UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

SOFTWARE ENGINEERING – LECTURE 15

Color Theory, Typography, and Gestalt Psychology

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Today, on Software Engineering

Usability Edition

Human Abilities

(perception, memory, cognitive processes...)

Technologies

(VR, AR, mouse, windowing, touch screens, ...)

Methodologies

(prototyping, lifecycles, ...)

Guidelines, Principles and Theories

Evaluation

(experiments, observation, ...)

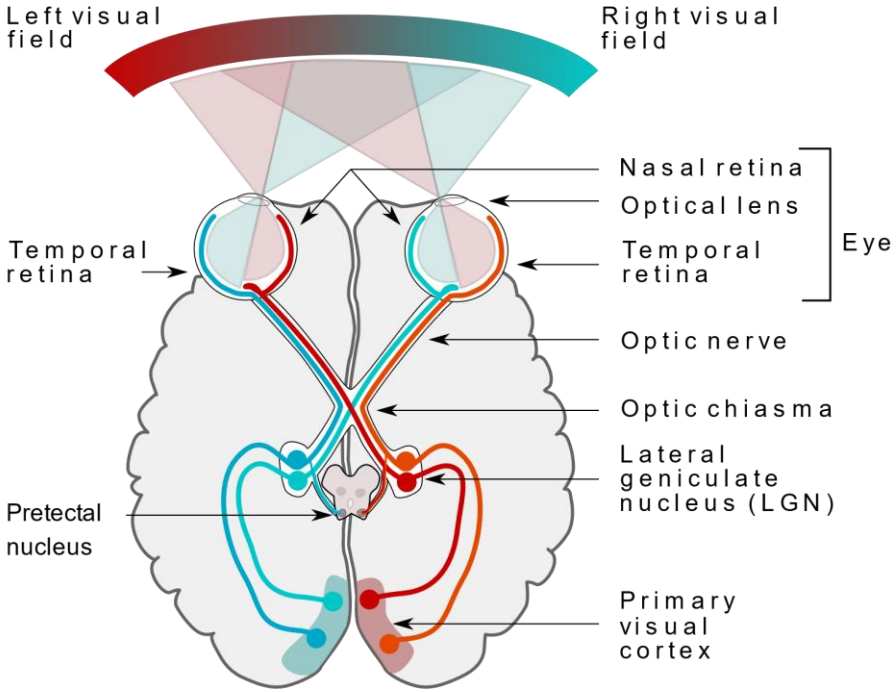
Colors, Typography, and Gestalt

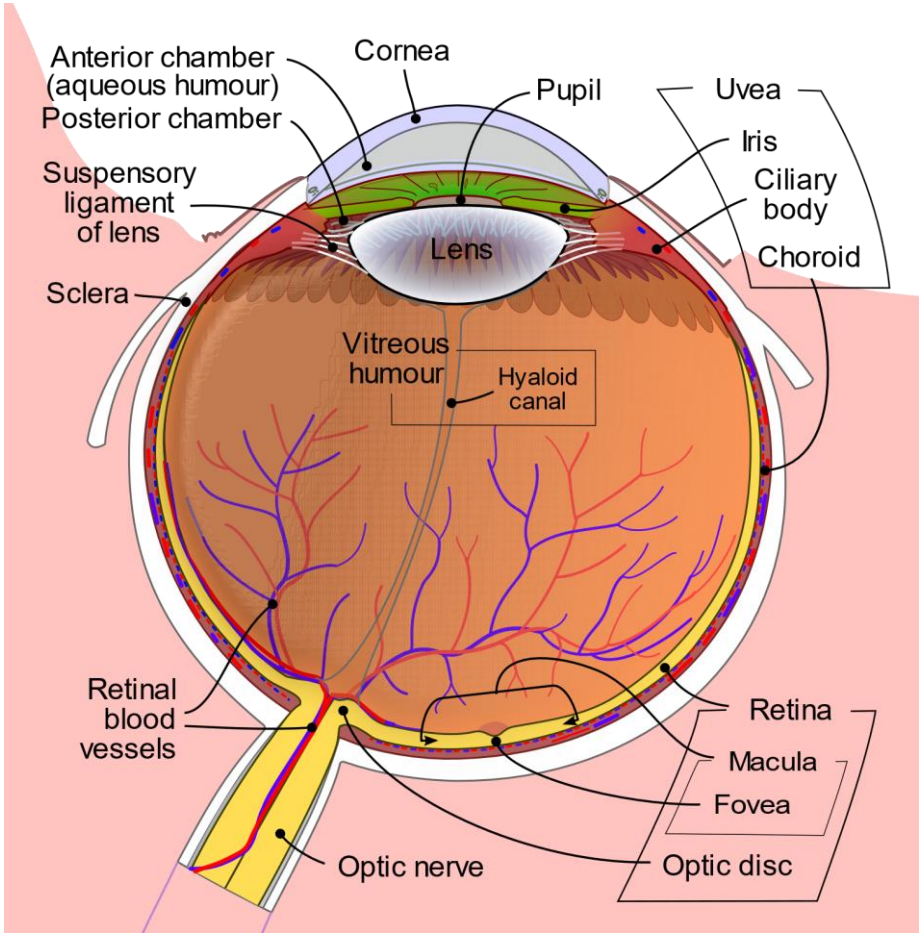
The human brain is **always perceiving meaning** (even when not intended)

