

# Data Visualization 4: Using Color

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Stat 133 by Gaston Sanchez

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# A little bit about Color

## About Color

Color isn't just about making your charts look pretty.

Color can serve as a visual cue just as the height of a bar or the position of a dot.

Colors can dramatically impact how we perceive and what we see in the data.

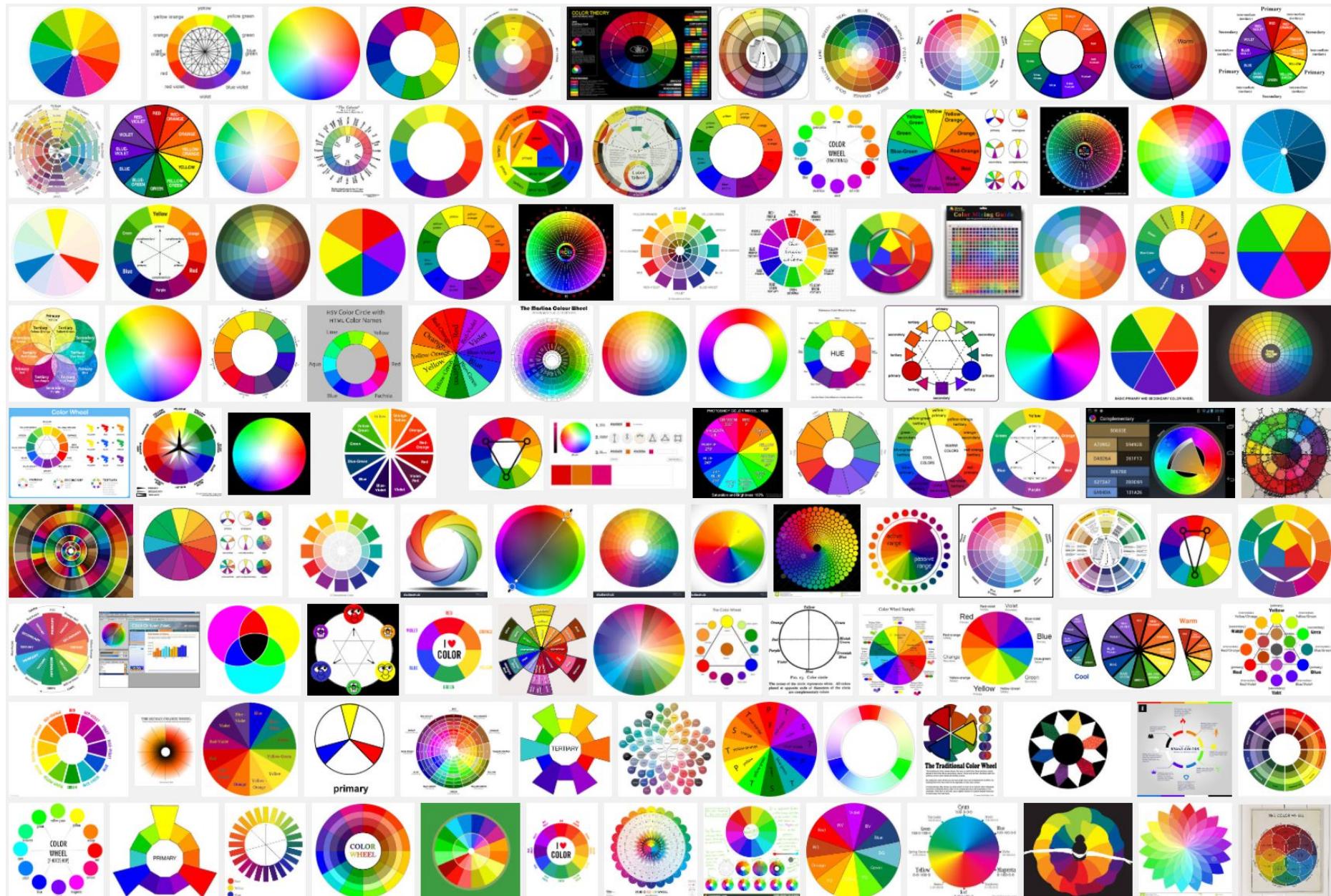
## Some Words of Caution

Color experience is remarkably subjective and personal.

It varies significantly across individuals (e.g. genetics, age, experience)

Color experience depends on the intensity of the light, and the context it is viewed.

# Color Wheel and Color Schemes



## About the Color Wheel

It shows different colors spaced evenly apart.

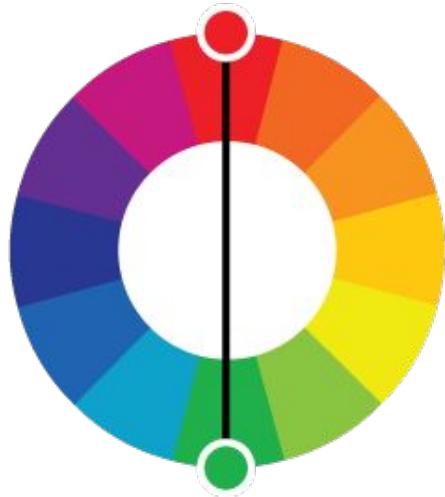
Each slice of the wheel represents a single hue.

Often, a slice will have different tints and shades of a hue.

It helps you visualize the relationships among colors.

It is perhaps the most used tool for data visualization and presentation purposes.

# Color Schemes



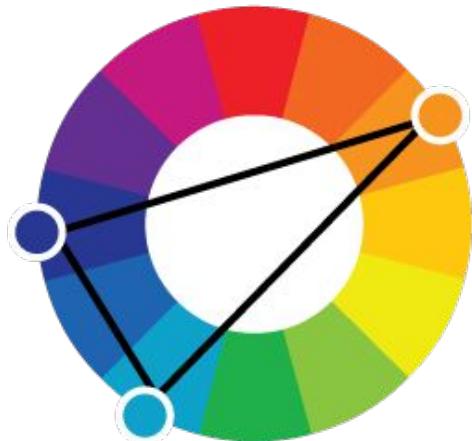
Complementary



Analogous



Triadic



Split complementary



Rectangular  
*Tetradic*



Square

## Monochromatic

Monochromatic schemes are based on a single hue.

The scheme contains different shades or tints of the same hue.

Typically used to encode quantitative values.

# The Economy Picks Up Speed

**TOTAL U.S. JOBS** IN MILLIONS



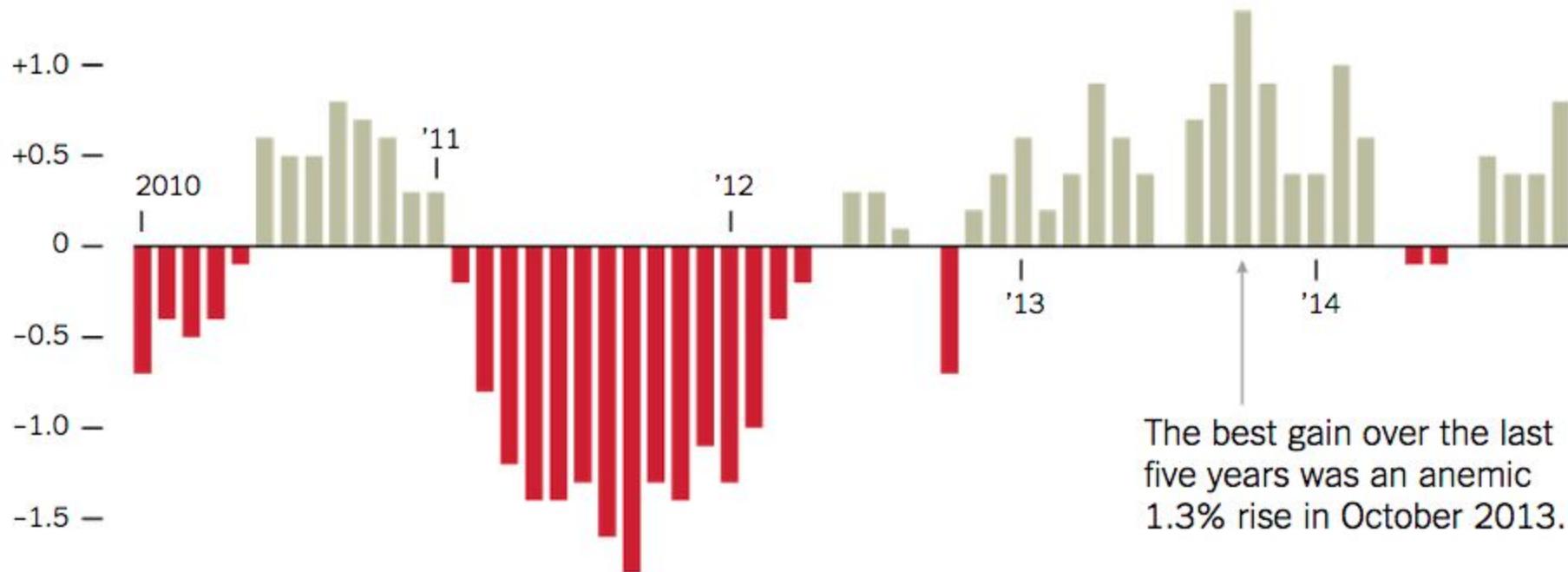
**REAL G.D.P.** IN TRILLIONS



Sources: Bureau of Labor Statistics; Bureau of Economic Analysis

## Wages Still Lag

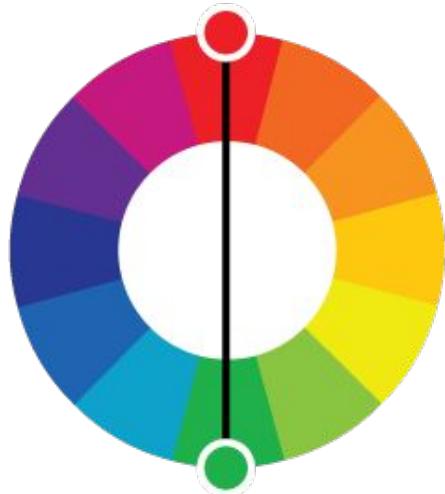
Year-over-year percentage change in hourly earnings of all U.S. private workers.



Figures take inflation into account.

Source: Bureau of Labor Statistics

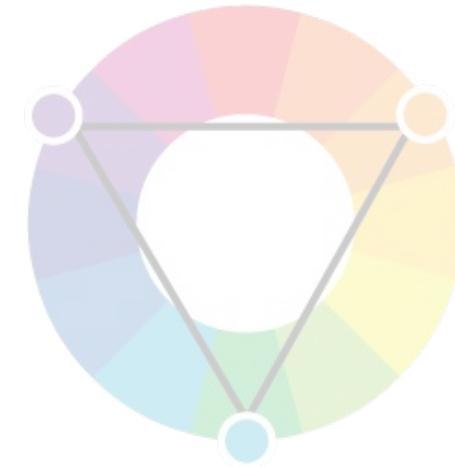
# Complementary



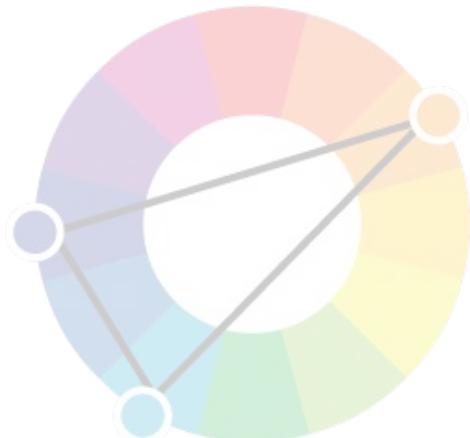
Complementary



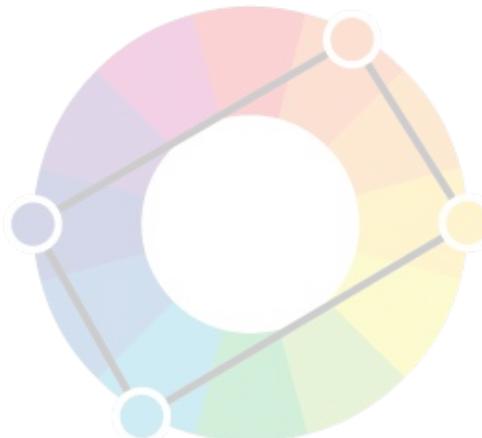
Analogous



Triadic



Split complementary



Rectangular  
Tetradic



Square

## Complementary

Complementary scheme combine two colors from opposite ends.

