Creativity of Arts and Design Using Color Schemes of Primary Colors Magenta, Cyan and Yellow [1]

Sanchai Santiwes [2]

Abstract

The purpose of this academic article is to establish the actuality of color theories, including those pertaining to primary colors, the mixing of colors, and color schemes. In particular, the traditional color theory that institutes the 3 primary colors red, yellow and blue as bases, which could not be formed through mixing of other colors, has been established as incorrect. This inaccuracy was first determined because in the present new technologies can make or produce many new colors. There are consequently 3 new primary colors magenta, cyan and yellow. Red can be mixed using magenta and yellow. Blue can be mixed using cyan and magenta. The 3 new primary colors were determined through subtractive mixing of reflected light.

Therefore, these 3 new primary colors have replaced the former. This change affects color theory regarding color schemes. Currently, if artists and designers want to create artwork using the principle of contrast in their composition, they may define or select complementary colors from the old color wheel, such as red and green, yellow and violet or blue and orange. These are different from the new complimentary colors. If they use the new color wheel, they will define complementary colors or pair contrast colors, such as magenta and green, cyan and red or yellow and blue.

This article expounds on the reliability of these theories according to experiments, proofs and rationalization. The results confirm the reliability of the 3 new primary colors magenta, cyan and yellow. The color wheel and color schemes should be defined using them.

Key Word (s): color theory / color scheme / colored light / arts and design

[1] This academic article was written from the author's experience and put together from the research and dissertation. It proposes a new color theory regarding color scheming and mixing.

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Introduction

This academic article was written from the author's experiences and put together from research for a dissertation about color and mixing. It was found that there were differences between mixing reflected light and pigment colors, especially attributed to subtractive versus physical mixing. Many results did not correspond, for example, the subtractive mixture of blue and yellow did not create green, while a physical mixing created green. Color schemes were arranged using a color circle or color wheel. Complementary colors according to the traditional color wheel have determined color arrangements or physical color mixing in arts and design, so that red is a complementary color or opposite to green, yellow is to violet, and also blue is to orange. On the other hand, red is a complementary color to cyan, yellow is to blue, and orange is to cyan-blue.

Unconvinced by traditional color theory, the author of this article began to study and experiment and found these differences, which needed to be expounded upon in terms of scientific information. If this article has any defects, the author would like to humbly accept the blame and responsibility. The author hopes the article will be creatively discussed and contribute to improving knowledge for the future of society.

In addition, it should be pointed out that the issues of focus in this article are not new to science. Rather, these issues have already been noticed and color theory questioned. Answers have been sought through experimentation and there are many forums for discussion on the internet. Some results of these inquiries, however, did not explain the phenomenon in terms of arts and design. The author, therefore, aims to explain and clarify the research for readers and will propose certain statements about color theory, color mixing, and color schemes as related to arts and design.

The color images in this article are simulations only and created for the purposes of explanation. They might be inaccurate or distorted to some extent.

The author will bring up these issues and questions, which do not have clear results, because if the conclusions of this research have a basis in reality, then they will affect our approach to color theory as it relates to the arts, which we learn and teach. It may completely change our thoughts and understandings about color theory in arts and design.

"Are the color theories and color schemes that we use in artwork and design correct and based on fact? Do we actually know and understand them? Or do we learn what we know from vivid experience and agree without questioning how the phenomena of color are used in arts and design?"

Review concept and theory referred

Humans have known colors since ancient times. Sir Isaac Newton found and proved that colors originate from light by refracting light through a prism. (Newton, 1721: 37, 56) The prism separated the white light into the many colors of the rainbow, 7 of which could be seen with the naked eye: violet, indigo, blue, green, yellow, orange and red. The colors formed a spectrum. It was proven that lighting is a result of frequency, and that the human eye is able to perceive these ranges of frequency because of rod and cone cells, which respond to light and colors. *"Rod cells take to nighttime or dark and respond to white and black light. Cone cells take to daytime or bright and respond to lighting colors"* (Siri-on Wichawut and others, 2007: 172) There are 3 kinds of cone cells, those that respond to red, those that respond to green and those that respond to blue. After the initial response, they will send some information regarding light and color through nerves to the brain for interpretation. This is how pictorial experiences are perceived.

