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Game Design and Perception of Colors

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Abstract

Colors and their usage have already been studied for over centuries and some finding from many centuries ago still hold value. However, new products appear every day and because they are used in different purposes, meaning their needs for color usage and design might differ in every product. This applies also to video games, where there are vast markets with differing target audiences with differing needs. This provided the background and need for further research.

The main task was to create an introduction to color usage and explanation of color perception in game design to anyone who has interest in game design. The theory part aimed to explain on a general level what kind of things effects how colors are perceived what to keep in mind when creating design with colors by using the concepts of color theory, color psychology, color symbolism as well as color harmonies.

As the implementation method, qualitative analysis was used to analyze different games with example figures with various aspects. These remarks of the example figures were then connected to the theories of color design to show concrete examples how these kinds of theories can be executed in practice.

Concerning results, it was possible generate a general guide for color design in games that provides a view into how color related things such as color harmonies are used in game by providing in-game examples of already published games.

As the conclusion, it was possible to notice that there are video games that take localization and color design into account in different ways such as aiming for universal color harmony and creating localized version of products to fit their target markets as well as audiences. However, it was noted that there is still need for more detailed and delimited approach from the perspective of art styles and colors as a whole, providing base for further research.

Keywords/tags (subjects)

Color Design, Game Design, Color Psychology, Color Symbolism, Color Harmonies, Colors and localization

Miscellaneous (Confidential information)

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1 Terminology

Hue: The name of the color: Red, orange, yellow, green, blue or violet and their tertiary colors. However, it can be used to describe also generally to describe the complete visual process of hue, **value** and **saturation** together (Holtzschue, 2011).

Chromatic: Color having hue (Holtzschue, 2011).

Achromatic: Color without hue. Black, white as well as greys are described as achromatic (Holtzschue, 2011).

Polychromatic: Color with multiple hues (Holtzschue, 2011).

Monochromatic: Color with only one hue (Holtzschue, 2011).

Value: the relative lightness or darkness of a color (Holtzschue, 2011).

Saturation or **chroma**: the hue strength or brightness of a sample, its *dullness* or *vividness*. Chroma means the purity of the color where high chroma does not have added achromatic elements whereas saturation means how weak or strong is the color (Holtzschue, 2011).

The artists' spectrum: a circle illustrating hues in their natural and spectral order. The artists' spectrum is also called **color circle** or **color wheel** and it has six hues consisting of the primary as well as secondary colors. The artists' spectrum can in an expanded version also include 6 tertiary hues in addition to the above mentioned six hues (Holtzschue, 2011).

Primary color: The simplest hue that cannot be divided into other colors or reduced into component parts. The primary colors are *red*, *yellow* and *blue* (Holtzschue, 2011).

Secondary color: Color on a midpoint of the primary colors and they have less contrast in hue than the primary colors. The secondary colors are green, orange and violet (Holtzschue, 2011).

Intermediate color: Color on a midpoint of primary and secondary hue. The intermediate colors are Yellow-orange, red-orange, red-violet, blue-violet, blue-green and yellow-green (Holtzschue, 2011).

Saturated color: A hue in its strongest possible form. They are also called as **pure colors** or **full colors** and they have the maximum chroma. It can consist of only one or mix of two primary colors and it cannot include black, white or gray (Holtzschue, 2011).

Cool and warm colors: Hues can be divided into cool and warm colors where blue, green and violet and every color between them are called cool colors. Red, orange and yellow and every color between them are called warm colors. The word color temperature is used to express how cool or how warm the color is (Holtzschue, 2011).

Analogous colors: Hues next to each other on the color wheel which contain two primary colors

but not the third. As an example red, red-orange and orange create a group of analogous colors (Holtzschue, 2011).

Complementary colors: Hues on the opposite sides of the artist's spectrum creating complementary pairs of red and green, yellow and violet as well as blue and orange (Holtzschue, 2011).

Tertiary colors: The colors which consists of a primary color and a secondary color such as red-orange. Another meaning to tertiary color is a (a)chromatic neutral, where a pair of complementary colors are mixed in a subtractive way creating gray or brown without apparent hue in the mixture and that cannot be described as a mix of black and white (Holtzschue, 2011).

Additive color mixing: Also known as mixing lights. Mixing two primary colors of light creates a secondary color of light. Mixing blue and green creates a color called *cyan*, mixing blue and red creates *magenta* and mixing red and green creates *yellow*. (Holtzschue, 2011). When lights of cyan, magenta and yellow are mixed, it creates white light and the human eye's perception of colors is based on this mixing of lights (Nassiry, 2004). This additive color model of mixing of lights of red, green and blue on a black base essentially creating white light can produce millions of colors is also known as the **RGB color system** and it is used in digital appliances such as computer screens (Pavilion, 2021).

Subtractive color mixing: The opposite of additive color mixing. In subtractive color mixing the above mentioned cyan, magenta, yellow as well as *key color* of black are used to create colors on a white base. This kind of color creation starting from white base essentially producing black by adding of subtractive colors is used in mediums such as printing and painting and if is often abbreviated and called as *CMYK* (Pavilion, 2021).

Tint: A hue mixed with white (Holtzschue, 2011).

Tone: A hue mixed with grey (Holtzschue, 2011).

Shade: A hue mixed with black (Holtzschue, 2011).

2 Introduction

As any product, video games tend to succeed in some countries, but fail to succeed in some other countries. It is wise to try analyzing as much as possible the reasons behind these factors that affect the popularity and success of the products.

As my personal observation, I had a cultural surprise how different do the video game shelves look in stores in Finland when compared to Japan. There are video games I had never heard of in Japan and there are popular video games in Japan which do not have much popularity in Finland. The same kind of tendency can be seen when comparing the most popular video games between Europe and Japan. If you compare the top 10 best-selling video games in Europe and in 2022 and compare the ranking position in Japan, you can see that some video games have quite a difference in popularity purely based on the selling order as shown in the Table 1:

Table 1

Comparison of sales rankings between the top 10 video games in Europe and their corresponding rankings in Japan in 2022

Name of the game	Ranking in Europe (no platform/version sorting)	Ranking in Japan (including platform/version sorting as well as popularity order)
FIFA 23	1	54 (Nintendo Switch) 77 (PlayStation 4)
Call of Duty: Modern Warfare 2	2	74 (PlayStation 4)
Elden Ring	3	10 (PlayStation 4) 27 (PlayStation 5)
Grand Theft Auto 5	4	Below 100 = not in the list
FIFA 22	5	72 (Nintendo Switch)
Pokémon Legends: Arceus	6	3 (Nintendo Switch)
God of War Ragnarok	7	71 (PlayStation 5)
LEGO Star Wars: The Skywalker Saga	8	Below 100 = not in the list
Horizon: Forbidden West	9	32 (PlayStation 5) 41 (PlayStation 4)
Gran Turismo 7	10	18 (PlayStation 5) 29 (PlayStation 4)

Note. European figures adapted from: https://wholesgame.com/news/top-20-best-selling-video-games-in-europe-year-2022/

Note. Japanese figures adapted from: https://www.frontlinejp.net/2023/02/02/top-100-best-selling-games-in-japan-2022/

When looking at the data above it is possible to deduce that there are some video games like Elden Ring and Pokémon Legends: Arceus, which are in the top ten in sales in both markets in 2022. However, at the same time, it is also possible to see as well that the most popular video games in Europe such as both FIFA video games, Call of Duty: Modern Warfare 2 and Grand Theft Auto 5 were much farther from the top and where Grand Theft Auto 5 did not make it into the top 100 most selling video games in Japan in 2022.

There are many reasons behind why some video games succeed in different countries and some do not. Nowadays it is rather easy to get your product distributed for example in mobile phone application stores and there is vast market for video game products in these kinds of places, but many times things such as ignoring localization and culturalization as well as lack of international strategy plan can hinder the worldwide popularity of the products (Chan, n.d.). Together with the localization issues, things such as game genre can affect the popularity of the game in different markets. For example, when researching a stereotype that the Japanese do not like shooter games, especially FPS (First Person Shooter), Kalle Heikkinen argues that the amount of shooter games in Japan is lower than in China or the United States and that Japanese are not keen on developing shooter games locally creating market to the overseas publishers (Heikkinen, 2020).

There is also one major personal impression in difference of the popular video games in the two countries, which was the colors used in the game design such as environment and overall looks of the game. This made me wonder what kind of colors and their combinations make the game look appealing and how these colors affect the perception of the game as well as is this perception cross-cultural or is it more market orientated. As for the cross-cultural perspective, it has been researched that there are colors and color combinations that intensify a certain feeling. For example, combination of orange/yellow and blue work well together in a cooking game, since orange and yellow intensify the feeling of hunger and blue reduces this feeling of hunger (Cieślak, 2022). As for the market orientated point of view, Juego Studios argue that game localization can help to enhance players' gaming experience across different cultures and languages and that adapting the game's art visuals to match different cultural norms and expectations and that this work includes changing colors according to local preferences (Juego Studios, 2023). But in addition to local preferences, colors can symbolize different things in different countries and thus they are perceived differently. For example, red can have associations with communism in places like

former Eastern European Bloc countries, whereas in China red symbolizes luck and happiness (Eriksen Translations, 2020). This kind of previous research regarding color theory and symbolism provides a base for further analysis and proves, that colors are important when it comes to how something is perceived from a visual point of view.

This is why I plan to research as my thesis how color usage affects the perception of video game products especially from a milieu as well as general appearance delimiting character design to increase the reliability as we as liability of the research. This research is done by analyzing popular video games in different countries along with color theory and how it is used in game design. Qualitative research is used as the main research method as there is need for analyzing the research materials in detail. Also, an interpretive case study was selected as the base of the research, since it can also be used in situations, where plausibility of the research defines quality better than validity and reliability. This kind of quality in the form of plausibility is necessary since things like perception and popularity of products can be a sum of many different things and for example in this case, the use of colors probably has not been the only deciding factor for buying or not buying a video game. Also, since interpretive case study focuses on how and why something is seen the way people see things in the form of social construction of reality, it provides a good base for research, since also colors can be perceived differently in different places, situations and cultures as it has been discussed above.

The games chosen to be analyzed in detail are *Final Fantasy 7 Remake* published by *Square Enix*, *Crash Bandicoot* published by *Naughty Dog*, *Angry Birds 2* published by *Rovio Entertainment*, *Cyberpunk 2077* developed by *CD Projekt*, *DRAGON QUEST® XI S: Echoes of an Elusive Age* published by *Square Enix*, *Limbo* published by *Playdead. Florence* published by *Annapurna Interactive*, *Beyond Blue* published by *E-Line Media* and The Last Case of Benedict Fox published by *Rogue Games, Inc.* The games were chosen from differing platforms, budget classes, genres, publication years as well as countries to get as much varying as well as abundant sampling data as viable.

3   Color theory

When researching colors, it is necessary to understand what the word color means. In broad terms, the *color* we experience is direct or reflected *light* where i.e., colors on a monitor are seen

as *direct light* and the colors of the physical world such as printed pages, objects and the environment are seen as *reflected light* (Holtzschue, 2011). *Light* refers to *electromagnetic radiation* that can be detected by the human eye (Stark, 2022). However, in addition to the light that can be detected by the human eye, there is also light that the human eye cannot detect These lights include *radio waves*, *microwaves*, *infrared radiation*, *ultraviolet rays*, *X-rays* as well as *gamma rays*. All these types of light are described by the concept of *electromagnetic spectrum*. The visible spectrum for a normal human being is from about 400nm to 700nm and this covers the all the colors of violet, indigo, blue, green, yellow, orange and red and the mixtures of these colors. (Nassau, n.d.). This research focuses on these colors visible for the human eye, but it is necessary to recognize that there are other types of colors as well.

As for the perception of colors, it is easier to observe colored light from a light source when compared to a color of a physical objects. When the light is emitted straight from the light source, it is possible to see the unchanged color of light whereas in physical objects the visible color is also called as *effect* that consists of two different factors: (1) the light that works as the *cause* for color generation (2) colorants such as paints and dyes that work as the *means* for color generation (Holtzschue, 2011).

Holtzschue also states, that all the colors are unstable, and that same color can seem different when it is e.g., placed in a different place related to other colors or when the medium is changed from a screen to a real-life object. The ideas of colors are also unstable where e.g., one person identifies the same color differently as another person and the meaning of colors as symbols may have different meanings as well as names in different situations (Holtzschue, 2011).

3.1   Colors and the Six Level of Response

In Holtzschue's book Understanding Color: An Introduction for Designers, colors are divided to six different group on their level of response and what effects how we perceive colors. The levels from the largest to smallest group are: 1) *Biological reactions to a color stimulus*, 2) *collective unconscious*, 3) *conscious symbolism-associations*, 4) *cultural influences and mannerisms*, 5) *influence of fashions as well as styles and trends* together with 6) *personal relationships* (Holtzschue, 2011).

Biological reactions to a color stimulus are about our brain reacting to a stimulus of light and its effect on the midbrain. (Holtzschue, 2011). For example, dark colors and surroundings remind of us regarding things like the nighttime and blue light from monitors can hinder the activity of the *circadian rhythm* also known as the *biological clock*.

On the second level of collective unconsciousness the *cognitive part of the brain* is activated and the sensation of color is identified by name. On this level our brain creates *associations* to the color i.e., red and the word red itself. On this level the associations are made *unconsciously* and they are *cross-cultural*. (Holtzschue, 2011). As an example, some might think about nature when thinking of green.

On the third level of conscious symbolism-associations, colors are utilized for *non-color ideas* as symbols and visual codes. (Holtzschue, 2011). For example, when thinking of national flags, people of Germany might think of their national flag by the colors of black, red and yellow, but people from Belgia could also think of the same colors as their own national flag, where the stripes are in different order and direction. This kind of using of color to symbolize something particular is called *color symbolism*. (Holtzschue, 2011).

On the fourth level cultural influences and mannerisms, colors can hold different meanings depending on the community and culture one is living. Colors as symbols are constantly changing their meaning as the time goes by, but there are also colors as symbols, such as black symbolizing death in the West, that maintain their color symbolism even long time periods (Holtzschue, 2011). The color symbols can be internationally agreed such as red as the color of the traffic sign or the traffic light for stop and green as the color of safety.

On the fifth level of influence of fashion, styles and trends the color associations are color preferences that are short term influenced, cyclical and transitory. (Holtzschue, 2011). These kind of color responses are used in consumer marketing to give a lift for sale figures.

On the sixth level of personal relationship with colors, the associations are usually strong and long lasting and color responses develop along time together with own experiences. (Holtzschue, 2011). As an example, it is possible to have negative connotations to pink, if you had to drink bad

tasting pink medicine as a child when sick. In these situations, the color pink might have associations to sickness as well as bad taste.

3.2 History of Color Theory

Color theory's purpose is to an bring an answer to questions regarding colors such as which colors go well with each other, what do colors mean, what are they and how to organize as well as how display them (Holtzschue, 2011).

The earliest writings regarding color date back to the ancient Greek, where the philosophers were striving to initiate color's significance as part of the wider universe. *Pythagoras* is attributed with creating *the harmony of the spheres*, which is a mathematical theory for creating pleasing musical sound utilizing the harmonic length of strings equivalent to the distance between planets. This ideal was also enlarged later to adapt forms and colors to respond the musical scale.

Also, Aristotle had influence on color theory because he addressed colors both from philosophic as well as scientific standpoints and his presumption that all colors are derived from black or darkness and white or light, retained its position as reality until the eighteenth century.

During renaissance, especially *Leonardo da Vinci* wrote on the functionality of mixing colors and what kind of philosophical as well as moral meaning does this mixing have, but it was the results of experiments by *Isaac Newton* that color as a topic obtained its place as a prevailing philosophic as well as scientific concept.

During the eighteenth century in Europe, people began to believe in irrefutable laws of nature and this is historical period is known as the *Age of Reason* or *Enlightenment*. During this time, also color combining was thought to have a natural law waiting to be found. According to Holtzshue, during the eighteenth, nineteenth and early twentieth century there were two themes dominating the color study: (1) Searching for an all-inclusive color system order with suitable form of visualization (2) Creating a field of study where this color system as well as color harmony could be further researched (Holtzschue, 2011). These agreements have prevailed to date and they constitute the unified framework of knowledge of colors also called as *color theory*. During the

emergence of this color theory and research, there were two dominating figures whose observations created the base for modern color theory: Isaac Newton and *Wolfgang von Goethe*.