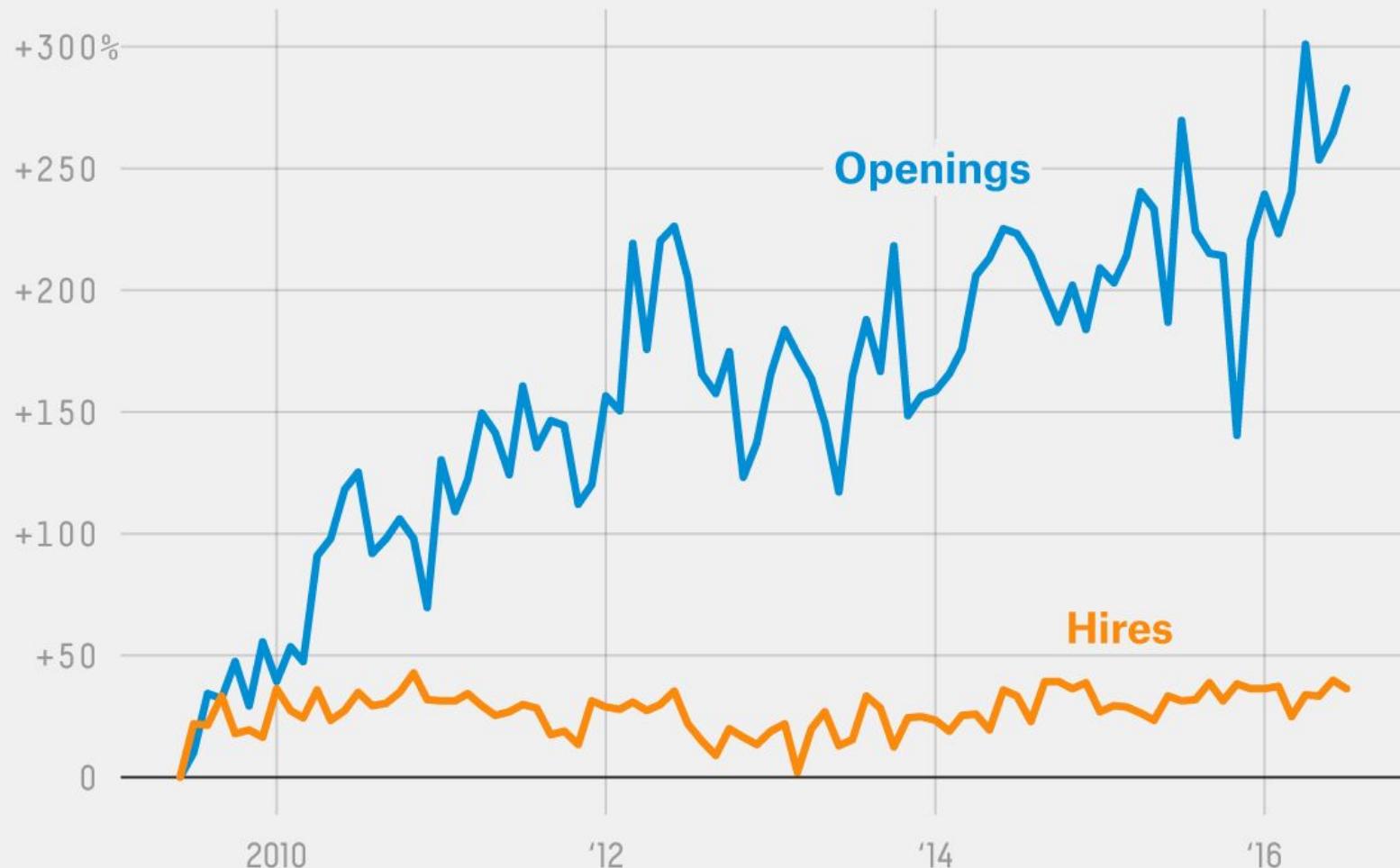
e.g. orange-blue, red-green, purple-lemon

Typically used to create a powerful look.

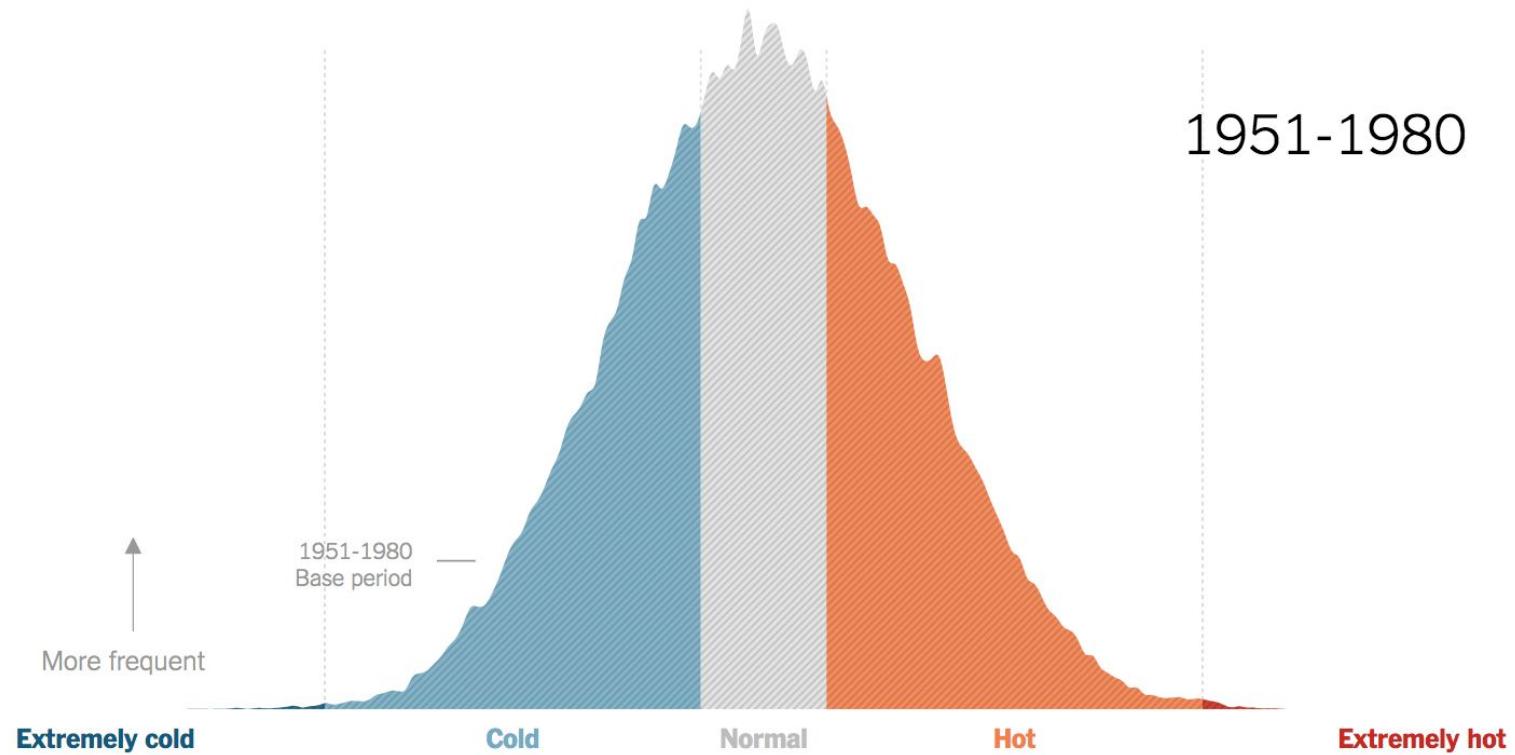
More often than not, they are used in a way that they clash (be careful).

# Manufacturers are posting jobs, not filling them

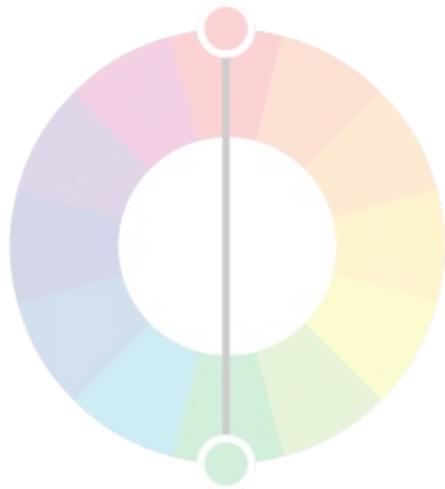
Change since June 2009, seasonally adjusted



**Summer temperatures**  
in the Northern Hemisphere



# Analogous



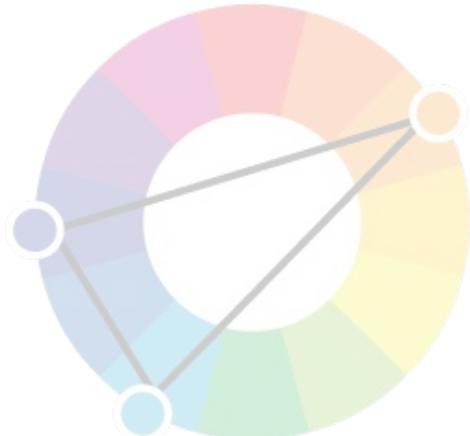
Complementary



Analogous



Triadic



Split complementary



Rectangular  
Tetradic



Square

## Analogous (aka Adjacent)

Analogous schemes is formed by three adjacent colors.

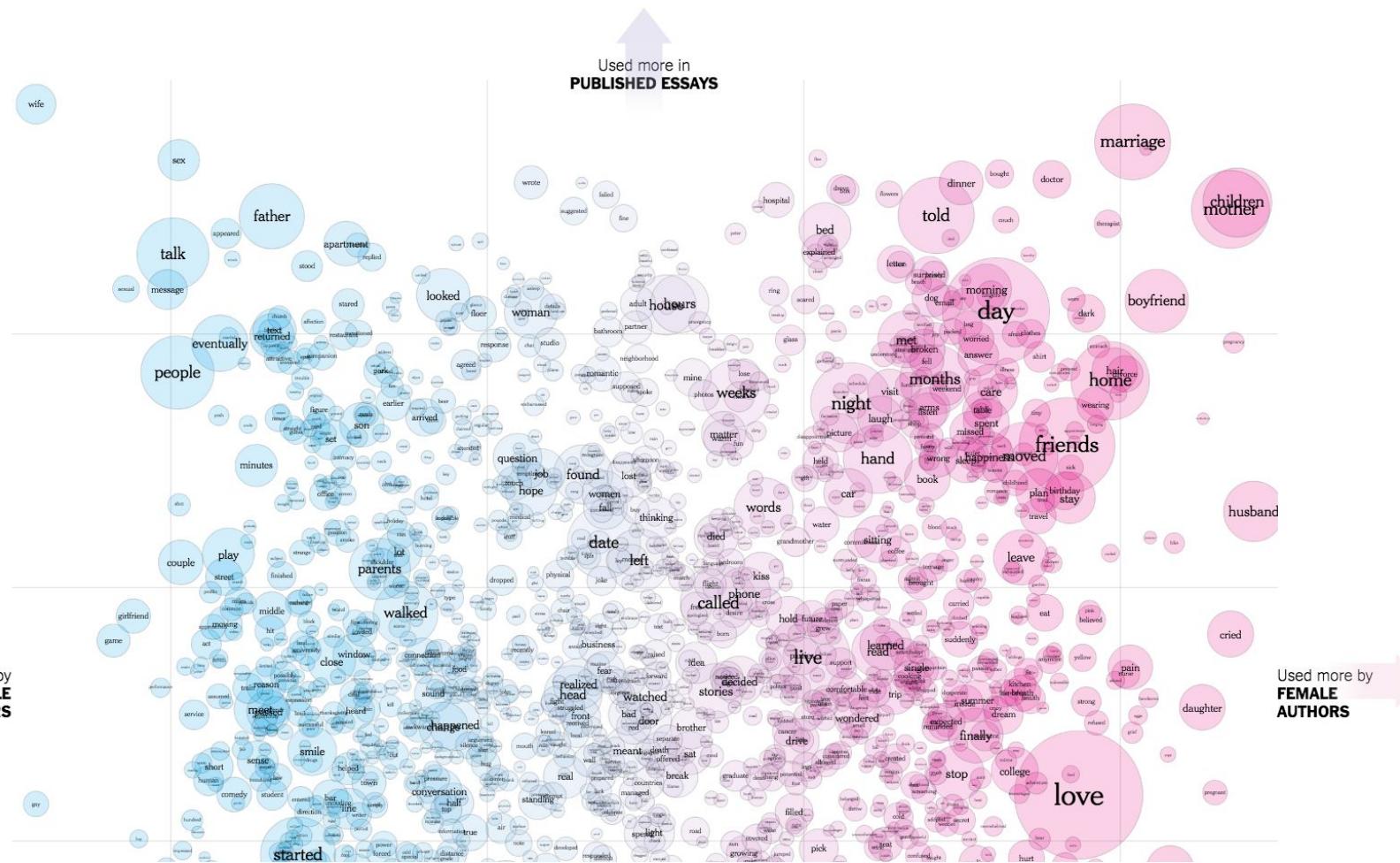
Creates a narrow, harmonious scheme.