Once humans understood and learned more about colors, matter and their surroundings, they could uncover methods of using color, including drawing, painting and mixing. Further learning, experimentation and observation brought about complex methods, which contributed to the evolution of intelligence, body control, and learning about emotion and mind, to the extent that humans developed the creativity of artwork. Experimentation, proving of concepts and repetition of phenomena, brought about the principal color theories and color schemes for usage in society. These theories could explain some phenomena, for instance, how color mixing could use primary colors for making secondary colors, knowledge of pictorial composition versus objects carrying color, and the usage of complementary or analogous color schemes.

Artistic principles and color theory have been taught and learned side by side and one informs the other. One learns the colors, theory, mixing, and usage in terms of one's artistic subject, from lower to higher education. The basic principles that one learns are as follows:

1) There are 3 primary colors: red, yellow and blue. These colors are able to be mixed using a variety of ratios, resulting in many colors.

2) There are not any colors that can be mixed, which will result in these 3 colors. Therefore, they are called primary colors.

3) One of these 3 primary colors mixed in equal ratio with another nearest it on the color wheel results in the phenomenon of a new color, referred to as a secondary color. Red is mixed with yellow to be orange, yellow and blue make green, and blue and red make

violet. (Note: Purple and violet are interchangeable. The author will refer to the color as violet in this article.)

4) If primary colors are mixed with secondary colors, they result in tertiary colors. For example, red is mixed with orange to be red-orange, green and blue make green-blue, etc. The mixing of these colors is also determined according to which colors are nearest each other on the color wheel and according to artists' needs.

5) If all the primary colors are mixed with equal ratio, they should make black. In reality, this black is an ideal color, though, because the 3 primary colors mix to be dark brown, dark grey or mud. It is not an absolute black.

6) The mixing of primary, secondary and tertiary colors can be arranged into a wheel shape like a dial. The wheel is used to explain color mixing, arrangement and schemes. It is this color theory that is used in creating artwork in arts and design.

7) Color schemes are defined according to color positions and their relations with other colors on the color wheel. For example, if colors are opposite to each other on the color wheel, they are contrasting colors, and if colors are nearby, they are harmonious colors. Using the established positions of these colors, one may create color schemes and draw lines relating 2 or more colors. For example, colors may be related to each other as points on a triangle, square or more complex shape within the color wheel. A scalene triangle or rectangle may also be used to define color mixtures. These methods have defined color theory and have been used to explain color groupings for arts and design.

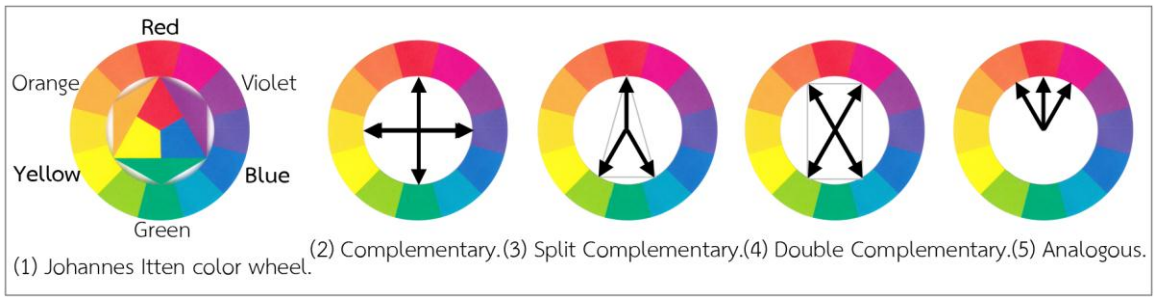


Figure 1: The color wheel of Johannes Itten with an explanation of primary and secondary colors according to traditional color theory.

Source: Tom Fraser, and Adam Banks, **Designer's color manual: the complete guide to color theory and application**, (San Francisco: Chronicle Books LLC, 2004), 44.

Artistic learning using color theory is meant to be a vivid experience or *"an experience that is an experience."* (John Dewey, quote in Rader, 1960: 170) It is deeply embedded in the

minds, thoughts and understanding of humans, and in whole cultures and traditions, which might be called civilization. It is a learning that has been inherited up to the present.