Isaac Newton noticed that when sunlight hits a prism, every wavelength bends or refracts and each wavelength emerges a separate beam of light with distinctly different colors because the prism made of glass slows each wavelength down. A well know example of this are in nature are rainbows, which demonstrate this experiment when droplets of water in the atmosphere act as small-scaled prisms and sunlight is broken into visible colors. During this experiment Newton identified seven spectral *hues* of red, orange, yellow, green, blue, indigo (blue-violet) and violet. As for the meaning of the word hue, Holtzschue (2011) described it as "*the name of the color*" (p. 12). There is still no certainty why Newton chose seven hues as the spectrum of light since indigo is difficult for many people to detect. However, there are theories such as trying to make the colors to correspond to the musical notes of the diatonic scale. This spectrum remains as the standard of physical science in ongoing recognition of his discovery (Holtzschue, 2011). Newton also managed to recombine separated beams back to white light and he hypothesized the nature of light concluding his results that light alone generates color in his published work entitled as Opticks in the year 1703. This conclusion remains as basis of modern physics.

Figure 1

Illustration of Newton's Prism Experiment (Grusche, 2015)

Before Isaac Newton made his experiment of splitting sunlight into its component wavelengths by passing it through a prism and creating his *color wheel*, also Finnish astronomer and priest *Aron Sigfrid Forsius* created the first color wheel inside a sphere in 1611 and this would be the first color wheel, but his texts was lost in the Royal Library in Stockholm and was only discovered in 1969 meaning his color wheel had little influence on color theorists and artists. His main thought was that if origin and relationships of the colors are to be correctly observed, it is necessary to begin with the five basic median colors of red, blue, green, yellow and grey from white and black, (Harding University, n.d.). Similarly, Forsius was the first person to realize that three-dimensional form is required if all the colors are to be included in the color wheel (Munsell, n.d.). The color space of Forsius is considered as the precursor of the Natural Color System (NCS) Colour Space (NCS Colour, n.d.).

Whereas Newton addressed colors of light and Goethe the ideas of the perception as well as aesthetics regarding color, around the same time *Jacques Christoph Le Blon* was dealing with practical realities of colors in printing. He recognized primary nature of red, yellow and blue while mixing pigments offering the first concept of three subtractive primary colors creating a foundation of present-day printing in his treatise *Coloritto* in 1730. Le Blon's theory was adapted by *Moses Harris* and he was the first to publish a true visualization of color organization believing that red, yellow and blue are the most different colors from each other, thus they should be placed at the greatest possible distances on a color circle. According to Holtzschue, this meant he had to discard the indigo from Newton's theory and he made the color wheel symmetrical where colors had equal intervals of colors and multiples of three (Holtzschue, 2011). This composition was later adopted by Goethe.

Figure 2

Color Wheel of Moses Harris (O'Connor, 2020)
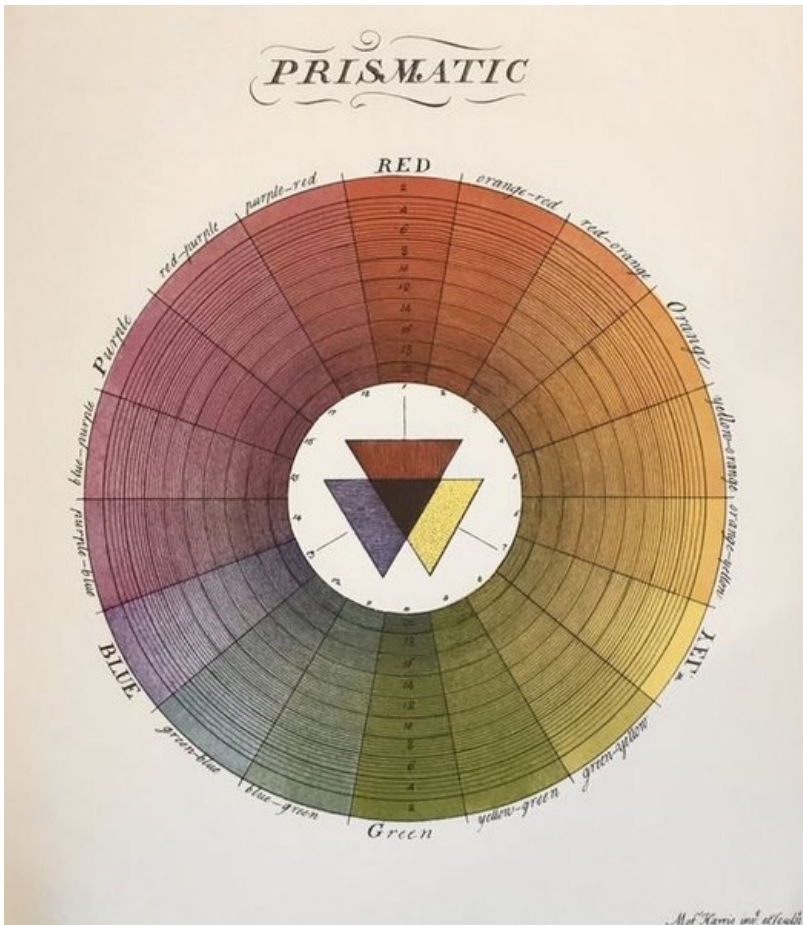
Goethe objected the approval of Newton's ideas and he spent considerable amount of effort to prove Newton wrong in his treatises and the first one called *Announcement for a Thesis in Color* was published in the year 1791. Goethe did not think of colors as light, rather he thought them as an entity of their as well as experienced reality of their own and had a different perspective when compared to Newton's ideas. According to Holtzschue, Goethe concentrated on the effects of colors whereas Newton was looking at causes (Holtzschue, 2011).

Goethe criticized that Newton's theories do not make it easier to grasp the world more vividly and even if Newton was correct, his theories did not have practicality in the real world. Goethe associated colors and beauty in his treatises and thought, that there are sinful as well as chaste colors and that moral character is affected by the colors in clothing as well as the skin color as well.

Goethe largely reported on the occurrence of simultaneous contrast and afterimage and endorsed that pure colors exist only in level of theory. He also characterized the principal contrasts of color as polarity meaning contrast or opposition and gradation meaning intervals. This simultaneous contrast was also addressed from a practical point of view by *Michel Eugene Chevreul* as he found it problematic to create black dyes, because the dye seemed to lose depth or darkness when positioned alongside other colors. His findings an impact on the *Impressionist* movement in painting.

Goethe contributed the color study a *six-hue color circle*, although Goethe proclaimed existence of only two primary colors of blue as well as yellow and that all the other colors descended from these two colors. Goethe's color circle and Leblon's red-yellow-blue primary color thinking constitute the basic artists' spectrum where there are six equal sized section of colors: red, orange, yellow, green, blue as well as violet. According to Holtzschue, even though Goethe's ideas were further developed by other artists and writers, almost every contemporary color study concept exists in Goethe's writings because his observations were very fundamental as well as wide-ranging (Holtzschue, 2011).

Figure 3

Goethe's Color Wheel with associated symbolic qualities (Goethe, 1809)
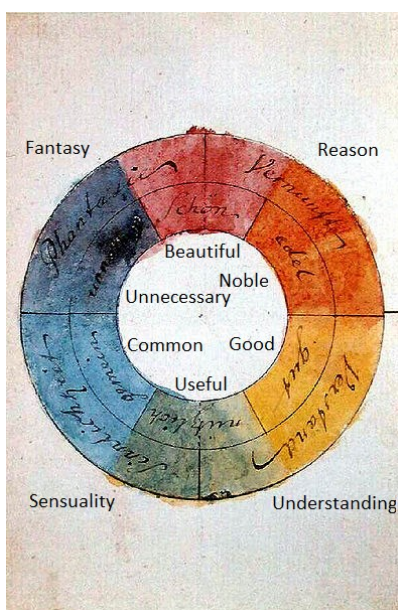
Note. Translation has been added to the symbolic qualities.

Both Goethe's six-hue spectrum of subtractive color as well as Newton's seven-hue model of the hues of visible light remain as valid theories to date, but they are used for different purposes. Newton's spectrum remains as the spectrum for scientists and Goethe's spectrum remains for artists describing different realities. However, Holtzschue stated that digital design has restructured the situation and today designers must be able to use and maneuver in both realities (Holtzschue, 2011).

Most of the color theorists during the turn of the eighteenth century after Chevreul and Goethe concentrated on codifying their findings to formal as well as scientific models. They concentrated on rules and order. They tried to find rigid laws of color harmony while creating all-inclusive system of color order. The first color orders were not three-dimensional, but two-dimensional shapes of rectangular, triangular or circular form. One of the most known and earliest three-dimensional models called *color tree* was done by *Albert Munsell* in his work *A Grammar of Colors* published in 1921. According to Holtschue, the color tree was a color space which had unlimited room for expansion where each color was assigned to an alphanumeric scale and Munsell had stated that there is no new color that cannot be granted a symbol and be placed on this color space, but at the same time not all the possible colors could be shown on this color space in practice (Holtzschue, 2011).

The Munsell color space is constructed using a vertical axis from black to white and placing hues around this vertical axis with progressive intervals opposite to its complementary pair and its independent. The tones of saturated hues are adjusted by increasing the amount of achromatic grey and each hue moves towards center of the axis losing chroma until each hue reaches grey of equal value. The intensity decreases by each step on each horizontal hue branch, but the value of the hue intensity stays untouched. However, complementary colors dilute each other both in saturation as well as value whenever they move towards each other from the different sides of the axel not ending up in achromatic grey but a chromatic neutral. Also, Munsell's color space originally included debatable associations between colors and morals, but the coherent color space is used in education as well as working life emitting these remarks (Holtzschue, 2011).

Figure 4

Munsell's Color Tree (Rus, 2007)
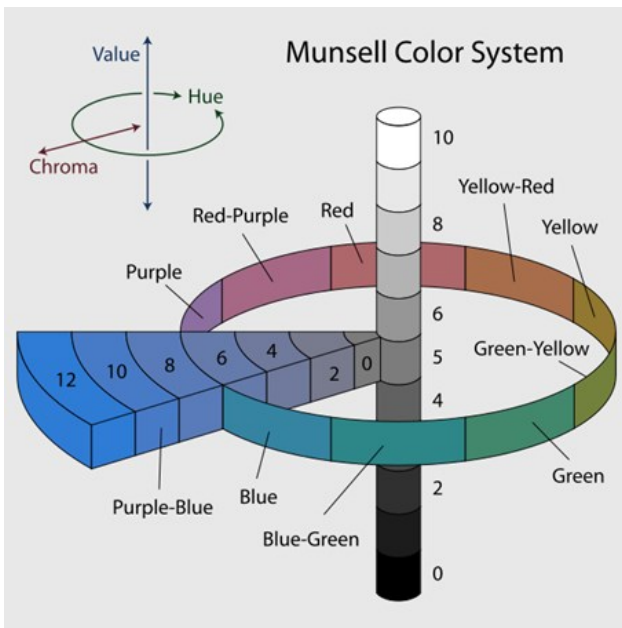
Figure 5

Munsell's Color Tree (Datumizer, 2020)
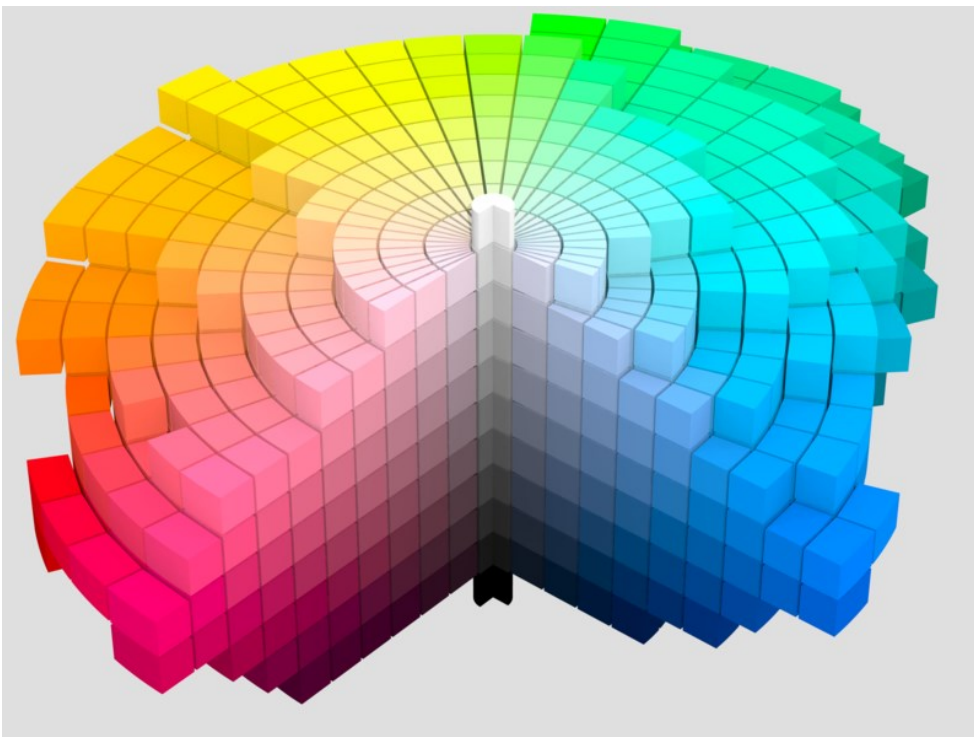
There was also a German art school called the *Bauhaus*, which also had an impact to coherent color theory. There are few persons who influenced Bauhaus and its students and they are *Wilhelm Ostwald*, *Wilhelm von Bezold* as well as *Ludwig von Helmholtz*. Ostwald was able to create a full-scale theory out of the conceptual color study in his work *Color Science* and his work *The Color Primer* including his eight-hue spectrum became a compulsory for color theory in many schools in German and English schools. As for Bezold and Helmholtz, they advanced color theory on the field of psychology and color vision's physiology.

Figure 6

Ostwald's Eight-hue Spectrum (Ostwald, 1916)
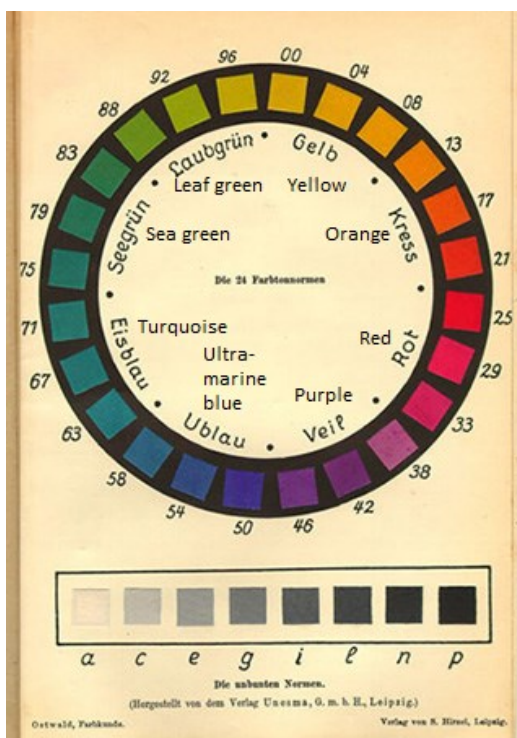
Note. Translation added to the color groups.

Even though some components deriving from the older quasi-scientific of color research were still not omitted in the Bauhaus art school, color study was divided to two parts in this school: Color study as art and aesthetics as well as color study as science. Light was part of the science territory; colorants were part of chemistry and engineering and psychology as well as physiology together with medicine oversaw the perception part of the color study. In Bauhaus there was also *Johannes*

Itten, who can be seen as a successor for Goethe's doctrine, since also he explored colors as contrast as well as opposing force systems. According to Holtszhue, there were seven different contrasts on his doctrine: Contrast of hue, value, saturation, warmth and coolness, complementary contrast, simultaneous contrast as well as contrast of extension, in this case meaning area (Holtzschue, 2011). Itten as well created his own twelve color harmony system on a color circle using series of chords composing a series of geometrical forms such as triangles and quadrangles. When these forms are placed on the color wheel, the corners of the form will show the harmonious colors that will suit each other. Holtszhue states, that even though these chords were mathematically based, Itten's way of thinking regarding color theory was less taut when compared to his predecessors and his focus was more on the individual perception of colors rather than mathematical relationships emphasizing that Itten's major work is named as *The Art of Color* (Holtzschue, 2011).

