result is an ongoing series I titled *ludus (chroma).* The series is comprised of large color prints and installations. Most of the works in this series have a playful color palette filled with hundreds of color samples. I generate algorithms to produce color palettes that were applied to vector drawings using randomization parameters (Figure 6).
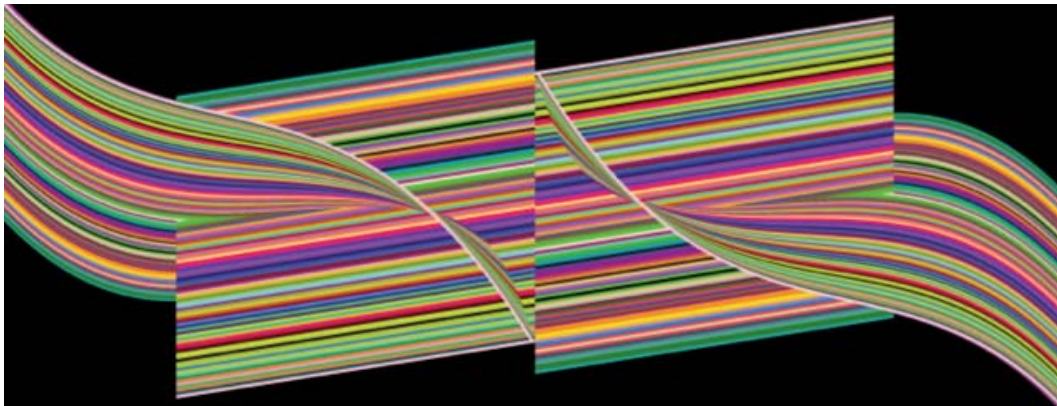
Figure 6. *Spectrum.* (2011, digital print). Featured at the Experience Color Exhibition, 2011-2012.

Lawson Computer Science Building, Purdue University.

CURRENT PROJECT: COLOR CODE SERIES

In the 1960s and 1970s, Josef Albers' Homage to the Square series represented a major shift in the arts by fostering new understandings of the effects of color interactions, more precisely their optical effect on each other. Now in the 21st Century, based on my Color Code series (Figure 7), I propose an 'Homage to the RGB Cube',
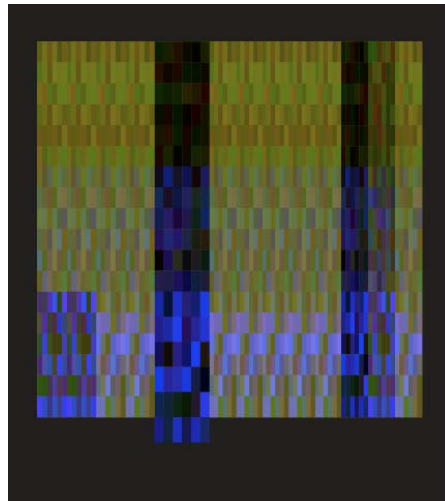

Figure 7: Color code #0002, 2012. Copyright © Petronio A. Bendito.

The purpose of the Color Code series is to embrace digital methods as a way of increasing our understanding of computational color design processes. Such an approach has the potential of uncovering new aesthetic experiences of color in the 21st Century. Consequently, the understanding of how RGB colors work is paramount for the project.

The Color Code series adopts a scientific research methodology in which instruments (algorithms) are developed and findings (color palettes) are produced. Subsequently, I analyze the palettes and select the colors that will be turned into time-based or 2D art forms, such as video and prints. Before this could occur, I created a series of studies for selected colors (Figure 8). Currently I have two research assistants working on the project, mostly running algorithms.
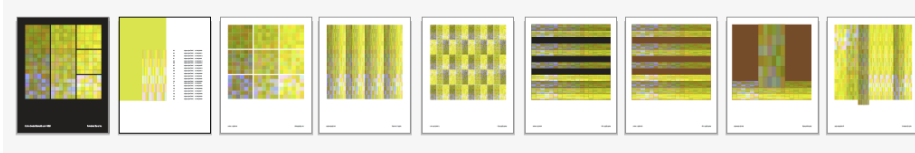
Figure 8: Color code #0001 digital sketchbook, 2012. Copyright © Petronio A. Bendito.

CONCLUSION

The RGB color cube has impacted several ways through which I express myself artistically. This symbiotic relationship with digital colors has allowed me to examine the source material that mediates our digital visual experiences—the RGB colors.

It is my belief that new media artists in the 21st Century will increasingly explore the RGB color cube in their works. In art school, the RGB color cube will be taught more prominently. By understanding the RGB color cube as a system of order, new aesthetic experiences will be created even as new algorithms to devise color relationships are created. Consequently, this shift poses new questions about the role of digital color in shaping a new media aesthetic.

Overall, my work capitalizes on scientific and computational processes to the service of the viewer's experience of color. Each work is a pursuit, a study. I see my color design process as a journey of experimentation, discovery and pioneering. Each RGB color scheme that I devise is a new arrival.

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