Everything learned, enhanced and discovered by the intelligence of humans has informed holistic thought, philosophy, knowledge and the sciences. In terms of the social sciences, this has resulted in explanations of phenomena. In terms of the sciences, this has caused the discovery of, for example, equations. These accomplishments have led to the advancement of technologies and more.

Arts and design has had its advancements as well, resulting in the development of technology and subsequently, new equipment and tools. These tools have been extremely useful for creativity within arts and design. This article focuses on the utilization of computer technology in artwork and design, as it's related to color theory and color usage.

Computer technology includes input equipment, such as the keyboard, mouse wacom pen or touching used to input parameters on touch-screens. Parameters are calculated by the machine and computer system. They have some sets of commands or programs, which aid calculations. Results are then shown through the output device, such as on the display monitor, printer or other equipment. In contrast to this technology, there is traditional equipment, such as pencils, pens, brushes, and colors using water, ink, pigment, etc. Such equipment is used to sketch, draw or paint on canvas or other materials.

Using graphic design software, artists and designers often design, define and use colors for their artwork by utilizing color selection. While software includes color palettes, or one may select from a color adjustment toolbox, all methods are exploited for a color that one needs. Therefore, using principles and color theory learned previously, one will relegate certain colors for one's deigning and creative artwork purposes.

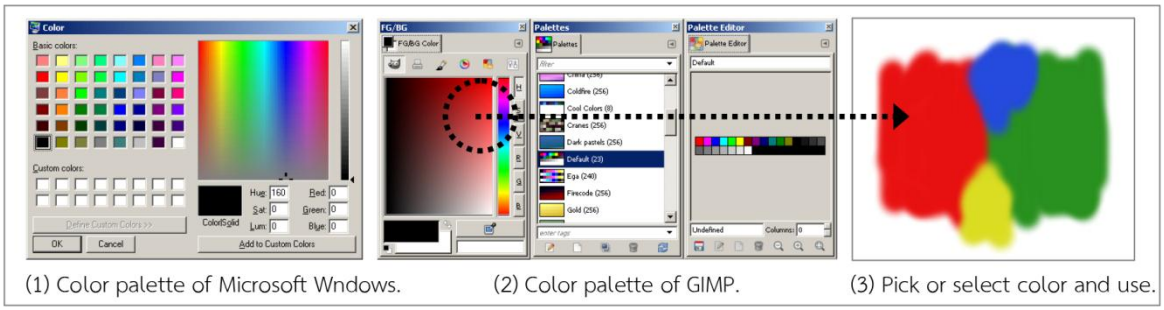


Figure 2: The color palette of computer software, which users will use for color selecting.

In the casethat an artist or designer wants to create their artwork with a color contrast scheme, they will allocate complementary colors to their artwork, for example, a red chair on a green carpet or a yellow curtain on a violet wall. In the event they want their

artwork to have a harmonious color scheme, they will allocate analogous colors, for example, a red chair on an orange carpet or a yellow curtain on an orange wall. Their decisions will follow the principles of color scheming, according to the theory that they've learned.

A literature review found that colors are a result of lighting falling under a specific range of frequencies. A specific frequency of lighting is thrown as a straight line into the eyes. This frequency impinges upon cells in the eyes and brain, the organs which receive feeling and create perception, respectively. This is then seen as color. In other words, lighting hits surface objects, which absorbs some frequencies, while reflecting others to the eyes and this is seen as color. *"When a natural light which has a frequency of white light hits a black surface, all frequencies of light will be absorbed, which causes no light to reflect. If a green surface is reflected by natural light, a range of short and long frequencies will be absorbed, and it appears as a green light."* (Zwimpfer, 1988: 102, 104)

Therefore, whether it is a color of light, a color is exposed through illumination or a pigment is painted on a surface, all colors which humans can see are absolutely defined by the frequency of light.