Colors, typography and design should be used carefully to convey the intended meaning and ensure good user experiences

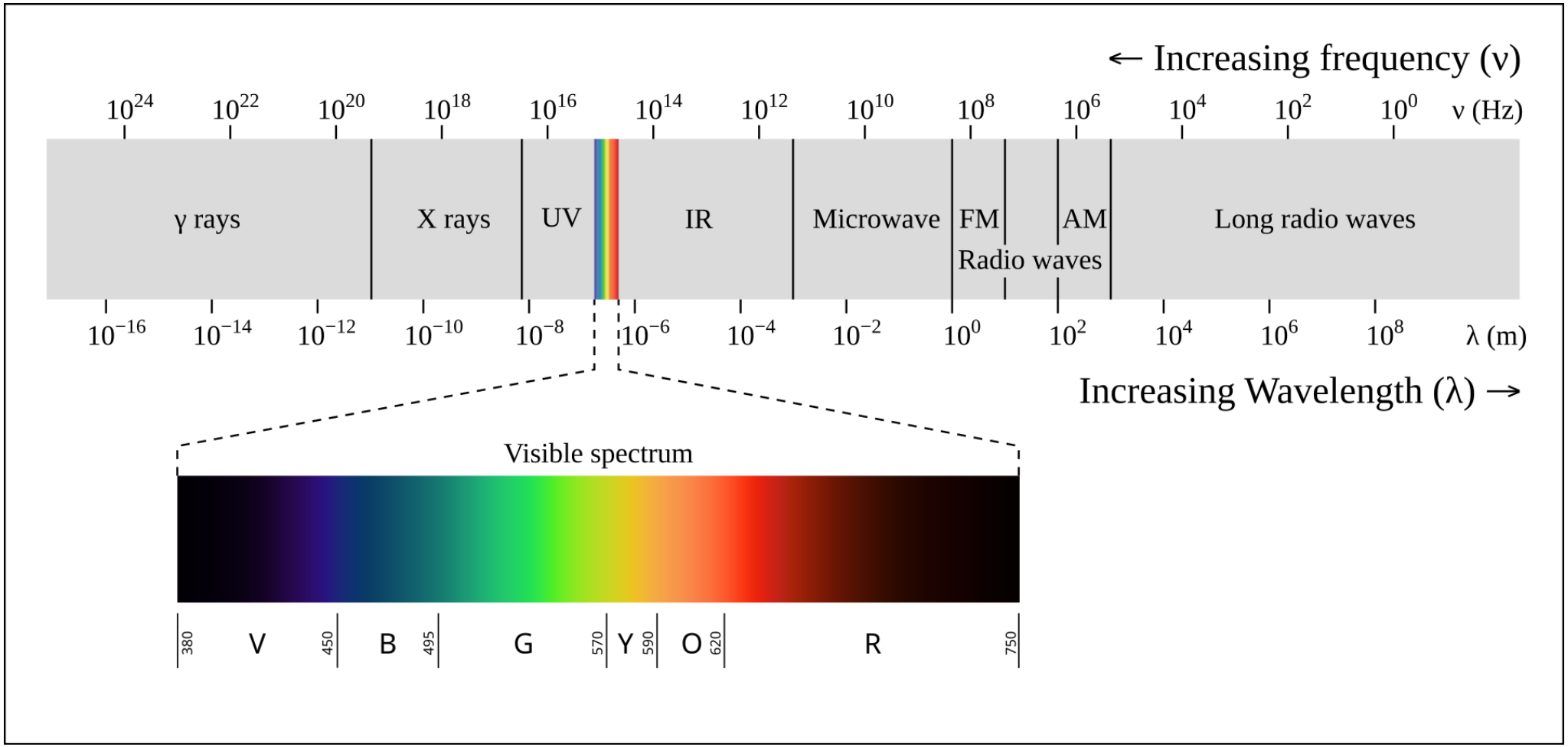
Colors

The Human Visual Perception





Visible Spectrum of Light



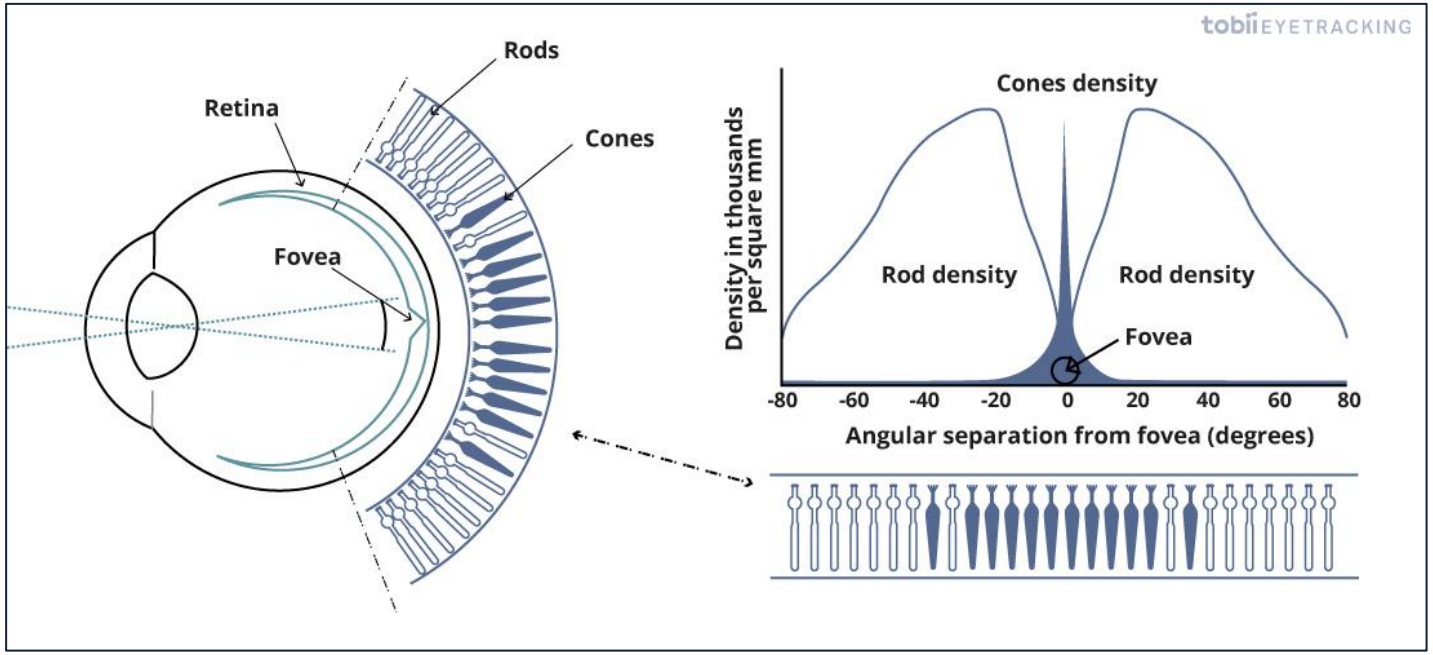
The Retina

The retina is covered with two kinds of **light-sensitive receptors**

- **Rods** (~120 million)
  - Sensitive to broad spectrum of light
  - Sensitive to small amounts of light
  - Cannot discriminate between colours
  - Sense intensity or shades of grey
  - Primarily for night vision and perceiving movement
- **Cones** (~6 million)
  - Used to sense colors