May provide a predominantly warm or cool feeling.

What's Going On in This Graph? | Feb. 13, 2018

FEB. 8, 2018

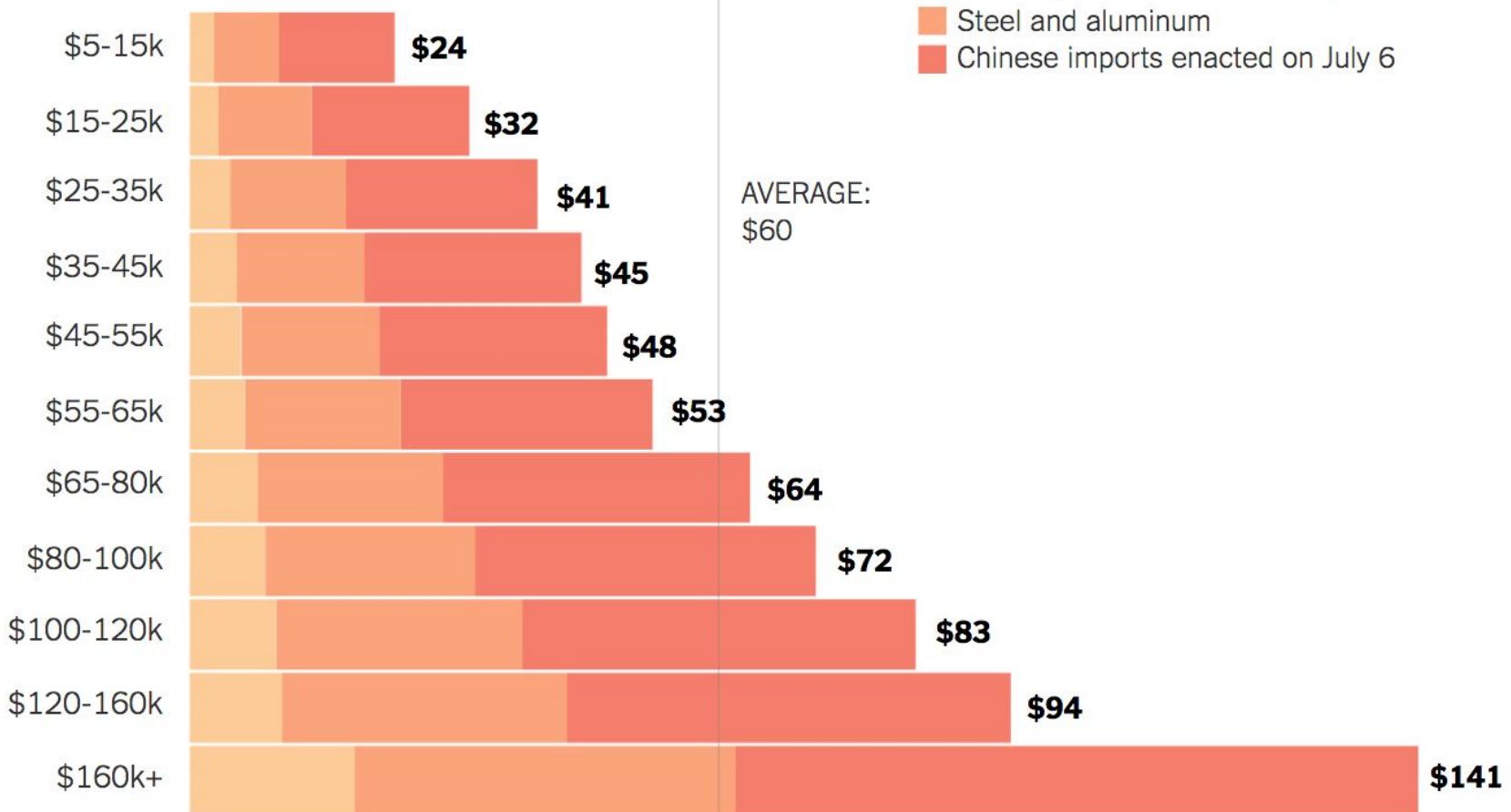
## How Certain We Are That A Word Was ...



# How much the tariffs will cost American families each year

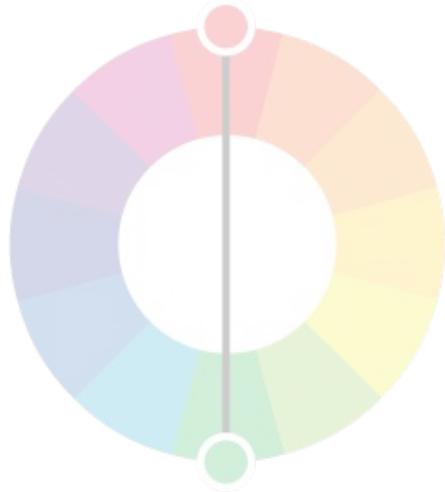
The New York Times

For households that earn:



\*Also includes steel and aluminum tariffs from China. Assumes consumers bear the full cost of the import taxes and do not change their buying behavior.

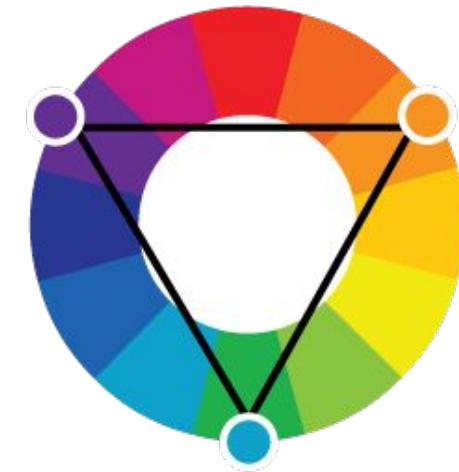
# Triadic



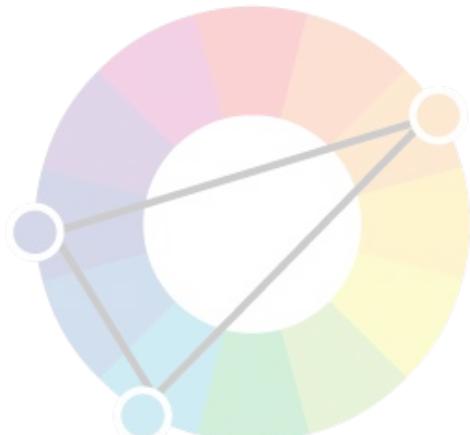
Complementary



Analogous



Triadic



Split complementary



Rectangular  
Tetradic



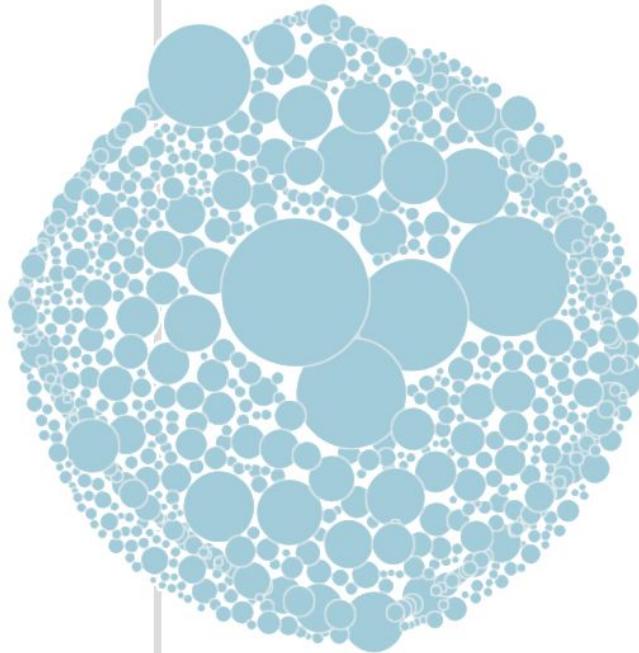
Square

## Triadic

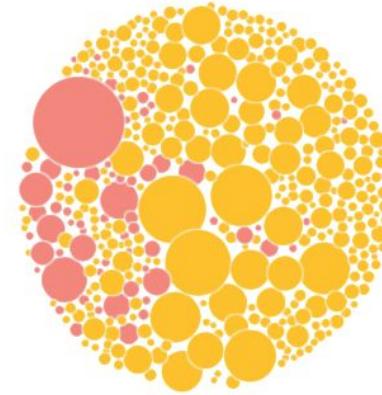
Triadic colors are equally spaced around the wheel.

Provides a vivid visual scheme.

Tends to provide more contrast than split complementary schemes.



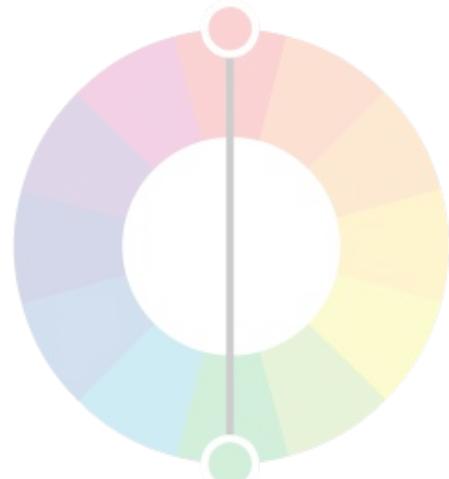
Products coming  
into the U.S.



U.S. products  
going abroad

With the possibility that exemptions might go away, the **European Union** threatened to retaliate with tariffs on **\$7.1 billion** worth of goods from the United States, a portion of which went into effect in June.

# Split Complementary



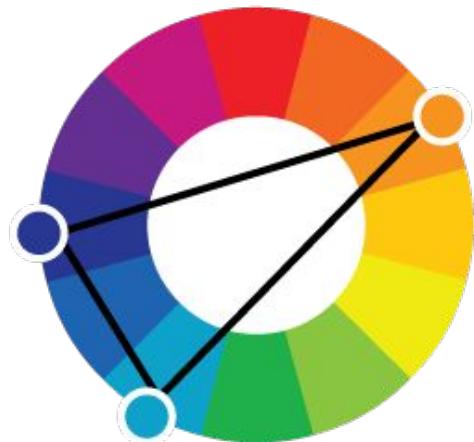
Complementary



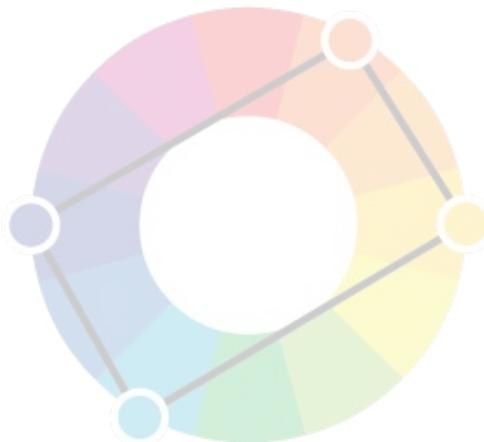
Analogous



Triadic



Split Complementary



Rectangular  
Tetradic



Square

## Split Complementary

Split complementary is a variation of the complementary scheme.

Uses colors on either side of a directly complementary color.

These schemes have a high visual contrast but with less tension than purely complementary.

There are large gaps between white children and their black and Hispanic classmates. The gaps are largest in places with large economic disparities.