For that reason, light is an important component to color. As mentioned above, humans see some colors due to their eyes responding to a range of frequencies. In reality, all objects in the universe have no color, or they are totally black. If an object has color, it is caused by some beams or frequencies of light shining and hitting the object being absorbed, while others are reflected to the eyes. This process causes humans to be able to see colors. Colored lighting can be mixed using one of 2 methods:

1) Additive color mixing uses the RGB (red, green and blue) color model as primaries to mix colored light. (Morioka, and Terry Stone, 2006: 10) It shines or projects the colored light so that the colors converge or clash with each other and a new color occurs.

2) Subtractive color mixing uses the CMY (cyan, magenta and yellow) primaries as transparent pigments. (Morioka, and Terry Stone, 2006: 11) It takes the principle of additive color mixing in reverse. Subtractive mixing may occur using pigment colors. It creates translucent color.

These 2 methods of mixing colored lighting are informed by scientific principle. The method of pigment color mixing is applied to an overlapping of transparent colors and dithering. These colors cause a blending of lighting frequencies to be thrown into the eyes.

On the other hand, there is also a method of physical color mixing (RYB): *"...physical mixing of artists' paints. Physical mixing of opaque paints involves a substantial component of additive-averaging as well as subtractive mixing. With transparent pigments the process is more purely subtractive."* (Briggs, 2007) Using opaque pigments, (Morioka, Adams, and Terry Stone, 2006:

11) primary colors mixed in a variety of ratios results in new colors. This color mixing is used in artwork and industry.

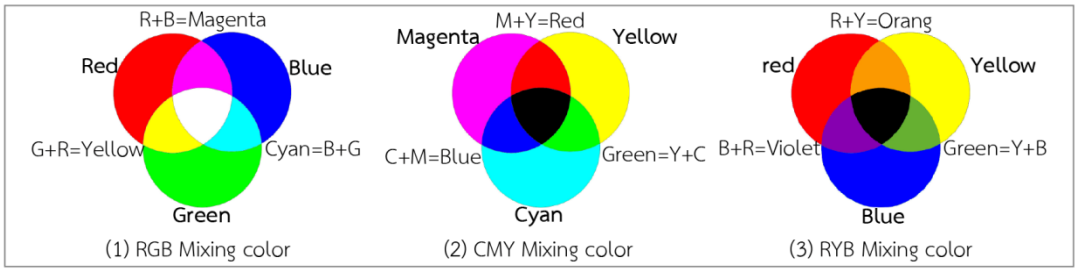


Figure 3: Additive color (RGB), subtractive color (CMY) and physical color mixing (RYB)

There is also a theory to explain gamuts of color. *"The gamut of a color display device is the set of all colors that the device is capable of displaying,...for any color system, the primaries of the system define the range, or gamut, of colors the system can produce,...These are systems that model the gamuts (or color sets) of specific instruments."* (Levkowitz, 1997: 4, 21, 33)

So while a color range can include the colors a human can see, what a monitor can display, those that can appear on printed matter, etc., in the case of a color gamut, its color range is defined by primary color mixtures that can be displayed.

This data and rational substantiated certain new principles of color theory in terms of the arts. New concepts were subsequently understood:

1) The discovery of Newton separated white light into a spectrum of colors. The spectrum could show all colors except magenta. Where was magenta? Magenta could be seen by using 2 prisms. If the head portion of the first prism, the violet portion of the spectrum, was combined with the tail portion of the second prism, which was the red portion of the spectrum, the mixing of violet and red made magenta.

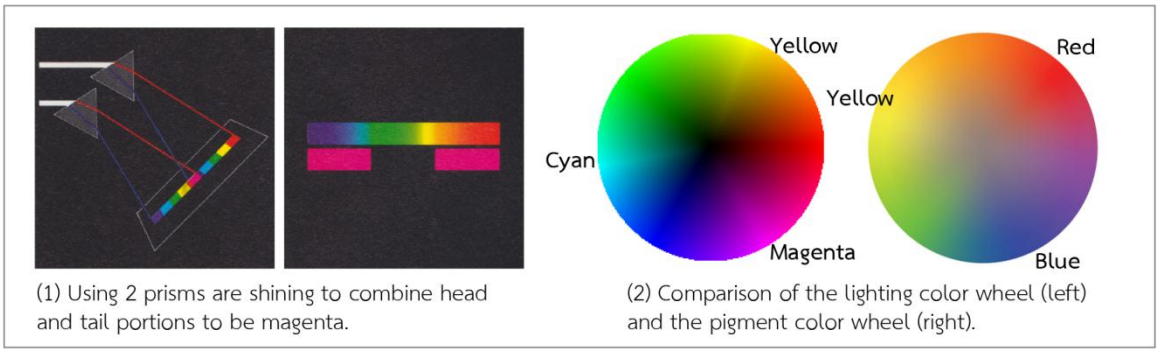
2) In the past, old technology did not produce 2 of the 3 pigment colors, magenta and cyan. These were achieved from the additive mixing of colored lighting.

