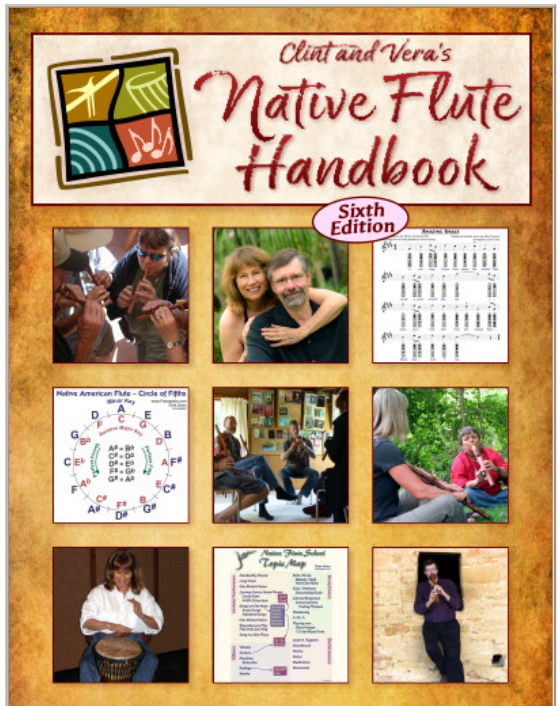
The Color of Sound

Sound and light share the fundamental nature of vibration. And, even though the sounds we can hear have a much lower frequency than light that is visible to us, there is a range of sound frequencies that have corresponding consonant colors. This page delves into consonant relationships between sound and color and and provides a tool to let you explore their relationship.



Click to download the Native Flute Handbook.
There is no cost for this 400+ page PDF book.

However, before diving too far down this particular rabbit hole topic, please realize that the vibrations of sound and light are very different. Sound is based on vibrations of air molecules as a moving compression wave. Light (and hence color) is based on an electromagnetic wave. While "frequency" is a measure commonly used for both compression and electromagnetic waves, the two types of waves have substantial differences.

Despite these challenges, the Sound⇔Color link has been reported to be potentially useful in many contexts including the treatment of synethesia, music education, meditation practices, and therapeutic music making.

Aspects of Sound and Color

Two basic questions need to be addressed when connecting sound with color:

1. **What apsect of sound are we dealing with?**
   Aspects of sound have been connected with color include:
   A. The vowel that is used by people who are doing vocal toning. Some vowels are "URRR…", "AHH…", and "EEE…".
   B. The fundamental (lowest) frequency component of the sound. This is often translated into pitch based on some pitch standard and tuning system (typically a pitch standard of A=440 or A=432 and a tuning system of 12-TET or some just-intoned tuning system).
   C. A musical interval such as a minor third or a perfect fifth.

2. **How are the colors being represented or specified?**
   Ways of representing colors abound. The various systems, called color models, are often related to the practical aspects of displaying colors on display screens or printers. These systems often have multiple components, such as the Red-Green-Blue systems used in Cathode Ray Tube displays. Another method for specifying colors is to use the visble colors we can see in the electromagnetic spectrum — the colors of light that we see in a rainbow. In this system, it is typical to give a single number — the frequency of the electromagnetic radiation — when specifying the color. Note that not all colors can be represented in every system. Some colors produced by a computer screen do not appear in the visible light spectrum.

Connecting Sound with Color

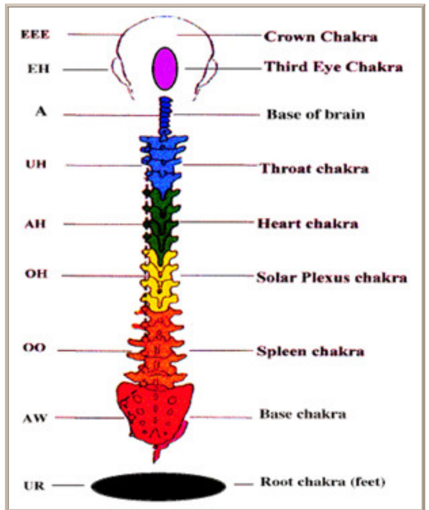
Many approaches to the Sound-Color relationship have been explored over the centuries. These approaches are either direct or indirect relationships.