The Retina: Distribution of Rods and Cones

- Center of retina has most of the cones
  - Allows for high acuity of objects focused at the center
- Edge of retina is dominated by rods
  - Allows for detecting motion of **threats in peripheral vision**



https://developer.tobii.com/xr/learn/eye-behavior/the-eye/

The Retina: Distribution of Rods and Cones

What does that mean for designers?

- Users fully focus on one part of the UI at a time
- Peripheral movement in a UI can be easily **distracting**

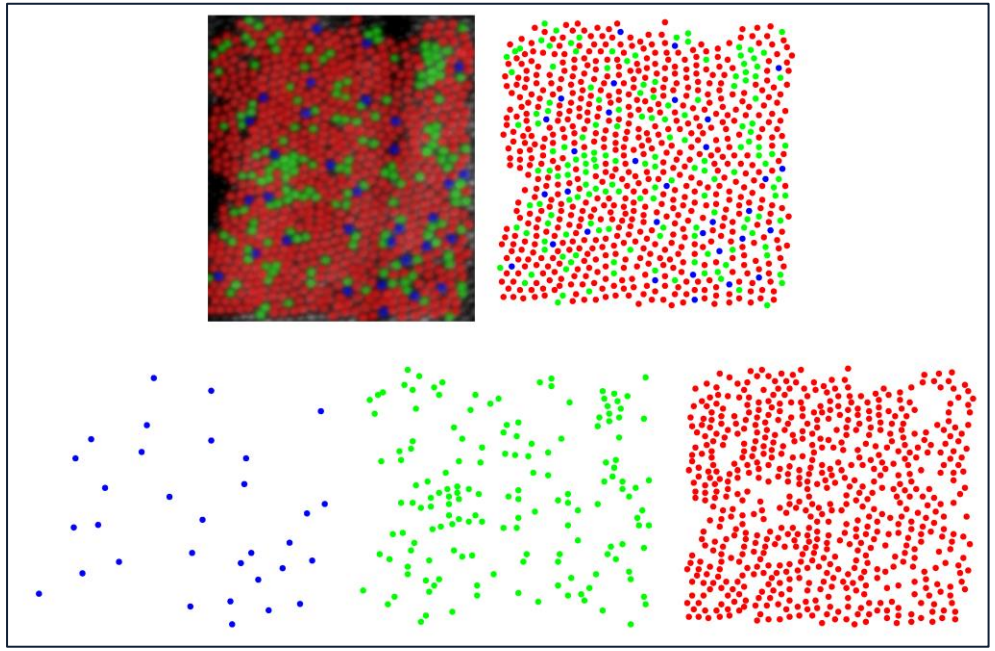
Color Perception via Cones

Not all cones are equal

- 3 different types, with specialized photopigments to sense color
  - Blue, green and red
- Each type of cones is sensitive to a different band of the light spectrum
- Ratio of neural stimulation for the three types gives us a continuous perception of colors

Color Perception via Cones

- Types of cones are not evenly distributed at the center of the retina
- Mainly reds, very few blues
  - Limited sensitivity to short wavelengths
  - High sensitivity to long wavelengths
  - Few blue cones in retina center
    - Harder to focus on small blue objects
  - With age, lens tend to absorb more short wavelengths
    - Further reduces sensitivity to blues



Beygi, A. (2023). Universality of form: The case of retinal cone photoreceptor mosaics. *Entropy*, *25*(5), 766.