3) Primary colors are base colors to be mixed into new colors. Therefore, primary colors may include any colors; they need not always be red, yellow and blue. They need not be a set of 3 colors. They may be 4 or 5 colors or more, which are depended on as the base colors when mixing.

4) The theory that the primary colors red, yellow and blue cannot be mixed from any other colors is wrong, because red can be mixed from magenta and yellow, and blue can be mixed from cyan and magenta. Yellow is the only color that remains as a color that cannot be physically mixed from other colors.

5) Therefore, some color bases which are actually primary colors include magenta, cyan and yellow. If they are mixed together, they will make red, green and blue, which are secondary colors. These 3 primary colors can be mixed in a variety of ratios to be many colors. They have a larger gamut than the 3 primary colors red, yellow and blue.

6) Every color can be described in terms of its hue. Certain primary colors mixed only physically are not able to create every color, because the physical mixing will also reduce saturation. So, by defining more primary colors, the color gamut expands, and it can be shown in a full-circle color wheel as follows:



(1) Using 2 prisms are shining to combine head and tail portions to be magenta.

(2) Comparison of the lighting color wheel (left) and the pigment color wheel (right).

Figure 4: Left, 2 prisms are used to show magenta, and right, a comparison of lighting and pigment color wheels.

Source: Zwimpfer, Moritz, **Color light sight sense.** (Pennsylvania: Schiffer Publishing, 1988), 85.

7) The above-mentioned realities and rational indicate that the color wheel as a circle is the result of principle or theory that has been restricted to arranging colors circularly. So, color schemes may be defined by relationships between colors irrespective of complementary or opposite positions, or positions of colors on the points of triangles or squares set within a color wheel. These were suppositions to inform principles of usage only.

8) The 3 true primary colors should be magenta, cyan and yellow, because through physical mixing these 3 primary colors produce the secondary colors red, green and blue. The tertiary colors include orange, violet, cyan-blue and many others according to a variety of ratios, many defined as unequal, or using some leveled up mixings. If these 3 primary colors are mixed with an equal ratio, the result will be total black as actually expected according to color theory. The result is not a dark grey or mud color. However, these physical mixings must be carried out on white paper only.

9) When the 3 primary colors are updated to actually be magenta, cyan and yellow, the color schemes in color theory are changed. For example, magenta is complementary with green, red is complementary with cyan, etc.

10)The color wheel is a model based on a circular shape or other shapes due to their use for providing explanation of color theory, mixing, scheming, etc. If the color wheel is a circular shape, some colors mixed by physical mixing will not be arranged linearly.

11)Some issues of color theory remain up-to-date and have not changed, for example, the feelings aroused by colors in terms of psychology, which are based on vivid experience or are learned or absorbed from a young age. The feelings aroused by color are not related to color mixing. The system of color schemes also remains in usage as before, but it is dependent on what the primary colors are. In addition, color temperatures and color brightness are accepted as before, because sure enough, color is light.