A direct relationship has some formula or mapping that translates between a pitch and a color. The mapping might be in only one direction (eg. pitch ⇒ color, where every pitch has a color, but not every color can be mapped on to a pitch), or it could be bi-directional.

An indirect relationship has some intermediate component that is mapped onto both pitches and colors, providing a sound–color link.

The image at the right — Vowel Sounds and Colors for Toning based on the Chakra System — is an example of an indirect relationship between discreet colors and vowel sounds used in toning. These are linked through the system of chakras, with each chakra assigned both a vowel sound and a discreet color.

Another aspect of the relationship is whether the colors and sounds that are linked form a discreet set of colors or sounds (for example, "red", "green", etc. and "C", "A♭", etc.) or a continuous spectrum (for example, the frequency of the light or the sound wave).

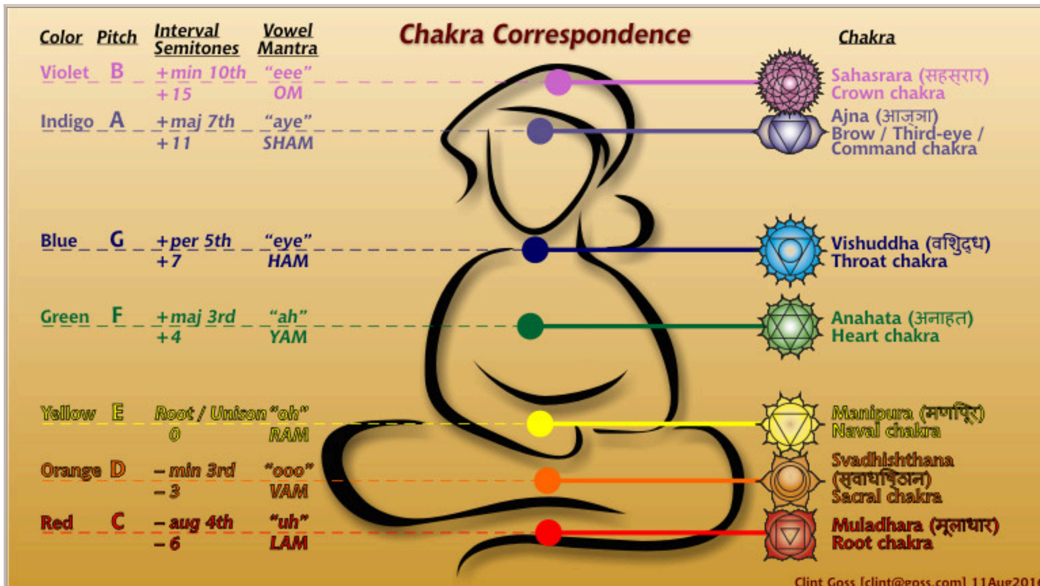


Vowel Sounds and Colors for Toning based on the Chakra System

Chakra Systems

This chakra correpondence chart is a composite of information I have gathered from various sources. It shows an indirect relationship between discreet colors and discreet pitches and discreet musical intervals:

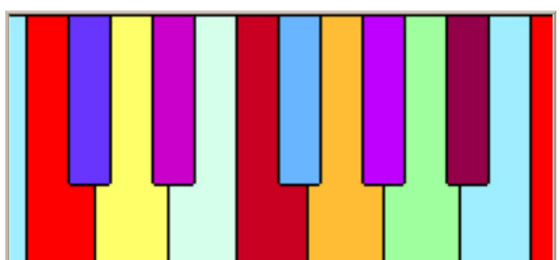
- The colors are from [Klotsche 2012], page ;
- The notes are from [Mercier 2000], page 80;
- The intervals are from [Paul 2006], page 272;
- The vowel sounds and mantras are from [Goldman 2011], figures 6.1 and 7.2;



Chakra Correspondence

Notice that the pitches are completely independent of the musical intervals. Also note that the chakras themselves do not agree with the not agree with the prior *Vowel Sounds and Colors for Toning* chart. I have found that these type of discrepancies occur frequently when combining information from different sources.

