Colour Theory 色彩理论

Introduction to Colour Theory 色彩理论简介:

Most people are only aware of 3 primary colours; however there are actually 6 different primary colours which are divided into two different primary sets. These are the **Additive** and **Subtractive Colour systems**, and these colour systems each have three unique Primary Colours; furthermore it is important to note that both colour systems are completely opposite to the other.

大多数人都知道三原色，殊不知其实有六种不同的原色。这六种原色分为两大类：加法和减法色系。每一类都包含三种独特的原色。值得注意的是，这两大色系完全相对立的。

As such it is important to understand that colour is a result of light being reflected by an object; therefore colour is the interaction between light which is a form of energy, and of matter which is either absorbing or reflecting that energy. This correlation of energy and mater begins to emphasize the science behind colour. This establishes the importance of considering the complexity that this correlation implies.

因此就要理解颜色是物体表面反射光的的结果。光是能量的一种形式，而物体要么吸收要么反射这能量，因而颜色就是光和物体的相互作用。这相互作用初步体现了颜色背后隐藏的科学。这就需要考虑到这相互作用所隐含的复杂性。

Visible light is part of the electromagnetic spectrum and is a form of radiation. The visible light spectrum ranges between a short wave length of 400nm (violet), to a long wave length of 700nm (red), and our ability to see colour is a result of that reflected light being absorbed by photoreceptors in our eyes. As each object will reflect light differently our eyes will perceive a different colour based on the wavelength of light being reflected by the object. It is also important to consider that energy and matter are opposite to each other and have an inverse correlation. This is why there are two unique colour systems. The **Additive colour system** of light and the **Subtractive colour system** of matter.

可见光是电磁波谱的一部分，是一种辐射。一般人眼可以感知的可见光的电磁波范围是400nm（紫）——700nm（红）。肉眼能感知颜色是因为我们眼球里的感光器吸收了被反射的光。每个物体反射的光不同，肉眼看到的颜色也不同。另外重要的是能量和物质是相对立的，它们之间反向联系。这就是为什么有两种不同的颜色体系：光的加法颜色体系和物质的减法颜色体系。

Colour Theory 色彩理论

Summary 概要:

In summary the **Additive primary colours** are the primary colours of light. When various colours of light are mixed together the total light energy of the colours will combine to become a brighter colour. **Subtractive primary colours** are the primary colours of matter such as pigments or inks. When various colours of matter are mixed together the colours will absorb some of the light energy that the other colour would have reflected. Since each colour reduces the amount of light being reflected the resulting colour will be darker.

简言之加法体系的原色是光的原色。当不同颜色的光混合时，各种颜色的光的能量会结合形成更亮的颜色。见法体系的原色是物质的原色比如色素和墨水。当不同颜色物质混合时，这些颜色会吸收原先其余颜色反射的光能量。每一个颜色除去了一些反射光，合成色会更深。

Colour Theory 色彩理论

Additive Colour System 加法色系

Additive colours are the 3 primary colours of light and is the colour system used by computer screens. Red, Blue, and Green pixels create every combination of colour that you see when viewing images on the computer screen. When various colours of light are mixed the resulting colour will become brighter, and white light is the combination of every colour of light, whereas black is the absence of light.

加法颜色是光的三种原色，也是计算机屏幕所用的色系。红、蓝、绿像素生成了计算机屏幕上所看到的图像的每一种颜色。当各种颜色的光混合时最终的颜色会更亮。白色光是所有颜色光的加合，而黑色是没有光。

Subtractive Colour System 减法色系

Subtractive colours are the 3 primary colours of matter and is the colour system used by different printing processes. Cyan, Yellow, and Magenta inks are used to create the various colours you see when you print a document. When inks are mixed the resulting colour becomes darker. Black is the combination of every colour of ink, whereas white is the absence of all colours which reveals the white of the paper.

减法颜色是物质的三种颜色，也是各种打印所用的色系。青、黄、品红墨水用来生成答应文件的各种颜色。当墨水混合时生成色更暗。黑色是每种颜色墨水的加合，白色是所有颜色的缺失所显示出的纸张的白。

Colour Theory 色彩理论

Applying Colour Theory 应用颜色理论

There is often confusion between colours like white and black when individuals have an incomplete understanding of colour theory. The argument that both white and black are a combination of every colour is a common debate amongst many students. The following section should help clarify this common misconception.