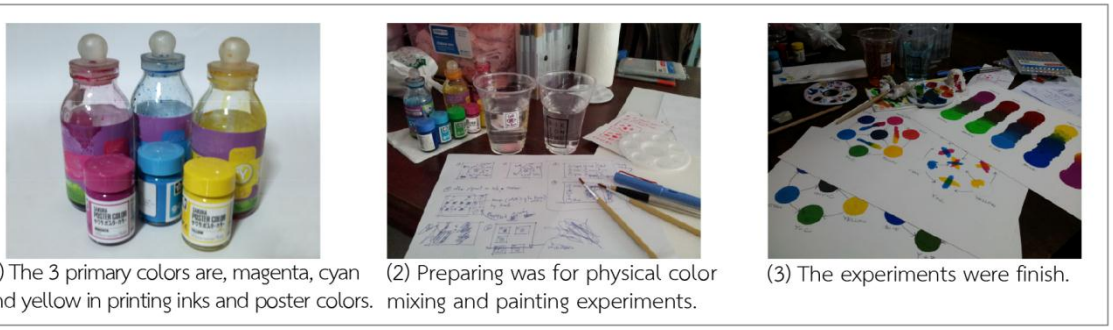
12)The color theory presented in this article is supported by 3 means: the evidence indicated by the above-mentioned explanations , the phenomenon of afterimages, and also, experimentation with physical color mixing to produce evidence.

"The color vision of humans is a phenomenon that occurs between the outer environment and the inner human organs. However, there are visions of color using other methods, for instance, if the eyes are closed and pressure is applied to the eye sockets, the vision of some colors will occur, or using some hallucinogen medicines, or the occurrence of afterimages." (Somchai Pomsuwan, 2005: 49)

The phenomenon of afterimages can be experimented with by looking at a picture with a colored area for about 30 seconds. Then, change to looking at a white area and an afterimage will appear, showing the complementary color indistinctly. If you are looking at magenta and change to look at white, you will see an indistinct green. If you are looking at red and change to look at white, you will see cyan. These are called negative afterimages. (Rucharee Nopppaket, 1997: 98-100)

Figure 5: A simulation of afterimages, showing the complementary colors indistinctly.

The author experimented with physical mixing by using color posters, specifically in the 3 primary colors magenta, cyan and yellow. The results of physical mixing were the secondary colors red, green and blue. However, the primary colors were not mixed with a 1 : 1 ratio to result in the secondary colors.



(1) The 3 primary colors are, magenta, cyan and yellow in printing inks and poster colors.

(2) Preparing was for physical color mixing and painting experiments.

(3) The experiments were finish.

Figure 6: The materials and preparing were for physical color mixing.

(1) Compared CMY and RYB color wheels were from poster colors.

(2) Linear brushes used each 2 beginning color by poster colors.

(3) Ink colors were mixed by physical mixing and be overlapped.

Figure 7: An experiment of physical color mixings overlapping poster colors and ink colors.

The proof showed that the primary colors were in the old traditional mixing could be mixed by the new 3 primary colors were including magenta, cyan and yellow.

However, the new 3 primary colors were not used to teach and learn about arts and design. Because of the basis education of arts remained to use the old 3 primary colors which were including red, yellow and blue.

The results showed that the old traditional mixing method of primary colors could be applied to the 3 new primary colors magenta, cyan and yellow.

However, the 3 new primary colors have not been used to teach and learn about arts and design. The basic arts education continues to use the 3 old primary colors red, yellow and blue.

Experiments and Materials

The above-mentioned truths and rational set the basis for a new theory of color. One may conduct experiments to support or disprove this theory and to expand upon how it could be used for creating artwork in arts and design. An experiment may be set up as follows:

1) To test perceptions about the new complementary colors and how they result in new color schemes, one may reproduce or create a simulation of a design or a composition of pieces of furniture on floors or carpets. These schemes may be compared with schemes created according to the traditional complementary colors. What models does an observer think to be correct?

2) Even if the observer considers the complementary colors according to traditional color schemes to be more correct than the new, was their decision based on vivid experience learned in the past or not? In support of this possibility, there have been those with congenital color blindness who did not know that they had the condition. They could live their everyday life in the colorful world as normal because they had learned the colors or had been told of them, to the point they could remember them and the learning had become vivid experience. This means that one who has difficulty seeing red will see grey or green-blue tones in its place. How can they see artwork which is red and green and yet perceive the complementary color, even though they see the artwork to be grey and green? Why is it? Is the answer because vivid experiences were deeply embedded in their minds, thoughts and understanding since they were young?

3) In fact, the complementary or opposite colors in works of art and design are selected from a range of opposite colors on the color wheel. They are not actually selected as colors that are opposite each other on a straight line. They are thus selected to be used for propriety and beauty in works of art and design.