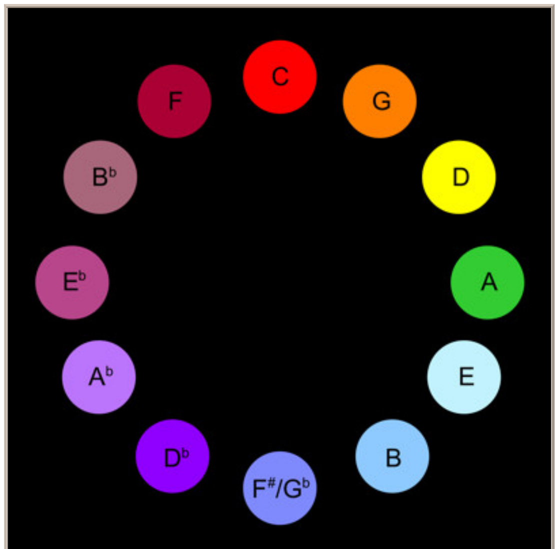
Scriabin Correspondence



Alexander Scriabin's Clavier à Lumieères system

Alexander Scriabin (1871–1915) developed a mapping between discreet pitches and discreet colors based on his experience with synesthesia, a condition that causes one sense to be percieved as a different sense. Scriabin perceived sound as color, and developed a mapping system called "clavier à lumieères" (literally "keyboard with lights") shown at the right.

Rather than a pattern that placed similar colors on adjacent keys, Scriabin's system (and, presumably, his system of perception) placed similar colors on notes that were a perfect fourth and a perfect fifth apart. So, when the notes are laid out in the manner of a Circle of Fifths, the colors appear to be more systematic and continuous:



The Scriabin Circle

It is an open question whether such a color coding of piano keys has an effect on how piano or music theory is learned.

Thanks to Erik Friedling for pointing out the work of Alexander Scriabin.

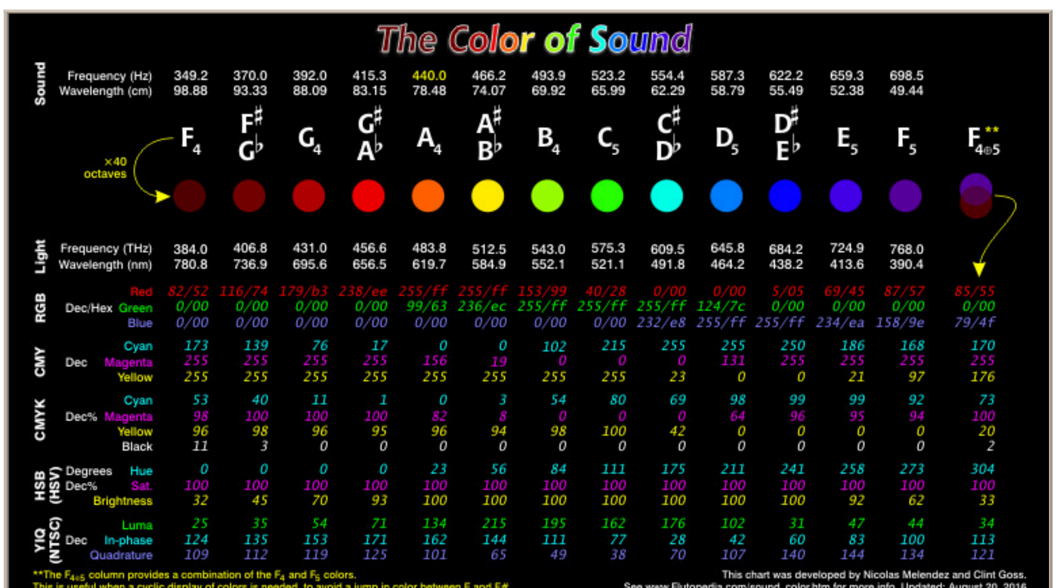
A Direct Relationship between Continuous Spectrums of Sound and Color

The rest of this page deals with a specific relationship betweein sound and color: a direct relationship between the continuous spectrum of frequencies of electromagnetic energy in the band of visible light and the pitches of sound in a continuous frequency spectrum of sound that are 40 octaves (a factor of 2^{40} = 1,099,511,627,776) below the frequencies of visible light.