Figure 7

Itten's Color Wheel (MalteAhrens, 2008)

In addition to Itten, there was also *Arthur Schopenhauer* who searched for color harmony using geometry as the tool. Schopenhauer used Goethe's color circle as the base of his calculation and

assigned different values for each hue depending on the luminosity of the hue in question. According to Holtschue, the total of values is 36 representing 360 degrees meaning a full circle and every complementary color pair adds to 12 or 120 degrees. The complementary pairs and their values are: red (6) + green (6) = 12, blue (4) + orange (8) = 12 as well as yellow (9) + violet (3) = 12 all adding up to 36 (Holtzschue, 2011). Thus, In Schopenhauer's theory the pair red and green creates color harmony when there is ½ red and ½ green on a certain area. With the pair blue and orange this ratio is ⅓ blue and ⅔ orange and with the pair yellow and violet the ratio is ¾ yellow and ¼ violet. The distribution of colors is demonstrated in the figure 8 below by utilizing a donut chart. However, Holtschue argues that this theory illustrates effectively how we sense these value differences between pure colors, but it should be kept in mind that light-reflectance of colors cannot be straightly calculated from their area. (Holtzschue, 2011).

Figure 8

Schopenhauer's Circle of Color Harmony Demonstration by Utilizing a Donut Chart
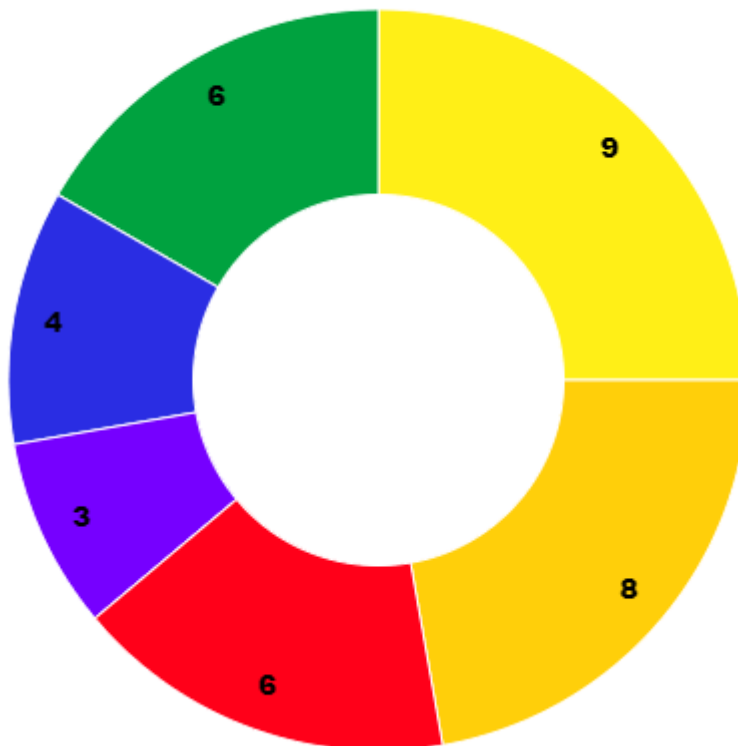
The above-mentioned color order systems created by these various color theorists provide a field where it is possible to research the laws of color harmony and according to Holtzshue there is one thing that each color theorist seeking color harmony agree: color harmony is based on order, especially in balanced correlation between complementary hues (Holtzschue, 2011). However, there was a person called *Josef Albers* originating from the same Bauhaus as Itten, who thought differently about the perception of colors. After fleeing from Germany in the 1930's, Albers became influential in the United States and he started to teach at the university of Yale. As the opposite for Itten's geometrical as well as theoretical way of thinking, Albers is known of thinking that visual experience was more important over theory while emphasizing the instability and relativity of color perception as well as the need for visual training for gaining true understanding of colors.

Albers's emphasis on visual experience over theory is topical even today and Holtszhue argues that color study has changed its attention from philosophical investigation more to the psychological as well as motivational effects of colors while also stating, that are also color theorists thriving to search and seek the conclusive laws for color harmony (Holtzschue, 2011).

4   Color Symbolism

In broad terms, *color symbolism means using colors to symbolize something*. The symbolism of colors is being mainly shaped by learned things from *the past* and *history*, *cultures, spoken language* and by *own individual experiences*.

Like art, also colors are *subjective phenomenon*, meaning it can drastically differ how different individuals perceive and associate different colors. But in addition to individual association levels, there are also colors that are used universally to symbolize same things such as red, which is often used in warning signs. Also, subjects such as religion, nature and science often have their own approach on color symbolism.

This subsection mainly focuses on color symbolism by giving some examples of what kind of meaning are often associated with the primary colors of red, yellow as well as blue and the secondary colors of orange, green and purple together with the achromatic colors of black, white and grey in different cultures and countries. Also, some examples are also given how nature and science connect on color symbolism and how things inherited from past effect on our perception of color today.

4.1 Color Symbolism from the Past and History

As mentioned earlier, there are color theorists from the past and history such as Goethe who have argued that certain colors embody different kind of meanings. For example, Goethe thought that there were plus as well as minus side on his color wheel. He thought of red, yellow and green and their in-betweens as the plus side of the color wheel and blue, red-blue as well as blue-red as the minus side of the color wheel. Goethe gave attributive words for every color on his color wheel where red is for beautiful, orange is for noble, yellow for good, green for useful, blue for common and purple for unnecessary. These attributes were labeled for four human characteristic traits where beautiful (red) and the noble (orange) were associated with rationality, good (yellow) and useful (green) were associated with intellectuality, useful (green) and common (blue) were associated with sensuality as well as unnecessary (purple) and beautiful (red) to fantasy.

Even though perception of colors evolves constantly and varies by cultures as well as individuals, it is possible to see how for example yellow is even today commonly linked for intellectuality on the level of symbolism. These kinds of learnings and research as well as traditions from the past creates the base for the color as symbols, that are reshaped constantly over time by different cultures and individuals by their own experiences.

4.2 Color Symbolism in Nature and Connection to Science

Nature also has its own way of communicating by color symbols, especially regarding danger. The warning colors vary depending on whether it is an animal or plant what is trying to convey the possible danger to for example predators. This is called *warning coloration* or *aposematism*.

In plants, these aposematic colors include black, white, red, orange, yellow, brown and the combinations of these colors. As for mushrooms, often ones with white gills are poisonous and ones that have red cap or stem are often poisonous or strongly hallucinogenic.

In animal kingdom, for example some insects such as wasps have evolved in a way that their coloring is giving the viewers a prewarning of toxicity with their stripes of black and yellow.

In science, the same kind of approach of using warning colors of the nature is commonly used in warning signs which often include red and yellow. It has been researched, that wavelength of red is the fittest in penetrating fog and it has the best visibility also in the dark or misty environment. Also, yellow's visibility together with the above-mentioned association with possible dangers of the nature makes it well-used color in traffic signs, which indicate potential danger, but red is used to describe the highest level of danger also because it is often associated with blood (Safety Sign Supplies, 2014).

4.3 Color Symbolism in Different Cultures and Countries

As mentioned earlier in this chapter, different colors hold different meanings depending on the cultures and countries and this section focuses on the main associations universally as well as differences between cultures and countries.

Red is often associated with fire, blood as well as sex and the positive meanings are passion, love, blood, energy, enthusiasm, excitement, heat and power, whereas negative meanings are aggression, anger, battle, revolution, cruelty as well as immorality. As for the cultural links, in Ivory Coast of Africa dark red indicates death and in South Africa red is the color of mourning. In France red indicates masculinity and in most of Asia it represents marriage, prosperity as well as happiness. In India red is the soldier's symbol (Stone et al., 2006). Red is also often linked to Christmas especially when together with green.

Yellow is often linked to sunshine and holds the positive meanings of intellectuality, wisdom, optimism, radiance, joy and idealism, whereas negative meanings hold jealousy, cowardice, deceit as well as caution. As for the cultural links, in Japan yellow is associated with courage and Hindu cultures yellow is worn to celebrate the festival of spring. In India yellow is the symbol of

merchant of farmer and in Egypt and Burma yellow is the color of mourning (Stone et al., 2006). In some countries such as Thailand Buddhist priests wear saffron yellow and orange robes.

Blue is usually associated to sea and sky and holds the positive meanings of knowledge, coolness, peace, masculinity, contemplation, loyalty, justice and intelligence, whereas negative meanings hold depression, coldness, detachment as well as apathy. As for the cultural links, in most of the world blue is thought as the color of masculinity, but in China blue is the color for little girls and in Iran blue is the color of mourning. In western bridal traditions blue is the color of love and worldwide it is the most popular corporate color (Stone et al., 2006).

Green is often thought as the color of plants and the natural environment and it holds the positive meanings of fertility, money, growth, healing, success, nature, harmony, honesty and youth, whereas negative meanings hold greed, envy, nausea, poison, corrosion and inexperience. As for the cultural links, in Islam green is linked with paradise and it is the symbolic color of Islam. In celtic cultures the Green Man was the god of fertility and in Native American cultures green is associated with the will or man's volition (Stone et al., 2006). Green is often connected to Ireland and the St. Patrick's Day.

Orange is often linked to autumn and citrus, and it holds the positive meanings of creativity, invigoration, uniqueness, energy, vibrancy, stimulation, sociability, health, whimsy and activity, whereas negative meanings hold crassness, trendiness and loudness. As for the cultural links, in Northern Ireland orange represents the Protestant movement and in native American cultures it relates to learning and kinship. In India orange signifies Hinduism and in Netherlands orange is the national color because the Dutch monarchs came from Orange-Nassau. (Stone et al., 2006). In Japan, orange is associated with love and happiness and represents civilization and knowledge.

Purple is often the color of royalty and spirituality and it holds the positive meanings of luxury, wisdom, imagination, sophistication, rank, inspiration, wealth, nobility and mysticism, whereas the negative meaning hold exaggeration, excess, madness and cruelty. As for the cultural links, in Latin America purple indicates death and in Thailand purple is a mourning color of widows after husband's death. In Japan purple is associated to ceremonies, enlightenment and arrogance

(Stone et al., 2006). In Japan purple is also the colors of royalty as well as warriors and it symbolizes strength.

Black is often associated with night and death and it holds the positive meanings of power, authority, weight, sophistication, elegance, formality, seriousness, dignity, solitude, mystery as well as stylishness and the negative meanings hold fear, negativity, evil, secrecy, submission, mourning, heaviness, remorse and emptiness. As for the cultural links, in China black is the color for little boys, and in Asia generally it is associated with career, knowledge, mourning and penance. (Stone et al., 2006). Black is sometimes the color of rebellion and it can also be seen in music genre outfits of punk, rock and metal music.

White is often the color for light and purity and it holds the positive meanings of perfection, marriage/wedding, cleanliness, virtue, innocence, lightness, softness, sacredness, simplicity as well as truth and it holds negative meanings fragility and isolation. As for the cultural links, in China and Japan, white is a funeral color. Worldwide a white flag is a universal symbol of truce. In India married women who wear white are thought of inviting unhappiness (Stone et al., 2006).

Grey is often the color of neutrality. It holds the positive meanings of balance, security, reliability, modesty, classicism, maturity, intelligence as well as wisdom and for the negative meanings it holds lack of commitment, uncertainty, moodiness, cloudiness, old age, boredom, indecision, bad weather and sadness. As for the cultural links, in among native Americans gray symbolizes honor and friendship. In Asia gray is associated with helpful people as well as travel. In America grey represents industry opposing environmentalism which holds the symbolic color of green. Worldwide grey is often linked to silver and money (Stone et al., 2006).

4.4   Color Symbolism as Individual Experiences.

The above-mentioned examples are from groups, that are from worldwide and different cultures, but even among same cultures and communities people feel and see colors differently. In her book, Holtzshcue quotes Josef Albers "If one says red and there are 50 people listening, it can be expected that there will be 50 reds in their minds. And one can be sure that they will all be different" (as cited in Understanding Color: An Introduction for Designers, 2011) and adds, that there are hundreds of different reds and many people think there is a fixed name for each red.

Holtzshcue also argues, that if members of the same group are asked to describe a red object by its color name, the answers are more likely to contain descriptive prefix such as fire-engine red, lipstick red (Holtzschue, 2011). These kinds of objects that are used to attribute what kind of red is an example of how different colors symbolize different kind of things for different people also regardless of the larger group they belong.

5   Color Psychology

Whereas color symbolism concentrates more on nuances how larger groups tend to perceive different colors, in broad terms *color psychology* concentrates on *how most people react similarly both physically and mentally to different colors*. This means, that in a sense color psychology is rather similar to the color symbolism's level of individual experiences. One of the pioneers of color psychology, *Carl Jung* described colors being the mother tongue of the subconscious (Stone et al., 2006). Because color psychology concentrates on the non-verbal communications of colors, it is also called as *color language*.

Color Psychology is often used in marketing since color are known to stimulate feelings. It has been researched by *The Institute for Color Research*, that a subconscious judgment regarding persons, environment and products are made within 90 seconds of the first observation and among this judgment, from 62 to 90 percent is based on color alone (Stone et al., 2006). Many times, companies want to make associations regarding their brand and the products by using different colors in their products and logos. For example, in food business orange, red and yellow are often used because they are known for creating impulses to the brain which increase the feeling of hunger. Red also can increase the feeling of excitement as well as blood pressure whereas blue creates an opposite reaction (Modi et al., 2019).

Colors also can influence how we perceive time and on our reaction times. It has been tested that red color help to react faster to stimulus when compared to blue (Shibasaki & Masataka, 2014). It has also been researched that blue and red influences how we perceive time with various results, but the main consensus is that this effect on perception of time could lie in the nature of the color where red increases the amount of arousal and blue the feeling of calmness.

These kinds of observations suggest that colors have a larger impact in our lives especially from a psychological point of view than we might be aware of, thus it might prove beneficial to take both color symbolism as well as color psychology into account when creating things that includes colors in some kind of form.

This chapter mainly focuses on color psychology by giving some examples of what kind of feelings are often associated with the primary colors of red, yellow as well as blue and the secondary colors of orange, green and purple together with the achromatic colors of black, white and grey.

As mentioned above, red is a highly stimulative color and it is thought of as a warm color. It can raise blood pressure and it impacts the nervous system the most. It effects positively our reaction speed and catches our attention the fastest. It also effects our metabolism by adding the feeling of hunger, which is why red is often used in restaurants. In the human eye, the most amount of color receptors called *cone cells* are the ones which react to red. We also have learned from nature and our surrounding cultures, that red often is the color for danger for example in the stop traffic sign. Red can have positive as well as negative connotations. Red is often associated with things like love, passion and excitement in company logos, but it can also increase the number of errors for example in writing. It was noted in research published in the *European Journal of Social Psychology*, that participants made 27% percent more grammatical as well as spelling errors when compared to participants, who used a blue pen and when filling words that can be both positive and negative words, the ones using red pen tended to choose more negative words (Howard, 2010). Depending on the situation where red is used, it can also have connotations to aggressiveness.

Like red, Yellow is a warm color and a stimulative as well as highly luminous color. It is often associated with feelings such as joy, hope, cheerfulness, confidence, self-esteem. Like red, it is also used to convey the idea of a danger, especially yellow high on chroma. In logos yellow is used to symbolize optimism, clarity and warmth. Because yellow is highly luminous color, it can be used to create contrast or help other colors to become more luminous, but for the same reason of being highly luminous it can also irritate eyes when used alone.