人们对颜色理论的认识不完全会导致对不同颜色的困惑，比如黑和白。学生常会对黑和白是每一种颜色的合成起争论。下面的部分会帮助你明晓这常见的误解。

Example 举例：

When paints are mixed together the resulting colour will continue to get darker. This is because paint is a form of matter. When a colour is added each colour will absorb some of the light energy that would have been reflected by the other colour. Eventually all the light energy will be absorbed by the different colours and light will no longer be reflected. When this happens there will be an absence of light energy being reflected and the colour black will be seen. In conclusion black is the combination of all colours. Since black is the combination of all colours many people may conclude that white must be the absence of colour; however it is important to understand the difference between additive and subtractive colour systems.

混合颜料会生成更深的颜色。这是因为颜料是物质。当加入一种颜料，每种颜色的颜料都会吸收那些原来会被其他颜色的颜料反射出去的能量的光。最终所有能量的光都会被各种颜色的颜料吸收去而不再有光被反射。这一发生，被反射的光能不复存在，黑色将显示在眼前。总之，黑色颜料是各种颜色颜料的加合。既然如此，不少人或许以为白色就是各种颜色颜料的缺失。然而，加法色系和减法色系的区别要先搞清楚。

Since paint is a substance and is not a form of energy the rules of the Subtractive Primary system apply. When colours are mixed each colour will reduce, or subtract, from the amount of light energy being reflected; therefore in conclusion we can state that black is the combination of all colours of matter.

颜料是物质不是能量，因此属于减法原色系统。当颜色混合时，每种颜色会从原先反射的能量的光中消除或者减去。所以黑色是各种颜色的物质的加合。

Colour Theory 色彩理论

However light, which is a form of energy is the exact opposite of matter. When different colours of light are added together the resulting colour will be brighter. For example if green and red light is blended together the resulting colour will be a bright yellow. This is because the red and green light energy will combine to create a brighter colour with more light energy. This is the opposite of if paints were mixed together. If you mix green and red paints together each colour would absorb some of the light energy that would have been reflected by the other colour. This would result in the colour becoming darker, and for this example the colour brown would be created instead of yellow.

然而光，作为一种能量，却和物质相反。不同颜色的光加在一起生成的颜色更亮。比如绿光和红光加合生成亮黄的光。这是因为红绿光的能量会加合形成一个更大能量的光，显示更亮的颜色。这与颜料加合相反。红绿颜料混合每个颜料会吸收被另外一个颜料反射的光能量。这导致了生成色更暗，生成棕色而不是黄色。

To conclude our example we can state that the colour white is the combination of every colour of light, whereas black is the combination of every colour in matter and is seen as black because it is absorbing every wavelength of light in the visible spectrum

总结一下，白色是所有颜色的光的加合，而黑色是所有颜色的物质的加合。看出来是黑色是因为物质吸收了可见光光谱里的所有波长的光（注：对辐射（光）来说，波长和能量成反比例关系，所有波长的光被吸收也就是所有能量的光被吸收）

Colour Theory 色彩理论

Describing Colour 描述颜色:

A TINT is a lighter version of a colour, whereas a SHADE is a darker version of that same colour; therefore pink is a lighter TINT of the colour red, and Maroon is a darker SHADE.

TINT	Primary Colour	SHADE
Pink	Red	Maroon

The Colour Star 色星:

The Colour Star below shows all 6 primary colours which includes the 3 additive primary colours (Red, Blue, and Green) and the 3 subtractive primary colours (Magenta, Cyan, and Yellow). This particular Colour Star shows the various shades and tints of each of the primary colours with shades becoming increasingly darker towards the center and lighter tints towards the outside tips of each colour wedge. Between each colour wedge is the intermediate colour which is created by mixing the two adjacent primary colours together. These diamond shape colour swatches show the 6 intermediate colours (Crimson, purple, Azure, Aqua, Olive, and Orange).

右面的色星显示了6种原色，其中3种是加法系原色（红、蓝、绿），另3种是减法系原色（品红、青、黄）。此色星显示了原色的各种色温和阴影。色温是星形的每个角里靠近外侧角尖的变浅的颜色，阴影是靠近中间的变深的颜色。在每一个原色的角之间是过渡色，它们是由相邻两种原色混合成的。图中那些钻石片显示了6种过渡色（绯红、紫、蔚蓝、浅绿、橄榄色、橙色）

Colour Theory 色彩理论

Colours as they would appear in the spectrum 颜色在色谱中的显示:

Visible light consists of a range of wavelengths along the electromagnetic spectrum, and our perception of colour is a result of our eyes which can detect these differences. Visible light ranges from violet to red; however the colour magenta does not exist as a single wavelength anywhere along the electromagnetic spectrum.