4) If the evidence and explanations in this article are correct, are the sectors of arts and design ready to change according to this new theory and these new concepts?

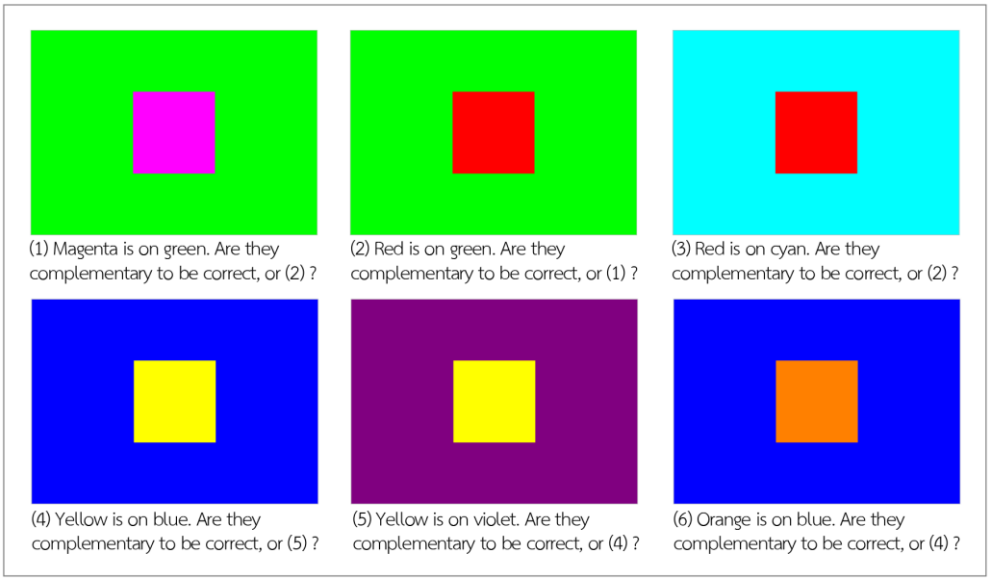


Figure 8: Comparisons between the traditional and latest complementary color schemes.

The author asks the reader, “What do you think about them?” “Which are correct?”