Unlike red and yellow, blue is thought of as a cool color. Blue is often paired with red when temperature is communicated through colors i.e., analogue temperature gauge where blue is the minus degrees and red is the plus degrees. In addition to the feeling of coldness, blue is often perceived as a color which soothing as well as calming effect. From a physical point of view, blue is associated to distance, since objects in a distance take on blue hue because the blue with short wavelength get caught up in the atmosphere between the viewer and the objects (Snow, 2015). Blue is associated with the feelings such as wisdom, hope, reason, trust, serenity, logic, peace, melancholy and sadness. In logo designs blue is often used to symbolize trust, strength as well as being dependable.

Green is a cool color and it is often used to create connotations to growth and freshness as well as fertility and it is commonly thought of as the color of the nature and balance. It is also often thought as the color of safety and this is why it is commonly used in traffic lights to signal it is safe to proceed. As for logo usage, green is used to convey the feeling of friendliness, toughness, durability, masculinity, peacefulness, growth, health as well as sustainability and eco-friendliness.

Orange is a warm color and it is thought of connotating emotions of warmth, kindness, joy, enthusiasm. Orange has similarities with yellow and red and it has emotion arousing effect, but not the same amount as red. Orange is also used in warnings and it has the ability of increasing contrast when put next to other colors. In logo design it is used to symbolize friendliness, cheerfulness and confidence.

Purple is a cool color and it has often has connotations in feeling of calmness, femininity, spirituality wisdom, creativity, royalty, power, ambition, luxury and light purple can feel romantic, but darker shades can represent sadness, mystery, uncertainty, frustration. Like blue and green, it can create calming effect. In logo design, purple represents femininity, glamour, charm, creativity, imagination and wisdom.

Black has the ability to create the illusion to make things seem smaller and it does not draw attention when compared to more luminous hues. Black has associations in darkness, death, sadness, powerfulness, mysteriousness, coldness and it can feel scary as well as intimidating for example in horror when black is used to affect the visibility of the surroundings to the viewer.

However, black is thought of also symbolizing elegance, sophistication, expensiveness and it can create the perception of seriousness and importance, professionalism, credibility and edginess in logo designs.

Whereas black gives an illusion of making things feel smaller, white can do the opposite and create an illusion of making things and spaces feel larger. White is often associated with hygiene, cleanliness, simplicity, coolness, emptiness, solitude, pureness, peacefulness and it is often used for example in clothing of the health sector employees such as doctors as well as logo design to symbolize purity. Together with black, white is used to create timeless logo designs.

Grey is often thought of as color of neutrality and balance, but it can also have associations to depression, sadness, intellect, futurism and modesty. When linked with silver finish it often is used to give a feeling of modernity and originality.

From the examples above, it is possible to notice that the same colors can have both negative and positive connotations depending on where they are used and are the colors used together with other colors. Also changes of hues, values and chroma can have a drastic effect on how the color is perceived and as discussed above, color perception is a subjective phenomenon where there might be large variations on how different people in different situations and cultures perceive different colors. This is why generally several researchers refrain of making excessively global statements regarding consumer behavior (Elliot & Maier, 2014). These kind of color associations and general rules can provide the base for the usage of colors, but they should be researched case-by-case, that which kind of colors and color combinations are the most suitable one for the work in question.

6   Color Differentiation and Mixing

6.1   Hue, Value and Saturation/Chroma

There are three different factors which affect how to color is seen: *Hue*, *value* and *saturation/chroma* (Holtzschue, 2011).

As mentioned earlier, the word *hue* can refer to two functions: 1) Hue as the name of the colors red, orange, yellow, green, blue and violet and their tertiary colors 2) Description of the complete visual process of above-mentioned colors with the added effect of value and saturation. When hues are considered from the perspective of being name of the colors, in other words *saturated hues*, they do not have any information how dark or light or how strong or weak the colors are. These other attributes affecting color perception are measured by value and saturation/chroma. When white is added to a hue, it is called a *tint*. In addition, when grey is added to a hue, it is called a *tone* and when black is added to white, it is called a *shade*.

Value signifies the relative lightness or darkness of a color. Value is often demonstrated by using a scale between black and white where white has the highest possible amount of value and black vice versa. Value has a function of creating contrast between objects so that they can be individuated from the background and it does not need hue to exist. A well know example of this are black-and-white pictures and drawings, which do not need colors to be able to individuate the different objects inside them. The only way to see a clear border between colors is to have difference in value also known as value contrast (Holtzschue, 2011). Value contrast can be used as a *stylistic device* to create strong images such as black-and-white images, which have the most amount of contrast. However, high-contrast images can create eye fatigue, which is why for example in some road signs dark green is used instead of black to decrease the amount of eye fatigue without losing inordinate amount of value contrast. (Holtzschue, 2011).

The surface of an object influences the value and how light or dark does it seem, since rough surfaces tend to absorb light instead of reflecting it and smooth surfaces tend to reflect the light better, making it seem lighter. As for color wheels, they are often evenly divided by hues, but the amount of value does not correlate concurrently with hues. The amount of value in a hue is often described as the luminosity of colors. *Arthur Schopenhauer's* color circle, mentioned in the chapter 3.2, addresses the colors by their value. In his color circle, yellow has the most amount of luminosity and value by holding 25% of the color circles surface area followed by orange (22%), red (17%), green (17%), blue (11%) and violet at the least amount of value and luminosity with 8% of the surface area.

Saturation is often also called as *chroma* and they are used interchangeably, but there is a distinction between the two: Chroma means the *purity of the color* where high chroma does not have added *achromatic elements* whereas saturation means *how weak or strong* is the color. In other words, both words refer to *hue intensity* describing contrast between dull and vivid. (Holtzschue, 2011). Saturation can be changed in three different ways. The first way is to change value meaning adding white or black, in other words, creating a tint or shade. The second way is dilute hues by adding gray. This way, the value of the color can remain the same creating a duller color than the original hue, but more chromatic than grey and the luminosity of the color stays the same as the original hue and gray. The third way is to dilute a hue using its complementary color. This way both saturation and value will change and in the midpoint of dilution a chromatic neutral is created meaning a color where it is not possible to differentiate the original hues (Holtzschue, 2011).

6.2   Additive Color Mixing

Additive color mixing is known as *mixing lights*. Mixing two primary colors of light creates a secondary color of light. Mixing blue and green creates a color called *cyan*, mixing blue and red creates *magenta* and mixing red and green creates *yellow*. (Holtzschue, 2011). When lights of cyan, magenta and yellow are mixed, it creates white light and the human eye's perception of colors is based on this mixing of lights (Nassiry, 2004). This additive color model of mixing of lights of red, green and blue on a black base essentially creating white light can produce millions of

colors is also known as the *RGB color system* and it is used in *digital appliances* such as *computer screens* (Pavilion, 2021).

Figure 9

Additive Color Mixing (RGB) as well as Subtractive Color Mixing (CMYK) (mpuq, 2018)
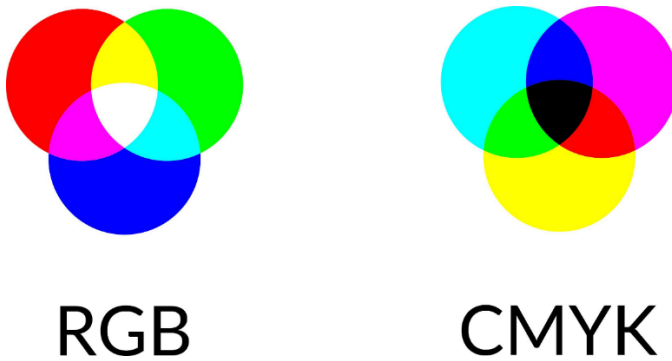
6.3 Subtractive Color Mixing

Subtractive color mixing: The opposite of additive color mixing. Whereas in additive color mixing colors are created by adding lights together on a darker surface to create lighter colors, in subtractive color mixing the above mentioned cyan, magenta, yellow as well as *key color* of black are used to create colors on a white base. In this method colors are seen as reflections of light from the pigments that are laid on this light-colored base surface. This kind of color creation starting from white base essentially producing black by adding of subtractive colors is used in mediums such as printing and painting and if is often abbreviated and called as *CMYK,* which derives its name from the first letters of the above-mentioned subtractive colors of cyan, magenta, yellow as well as key color "K". When compared to the millions of possible colors in RGB color mixing in digital devices, the colors in CMYK are limited by the ink pigments and tints making it possibly to create only several hundred thousand colors meaning it is important to differentiate the correct use of the color mixing method meaning using RGB on digital devices and CMYK on printed mediums (Pavilion, 2021).

6.4 Optical Color Mixing and Pointillism

In optical color mixing, the final perceived color is created inside the eye and the brain, not on the surface of the object. This kind of optical mix is created by placing different small colored dots or

patches next to each other creating a new color inside our mind. It is required that the viewing distance and the size of the mixing pattern are correlated in a correct way since too rough and visible pattern end up abolishing the optical illusion and too detailed pattern from too much distance will give the image of a featureless flat paint (Holtzschue, 2011). In art, this kind of optical color mixing is called *pointillism*, where unmixed colored dots are used as patterns to create images and it was fundamentally developed by French artists *Georges Seurat* and *Paul Signac* in 1886 (Art in Context, 2023).

Figure 10

Demonstrating Pointilism by using the artwork Femmes au Puits, Paul Signac 1892 (Piscis13, 2009)
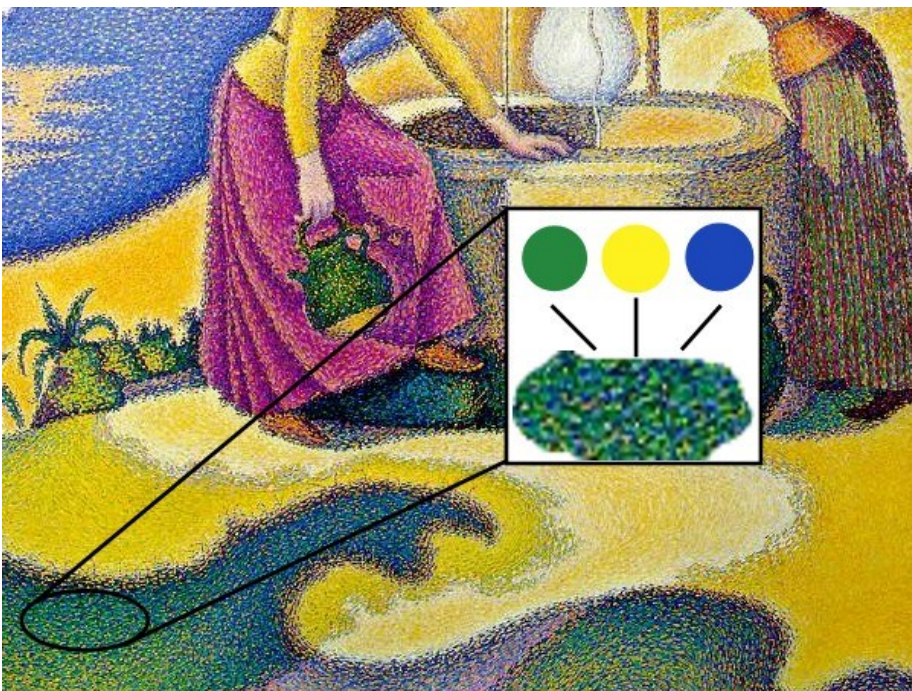
6.5   Color Harmonies

Color harmony is used to describe color combinations and relationships between colors, that are pleasing to the eye. Together these combinations are used in creating *color palettes* and *color schemes*.

Monochromatic color harmony contains only one main color and the different colors are created by using tints, tones and shades of the main color. Monochromatic color harmony is used in: 1)

making the work easier because it is not necessary to think the compatibility with different hues 2) generate visually cohesive appearance 3) complementing the contents without drawing attention to itself 4) associating brands with a certain color (Kliever, n.d.).

Complementary color harmony makes use of opposing relationship of colors on the color wheel such as orange and blue. This kind of color harmony creates high contrast especially when the colors are at their full saturation and this is why complementary color harmony is used for drawing attention, expressing boldness, liveliness and youthfulness and inspiring action (Schinkel, 2017). However, because of their high contrast they can be hard to use user-friendly since they might have a straining effect to the eyes. In this kind of cases intense contrasts can be diluted by creating shades or tints of the colors. (Schinkel, 2017).

S*plit complementary color harmony* is a variation of complementary color harmony, where there is one base color and one complementary color is replaced by two adjacent colors. For example, in this kind of color harmony orange instead of blue, it has the opposing colors of blue-green as well as blue-violet. This color harmony is more versatile when compared to the regular complementary color harmony and it used for creating an impact without being too high in contrast and aggressiveness (Schinkel, 2017).

Analogous color harmony can consist of two primary colors but not the third. However, it contains three different colors. Analogous color harmony is said to create aesthetically pleasing as well as calming effect. Analogous color harmony is often found in nature and it is often used to complement nature and natural subjects. It can be used to add the feeling of dynamics as well as visual interest to a monochrome palette creating a unified appearance supporting the primary theme of the conveyed message (Schinkel, 2017). A well-known example of this in nature are the autumn leaves, where there are often harmonic analogous colors from orange to red as well as yellow to orange. Shades and tints can be used to increase the amount of visual interest in analogous color harmony, but it is recommendable to use as much as analogous color harmony without mixing cool and warm colors, which could have a complicating effect on the color harmony (Schinkel, 2017).

In *triadic color harmony*, the harmony consists of three different color that are spaced evenly around the color wheel. For example, the main colors of yellow, blue and red create triadic color harmony. This color harmony is often used in concepts which need more than two colors. Disadvantage of this color harmony is the high contrast of when using saturated colors, but this can be balanced by choosing a dominating color and using the other two colors as supporting accent colors similar to the supporting colors of the split complementary color harmony. In addition, it is possible to dilute contrast by using tints and shades and they can create sense of calmness and tranquility whereas saturated colors are ideal for youthful as well as bright designs and concepts (Schinkel, 2017).

There are two types of color harmony models which use four colors divided to two complementary pairs. These are called *Tetradic color harmonies*. The first tetradic color harmony model is the rectangular form, which is also called as the *double split complementary color harmony*, where there is one hue between the pairs such as yellow-orange between yellow and orange. The second tetradic color harmony model is the square form, where there are two colors between the pair such as orange and orange-yellow between yellow and orange-red. These color harmonies are often used in designs where there are color-coded elements as well as need for eye-catching designs. In these color harmony models, it is recommendable to try to balance the colors between cool and warm colors to avoid the colors to appear garish and strive balance by choosing one dominating color while keeping the other three as support accent colors. (Schinkel, 2017).

Figure 11

Seven Types of Color Harmonies
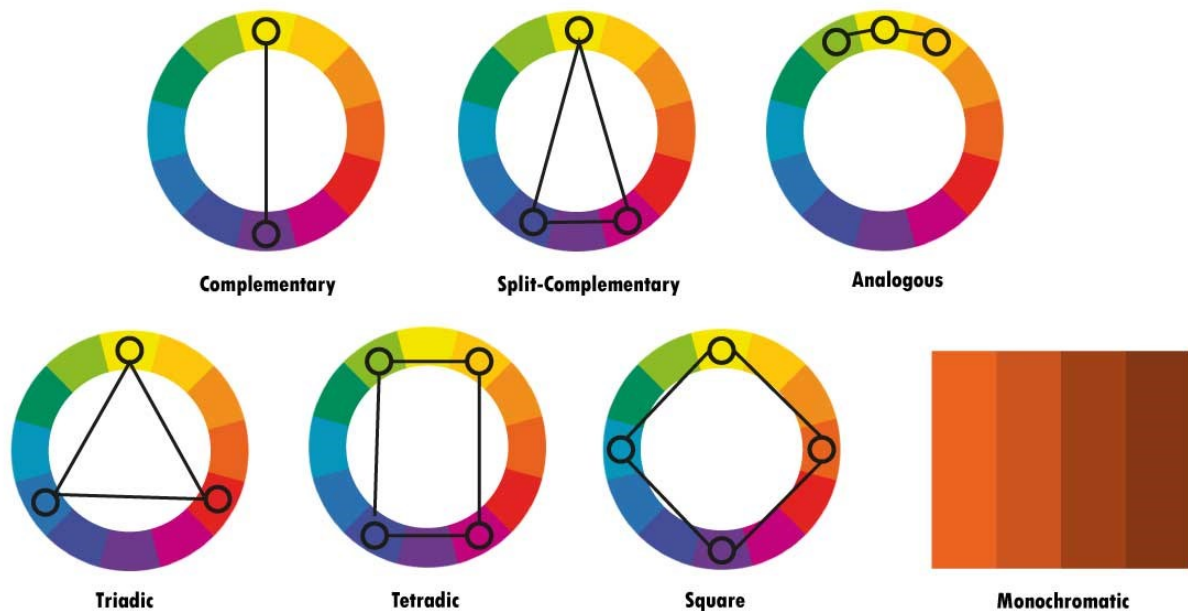
6.6 Physiological as well as Geographical Effects and Color Blindness in Color Perception

As it has been pointed out earlier in the chapter 3.1 as well as chapter 5, colors we see are biological reactions on the midbrain to a color stimulus which are picked up by the cone cells inside the eye. However, these reactions of the cone cells are biased in our brain because our brain include a built-in function of color correction and adaptability for different kind of situations. This is phenomenon called *color constancy* and according to Anya Hurlbert of Newcastle University this phenomenon is about our brain compensating the different colors to make the object seem as we remember it affecting our perception of the world. Hurlbert provides an example, that a banana looks yellow in kitchen, but it also looks yellow when brought into different lighting conditions such as outside and adds, that our brain adjusts the difference in the lighting to make the object look the same color and even the shape of the banana may be the key to seeing it as yellow (Duggan, n.d.). This color correction of color constancy is demonstrated Adam Claridge-Chang in the figure 12, where there are strawberries that seem red even though there are no red pixels in the picture and the colors seem different when dragged onto a white background.