可见光在电磁波谱占了一定范围的波长，我们对颜色的感知是肉眼鉴别这些波长区别的结果。可见光范围从紫到红，而所谓品红并不是以电磁波谱中任何一个单一波长的光的形式存在。

Magenta is known as an “extraspectral” colour which results from superimposing violet and red wave lengths. The discovery of magenta by Sir Isaac Newton was a significant development in the study of colour theory because it allowed for the creation of the first scientifically balanced colour wheel.

品红被认为是“谱外色”是因为它重叠了代表紫和红波长的光。伊萨克牛顿对品红的发现是颜色理论研究的一大进步。它促成了第一次科学上平衡的色轮的创造。

~ 450 – 400 nm	Purple / Violet	紫色
~ 490 – 450 nm	Blue	蓝色
~ 480 – 500 nm	Azure	蔚蓝色
~ 520 – 490 nm	Cyan	青色
~ 510 – 530 nm	Aqua	浅绿色
~ 560 – 520 nm	Green	绿色
~ 550 – 570 nm	Olive	橄榄色
~ 590 – 560 nm	Yellow	黄色
~ 635 – 590 nm	Orange	橙色
~ 700 – 635 nm	Red	红色

~ 635 + 400 nm	Crimson	绯红色
~ 700 + 400 nm	Magenta	品红色

Colour Theory 色彩理论

An Introduction to Chromatic Visual Anomalies 色视觉异常简介:

The term colour blindness is commonly used to describe various visual anomalies that result in reduced colour vision; however the term colour blindness often results in a misconception about what it means to have such an affliction. Often people think that individuals who are colour blind cannot see colour at all; however, in reality almost everyone who is diagnosed as being colour blind are able to see some colour but they see each colour differently that individuals with normal colour vision do. Therefore the term chromatic visual anomalies more accurately describes the affliction as it recognizes that the individual's ability to recognize colour deviates from the established norm but is still present in some form.

色盲这术语通常用来形容各种视觉异常造成的视觉的缺损，而此术语经常导致了对此种疾病的误解。通常人们认为色盲的人看不到颜色。但是，事实是基本每个被确定为色盲的人都能看到一些颜色，而看到的每种颜色和正常人看到的不一样。因此，色视觉异常这术语更能准确描述这些症状，因为它考虑了个体认识的颜色虽然和公认的标准不一样，却仍然存在某种形式的认识能力。

The notion of colour blindness, or more accurately of various chromatic visual anomalies dates back to 1798 when the chemist John Dalton published the first academic paper on the topic. Daltons paper was titled "*Extraordinary facts relating to the vision of colours"*. Dalton first made the discover after coming to the realization that his own colour vision was impaired. The general condition was named "Daltonism", however the scientific term Deuteranopia is now used to describe this specific visual anomaly.

色盲的概念，或更准确地说，色视觉异常的概念追溯到1798年。那时化学家John Dalton发表了第一篇相关的论文。Dalton的论文取名"颜色视觉的奇特事实"。Dalton意识到他自己的视觉是有缺陷的，然后有了此发现。这种普遍症状被取名为"Dalton症"， 而现今用"Deuteranopia"这一科学术语来描述此类特殊的视觉异常。

Furthermore, recent research has proven that chromatic visual anomalies do not affect everyone equally. In fact individuals with Northern European ancestry have the highest probability of having a form of colour vision deficiency with as many as 8% of men and 0.4% of women being afflicted by some form of visual anomaly. The reason that more men are affected by visual anomalies than women is because the genes that are responsible for colour vision are on the X-chromosome. This makes visual anomalies in males much higher as males only have one (1) X-chromosome whereas females have 2; therefore the probability that both colour genes on the X-chromosomes are defective in women is much lower than in males.