Image Detection and Focus

- Shapes are detected by finding edges
- Edges are found by using brightness and color difference
- Blue edges and shapes are harder to detect
- Different wavelengths of light focused at different distances behind eye’s lens
  - Constant refocusing causes fatigue
  - Saturated colors (i.e., pure colors) require more focusing than desaturated ones (i.e., pastels)

THAT'S WHY THIS SLIDE IS SO PAINFUL TO READ!

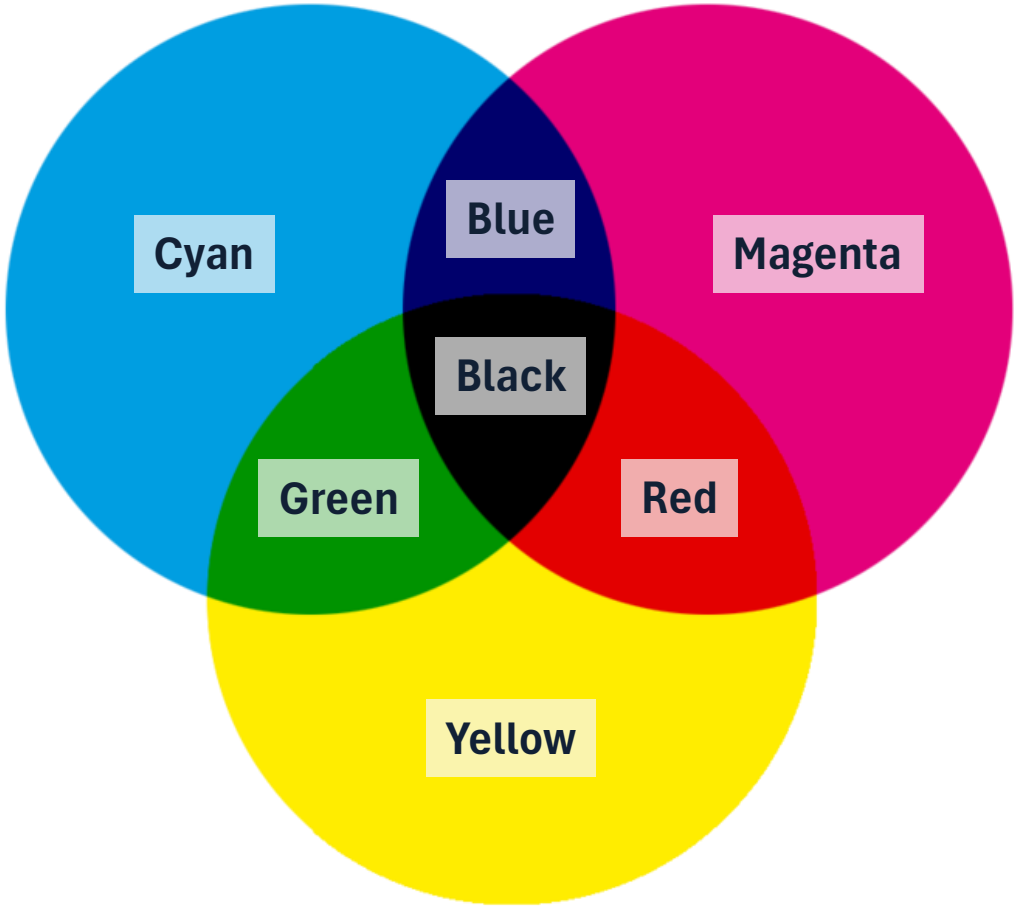
- Blue and red are both saturated colors
- Different wavelengths of light are focused at different distances behind the eye's lens
  - Constant refocusing causes fatigue!