This Sound⇒Color relationship is shown in a chart and a calculator further down on this page.

The Color of Sound Chart

In August 2016, Nicholas Melendez (aka "Nexdrum") sent me a chart that he had developed independently based on his own calculations. The colors on the chart matched almost perfectly with the colors produced by the calculator further down on this page. I developed an expanded version of Nicholas's design, with additional information that may be useful … click on the image for a larger version:



The Color of Sound

		F_4	F♯/G♭	G_4	G♯/A♭	A_4	A♯/B♭	B_4	C_5	C♯/D♭	D_5	D♯/E♭	E_5	F_5	$F_{4⊕5}$**
Sound	Frequency (Hz)	349.2	370.0	392.0	415.3	440.0	466.2	493.9	523.2	554.4	587.3	622.2	659.3	698.5	
	Wavelength (cm)	98.88	93.33	88.09	83.15	78.48	74.07	69.92	65.99	62.29	58.79	55.49	52.38	49.44	
×40 octaves															
Light	Frequency (THz)	384.0	406.8	431.0	456.6	483.8	512.5	543.0	575.3	609.5	645.8	684.2	724.9	768.0	
	Wavelength (nm)	780.8	736.9	695.6	656.5	619.7	584.9	552.1	521.1	491.8	464.2	438.2	413.6	390.4	
RGB Dec/Hex	Red	82/52	116/74	179/b3	238/ee	255/ff	255/ff	153/99	40/28	0/00	0/00	5/05	69/45	87/57	85/55
	Green	0/00	0/00	0/00	0/00	99/63	236/ec	255/ff	255/ff	255/ff	124/7c	0/00	0/00	0/00	0/00
	Blue	0/00	0/00	0/00	0/00	0/00	0/00	0/00	0/00	232/e8	255/ff	255/ff	234/ea	158/9e	79/4f
CMY Dec	Cyan	173	139	76	17	0	0	102	215	255	255	250	186	168	170
	Magenta	255	255	255	255	156	19	0	0	0	131	255	255	255	255
	Yellow	255	255	255	255	255	255	255	255	23	0	0	21	97	176
CMYK Dec%	Cyan	53	40	11	1	0	3	54	80	69	98	99	99	92	73
	Magenta	98	100	100	100	82	8	0	0	0	64	96	95	94	100
	Yellow	96	98	96	95	96	94	98	100	42	0	0	0	0	20
	Black	11	3	0	0	0	0	0	0	0	0	0	0	0	2
HSB (HSV)	Degrees Hue	0	0	0	0	23	56	84	111	175	211	241	258	273	304
	Dec% Sat.	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Brightness	32	45	70	93	100	100	100	100	100	100	100	92	62	33
YIQ (NTSC) Dec	Luma	25	35	54	71	134	215	195	162	176	102	31	47	44	34
	In-phase	124	135	153	171	162	144	111	77	28	42	60	83	100	113
	Quadrature	109	112	119	125	101	65	49	38	70	107	140	144	134	121

**The $F_{4⊕5}$ column provides a combination of the F_4 and F_5 colors. This is useful when a cyclic display of colors is needed, to avoid a jump in color between F and F#.

This chart was developed by Nicolas Melendez and Clint Goss. See www.Flutopedia.com/sound_color.htm for more info. Updated: August 20, 2016

The Color of Sound Chart

Some notes on this chart:

The range of this chart is somewhat wider than the calculator at the top of this page, since the visible color spectrum extends slightly more than one octave worth of frequencies. I have included both F_4 and F_5, which, when scaled up 40 octaves, have corresponding colors near the infrared and ultraviolet ends of the spectrum, respectively.

I have also added a column at the end that combines both F_4 and F_5. This is useful in cases where a cyclic display of colors is needed, to avoid a jump in color between F and F♯.

The conversion from the RGB colorspace to CMY, CMYK, HSB (aka HSV), and YIQ (used in NTSC displays) were performed by Corel Draw X3.