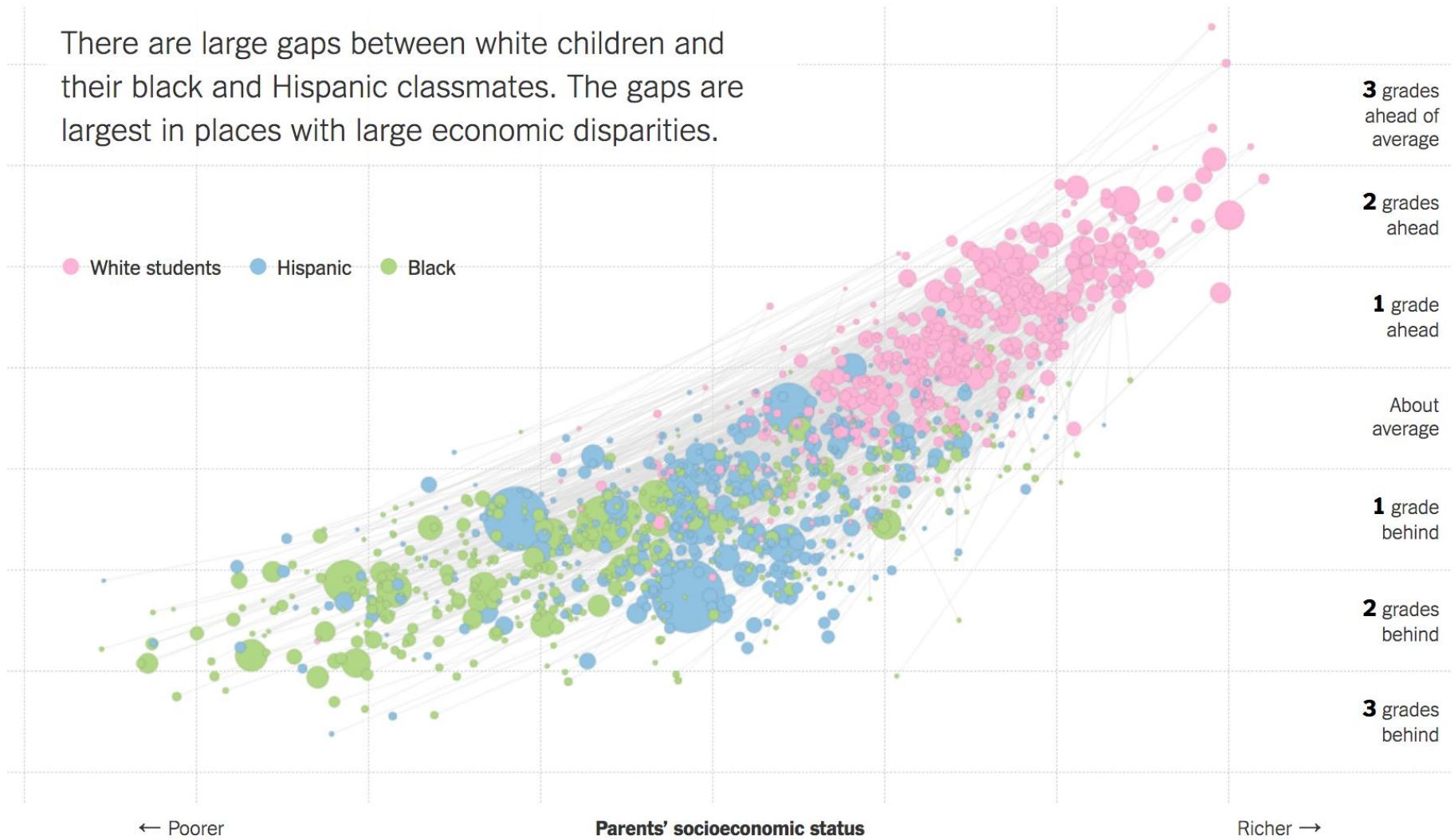


Chart shows districts with at least 100 white, 100 black and 100 Hispanic students per grade. Reliable estimates are not available for Asian-Americans.

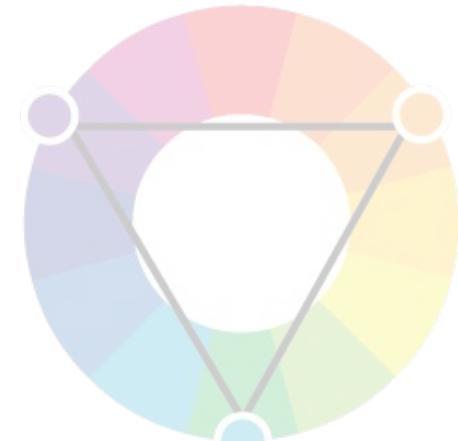
# Tetradic



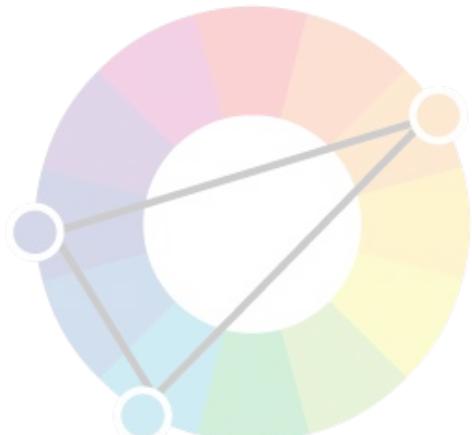
Complementary



Analogous



Triadic



Split complementary



Tetradic



Square

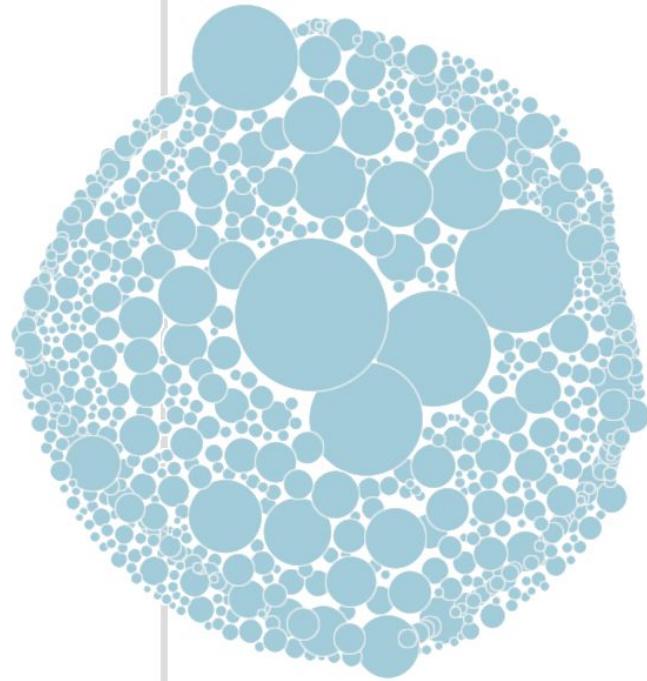
## Tetradic (aka Rectangular)

It uses two pairs of complementary colors.

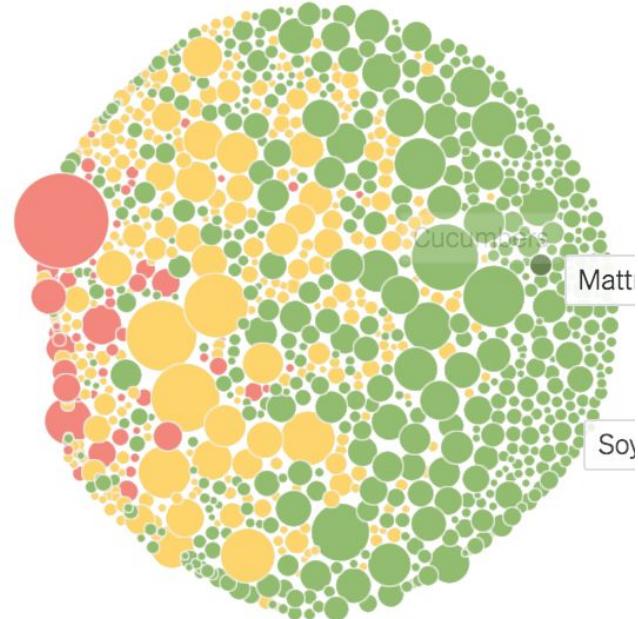
Provides contrast while retaining harmony.

Difficult to harmonize if all 4 hues are used in equal amounts.

It's better to pick a dominant color.



Products coming  
into the U.S.

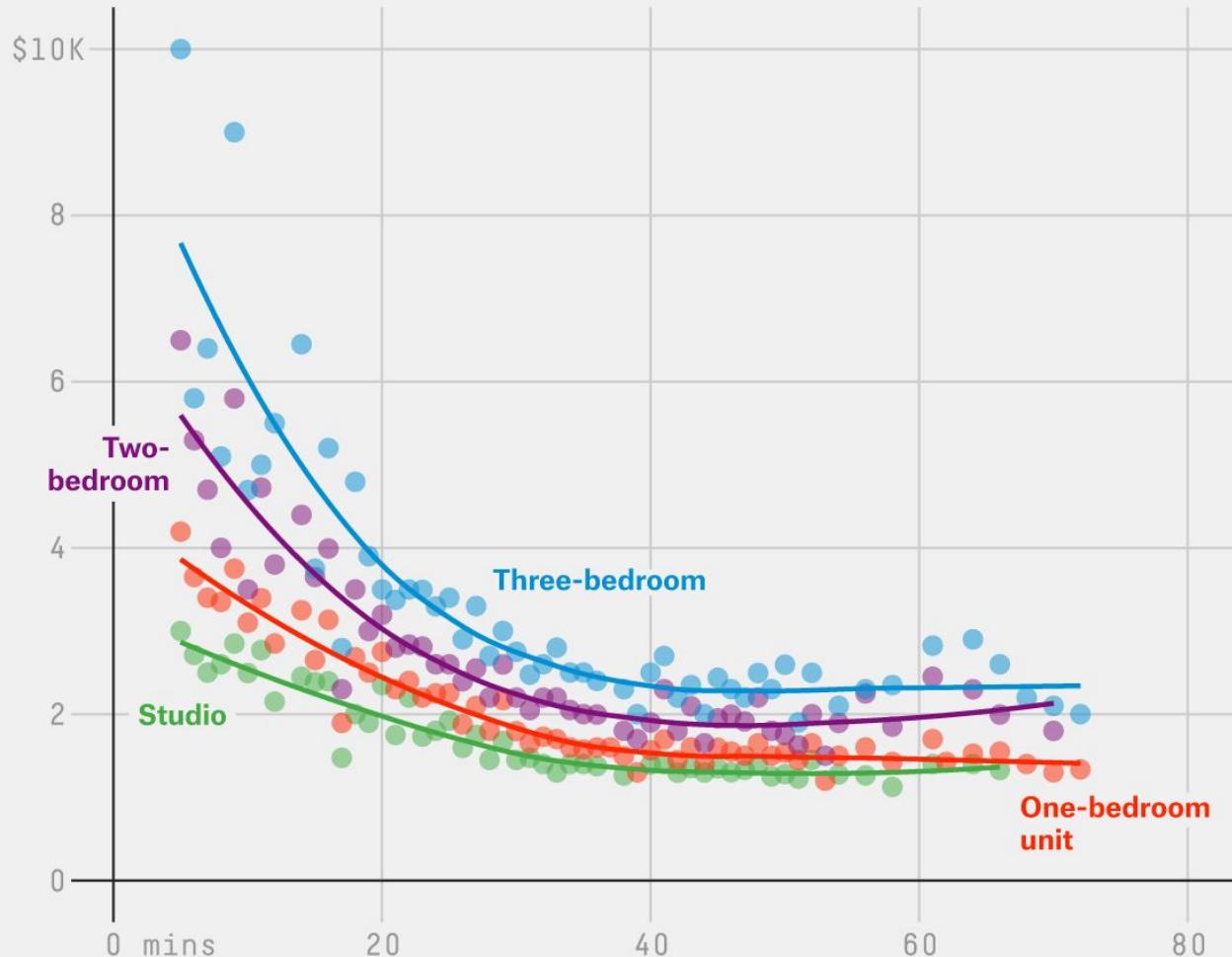


U.S. products  
going abroad

Canada then entered the fight, announcing tariffs on about \$12.8 billion in American goods. They took effect on July 1, singling out even more products than originally announced.