Color Models

- Color models are abstract mathematical models
- They describe how colors can be represented by tuples of numbers
- Two widely-used color schemes are:
  - CMYK
  - RGB

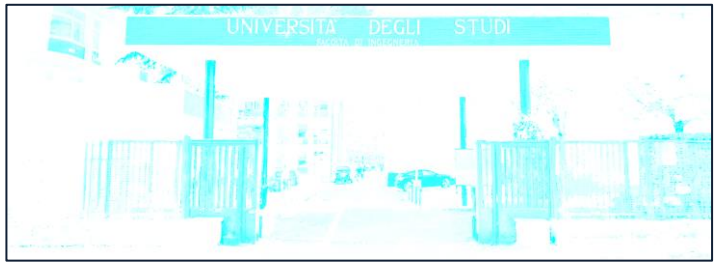
CMYK Color Model

- CMYK is a **subtractive** color model
- Cyan, Magenta, Yellow, Key (black)
- Generally used for printed material
- Uses ink pigments to display color
- Colors result from reflected light



CMYK Color Model

C



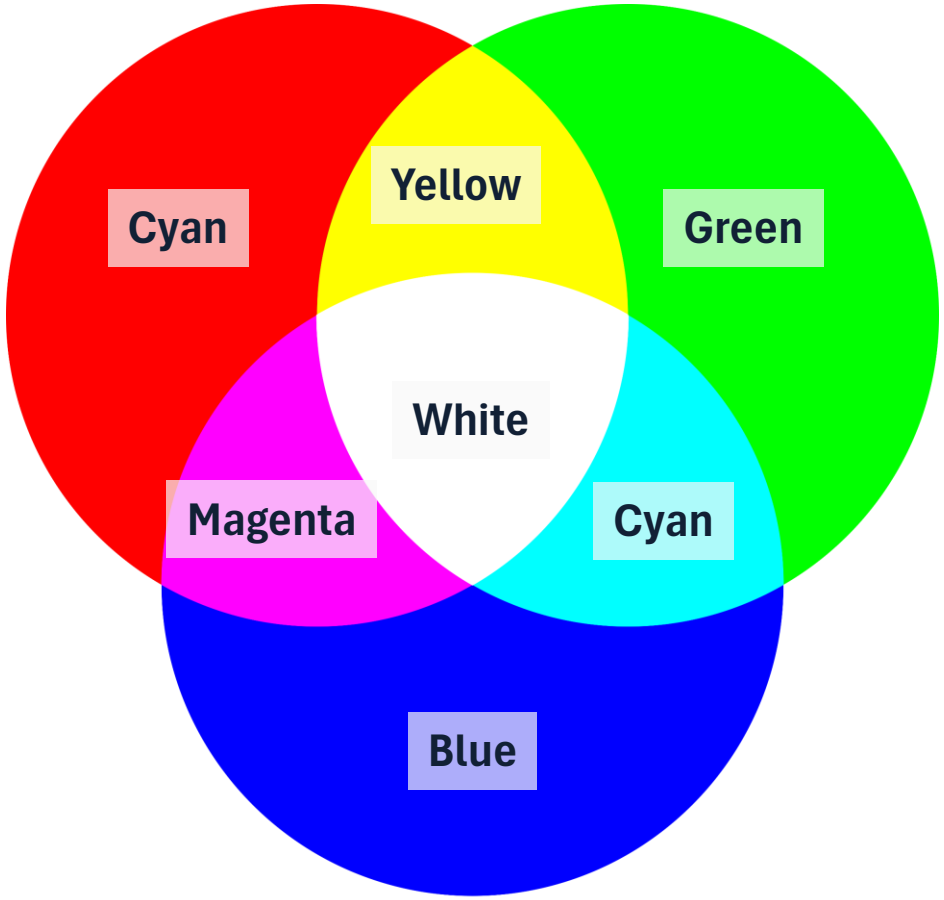
Y

M

K

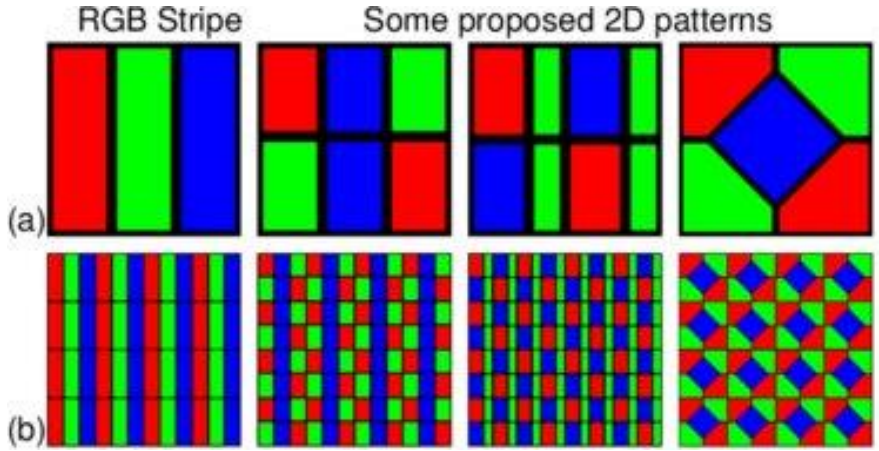
RGB Color Model

- RGB is an **additive** color model