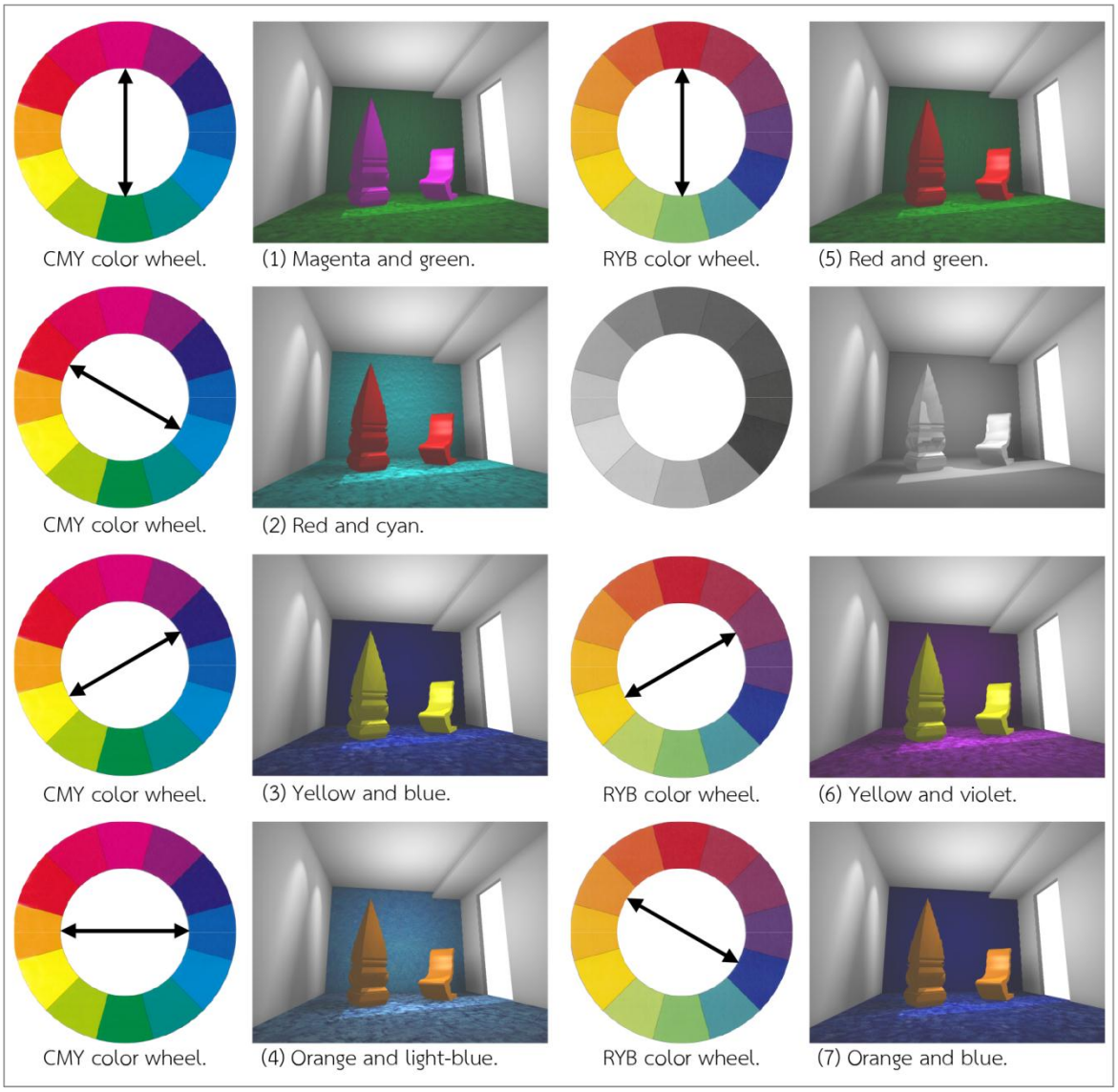


Figure 9: These examples of interior architectural design show case the complementary colors, comparing the CMY and RYB color wheels.

Source : Tom Fraser, and Adam Banks, **Designer’s color manual: the complete guide to color theory and application**, (San Francisco: Chronicle Books LLC, 2004), 40, 41.

Results

The results obtained from the experiments conducted, materials and simulations studied, reasonable explanations found and comparisons of color theory, color mixing and color wheels verify the 3 new primary colors magenta, cyan and yellow as correct. Color wheels and color schemes should use these colors as their basis. Readers, however, may agree or disagree with this.

One may be convinced to agree from seeing the experiments, proofs, explanations and comparisons. On the other hand, disagreement may be caused by former experiences learned from a young age, which have become vivid experience.

However, the author has shown discernment with explanations, proofs and comparisons, which indicate the veracity of these results, though these results may appear both clear and unclear. Therefore, the results need further proof and should be applied further within real artwork or research in terms of putting knowledge to practice to come to more substantiated truths.

Conclusion

Primary colors are the base colors to be used for mixing and forming new colors. They can be considered complete and whole colors because they are unique hues. Therefore, there are more than 3 primary colors.

The traditional belief was that the 3 primary colors were red, yellow and blue, as no colors could be mixed to get these 3 primary colors. That belief has been proven wrong because of the advancement of technology. We can make and produce many hues now, which include the 3 new primary colors magenta, cyan and yellow. They in turn can be mixed to be red and blue.

The color wheel model was created in a circular shape for explanatory purposes regarding color mixing and color schemes. This brought about color theory. If we change to use the 3 new primary colors, color schemes will also change. On the other hand, the theory of feelings aroused by color in terms of psychology remains true.

This article experimented with 3 methods of explanation: the outlined evidence, the phenomenon of afterimages, and the experimentation with physical color mixing. Each of these methods supports the use of the new complementary colors.

However, complementary colors are ranges of colors. There are many colors within these ranges. The system of color sheming may not be so set, because contrasting colors can be selected and paired from those ranges.

Nevertheless, if the evidence and explanations in this article are correct, the sectors of arts and design should consider being ready to change their practice according to this new theory and the resulting new concepts.

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