Figure 12

Optical Illusion Demonstrating Color Constancy (Cladrige-Chang, 2017)

There are many ways to deceive the color vision and common example of this kind of deception are *afterimages*, which are false images including light stimulus that stay visible in the vision even after the original light stimulus has already disappeared (Debrowski, 2021). These afterimages can be categorized into three different groups: 1) Negative afterimages 2) Positive afterimages and 3) a medical illness symptom group of Palinopsia. According to *the opponent process theory*, negative afterimages cone cells get fatigued by a long explosion of the same color and this is when the inverse-colored cones start to assist the fatigued cone and when the original light stimulus is taken away, an afterimage of complementary colors can stay in vision for several seconds (Debrowski, 2021). In positive afterimages the afterimage seen is the same color as the original light stimulus, but it lasts usually only around half a second. Common example of this kind of positive afterimage are movies, where the framerate of the video is 24 frames per second, but the average human eye can function up to 75 frames per second. In this situation positive afterimages provide an in-between image making the movement look smoother (Debrowski, 2021). As for the palinopsia,

there are hallucinatory and illusory palinopsia and difference between the natural positive as well as negative afterimages is that palinopsia type of afterimages tend be more intense and they last longer when compared to the natural afterimages meaning there might be need to consult an eye doctor because of the underlying condition creating the palinopsia afterimage (Debrowski, 2021).

There is also another disorder affecting our vision and perception of color called color blindness. When mixing different colors, it is recommendable to create color palettes which also are well visible to people having color blindness, since about one in twenty people have some kind of color blindness meaning the malfunction of the color cones which are used to detect colors inside the eye (Nichols, n.d.). There are three different kind of color blindness: *Monochromatism*, *dichromatism* as well as *anomalous trichromacy* (Pesko, 2020).

Monochromatism also known as complete color blindness means a color blindness where there is only one or zero functioning color cones inside the eye. This means, that vision can deploy only shades of gray, black as well as white and it is the rarest form of color blindness (Pesko, 2020).

Dichromatism is color blindness where there are two different color cones functioning inside the eye and there are three different subcategories to dichromatism: 1) *tritanopia dichromatism*, where the person is unable to see blue colors 2) *deuteranopia dichromatism*, where the person is unable to see green colors 3) *protanopia dichromatism*, where the person is unable to see red colors. The color cones of red and green often overlap inside the eye meaning, that being unable to see red or green effects the perception of the other one. These cases are the most common type of color blindness and on these situations, blues and yellow seem vibrant whereas browns, oranges, reds as well as greens are harder to differentiate from each other. However, even though it might be hard to perceive reds and greens next to each other, a person not being able to see red can see green colors when they are alone and vice versa (Pesko, 2020).

The different types of dichromatism have different effects how other colors are perceived. Persons having difficulties with perceiving red also have higher tendency to confuse black and red, dark browns with dark greens, oranges and reds, some blue tones with reds, purples and dark pinks (Pesko, 2020). Persons having difficulties with perception of green might confuse reds and greens, bright greens as well as yellows, pale pink colors and light greys, reds and browns. (Pesko,

2020). People struggling with perception of blue have difficulties to see yellow and blue and might confuse light blues and greys, dark purple with black and greens with blues, oranges and reds. (Pesko, 2020).

Anomalous trichromacy refers to a color blindness where all the color cones are present inside the eye, but there are difficulties with light sensitivity meaning a decrease of colors perceivable tints, shades or tones in the color spectrum. This kind of color blindness one of the most common types of color blindness. As with the dichromatism, also in the anomalous trichromacy the color differentiation is difficult, but as the main difference there is no complete loss of colors. In anomalous trichromacy, red deficiency means seeing red, orange, yellow, and some yellow-green colors as less vibrant and saturated. Likewise, green deficiency means make it more difficult to perceive different tints, shades or tones of green, brown, orange and red. Also, in anomalous trichromacy, blue deficiency creates difficulty of differentiate yellows and blues. (Pesko, 2020).

There are multiple ways of creating a design that is also user-friendly to people having color blindness. As mentioned above, there are color combinations which people having different kinds of color blindness can feel hard to see, which should be avoided if possible. These color combinations consist of green-red, green-brown, blue-purple, green-blue, light green - yellow, blue-grey, green-grey as well as green-black (Collinge, 2017). However, it is not possible to avoid using these color combinations in every design. In these kinds of situations there are four other methods to help perception of design: 1) using the least number of colors possible to decrease the risk of confusion 2) usage of symbols and forms together with colors 3) increasing the amount of contrast between the colored areas by adding patterns and textures inside them 4) using a range of clearly contrasting colors that can be differentiated without color vision (Collinge, 2017). In the recent years, there are also software in computing and gaming industry, which have also built-in color blindness modes, which help the users to use the products regardless of their color vision.

As it has been pointed out in the chapter 4, meanings and symbolism of colors differ geographically and people from different parts of the world can feel the colors differently. In addition to this kind of symbolism, also language and the categorization of colors can affect how we perceive them. According to Jescey Visagie, the tribe of Namibian Himba have differing color categorization when compared to western language categorization. Among this tribe the word

serandu is used to describe reds, browns, oranges and some yellow. The word *dambu* is used to describe a variety of greens, red, beige and yellows and this word is also the term used for a Caucasian person. *Zuzu* is used to describe most dark colors such as black, dark red, dark purple, dark blue. The word *vapa* is used for some yellows and white. Lastly, the word *buru* is used for describing a collection of greens and blues (Visagie, 2016). According to research regarding the color perception of this tribe, it was found out that the test subjects of the tribe members were able to quickly recognize different shades of green which could take longer for western eyes because the tribe has multiple words for different shades of green. However, the researchers also found out, that because the same word is used for describing blue and green, it took longer for the test subjects to differentiate blue from a group of greens (Visagie, 2016). This kind of grouping of green and blue can also be found in Japanese, where there is two words for green: *Midori* as well as *ao*, which also mean blue. The reason why the character for blue is used often instead of green in Japanese is because the unique word for green came much later and originally the word ao was used for describing both blue as well as green. For example, the word for the English equivalent for green vegetables also uses the character for blue. The word ao is also used to describe things as fresh, where English would use green. Also, even though traffic lights are green, they are still called as blue traffic light (*aoshingō*). Also, in Russian there are two words for blue where one is for lighter shades and one for dark shades. In research, it was found out that native Russian speakers where faster to identify different shades of blue faster than native English speakers (Duggan, n.d.).

6.7   Color Perception and Working in a Digital Environment

As mentioned earlier in the chapter 6.6, human brain has the ability to create color corrections to make things seem constantly the same color even when the lighting chances. This can have unwanted consequences when working in a digital environment, since there are devices that cannot adjust colors automatically such as computer displays and they can show colors in factory settings differently even among the same maker's displays. For example, when editing a photo of person, the color of the skin can differ drastically depending on the color settings of the display and the camera's settings which was used to take the picture. This is why it is important to calibrate the displays to make the colors seen as natural and consistent as possible also in other devices. Also, things such as color temperature of the lighting in the working space, glares from the screen and the luminosity of the environment and the angle of the lighting towards the display

affect how color appear on it. The optimal color temperature is around 5000 on the *Kelvin scale* because it is closest to the color temperature of the sun and lighting should be slightly behind the working space if the working surface is tilted and around 45 degrees on the side of the working surface if the surface is flat to avoid glares (Fussell n.d.). Also, one way to reduce glares is using display or sheet that has anti-glare feature.

Colors and especially white balance are important also in photography. On cameras, there is often a built-in automatic white balance correction setting called *Auto-white balance* (AWB). This setting tries to guess the which is the true white in the environment. In addition to the AWB, there are usually two different ways to calibrate the camera's settings to match the environment which are white balance presetting and manual settings. As in displays, also in cameras the white balance uses the Kelvin scale. It is important to first set the right white balance, because it also affects how the other colors are recorded. A picture with too low and cool white balance setting will make a blue coating to the picture and vice versa, too high and warm setting will usually end up having a coating of yellow over the picture.

Figure 13

Demonstration of Different Color Temperatures as well as White Balances(Alex1ruff, 2016)
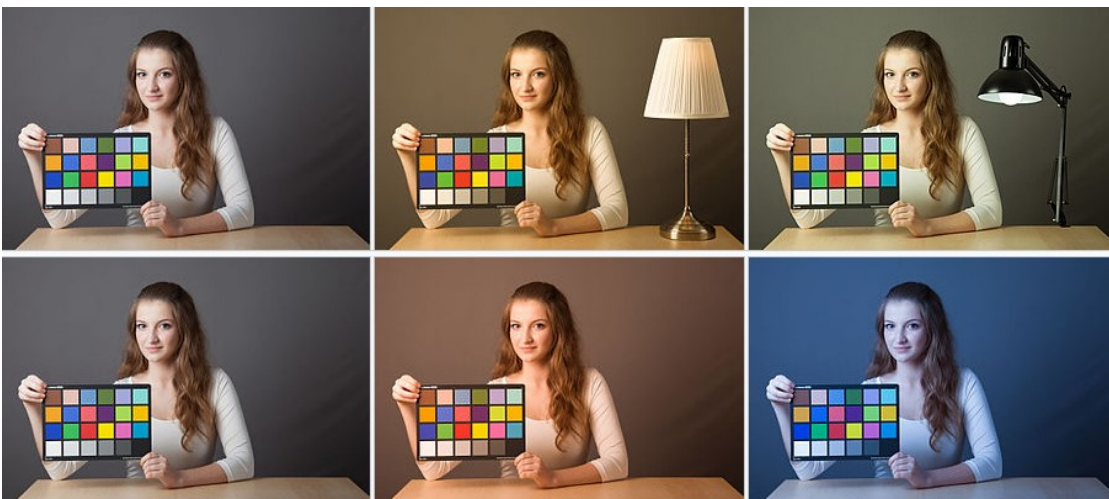
Note. This image is excerpt of six separate digital camera images by Wikimedia Commons user Alex1ruff that are combined to one image under license CC BY-SA 4.0. The first three images on the upper row are a comparison for different light qualities in the order of neutral, warm and cold light settings. The next three images on the lower row are examples of different white balances for neutral light with the settings of as shot, cloudy as well as tungsten.

In photography, it is also difficult to imitate the color perception of the human eye especially in automatic focus mode since the exposure settings especially in nature related pictures tend to be over/underexposed depending on the things such as which part of the scene is focused. Digital cameras also lose image data during compression, but many cameras recently can shoot in a so-called *RAW mode*, where all the data is uncompressed and unprocessed. Taking a picture with different exposure settings in RAW mode and editing them afterwards in a photo editing software provides the closest end result resembling the color reception of the human eye.

7 Color Effect in Game Design

The chapters above concentrate on color theory and the subdivisions on a general level. This chapter concentrates on color theory from a game design point-of-view and concentrates on how color related aspects such as color theory, color symbolism, color psychology as well as color harmonies are considered and utilized in game design to have an effect on the perception of the games. Adobe color wheel is used for deciphering the colors used in the reference materials and creating the descriptive color palettes. As mentioned earlier in this research, colors are subjective phenomenon meaning, that there is no absolute answer how the color should be perceived. Thus, this chapter can only provide viewpoints from the perspective of above-mentioned theories regarding colors and every individual might feel the colors differently.

There are five different aspects where colors are used in games and that are analyzed in this chapter: 1) visual appealing 2) signifying faction 3) communicating function 4) world building 5) emotion building (DVNC Interactive, n.d.).

7.1 Color for Visual Appeal

As mentioned in the chapter 3.4, the decision of buying a product largely depends on also the color of the products and that subconscious judgment regarding products are made within 90 seconds of the first observation and among on this judgment, from 62 to 90 percent is based on color alone. This is why game companies put a significant amount of consideration for the *game covers* also known as *box art* or *cover art*. During the localization process, some companies redesign the whole cover art to match the market. As an example, in the remake of the *Final*

Fantasy 7, the whole cover art was changed in a way, that in the Japanese version there is only the game's logo on a black background, but in the North America as well as European versions the base color is white and it features milieu of the game as well as the protagonist on the cover art as seen in the figure 14. However, *Square Enix*, the Japanese developer company of the game also left the possibility to have the same color art as in Japan making the game cover art reversible.

Figure 14

Final Fantasy 7 Remake Deluxe Edition Contents (Square Enix, 2019)

This game is not the only game that has made changes to the graphics and colors when localizing products. For example, American video game developer's game Crash Bandicoot's concept art was redesigned to the Japanese market in 15 minutes to make it more saleable in the Japanese market (Culture of Gaming, 2022). The design concentrated on making the character look like for more of a *manga* styled appearance, which means comics or graphic novels originating from Japan. According to software company Adobe, common traits for a manga art style for characters are bigger eyes with smaller mouths as well as height of chin, nose and forehead which differ significantly from a real human body (Adobe, n.d.). It is possible to see the same kind of editing in the Crash Bandicoot: the green eyes were changed to bigger as well as black and white versions, the mouth was edited to a smaller one and overall number of details such as texture of fur was

replaced with a matte surface with brighter colors making the character to have more contrast as shown in the figure 15 below.

Figure 15

Original Design of the Crash Bandicoot on the Left and Design for the Japanese on the Right (Naughty Dog, 1996)


This kind of need for localization of game products for different markets can be seen on the when looking at the popularity of these art styles in different markets. According to research carried out GameRefinery regarding the popularity of mobile game art styles and genres, it was found out that among the top 200 grossing mobile games in 2021 from the markets of United States, China as well as Japan, in Japan manga art style was used in 54 percent of the games. Cartoon style, meaning western style cartoon, was used in 24 percent of the games and realistic art style was used in 22 percent of the games. China was closer to the Japanese market where the percentage for manga art style was 33 percent, cartoon style covered 26 percent and realistic art style was found in 41 percent of the games. The percentage of the art styles in United States differed the most when compared to Japan where manga art style was found in 6 percent of the games, cartoon art style was found in 45 percent of the games and 49 percent of the games had realistic art style (Kiiski, 2021). This implies, that different markets prefer different art styles in games and

this should not be neglected during the localization process of a game product. But in addition to the art style of the products, in the case of Crash Bandicoot, one can also notice from the Figures 16 as well as 17 that the colors have also been edited for the Japanese version having greater contrast and brightness of colors and that there is a tetradic color harmony used in the artwork where the base color is orange, and it is accompanied by blue as the complementary color and detail colors of red and green.