- Red, Green, Blue
- Designed for computer displays
- Uses light to display color
- Color result from emitted light

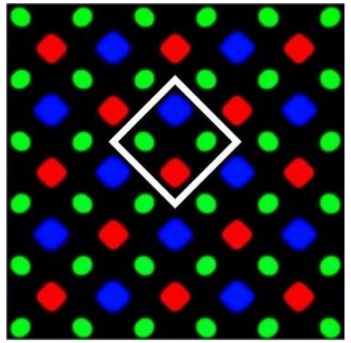


RGB Color Model

- Displays cannot produce different color channels at the same position
- The pixel grid is typically divided into single-color regions (subpixels)
  - These regions contribute to the displayed color when viewed at a distance



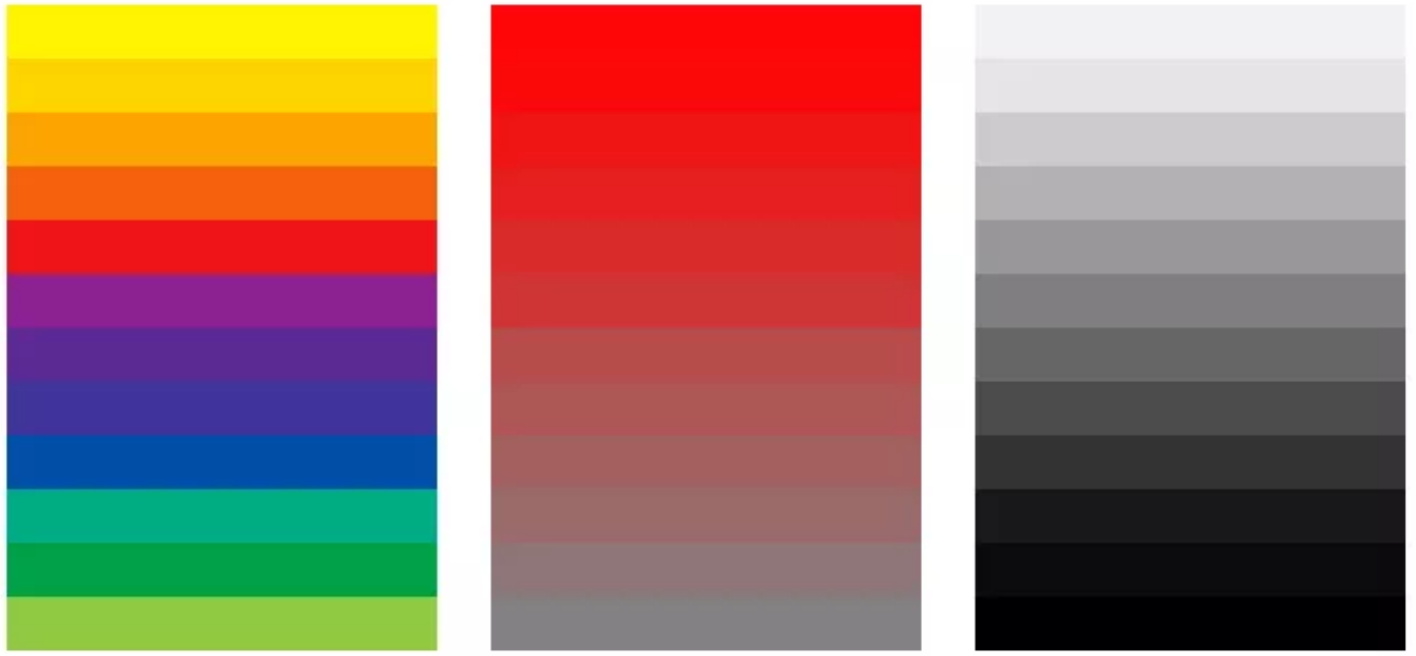
Subpixel patterns in modern displays. Kerofsky, L. J., & Messing, D. S. (2005). Optimal rendering for Colour Matrix Displays. *ADEAC*, *5*, 123-126.