Pitch-to-Color Calculator

by Clint Goss, version 1.02

Browser Compatibility Note: This tool does function properly on all browsers. It has been tested on these browsers:

- **OK** — Internet Explorer 9.0.8112.16421, tested 6/14/2011, on Win7 64-bit.
- **OK** — Google Chrome 12.0.742.91 m, tested 6/14/2011, on Win7 64-bit.
- **Fail** — Mozilla Firefox 4.0.1, tested 6/14/2011 on Win7 64-bit. Seems to fail to execute any JavaScript code, even with the configuration for JavaScript turned on. No JavaScript errors were flagged — just no execution of the code.
- **Fail** — Mozilla Firefox 5.0, as reported by D. J. on 6/24/2011.
- **OK** — Apple The New iPad (third Generation), iOS 5.1, tested 3/18/2012.
- **OK** — Internet Explorer 11.0.9600.18314, tested 8/8/2016, on Win7 64-bit.

Inputs

Fundamental Note
F♯4 + –

Note Bias		
◉ + ○ –	0 cents	+1 –1 +10 –10

Pitch Standard
A4 = 440 Hz + –

Environment		
	Temperature	**Relative Humidity (%)**
Note played at:	72 °F	45 %

Calculate Reset

Results

Color of Light that is Resonant with the Pitch Above

Details
The resonant color of light that is 40 octaves above an $F\sharp_4$ at standard pitch A4=440 has a frequency of 406.81 THz. This color has a wavelength of 736.93 nm. The equivalent RGB colors (shown above) that approximate this color of light are #750000, based on a modified version of Dan Bruton's color approximation algorithm. The frequency of an $F\sharp_4$ at standard pitch A4=440 is 369.99 Hz. At a temperature of 72°F (22.22°C), the speed of sound is 345.31 m/sec (1132.91 ft/sec). Under these conditions, an $F\sharp_4$ at standard pitch A4=440 has a wavelength of 93.33 cm (36.74 inches).

Documentation

This calculator lets you specify a note and observe the color that is consonant with that note. “Consonant" means that the color has a frequency that is some number of octaves above the frequency of the sound.

The easiest thing to do is to play with the various inputs, in particular the **+** and **–** buttons, and see how the colors change. The details box shows the internal details of how the calculation was made, and might be interesting for some folks.

Some things to note:

1. Changing the temperature or humidity does not affect the color. The color is based on the frequency (determined by the note, the tuning bias, and the A4 pitch reference). However, the temperature and humidity do affect the corresponding wavelength, show in the detail box.
2. Error checking on the input is not complete. If you enter an inappropriate entry (such as something other than a number), results can be unpredictable.

For more background information on this calculator, including the folks who contributed to the code base, see the Tools and Calculators Overview page.

If you find any problems or suggestions regarding this page, please contact me.

Applications

I personally consider the link between sound and color as provided on this calculator to be tenuous or even whimsical, at best. Sound is based on vibrations of air molecules as a moving compression wave, and light (and hence color) is based on an electromagnetic wave. While “frequency” is a measure commonly used for both compression and electromagnetic waves, the two types of waves are quite different.

However, in situations where you wish to represent pitch as ***some*** color, this mapping might be useful in the absence of any other scheme. This mapping has also proved useful when mapping some colors back onto pitches, for my development of workshops on playing techniques based on emotions.

Also, I have received reports from practitioners who have successfully used this sound↔color relationship in their treatment of conditions such as synesthesia.

Converting Sound to Color

The code above converts the frequency of sound to a frequency of light by doubling the sound frenency (going up one octave each time) until it reaches a frequency in the range of 400–800 THz (400,000,000,000,000 – 800,000,000,000,000 Hz).

That frequency is then converted into a wavelength of light, using the formula:

```
wavelength = speedOfLight / frequency
```

The speed of light that is used is the observed speed of light in a vacuum (299,792,458 m/sec).

I believe that this is a reasonable approach, even though we are not playing these sounds in a vacuum. The code for rendering colors (see below) is based on this same constant for speed of light; When looking at resonance, I believe that it is really the frequency of the sound and light that we want to match, not the wavelength.