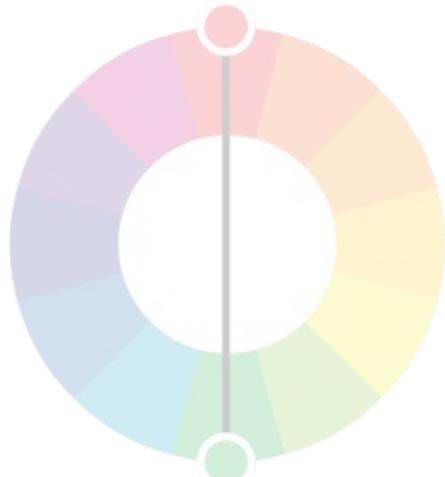
# New Yorkers pay up for a shorter commute

Median monthly NYC rent in 2015 vs. commute time by subway



Rental prices are based on FiveThirtyEight's analysis of 2015 listings on StreetEasy. Commutes are calculated as the average time from the subway station nearest a home to the nearest 42nd Street and Chambers Street stations. Commutes without at least 10 listings are excluded.

# Square



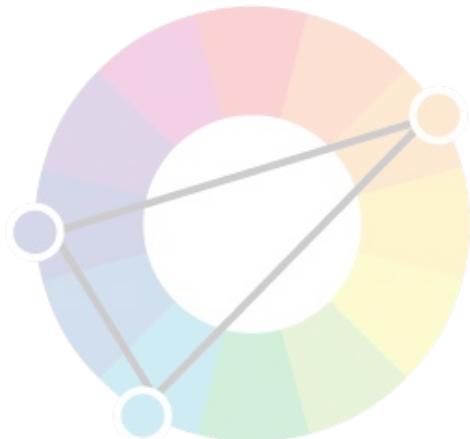
Complementary



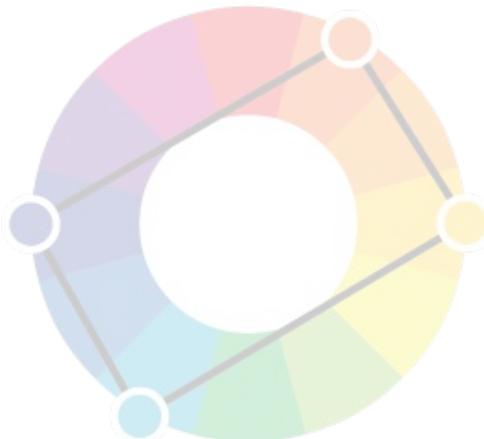
Analogous



Triadic



Split complementary



Rectangular  
Tetradic



Square

## Square

Similar to tetradic scheme.

It also uses two pairs of complementary colors.

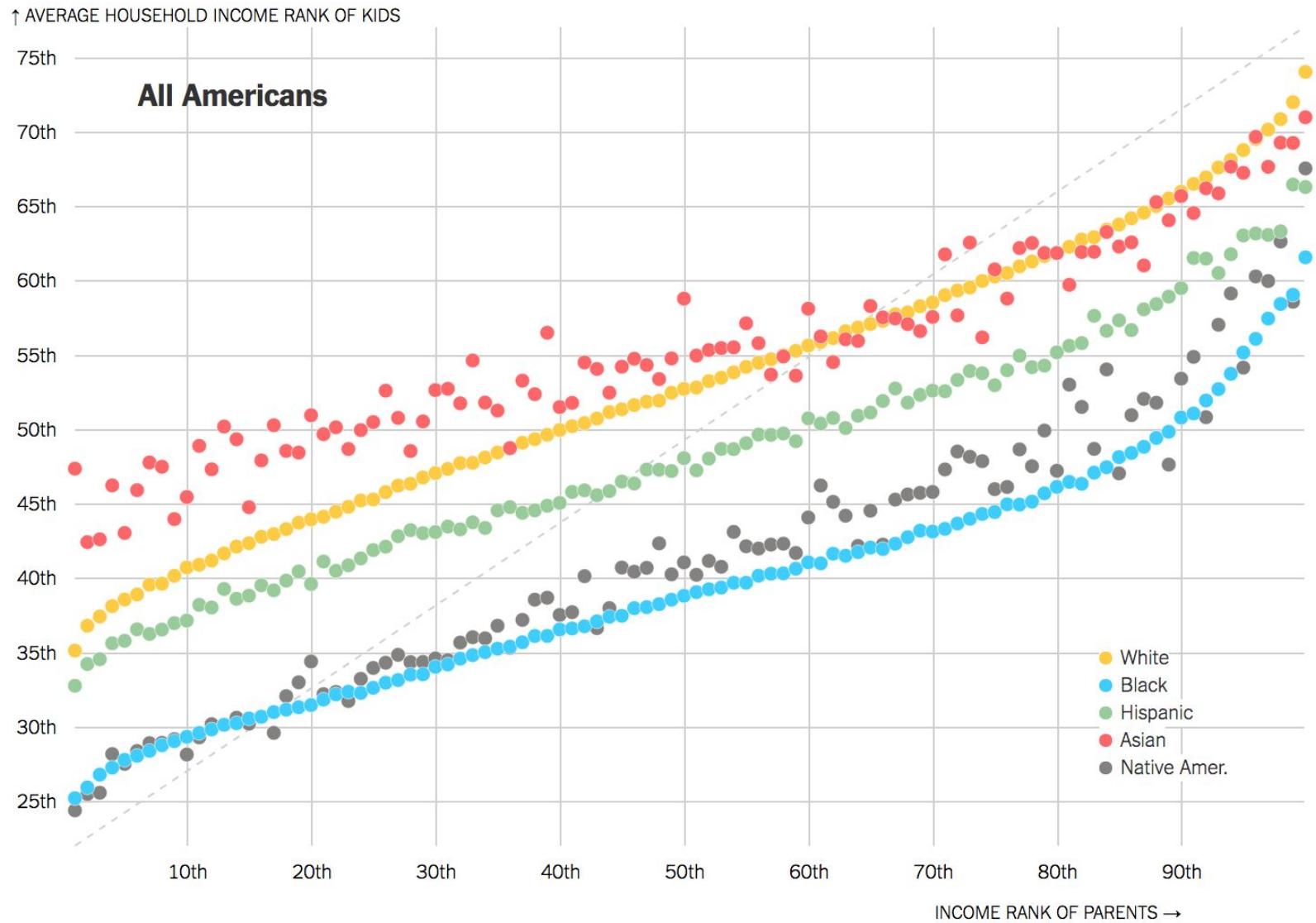
Provides contrast while retaining harmony.

Difficult to harmonize if all 4 hues are used in equal amounts.

It's better to pick a dominant color.

# The high mobility rate for Asian-Americans is partly about immigration.

The New York Times



Based on a sample of the children. Few Native Americans have immigrant mothers; their differences in income are not meaningful.

## Background Color

Before deciding on a color palette, you should consider your background color.

The background may drastically affect your palette (for better or worse).

Be careful with the contrasting effects.

# Naming Colors and Color Models

# Specifying Colors

There are various ways to specify colors with graphing software (also applicable in R)

- By using the color's name (in English) e.g. turquoise
- By using a standard color space: e.g. RGB, HSV
- By using a hexadecimal string: e.g. "#FFAA00"

## #5984d4 Color Hex



#5984D4  
(89, 132, 212)

★ 0 Favorites     0 Comments

## Color spaces of #5984d4

RGB	89	132	212
HSL	0.61	0.59	0.59
HSV	219°	58°	83°
CMYK	0.58	0.38	0.00 0.17
XYZ	24.2548	23.3798	65.5218
Yxy	23.3798	0.2143	0.2066
Hunter Lab	48.3527	4.9225	-46.4959
CIE-Lab	55.4614	9.1206	-45.6423

[#5984d4 Color](#)[Shades Tints](#)[Rbg Cmyk %s](#)[Color Schemes](#)[Color Preview](#)[CSS Codes](#)[Related Colors](#)[Facebook](#)[Google+](#)[Twitter](#)

#5984d4 color RGB value is (89,132,212).

#5984d4 hex color red value is 89, green value is 132 and the blue value of its RGB is 212. Cylindrical-coordinate representations (also known as HSL) of color #5984d4 hue: 0.61 , saturation: 0.59 and the lightness value of 5984d4 is 0.59.

The process color (four color CMYK) of #5984d4 color hex is 0.58, 0.38, 0.00, 0.17. Web safe color of #5984d4 is #6699cc. Color #5984d4 contains mainly BLUE color.

## Base Numbers

Base	Red	Green	Blue
Binary	01011001	10000100	11010100
Octal	131	204	324
Decimal	89	132	212
Hex	59	84	D4

# What's a Color Model (aka Color Space)?

A **color model** or **color space** is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values (or color components).

# Color Models

18th century color enthusiasts focused on a specific problem: how to define and represent all possible colors as a single color order system.

The early color models were motivated by a scientific interest in summarizing color perception.

Most research behind modern color theory was performed in the 1920s and 1930s (mainly in UK) with two main goals: understand color vision, and develop commercial technology for color matching.

# Color Models and Trichromatic Theories

Modern color theory is based on the so-called **trichromatic notion**: three chromatic signals go from the eye to the brain.

There is not a unique trichromatic theory but several ones.

Keep in mind that any trichromatic theory cannot generate all the colors perceived by the human brain.

# Name of Colors (in English)

## Function `colors()`

The easiest way to specify a color in R is simply to use the color's name. The R function `colors()` provides the available names.

```
# first 30 colors
colors()[1:30]

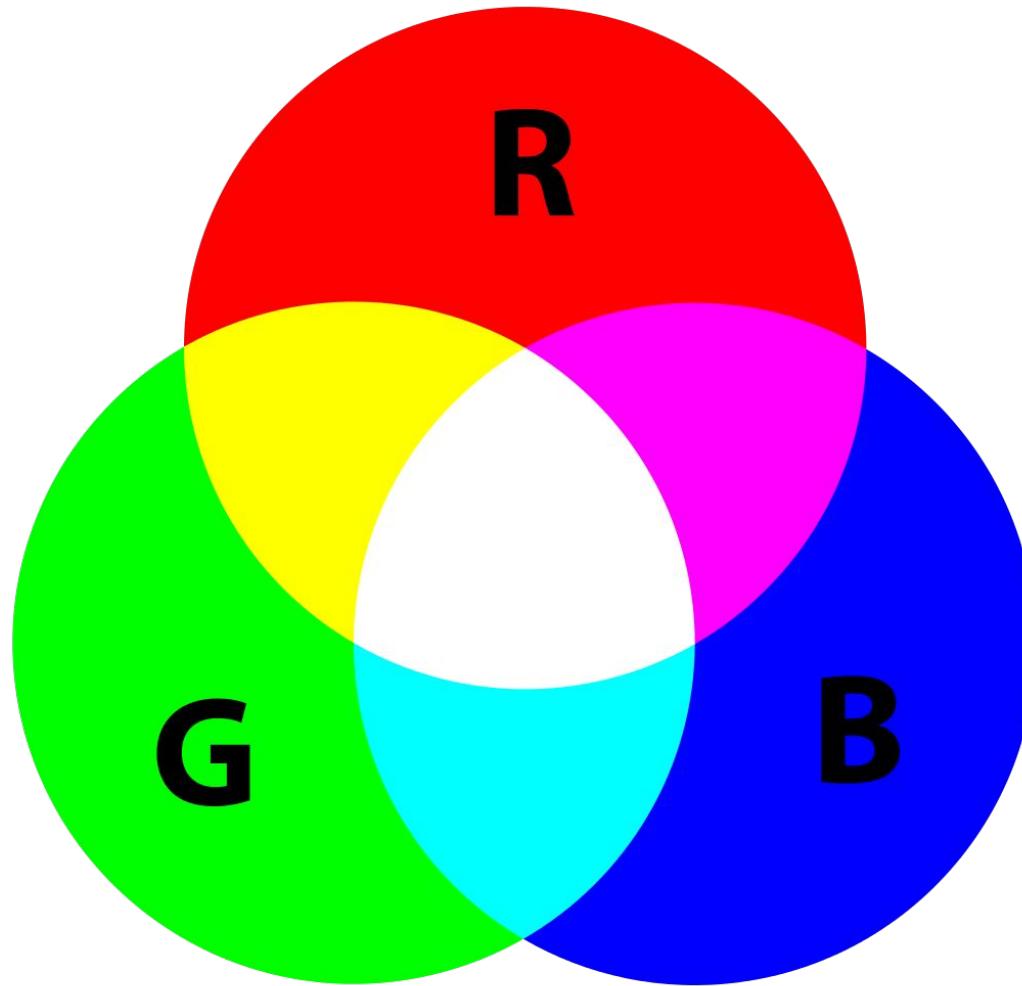
## [1] "white"          "aliceblue"        "antiquewhite"    "antiquewhite1"
## [5] "antiquewhite2"  "antiquewhite3"   "antiquewhite4"   "aquamarine"
## [9] "aquamarine1"    "aquamarine2"    "aquamarine3"    "aquamarine4"
## [13] "azure"           "azure1"          "azure2"          "azure3"
## [17] "azure4"          "beige"           "bisque"          "bisque1"
## [21] "bisque2"         "bisque3"         "bisque4"         "black"
## [25] "blanchedalmond" "blue"            "blue1"           "blue2"
## [29] "blue3"           "blue4"
```

# 657 R built-in color names

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250
251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275
276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325
326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350
351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375
376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425
426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475
476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525
526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575
576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625
626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650
651	652	653	654	655	656	657																		

# RGB Model

# RGB



# RGB

Red, Green, and Blue light sources are combined to display colors on television and computer monitors.