Figure 16

Comparison the Main Colors of the Figure 15 (Original on the Left, Japanese Market Version on the Right) Picked to the Adobe Color Wheel Using the Eyedropper Tool
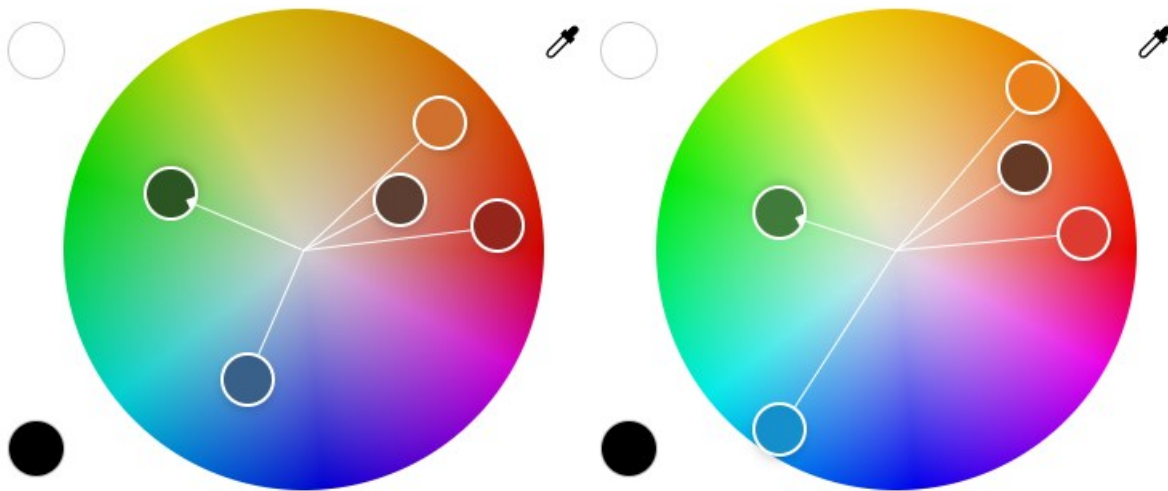
Figure 17

Comparison the Main Colors of the Figure 15 (Original on Top, Japanese Market Version on the Bottom) Picked to the Adobe Color Wheel's Color Palette Using the Eyedropper Tool

Another example of changing coloring the in the localization process to make the product more appealing to the target audience can be seen in the Finnish video game developer Rovio

Entertainments' Angry Birds 2 and its Chinese New Year update, where the background of the login page was changed from light blue to a darker version to match the other details of the graphics including fireworks. Also, the characters got traditional hats including shades of red. As discussed earlier, red is a color of celebration in China, so in this way the color usage can be seen as emphasizing the celebration.

Figure 18

Comparison of the Regular Version of the Login Page of Angry Birds 2 and the Chinese New Year Version (Rovio Entertainment, 2015)

Color can also have association in different things such as emotions and brands as noted in earlier chapters. This also applies to video games as well and for example, the Polish video game developer CD Projekt Red has been able to create their own color which is associated to game Cyberpunk 2077 and it is called the *Cyberpunk yellow*. As seen in the figure 19, it is a bright yellow and it is used also in the logo as well helping to create this association. According to *Michał Janiszewski*, lead environment artist of Cyberpunk 2077, the color was chosen because it is easy to remember creating an association like the beverage *Coca-Cola* holds to red as well as white and that the creators wanted for the game to stand out from other games of the same genre, which are often thought to be associated to red or blue. (Kessler, 2022)
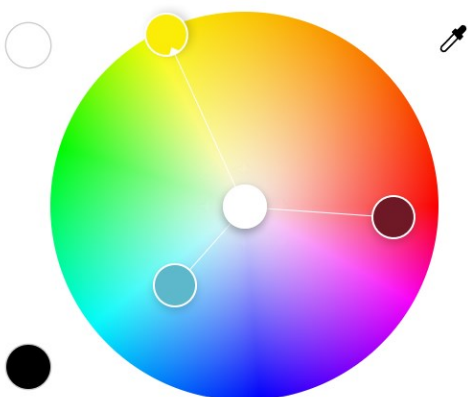
Figure 19

Cyberpunk 2077 yellow and Triadic Color Harmony (CD Projekt RED, n.d.)

From the color theory point-of-view, the figure 19 above utilizes triadic color harmony using the primary colors of yellow, red and blue, where the yellow color function as the base color and the red and blue are kept as supporting colors. Also, the base color has the most amount of saturation whereas the supporting colors of blue and red are diluted creating a softer contrast between the colors as it can be seen in the figures 20 as well as 21.
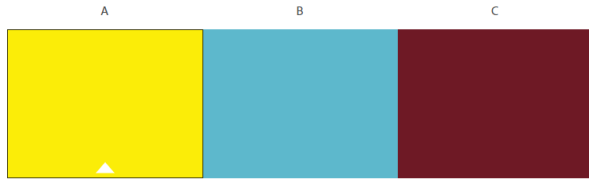
Figure 20

Main Colors of the Figure 19 Picked to the Adobe Color Wheel Using the Eyedropper tool

Figure 21

Main Colors of the Figure 19 Picked to the Adobe Color Wheel's Color Palette Using the Eyedropper tool

7.2   Color for Signifying Faction

As mentioned in the chapters 3.3 as well as 3.4., people often have psychological associations regarding colors where for example someone might think of blood or aggressiveness when seeing the color red. Also, from a physical point-of-view, the color red for example is known to catch the attention the best among the spectrum of the color wheel.

This kind of color symbolism and color psychology is also used in game design, where it is possible to create factions based on color usage. As an example, there are games where the enemies are highlighted using red color. For example, the enemy in the game footage below has red in the goggles as well as in the torso, making it easy to differentiate this enemy from the surroundings.

Figure 22

Faction symbolism in Cyberpunk 2077 (CD Projekt RED, n.d.)

Often in addition to create the image of hostility, green is used to symbolize allies. From the color blindness point-of-view these kinds of factions divided to green and red might not be the ideal way to convey who is the enemy and who is the ally, but nevertheless it is still an influential way of getting the player's attention, if there is high contrast between the object and the surroundings.

7.3   Color for Communicating Function

In games, different colors are used for different communicating purposes. For example, in many games purple is used to communicate poison and toxic state, red is often used to signal danger and low health, green is also many times a health-related color, but in the way of recovery. Blue is often the color of safety, so many times allies are color coded as blue and non-harming *non-playable characters (NPC)* are color-coded as green. Colors can also be used to emphasize objects which players should be aware about and might have an effect for the game. For example, in Cyberpunk 2077, the items have color-coding which symbols the rarity of the item where white is for common, green for uncommon, blue for rare, purple for epic and orange for legendary. In *DRAGON QUEST® XI S: Echoes of an Elusive Age* by Square Enix, yellow arrow is used throughout

the game to indicate the items and the items that are not loots and are harder to find from the environment, are emitting blue light as seen in the figure 23 below.
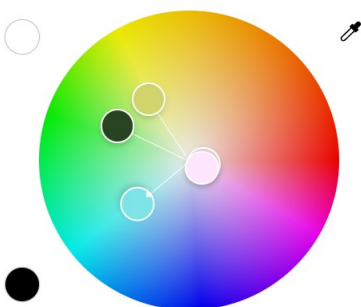
Figure 23

Color symbolizing function in DRAGON QUEST® XI S: Echoes of an Elusive Age (Square Enix, 2017)

When the colors are imported into a color wheel, it is possible to deduce that function colors create an analogous color harmony, where there can be only to primary colors out of three. As mentioned in the subchapter 6.5, this kind of color harmony is used to create an aesthetically pleasing effect. In this case, yellow is used as the base color as it is the most luminous color and contrast of the three in this environment. In this situation blue and green are used as supporting colors.
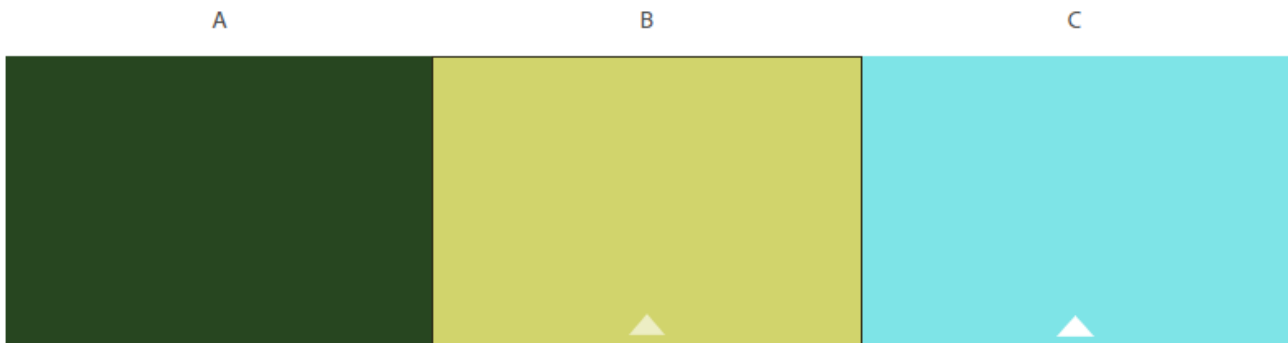
Figure 24

Main Colors of the Figure 23 Picked to the Adobe Color Wheel Using the Eyedropper Tool

Figure 25

Main Colors of the Figure 23 Picked to the Adobe Color Wheel's Color Palette Using the Eyedropper Tool

In Angry Birds 2, one can also notice that the level design uses complementary color harmony for differentiating warp gates from each other where the first warp gate is glowing in blue and the second one in orange. Because the colors are complementary colors, it is easier to recognize which one to use and, in a way, it resembles the logic of traffic lights where green is for permission to go and red an order to stay put.

Figure 26

Complementary color harmony communicating function in Angry Birds 2 (Rovio Entertainment, 2015)

7.4   Color for World Building

Colors in world building often vary based on the milieu and type of the game they are used in. It is advisable to consider beforehand that what kind of functions does one want from colors of the game world, since different color can create different kind of atmospheres to the game. If the purpose of the game is to be as realistic as possible, it may be advisable to leave for example environmental colors as they are in real life, since many times the colors of the natural constitute some kind of color harmony such as analogous color harmony, as discussed in the chapter 6.5. However, there are places where it is possible to effect on things such as mood of the environment without losing the sense of reality. For example, even though connotation of the sky is often blue, it can appear in many different colors such as grey, red, orange. There colors depend on variables such as the time of the day and the weather. As an example, by taking advantage of the color such as grey, it is possible to convey a message of sadness as well as depression.

If the purpose of the colors in world building is to use them as stylistic device, it is possible to convey different kinds of emotions and atmospheres by using different kinds of color harmonies.

Achromatic color palettes can help to create alarming environment such as in *LIMBO* from the Danish video game developer company *Playdead*, where the whole game is in monochromatic colors of black, grey and white. As it can be observed on the figure 27 below, the color black is used to emphasize the player's character and the surface of the level, with lighter grey to bring contrast to the player's character. Dull shades of grey and black is used to bring sense of depth to the environment as well as to highlight certain details from the environment.

Figure 27

*Monochromatic color palette in Limbo (Playdead, 2010)*

In Cyberpunk 2077, even though the tone of the milieu in the figure 28 below is dark, the use of colors such as purple and red conveys a message of nightlife and a so-called red-light district, since these colors are often associated to things related to sexuality and intimacy. This scene uses a tetradic color harmony and it is often used to pursue eye-catchiness. As it was discussed in the chapter 6.5, it is advisable to balance the amount of cool and warm colors while choosing a dominating base color while keeping the other three as supportive accent colors. In this scene, one can notice that the different kinds of reds have the dominance over the scene whereas blue, yellow and green function as supportive accent colors.

Figure 28

Tetradic color harmony in Cyberpunk 2077 (CD Projekt RED, n.d.)
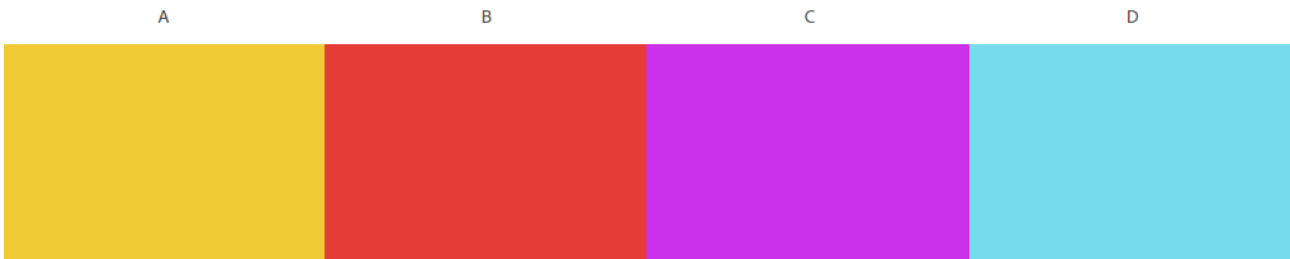

Figure 29

Main Colors of the Figure 28 picked to the Adobe Color Wheel Using the Eyedropper tool
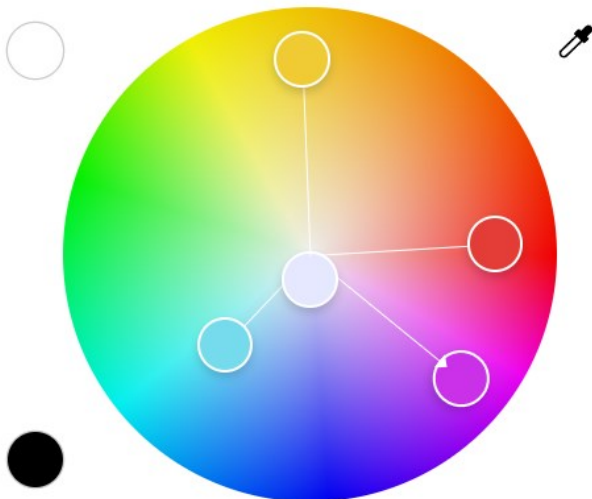
Figure 30

Main colors of the Figure 28 Picked to the Adobe Color Wheel's Color Palette Using the Eyedropper Tool

If the art style of the game is realistic, it might be more difficult to use different colors without making the user to have a feeling of out of place. For example, if the water in a realistic art style would be red meaning the complementary color of blue, the user might not recognize it as water and this might end up in an unnaturalistic feeling. But if the art style and the milieu is cartoon style, it can be easier to have more freedom of color usage without getting the above mentioned unnaturalistic feeling. For example, in Angry Birds 2 one part of the milieu consists of purple and other colors that are not visible that often in nature, but one can even feel the milieu as harmonious as well as pleasing because of the color harmony of analogous colors.