既而近来的研究又证明了视觉异常对每个人影响都不一样。事实上，北欧血统的个体有最大的概率带有某种形式的颜色视觉缺陷。8%的男人和0.4%的女人患有一些视觉异常。男人比女人概率大因为负责视觉的基因在X染色体上。这使得视觉异常在男人中更多因为男人只有一条X染色体，而女人有2条。所以两条染色体上的颜色基因在女人中同时出问题的概率要比在男人中小得多。

There are several different forms of chromatic anomalies and some forms are more common than others. According to Michael Kallonaitis and Charles Luu's research paper *"The Perception of Colour"* which was published on July 9th 2007: **Deuteranomaly** is the most common anomaly with 6% of males and 0.4% of females being afflicted, **Protanomaly** being the second most common anomaly with 1% of males and 0.01% of females, and **Tritanomaly** being equally as rare for both males and females with approximently 0.01% for both genders.

有各种形式的色视觉异常。某些形式更常见。据2007年7月9号Michael Kallonaitis 和 Charles Luu's的论文"视觉感知"，绿色弱在男性中占6%在女性中占0.4%，位居第一；红色若是第二常见异常症，在男性中占1%女性中占0.01%；蓝色弱在两性中都罕见，比例也都是0.01%。

Ethnicity also has a significant role in determining the statistical probability of visual anomalies. The American Academy Of Ophthalmology conducted a major multi-ethnic study of chromatic visual anomalies amongst a group of preschoolers between the ages of 3 and 6 in Los Angeles, California. The principal investigator was Dr. Varma Rohit who supervised the study. Dr. Varma Rohit was the Chairman of Department of Ophthalmology at the University of Southern California School of Medicine at the time of the study. The study sample size included 4,005 preschoolers. The percentages that were established by the study are as follows:

种族也在色视觉异常的统计中扮演重要角色。美国眼科学协会对加州洛杉矶的3至6岁的多种族学前儿童做了一大研究。主要调查者是Varma Rohit博士，他是当时南加州医学院的系主任。研究样本容量有4005学前儿童。研究得出了一下比例：

- 5.6% of Caucasian boys were diagnosed with a chromatic visual anomaly
- 5.6%白人男孩有色视觉异常
- 3.1% of Asian boys were diagnosed with a chromatic visual anomaly
- 3.1%亚洲男孩有色视觉异常
- 2.6% of Hispanic boys were diagnosed with a chromatic visual anomaly
- 2.6%西班牙男孩有色视觉异常
- 1.4% of African-American boys were diagnosed with a chromatic visual anomaly
- 1.4%非洲裔男孩有色视觉异常

***Note:** the study concluded that the instances for visual anomalies in female participants was so low that the numbers could not accurately be described; therefore only data pertaining to male participants was published in the study.*

注：此研究得出的女性色视觉差异比例太小以致无法准确用数字描述，因此只有男性的数据被公布。

Although findings of different studies vary slightly the results of these various studies continue to support the following generalizations; the probability of having the defective X-chromosome which is responsible for causing a chromatic visual anomaly is significantly higher in males than in females and varies between different ethnic groups. Caucasians have the highest probability of having the defective X-chromosome followed by Asians, Hispanic, and finally individuals of African decent have the lowest probability of having a genetically inherited visual anomaly.

虽然不同的研究产生略不同的结果，下述的规律不变：拥有导致色视觉差异的缺陷X染色体的概率在男性中要比在女性中高得多，并且不同的种族这一概率不同。白人最容易拥有此缺陷X染色体，其次是亚洲人，再次是西班牙人，最后是非洲裔。他们遗传色视觉异常的概率最低。

Percentage of the Population with Visual Anomalies
患视觉异常症的人占人口的比例

Colour Deficiency	Males	Females	Total
Normal Vison正常视觉	83.982%	99.052%	83.034%
Minor Visual Anomalies 轻微视觉异常	8%	0.5%	8.5%
Deuteranomaly 绿色弱	5%	0.4%	5.4%
Deuteranopia 绿色盲	1%	0.01%	1.01%
Protanomaly 红色弱	1%	0.01%	1.01%
Protanopia 红色盲	1%	0.01%	1.01%
Tritanomaly 蓝色弱	0.01%	0.01%	0.02%
Tritanopia 兰色盲	0.008%	0.008%	0.016%
Achromatopsia 全色盲	<0.0001%	<0.0001%	<0.0002%

Data by: Dr. Jeff Rabin, OD, PhD,
Visual Function Laboratory Ophthalmology Branch USAF School of Aerospace Medicine.