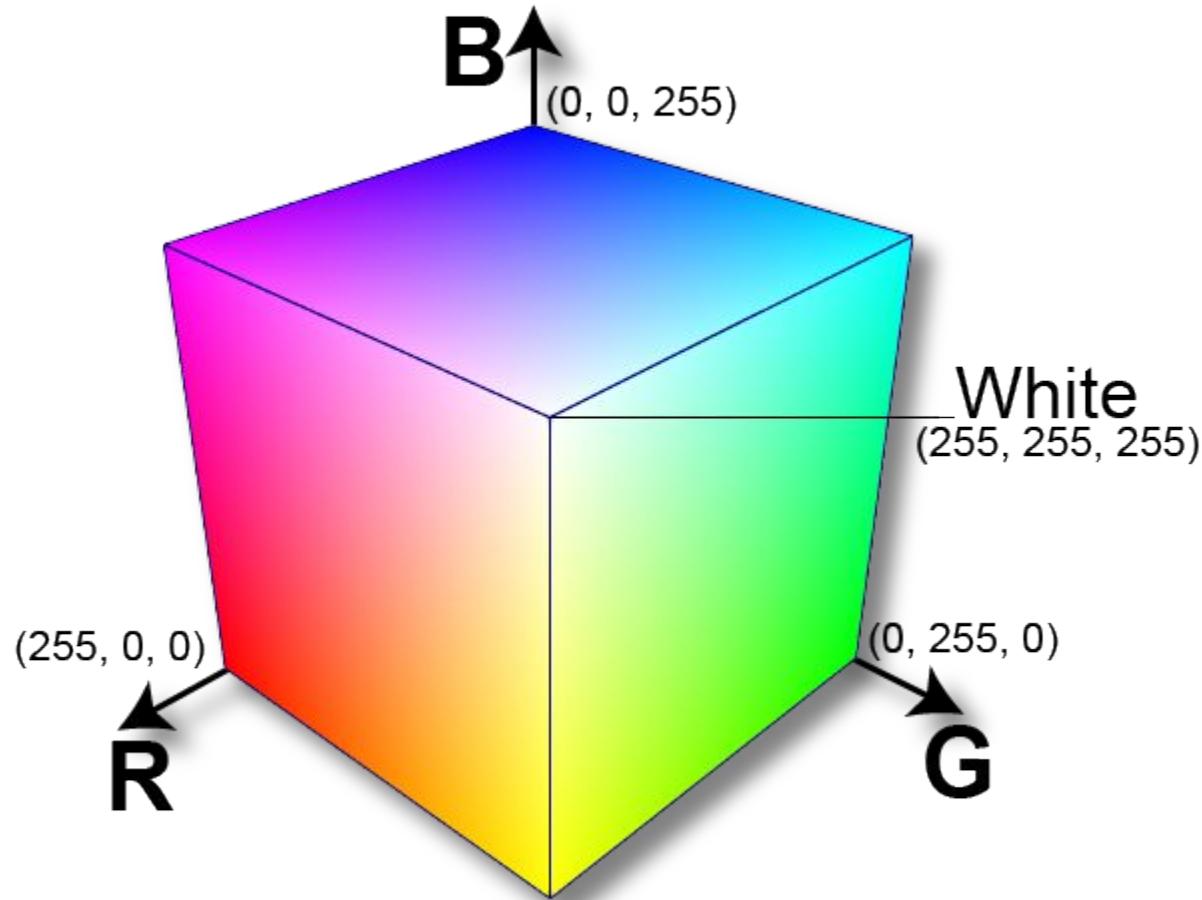
Any color you see on a monitor can be described by a series of 3 numbers (in the following order)

- A red value
- A green value
- A blue value

# RGB reference colors

RGB Values	Color (hue)
255, 0, 0	red
0, 255, 0	green
0, 0, 255	blue
0, 0, 0	black
255, 255, 255	white

# RGB: Cube Model



# RGB

Although the RGB mode provides a full description of color, it does not provide a natural way to think about color.

# Hexadecimal Notation

## Hexadecimal Notation

A color is specified as a string beginning with a hash symbol “#” and followed by six hexadecimal digits:

#FF0000 (red)

#00FF00 (green)

#0000FF (blue)

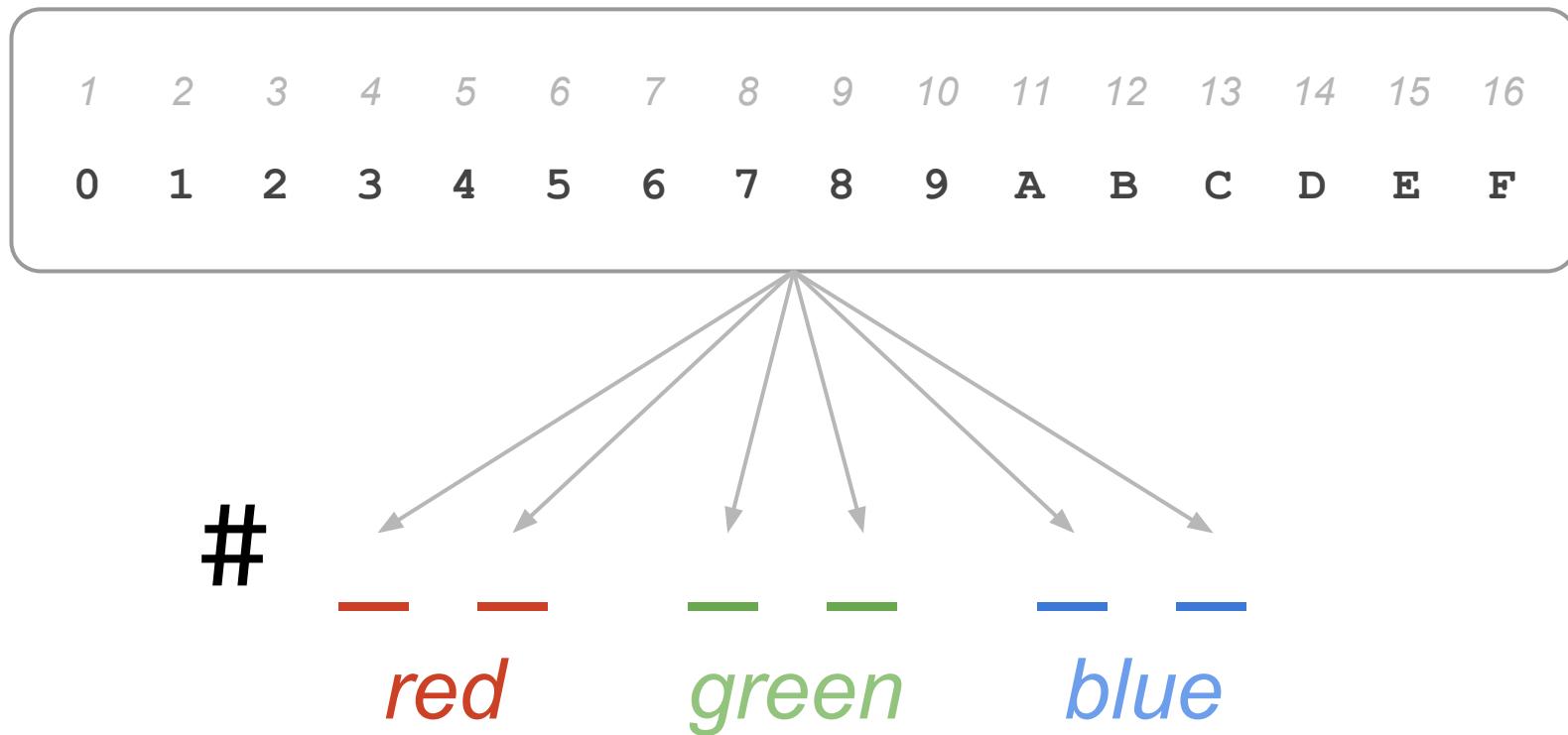
## Hexadecimal Notation

The hexadecimal representation uses 16 different symbols: 10 digits and 6 first letters (A, B, C, D, E, F).

The digits 0-9 represent values zero to nine.

The letters A-F represent values ten to fifteen.