Figure 31

Analogous color harmony in milieu design Angry Birds 2 (Rovio Entertainment, 2015)

7.5 Color for Emotion Building

As mentioned in the earlier color theory related chapters, color can be used to convey different kinds of emotions and certain colors perception can vary depending on the things such as market and culture where the users originate. In the game *Florence* developed by *studio Mountains* and published by American video game developer *Annapurna Interactive*, colors are used to convey the emotional state of the protagonist. When the characters are happy, the game uses vivid colors such as yellow to express this and when the characters get sad the color usage fades to a more monochromatic style using only black, white and grey as the colors of the scene.
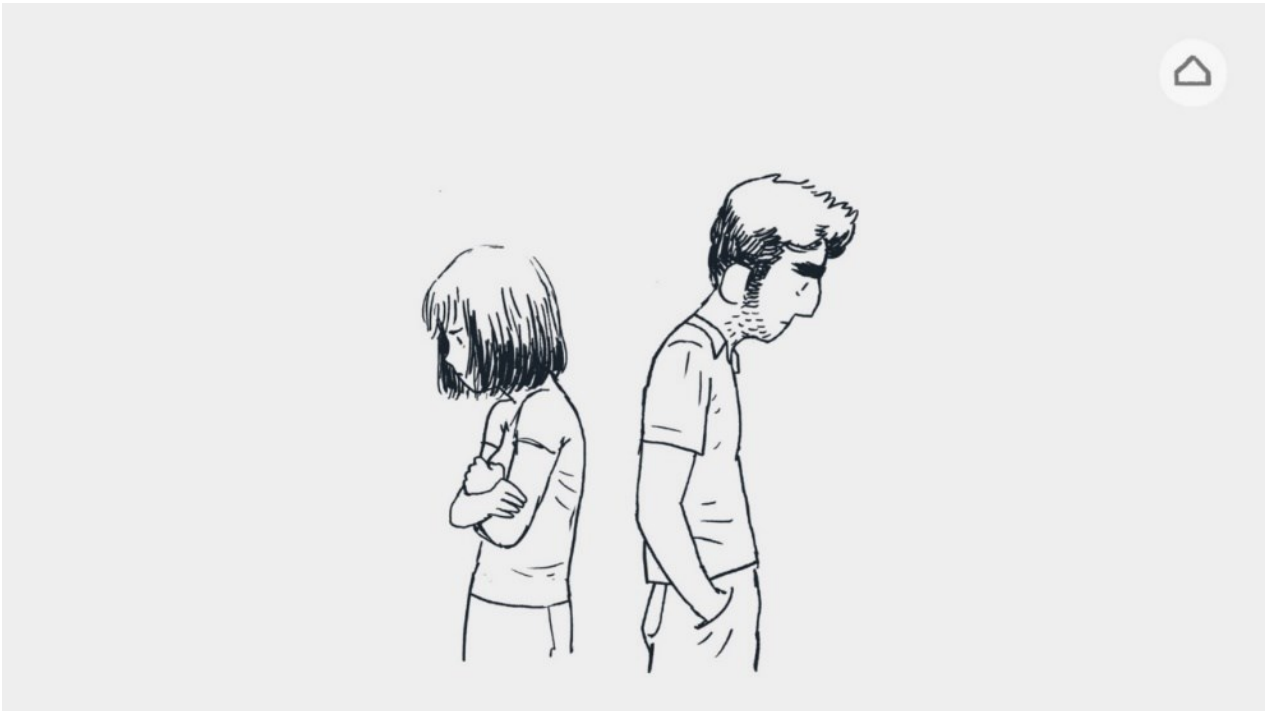
Figure 32

*Feeling of happiness in Florence (Annapurna Interactive,2020)*

Figure 33

Feeling of sadness in Florence (Annapurna Interactive,2020)

Even though the color blue is often associated in feelings like coldness, melancholy and sadness, it can also be used to provoke calming and relaxing feelings among the users. For example, Karolina Cieślak provides examples of the diving game Beyond Blue published by American game related publisher E-Line Media as well as The Last Case of Benedict Fox, a gothic 2,5D narrative action-adventure published by American video game publisher Rogue Games, Inc and argues that blue is good for making the user feel relaxed and that in the example games blue can seem as relaxing at the first glance as well as building harmonious atmosphere of peace (Cieślak, 2022).

Figure 34

Blue world of Beyond Blue (E-Line Media, 2020)
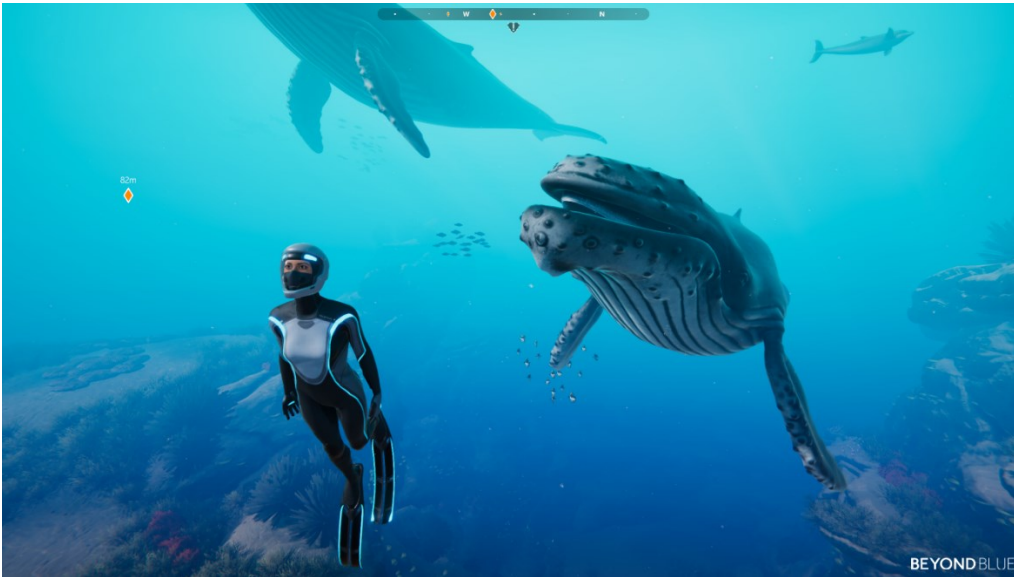
Figure 35

A scene of The Last Case of Benedict Fox with the blue as the main color (Rogue Games, Inc., 2023)


However, one can argue that some users might feel the scene intimidating and freightning at some level depending, since the milieu uses dark shades of colors to emphasize that it is night time. For a person who has *nyctophobia* also known as *fear of the dark*, it is common to fear dark environments and also things, that one cannot see (Cleveland Clinic, 2022). These kind of dark

environments where it is hard to get a complete grasp of the surroundings are often used in genres like horror, suspense and thrillers, where darkness is used to build up the tension of the scene. Thus, even though the colors of the scene are harmonic, the output and the perception of the scene via color usage can end up in different kinds of outcomes.

As stated above, blue can also evoke feelings of such as melancholy. Another example of this kind of ambivalent effect of blue can be seen in the default theme of PlayStation 4 by multinational video game and digital entertainment company Sony Interactive Entertainment. It uses an ambient style of music which is often used in relaxation music and it is paired with a blue background as seen in the figure 36, so one might think automatically, that the visuals and sound of the theme sound calming and relaxing. In reality, there are users that also feel the default theme of the PlayStation 4 as depressing (Noldyn, 2020). But as the blue theme in figure 36 is dark blue which is commonly thought as a calming color, a notion arises that it is possible that this kind of perception of the theme could be because of synesthesia. Synesthesia means a situation where people can experience a sense through another one such as color through sound (MasterClass, 2021). In this sense, when creating color related products, it is important to observe the product as a whole rather than focusing solely on color usage.

Figure 36
PlayStation 4 Default theme and the blue background (Sony Interactive Entertainment, 2013)
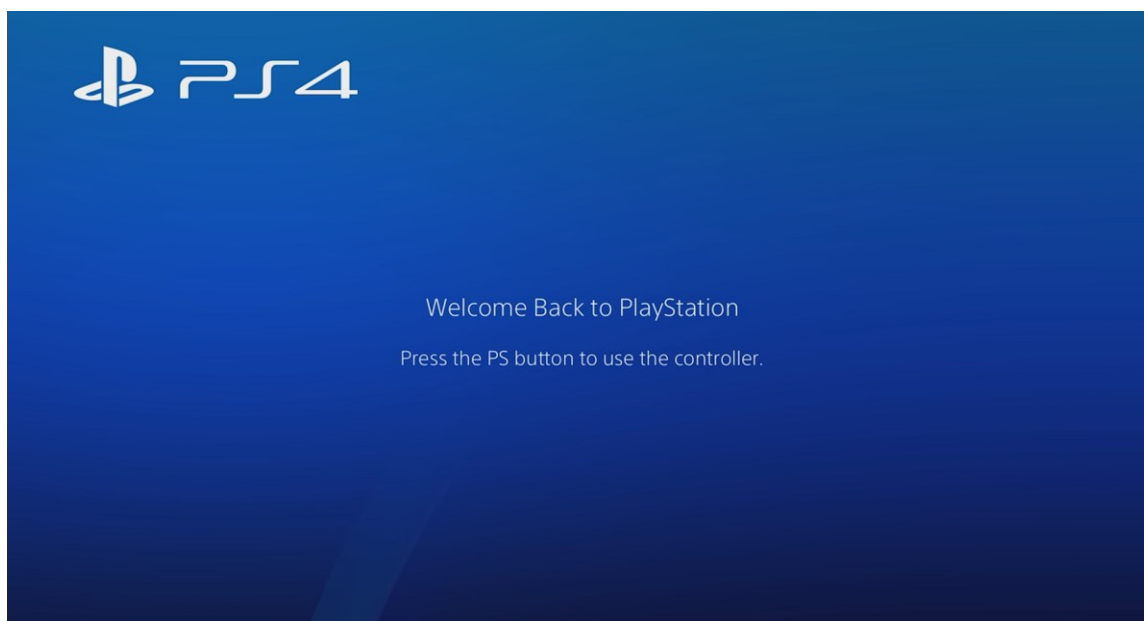
In Angry Birds 2 published by Rovio Entertainment, the colors can be seen as used to evoke a path for clicking using the color symbols. As seen in the figure 37 below, after failing to accomplish a level, the character looks sad and disappointed on a purple background, which is thought as a mourning color so it can be seen as emphasizing the feelings of the character. The player is given three options: 1) play on the level by using the built in currency, if there is enough to pay for the continuation 2) Buy more currency of the game by using in-game purchases with real currency 3) End the level and start over from the start of the level losing a life. On the first option of using already held currency, the button is on an orange background, which can be seen as symbolizing things like energy, health and activity in this context. The orange is also the basic color of the user interface and most of the buttons in the game have this same base color. If the game is continued, the player gets three extra cards, meaning characters as well as the number of turns. The cards are on a light blue base color, which in this case can be associated to things like justice and loyalty towards for own troops and can be as provoking the feeling of reliability and trustworthiness. The second option for the player is to buy new currency inside the game by using real-life money. The button including the price for the purchase is on green color, which can be seen as symbolizing money, healing, success, growth as well as safety. In this way, the message of the color can be seen as a reassurance for the player, that real money purchases are safe and help the player to grow as the turns of performance, since the characters grow stronger the more levels are cleared. As for the final option of ending the level and starting over, the button has a symbol of X, which is often used in applications for symbolizing exit and closing. This button has also the same orange base color as using the game's currency.

Figure 37

Different emotion colors in Angry Birds 2 (Rovio Entertainment, 2015)

If the player decides not to use any currency and ending the game, a second screen appears. This shows an animation of a heart breaking into pieces and the enemy pigs laugh mischievously. The background color fluctuates between red and orange-red and it can see as emphasizing the mischievous laugh and provoking the feelings of aggression and anger or excitement. In this way, a possible interpretation of the color is to make the player more indulged to the game and to arouse the feeling of competitiveness encouraging the player to try again.

Figure 38

Red background after failing to accomplish a level in Angry Birds 2 (Rovio Entertainment, 2015)

8   Results

By analyzing the samples and the images used located in the chapter 7 and its subchapters, through the concepts of color theory, color symbolism, color psychology as well as color harmonies, it is possible to deduce that colors have a significant role on how the game functions, how it is perceived and how the colors are used as a way of communication between the game and the user.

As for the function of color as visual appeal, through the examples of Final Fantasy 7 Remakes cover art and Angry Birds 2's in-game login page, one can deduce that localization process and the use of colors applies both physical as well as digital copies of the video games and that they are an important part of marketing the products. By analyzing the games of Angry Birds 2 and the concept art of the Crash Bandicoot for different markets one can deduce, that even though colors were customized for different markets, also other aspects of design such as proportions of the characters, art style and cultural references were also taken into consideration in the localization process. In addition, it was possible to notice, that even though colors as well as graphic related factors are customized for different markets, video games developers made use of color harmonies as part of their game design regardless of where they were created. By comparing the color usage in the target example video games, one can notice that in overall they make use of all the main color harmonies of achromatic, complementary, analogous, triadic, tetradic color harmonies to make the games visually appealing.

Through the Crash Bandicoot example, it was also possible to connect this need for localization process including customizing the colors to the market by finding a correlation in the popularity of the art styles in different markets based on the GameRefinery's data regarding the popularity of art styles in different markets. One can also notice through the Cyberpunk 2077 triadic color harmony example, that colors were used to create color harmony and at the same time, branding for the game was established through the unusual color choice of yellow in a cyberpunk genre game.

Also, it was possible to demonstrate how colors work as a tool for signifying faction and as function of communication and how these tools abide the concepts of color symbolism, color psychology as well as color harmonies through the examples of Cyberpunk 2077 and DRAGON

QUEST® XI S: Echoes of an Elusive Age. It was noticed, that in these kinds of situations the contrast of complementary colors was used to create a straightforward way of communication which emphasizes the message for the user what should be done in that situation.

As for the color working as a tool for world building, it was possible to demonstrate through the examples of Cyberpunk 2077, Limbo as well as Angry Birds 2 how different color combinations work in different kind of games and their milieus and how they are used to convey atmospheres and feelings. It was also demonstrated how colors like purple, which usually do not appear in nature as the dominating color of the environment, could be used as the main color of the milieu if the art style of the game was cartoon like and not realistic.

Lastly, through the examples of Florence and Beyond Blue as well as Angry Birds 2, it was possible to demonstrate how powerful colors are as tools for conveying emotions and how it is possible to lead the user using colors for example in monetarization purposes of the game. Through the examples of the game The Last Case of Benedict Fox as well as default theme of the PlayStation 4, it was possible to demonstrate that even though certain colors are thought to represent certain emotions, they can also have the opposite meaning when they are used together with other colors in different milieus and when the colors are also connected to audio design.

All in all, the results suggest, that colors are used in many ways, as mentioned above, to create pleasing user experiences, but their perception might differ and hold different meanings depending on the user's personal traits such as own experiences regarding color and cultural background.

The findings suggest that at the start of the game creation project one should already pay attention to these matters in terms of color design and localization. In ideal situation the game should also have localization regarding colors and art style just as there is localization for different languages inside a game. However, this might not be attainable situation especially in smaller projects which might not have that much funding and resources to accomplish many kinds of localizations. In these cases, it is advisable to keep in mind the color design concepts of color theory, color psychology as well as color symbolism and aim for color usage, which has the least number of negative connotations regardless the market to make the game as globally pleasing as

possible. Regardless how many kinds of localizations are planned to be used in the game design, it is advisable to start the testing phase as soon as possible with as large and versatile demographic groups as possible from different markets to get to know the deficiencies of the project as soon as possible.

9   Discussion and Conclusion

This research was done with the intention of providing an introduction of concepts regarding color design as well as usage and how colors affect the perception of the products by analyzing games and their color usage from the perspective and concepts of color theory, color psychology, color symbolism as well as color harmonies by using qualitative analysis method. The focus of the color analysis was on milieus and other factors such as common appearance affecting how the video game products are perceived. Color usage regarding character design was intentionally delimited from this research. Color in games as a whole would be overly vast topic to cover in this kind of research, so this kind of delimitation was executed to make the research more manageable and to narrow down the research theme. The delimitation of the topic was also specified to improve the validity as well as reliability of the research.

The results of the analysis comply with the theories of color design. And it was possible to find connections as well as real-life examples of existing literature regarding the topic such as the importance of localizing also the art of the game and how it might affect the popularity of the product if omitted during the design process. However, it is important to note, that colors are a subject that are around us affecting our daily lives and as mentioned earlier in the research, colors are a subjective phenomenon meaning, that there is no one correct way to demonstrate colors in a way, that they and their interpretations could be addressed as absolute truths. This means, that color usage should be considered case-by-case and that there is no color combination, that would work in all situations regardless of where it is used. The objective of this research was rather to provide a viewpoint that it is important to take color design and its theories into account beforehand when creating game designs and localization to make the game creation progress as smooth as possible from the start.

In overall, the delimitation could have been even further restricting, as several featured areas of this research could compose research of their own, such as color harmonies in games as well as

how graphics and colors are used together to create pleasing designs. The vast scope of the research topic led to the relatively small results regarding each aspect covered in the analysis section, nullifying validity as well as reliability of this research by some degree. However, as mentioned above, the results prove tendency as well as similarity to other literature regarding color as well as game design. Also, as the goal of the research was to create and introductory guide of concepts regarding color design as well as usage and how colors affect the perception of the video game products, the results of the analysis are sufficient from the point of view of reliability as well as validity, and they demonstrate the necessity and practicality to some extend of color design regarding video game production. In retrospect, stricter delimitation could have made it possible to gather greater amount of data and opportunity to analyze them on a deeper level. Also, as the main focus of the research was to analyze how colors effect on perception of video games, stricter delimitation could be allowed to gather data in quantitative format as well in the form of a survey and analyzing the results using both qualitative as well as quantitative methods.