Rendering Colors of Light

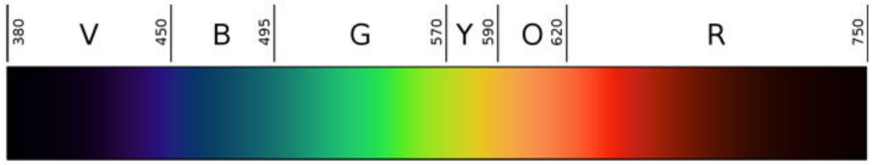
To display a particular wavelength of light on HTML Web pages is problematic.

Colors of light are pure frequencies that our eyes perceive as a single color. The RGB (red, green, blue) color system used by HTML and as displayed on most color monitors uses a blend of three pure light sources (a red gun, a green gun, and a blue gun, in the case of the older CRT displays) to create the impression of a single color to our eyes. In the RGB system our eyes perceive some colors that do not exist as pure colors of the spectrum, such as pink and white. These colors are blends of multiple colors from the pure spectum. The RGB color model is called an “additive" color system, because it is adding colors together to render a perceived color.

To render pure colors as RGB, I have used this table from [Bruno 2006], page 2:

Color	Frequency	Wavelength
violet	668–789 THz	380–450 nm
blue	631–668 THz	450–475 nm
cyan	606–630 THz	476–495 nm
green	526–606 THz	495–570 nm
yellow	508–526 THz	570–590 nm
orange	484–508 THz	590–620 nm
red	400–484 THz	620–750 nm

To approximate these colors in the RGB color model, I coded a JavaScript routine that is based on code implemented in C# by Phillip Laven that was originally from a Fortran coding of an algorithm from *Dan Bruton's Color Science Page*. Note that my JavaScript version is heavily modified, so the results do not match these earlier C# and Fortran implementations, but more closely approximate this rendering done in 2010 by David Eccles (generated from code he implemented in R):



A description of this rendering is provided on the *Wikimedia page for this image*, and the code that generated this image is available at *this code page*.

If you print these color renditions, the problems of color rendition are compounded. Most printers use yet another color model, CMYK (Cyan, Magenta, Yellow, Black). Not only are the RGB colors converted to CMYK colors somewhere along the path from web page to printer, but the printer color model is a "subtractive" model — the paper starts out white and material is tossed onto the page to make it darker.

So, the bottom line is, the color renditions used on Flutopedia for color rendering of wavelengths of light are, at best, a "good try" at displaying colors, but should not be used for work that calls for a more serious treatment.

Converting RGB Colors to Color Frequencies

I've been asked about the possibility of converting an RGB color into a frequency of light. This poses some issues. As part of the pitch-to-color calculator, we're mapping one number (frequency) onto three numbers (R, G, and B). But we're not producing **all** possible combinations of R, G, and B … just some of them. That means that, if you pick an arbitrary R, G, and B, it might not have any frequency that (in my algorithm) would have generated that RGB.

An analogy could be made to drawing a line on a map. Each point on the line can be identified by its distance from the start of the line, and each point on the line has an [X,Y] coordinate on the map. However, each [X,Y] coordinate on the map does **not** have a position on the line.

Another way to look at this is … consider the rainbow. Can you find brown in it? Not really. But there's brown in RGB space.

Revision History

August 11, 2016

- Add information about chakra systems and Alexander Scriabin.

August 8, 2016

- Add the Color of Sound chart in collaboration with Nicholas "Nexdrum" Melendez.
- Add caveat section.

October 9, 2012

- Added a note about the issues of converting RGB colors to frequencies.

Version 1.02 — December 12, 2010

- Overhaul to improve colors, fix black colors, and add onChange() events to all inputs.

Version 1.01 — December 11, 2010

- Initial release.

Prev Next

To cite this page on Wikipedia: <ref name="Goss_2022_sound_color"> {{cite web |last=Goss |first=Clint |title=The Color of Sound - Pitch-to-Color Calculator |url=http://www.Flutopedia.com/sound_color.htm |date=7 June 2022 |website=Flutopedia |access-date=<YOUR RETRIEVAL DATE> }}</ref>