# Hexadecimal notation



## Hexadecimal Notation

Hexadecimal color: #975015

# declares that is a “hex number”

The other six are really three sets of pairs

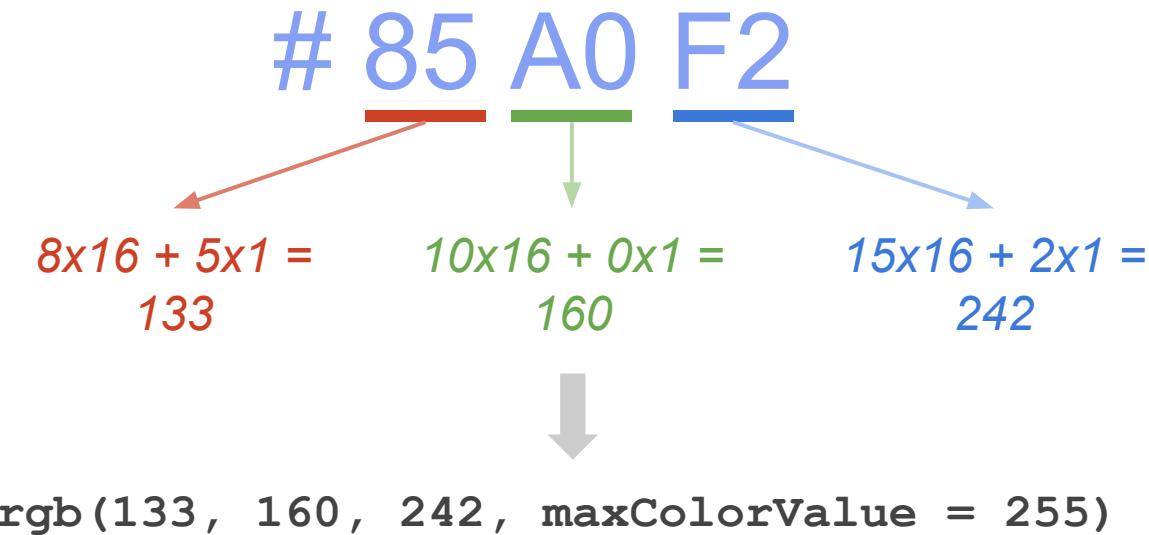
Each pair controls one primary color

The first pair corresponds to red

The second pair corresponds to green

The last pair corresponds to blue

# From HEX to RGB



## Hexadecimal Notation

**0** is the smallest representation (absence of color)

**F** is 15 times the intensity of color

**00** is equal to zero hue

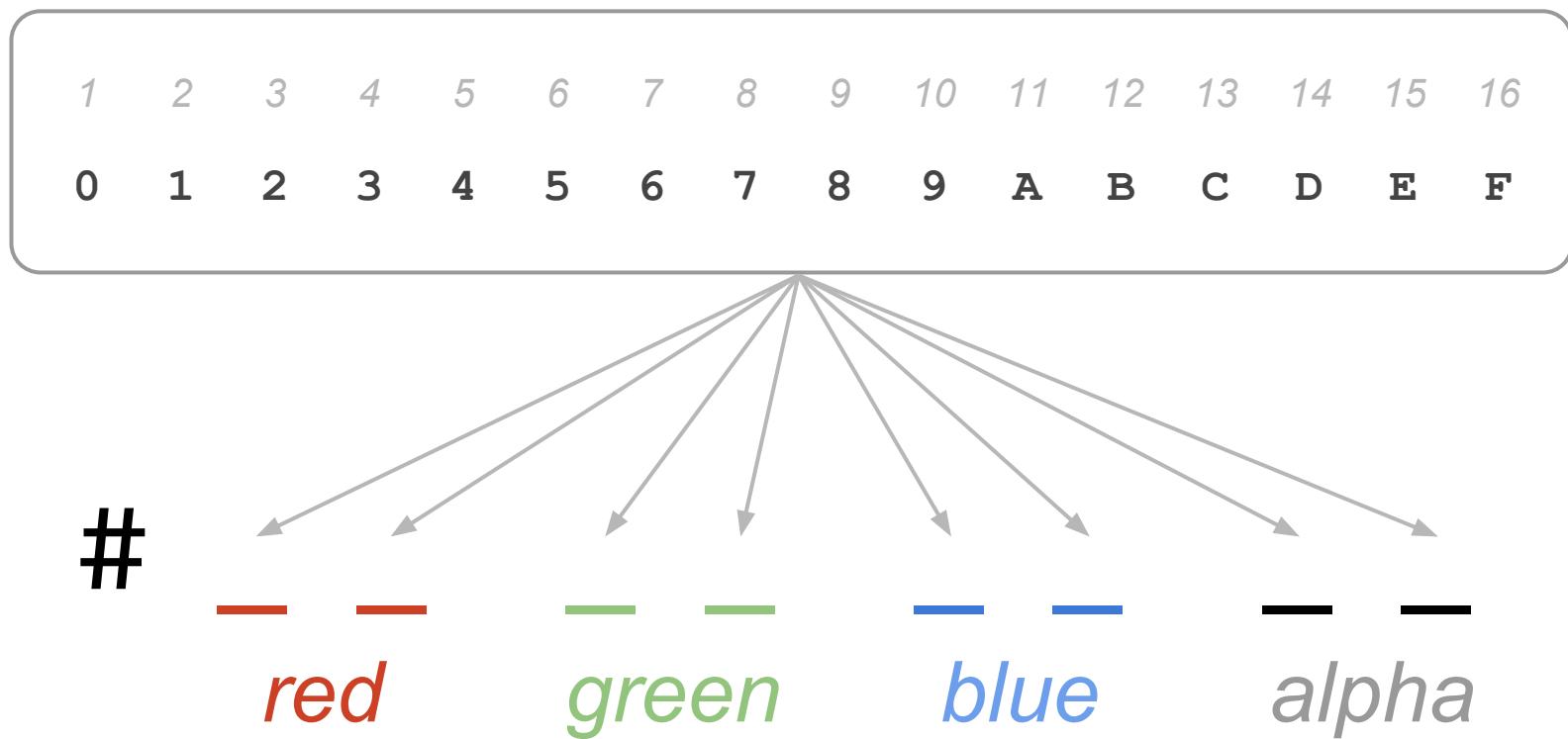
**FF** is equal to a pure color

**#000000** = black

**#FFFFFF** = white

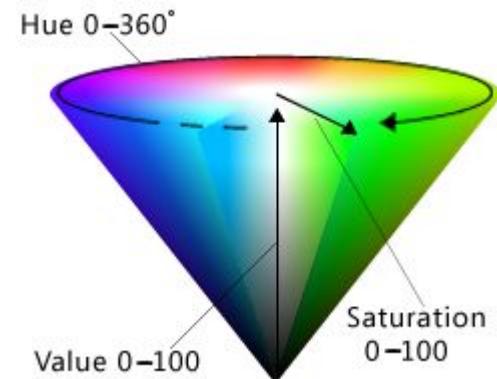
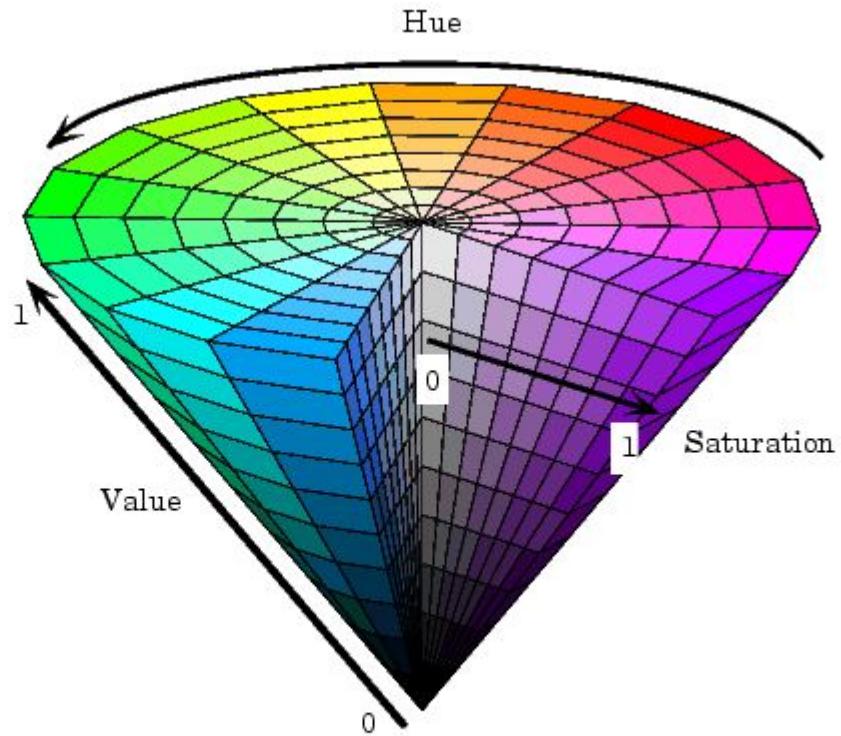
Equal digits produce a shade of gray

# Hexadecimal notation with Alpha channel



(HSV) Hue  
Saturation  
Value

# HSV Conic model



## Hue, saturation, and value

**Hue** is what we usually refer to as color, e.g. red, green, blue, orange, etc.

**Saturation** is the intensity of the color.

**Value** is how light or dark a color is.

# Some Useful Tools



hex color



All

Images

Videos

News

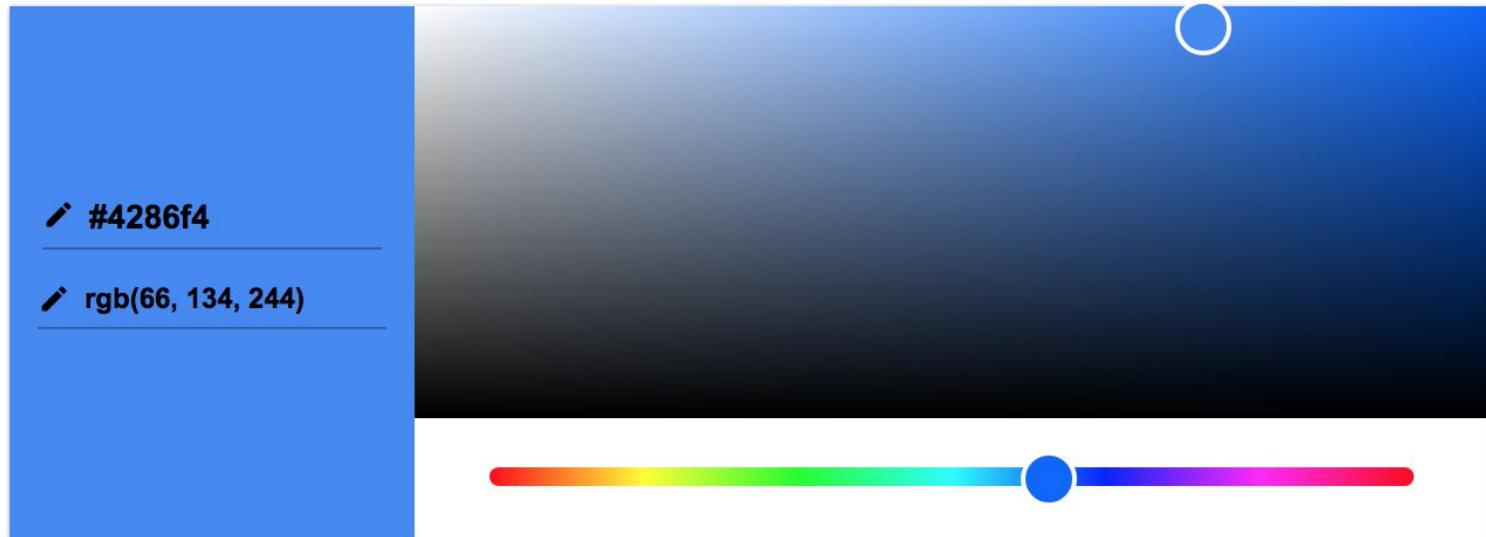
Books

More

Settings

Tools

About 147,000,000 results (0.32 seconds)



Show colour values

Feedback

## #5984d4 Color Hex



#5984D4  
(89, 132, 212)

★ 0 Favorites     0 Comments

## Color spaces of #5984d4

RGB	89	132	212
HSL	0.61	0.59	0.59
HSV	219°	58°	83°
CMYK	0.58	0.38	0.00 0.17
XYZ	24.2548	23.3798	65.5218
Yxy	23.3798	0.2143	0.2066
Hunter Lab	48.3527	4.9225	-46.4959
CIE-Lab	55.4614	9.1206	-45.6423

[#5984d4 Color](#)[Shades Tints](#)[Rbg Cmyk %s](#)[Color Schemes](#)[Color Preview](#)[CSS Codes](#)[Related Colors](#)[Facebook](#)[Google+](#)[Twitter](#)

#5984d4 color RGB value is (89,132,212).

#5984d4 hex color red value is 89, green value is 132 and the blue value of its RGB is 212. Cylindrical-coordinate representations (also known as HSL) of color #5984d4 hue: 0.61 , saturation: 0.59 and the lightness value of 5984d4 is 0.59.

The process color (four color CMYK) of #5984d4 color hex is 0.58, 0.38, 0.00, 0.17. Web safe color of #5984d4 is #6699cc. Color #5984d4 contains mainly BLUE color.

## Base Numbers

Base	Red	Green	Blue
Binary	01011001	10000100	11010100
Octal	131	204	324
Decimal	89	132	212
Hex	59	84	D4

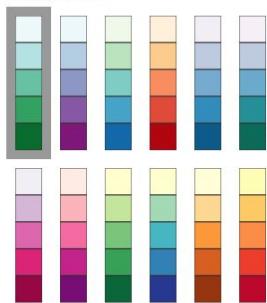
Number of data classes: 5

Nature of your data:

sequential  diverging  qualitative

Pick a color scheme:

Multi-hue:



Single hue:



Only show:

- colorblind safe
- print friendly
- photocopy safe

Context:

- roads
- cities
- borders

Background:

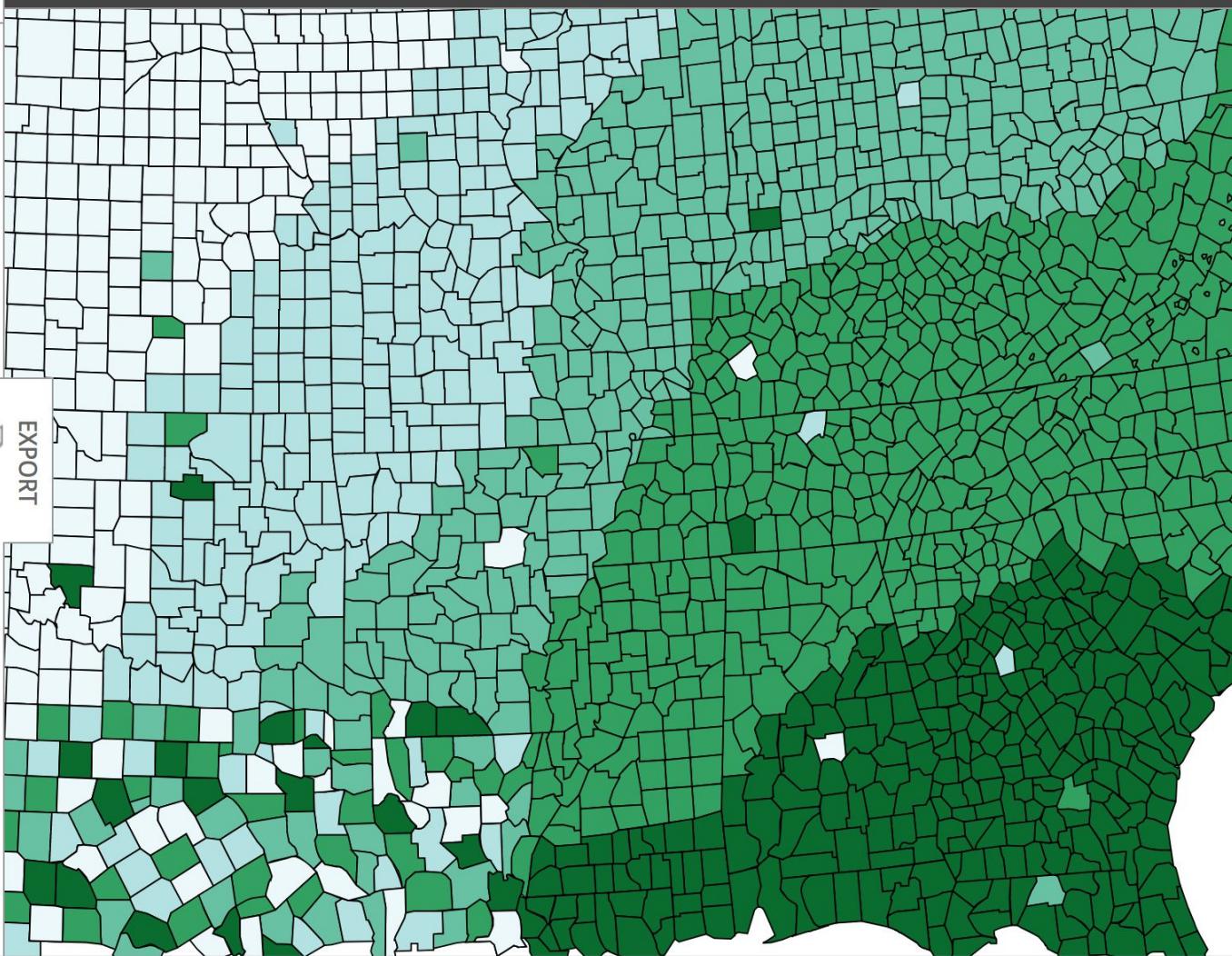
- solid color
- terrain

color transparency

how to use | updates | downloads | credits

COLORBREWER 2.0

color advice for cartography



English ▾

Like it? ▾

Paletton Live Colorizer

Mobile [scheduled]

More apps [scheduled]



< UNDO

REDO >

RESET

RANDOMIZE...

MORE INFO ▾



Monochromatic (1-color)  
 add complementary

My Palette:

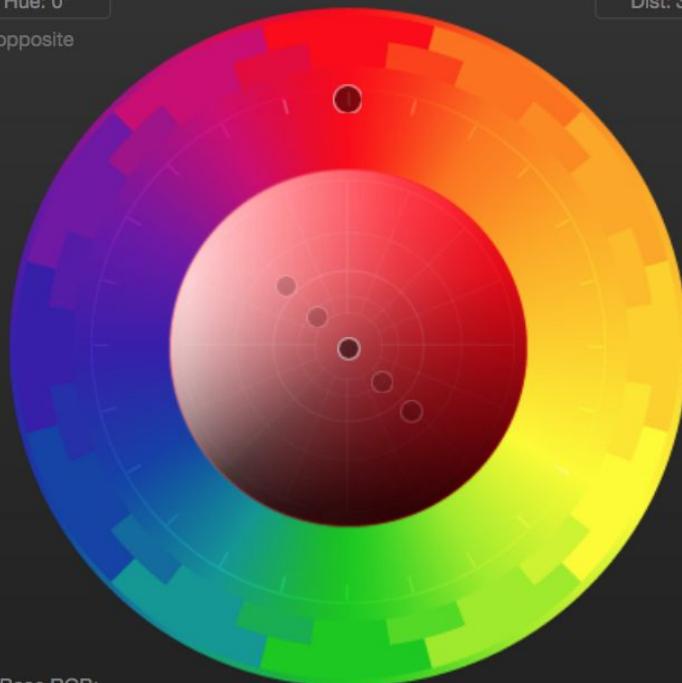


[Share palette ▾](#)

Hue: 0°

opposite

Dist: 30°



Base RGB:

AA3939

Fine Tune...

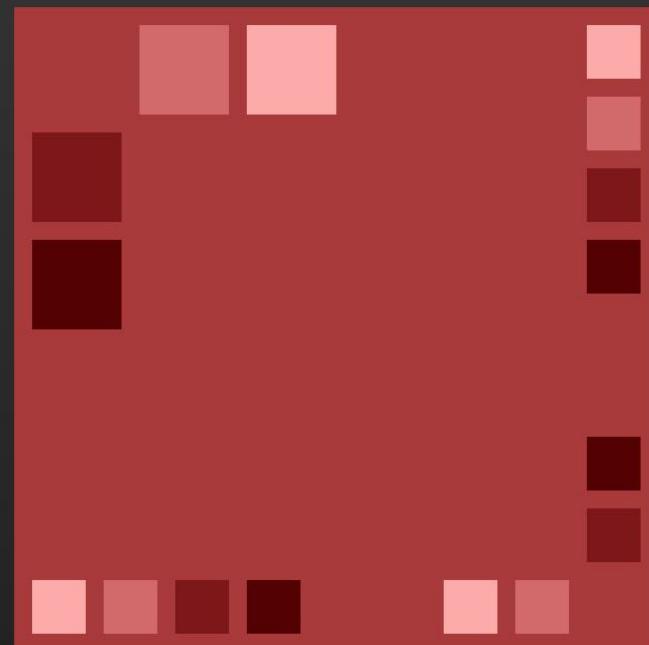
COLORS

PRESETS

PREVIEW ▾

EXAMPLES...

TABLES / EXPORT...



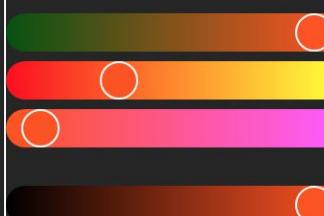
Vision simulation ▾

[IMPORT IMAGE](#)[COLOR WHEEL](#)<https://color.adobe.com/create/color-wheel/>[What are CC Libraries?](#)

Change Color Harmony

[Save Color Theme](#)

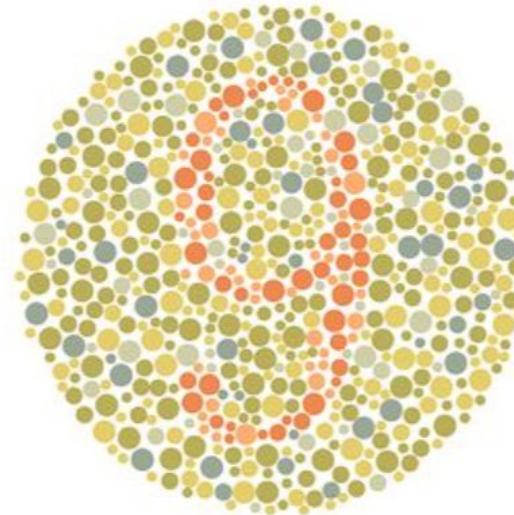
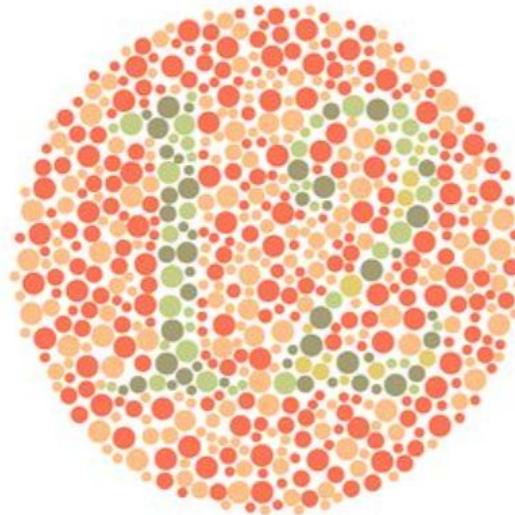
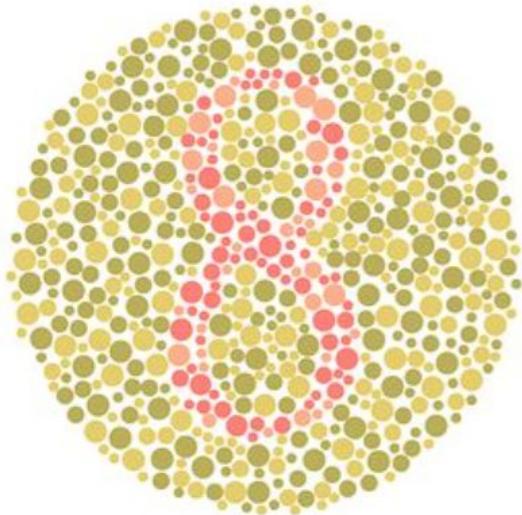
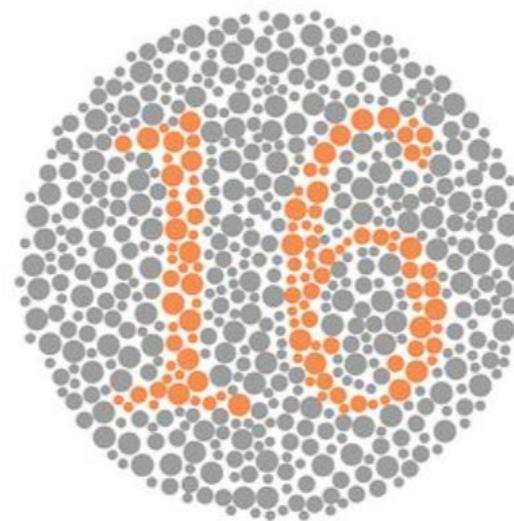
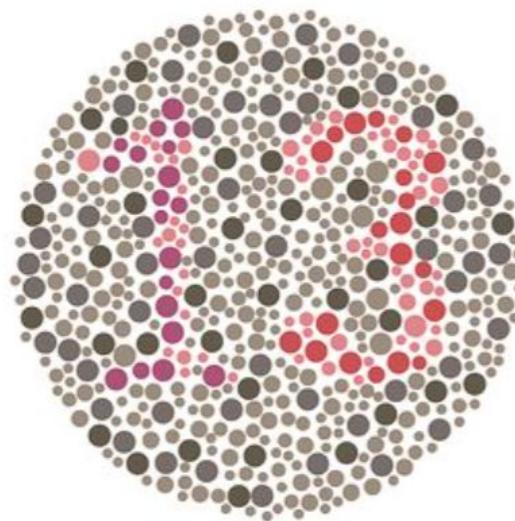
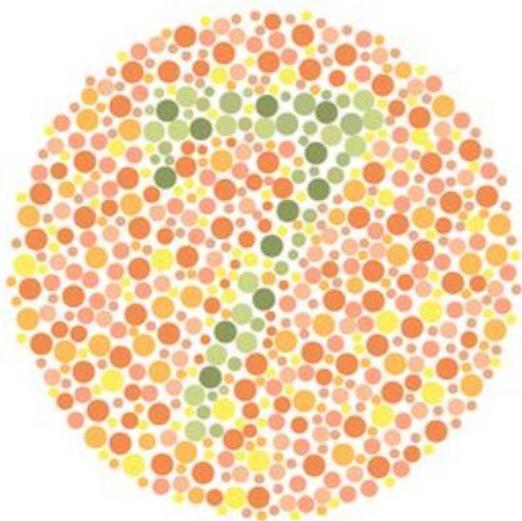
Analogous



► RGB 255 83 13  
HEX FF530D



# Color Blindness



## Color Blindness

Keep color blindness in mind.

About 1 in 12 people have some sort of color vision deficiency.

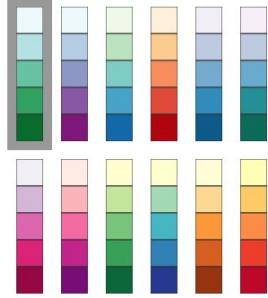
Be sure to use varying brightness. Also consider using distinguishable shapes.

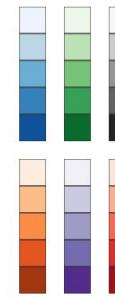
Check your visualizations for contrast before presenting them to an audience.

Number of data classes: 5

Nature of your data:  
 sequential  diverging  qualitative

Pick a color scheme:

Multi-hue: 

Single hue: 

Only show:  colorblind safe  print friendly  photocopy safe

Context:  roads   
 cities   
 borders 

Background:  solid color   
 terrain 

color transparency 

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**COLORBREWER 2.0**  
color advice for cartography

5-class BuGn     

#edf8fb  
#b2e2e2  
#66c2a4  
#2ca25f  
#006d2c