Lastly, there were results supporting the authors personal remarks regarding the difference between popular games between Japan and other countries, but further research is needed to get more comprehensive understanding regarding of the validity of the phenomenon. This kind of further research could prove useful and create better marketing opportunities. As mentioned earlier in this research, colors and other graphics related concepts often are designed side-by-side and that different art styles are more popular in other parts of the world than others. As a one possible future study, it could prove useful to research these art styles and their color usage in more detail, because there is still vagueness in the localization process resulting in games, that may not be successful in some markets. This means, that further research might create opportunities for new markets for the game companies. While the popularity of a video game consists of many different factors such as genre, platform or target group of the game, when taking into consideration of the dispersion of popularity of games in different markets as stated in the introduction, it is safe to say it is beneficial to take color design into account when aiming to create user friendly as well as pleasing game designs. While this research focuses on the color usage on video games, one must keep in mind that the color theories also apply to other products as well such as board games. In this way, this research can be used also outside of video game creation as well.

References

Adobe. (n.d.). *How to draw manga: Getting started for beginners*.

> https://www.adobe.com/creativecloud/illustration/discover/how-to-draw-manga.html

Art in Context. (2023 April 4). *Pointillism – The Neo-Impressionist Dot Painting Technique*.

> https://artincontext.org/pointillism/

Chan, V. (n.d.). *Why Mobile Games Often Fail at International Expansion?*.

> https://www.oneskyapp.com/blog/mobile-games-often-fail-international-expansion/

Cieślak, K. (2022, February 17). *Color psychology in game design – how do colors help design better games?*. https://tryevidence.com/blog/color-psychology-in-game-design-how-do-colors-help-design-better-games/

Cleveland Clinic. (2022, March 28). *Nyctophobia (Fear of the Dark)*.

> https://my.clevelandclinic.org/health/diseases/22785-nyctophobia-fear-of-the-dark

Collinge, R. (2017, January 17). *How to Design for Color Blindness*.

> https://www.getfeedback.com/resources/ux/how-to-design-for-color-blindness/

Culture of Gaming. (2020, August 26). *How Games Have Been Altered in Different Countries*.

> https://cultureofgaming.com/how-games-have-been-altered-in-different-countries/

Debrowski, A. (2021, September 15). *How afterimages play tricks on your eyes*.

> https://www.allaboutvision.com/resources/human-interest/afterimage/

Duggan, G. (n.d.). *Your brain is lying to you — colour is all in your head, and other 'colourful' facts*.

> https://www.cbc.ca/natureofthings/features/your-brain-is-lying-to-you-colour-is-all-in-your-head-and-other-colourful-f

DVNC Interactive. (n.d.). *Color Theory in Games – An Overview*.
https://dvnc.tech/2018/06/04/color-theory-in-games-an-overview/amp/

Elliot, A., Maier, M. (January 2014). *Color Psychology: Effects of Perceiving Color on Psychological Functioning in Humans*. https://www.annualreviews.org/doi/10.1146/annurev-psych-010213-115035

Eriksen Translations. (2020, February 3). *How Translating Colors Across Cultures Can Help You Make a Positive Impact.* https://eriksen.com/marketing/color_culture/

Frontline Gaming Japan. (2023, February 2). *The top 100 best-selling video games in Japan, 2022*.
https://www.frontlinejp.net/2023/02/02/top-100-best-selling-games-in-japan-2022/

Fussell, M. (n.d.). *Lighting Your Art Studio*. https://thevirtualinstructor.com/blog/lighting-your-art-studio#:~:text=Any%20light%20around%205000K%20is,the%20cooler%20end%20of%20things.

Harding University. (n.d.). *Color Theorists 1800+*. Retrieved April 5, 2023, from
https://sites.harding.edu/gclayton/Color/PPTs/A260Ch06bTheorists1800_online.pdf

Heikkinen, K. (2020, April 15). *We examined 7 Chinese and Japanese Mobile Gaming Stereotypes and Here's What We Found!.* https://www.gamerefinery.com/we-examined-7-chinese-and-japanese-mobile-gaming-stereotypes-and-heres-what-we-found/

Holtzschue, L. (2011). Understanding Color: An Introduction for Designers 4th (fourth) edition. John Wiley & Sons, Inc.

Howard, M. (2010, June 16). *Red Ink Is Bad News*.
https://tuftsjournal.tufts.edu/2010/06_1/features/04/

Juego Studios. (2023, January 2). *The Importance of Game Localization for Game Developers*.
https://www.juegostudio.com/blog/game-localization

Kessler, A. (2022 May 26). *CD Projekt RED Explained Why It Used Bright Yellow For Cyberpunk 2077*. https://80.lv/articles/cd-projekt-red-explained-why-it-used-bright-yellow-for-cyberpunk-2077/

Kiiski, E. (2021, March 24). *Popularity of mobile game art styles and genres – data breakdown*. https://www.gamerefinery.com/popularity-mobile-game-art-styles-genres/

Klieven, J. (n.d.). *How to design with monochromatic colors—with expert tips from a designer.* https://www.canva.com/learn/monochromatic-colors/

MasterClass. (2021, August 30). *How to Use Synesthesia in Your Writing*. https://www.masterclass.com/articles/how-to-use-synesthesia-in-your-writing

Modi, P., Jha, K., Kumar, Y., Kumar, T., Singh, R., Mishra, A. (2019). The effect of short-term exposure to red and blue light on the autonomic tone of the individuals with newly diagnosed essential hypertension. *J Family Med Prim Care*, 8(1):14-21. 10.4103/jfmpc.jfmpc_375_18.

Munsell, A. (n.d.). History of Color Systems. *Munsell*. https://munsell.com/color-blog/history-of-color-systems/

Nassau, K. (n.d.). The visible spectrum. In *Britannica*. Retrieved April 5, 2023, from https://www.britannica.com/science/color/The-visible-spectrum

Nassiry, S. (2004). *The Psychological and Physiology of Color*. http://www.people.vcu.edu/~djbromle/color-theory/color04/sarwar/index.htm#:~:text=Color%20vision%20in%20humans%20is,of%20the%20additive%20color%20system.

NCS Colour (n.d.). *Our History*. https://ncscolour.com/about/our-history/

Nichols, D. (n.d.). *Coloring for Colorblindness*.
https://davidmathlogic.com/colorblind/#%23E1BE6A-%2340B0A6

Noldyn. (2020). *I don't know if it's just me but I find the default PS4 theme depressing as hell*
[Comment on the online forum post *Is the PS4 Default theme depressing?*]. Reddit.
https://www.reddit.com/r/PS4/comments/j475jx/is_the_ps4_default_theme_depressing/

Pesko, P. (2020 July 27). *Different Types of Color Blindness*.
https://pilestone.com/blogs/news/different-types-of-color-
blindness#:~:text=The%20three%20different%20types%20of,and%20protanopia%20(red%
20light).

Safety Sign Supplies. (2014, August 5). *Why are warning signs red, yellow, blue or green?*.
https://www.safetysignsupplies.co.uk/news/why-are-warning-signs-red-yellow-blue-or-
green~801740148.html#:~:text=Red%20was%20first%20chosen%20because,or%20on%20a
%20misty%20day.

Schinkel, S. (2017, October 20). *Color Theory: Color Harmonies*.
https://blog.thepapermillstore.com/color-theory-color-harmonies/

Snow, S. (2015, June 5). *How the Emotional Power of Color Can Tap into Your Audiences' Brains*.
https://www.socialmediatoday.com/news/how-the-emotional-power-of-color-can-tap-
into-your-audiences-brains/454066/

Shibasaki M, Masataka N. (2014, July 31). *The color red distorts time perception for men, but not
for women*. *Scientific* Reports. 31;4:5899. 10.1038/srep05899.

Stark, G. (n.d.) light. In *Britannica*. Retrieved April 5, 2023, from
https://www.britannica.com/science/light

Stone, T. L., Adams, S., & Morioka, N. (2006). *Color Design Workbook: A Real-world Guide to Using
Color in Graphic Design*. Rockport Pub.

Visagie, J. (2016, September 2). How do Namibian Himbas see colour?. https://gondwana-collection.com/blog/how-do-namibian-himbas-see-colour

WholesGame. (n.d.). *Top 20 best-selling video games in Europe – Year 2022*. https://wholesgame.com/news/top-20-best-selling-video-games-in-europe-year-2022/

Image references

Figure 1: Grusche, S. (2015, December 17). *Isaac Newton performing his crucial prism experiment - the 'experimentum crucis' - in his Woolsthorpe Manor bedroom. Acrylic painting by Sascha Grusche (17 Dec 2015).*
https://commons.wikimedia.org/wiki/File:Newton%27s_Experimentum_Crucis_(Grusche_2015).jpg

Figure 2: O'Connor, Z. (2020, March 29). *Harris's 'colour wheel' showing how a range of colours can be made from red, yellow and blue.*
https://commons.wikimedia.org/wiki/File:Moses_Harris,_Prismatic_Colour_Wheel,_1766.jpg

Figure 3: Goethe, J.W. (1809). *Farbenkreis zur Symbolisierung des menschlichen Geistes- und Seelenlebens, 1809.*
https://commons.wikimedia.org/wiki/File:Goethe,_Farbenkreis_zur_Symbolisierung_des_menschlichen_Geistes-_und_Seelenlebens,_1809.jpg

Figure 4: Rus, J. (2007, April 16). *The Munsell color system, showing: a circle of hues at value 5 chroma 6; the neutral values from 0 to 10; and the chromas of purple-blue (5PB) at value 5.*
https://commons.wikimedia.org/wiki/File:Munsell-system.svg

Figure 5: Datumizer. (2020, January 20). *Three-dimensional representation of the 1943 Munsell renotations (with portion cut away). Notice the irregularity of the shape when compared with Munsell's earlier color sphere.*
https://commons.wikimedia.org/wiki/File:Munsell_1943_color_solid_cylindrical_coordinates_gray.png

Figure 6: Ostwald, W.F. (1916). *Farbtonnormen und unbunte Normen.*
https://www.colorsystem.com/wp-content/uploads/32ost/OstwaldNormen.jpg

Figure 7: MalteAhrens (2008, February 2008, August 07). *Farbkreis Itten 1961*.

    https://commons.wikimedia.org/wiki/File:Farbkreis_Itten_1961.svg

Figure 8: Schopenhauer's Circle of Color Harmony Demonstration by Utilizing a Donut Chart

Figure 9: mpuq. (2018). *RGB & CMYK PNG icon* [Image of RGB & CMYK color mixing]. iconspng.

    https://www.iconspng.com/image/67713/rgb-cmyk

Figure 10: Piscis13. (2009, February 14). *Paul Signac, Femmes au Puits, 1892, showing a detail with

    constituent colors* [Image demonstrating pointillism]. *Musée d'Orsay, Paris*.

    https://en.wikipedia.org/wiki/Pointillism#/media/File:Paul_Signac_Femmes_au_puits_189

    2d%C3%A9tailcouleur.jpg

Figure 11: Seven Types of Color Harmonies *Seven Color Harmonies*.

Figure 12: Claridge-Chang, A [@adamcchang] (2017, March 2). *A version with some of the reddest

    pixels' hue dragged onto a white background. @social_brains HT @Frauenfelder*. [Tweet;

    thumbnail link to article]. Twitter.

    https://twitter.com/adamcchang/status/837218395636412416

Figure 13: Alex1ruff. (2016, April 25). *Color Balance* [Series of images demonstrating white

    balance]. https://en.wikipedia.org/wiki/Color_balance

Figure 14: FINAL FANTASY VII [@finalfantasyvii]. (2019 November 27). *The #FinalFantasy VII

    Remake Deluxe Edition comes with a Sephiroth steelbook case, hardback artwork, mini-

    soundtrack CD, and includes the Cactuar* [Tweet; thumbnail link to article]. Twitter.

    https://twitter.com/finalfantasyvii/status/1199735136062980096/photo/1

Figure 15: Crash Bandicoot (PlayStation version) [Video Game]. (1996). Naughty Dog.

    https://miro.medium.com/v2/resize:fit:4800/format:webp/0*mv-XUFMyPAe6HhX8.jpg

Figure 16: Comparison the Main Colors of the Figure 15 (Original on the Left, Japanese Market
Version on the Right) Picked to the Adobe Color Wheel Using the Eyedropper Tool

Figure 17: Comparison the main colors of the figure 15 (original on top, Japanese market version
on the bottom) picked to the Adobe Color Wheel's color palette using the eyedropper tool

Figure 18: Angry Birds 2 (Android version) [Video Game]. (2015). Rovio Entertainment.
https://altagram.com/wp-content/uploads/2021/04/Angry-Birds-2-Engish-and-Chinese-
version.jpg

Figure 19: CD Projekt RED. (n.d.). *Cyberpunk2077NG_Cover_art_RGB-en* [Digital art]. https://cdn-l-
cyberpunk.cdprojektred.com/wallpapers/1080p/Cyberpunk2077NG_Cover_art_RGB-en.jpg

Figure 20: Main Colors of the Figure 19 Picked to the Adobe Color Wheel Using the Eyedropper
tool

Figure 21: Main Colors of the Figure 19 Picked to the Adobe Color Wheel's Color Palette Using the
Eyedropper tool

Figure 22: CD Projekt RED. (n.d.). *screen-image-mercenary-e79283ec* [Digital art].
https://www.cyberpunk.net/build/images/home3/screen-image-mercenary-e79283ec.jpg

Figure 23: DRAGON QUEST® XI S: Echoes of an Elusive Age (PlayStation 4 version) [Video game].
(2017). Square Enix.

Figure 24: Main Colors of the Figure 23 Picked to the Adobe Color Wheel Using the Eyedropper
Tool

Figure 25: Main Colors of the Figure 23 Picked to the Adobe Color Wheel's Color Palette Using the
Eyedropper Tool

Figure 26: Angry Birds 2 (Android version) [Video Game]. (2015). Rovio Entertainment.

Figure 27: LIMBO (Steam version) [Video game]. (2010). Playdead.

Figure 28: CD Projekt RED. (n.d.). *Cyberpunk2077_Its_good_to_be_in_town_RGB-en* [Digital art].
https://cdn-l-
cyberpunk.cdprojektred.com/gallery/1080p/Cyberpunk2077_Its_good_to_be_in_town_RG
B-en.jpg

Figure 29: Main Colors of the Figure 28 picked to the Adobe Color Wheel Using the Eyedropper
tool

Figure 30: Main colors of the Figure 28 Picked to the Adobe Color Wheel's Color Palette Using the
Eyedropper Tool

Figure 31: Angry Birds 2 (Android version) [Video Game]. (2015). Rovio Entertainment.

Figure 32: Florence (Steam version) [Video game]. (2020). Annapurna Interactive.
https://cdn.cloudflare.steamstatic.com/steam/apps/1102130/ss_fe7d6ef1f2bf34692e29f8
650c432df1908f914b.1920x1080.jpg?t=1660851948

Figure 33: Florence (Steam version) [Video game]. (2020). Annapurna Interactive.
https://cdn.cloudflare.steamstatic.com/steam/apps/1102130/ss_9e029df44296f3d21a61e
96d0a7bea4447be2c14.1920x1080.jpg?t=1660851948

Figure 34: Beyond Blue (Steam version) [Video game]. (2020). E-Line Media.
https://www.beyondbluegame.com/wp-content/uploads/2020/02/Beyond-Blue-Atoll-
03.png

Figure 35: The Last Case of Benedict Fox (Steam version) [Video game]. (2023). Rogue Games, Inc.
https://cdn.akamai.steamstatic.com/steam/apps/2023360/ss_5590a99c51bdbdafdb5a28e
ddeb41913462c03b1.1920x1080.jpg?t=1682611411

Figure 36: PlayStation Default theme (PlayStation 4 version) [Video game concole]. (2013). Sony

Interactive Entertainment

Figure 37-38: Angry Birds 2 (Android version) [Video Game]. (2015). Rovio Entertainment.