Diamond Pixel™ subpixel layout, used in modern OLED displays manufactured by Samsung

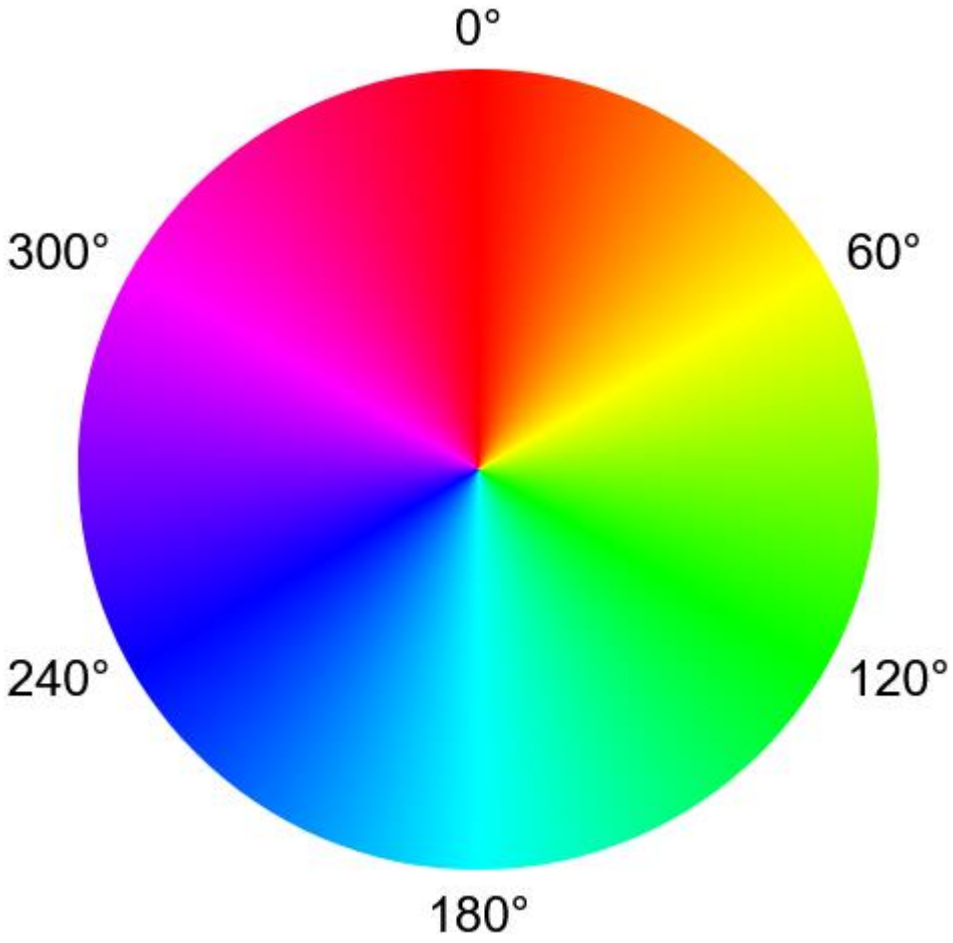
Perceptual Dimensions of Color

- HSL (Hue, Saturation, Lightness) is one of the most common representations of colors in an RGB color model



Hue

- Hue is the **dominant wavelenght** in a color
- In HSL, it’s a value in 0-360
  - 0 (and 360) are red
  - 60 is yellow
  - 120 is green
  - 180 is cyan
  - 240 is blue
  - 300 is magenta



Saturation

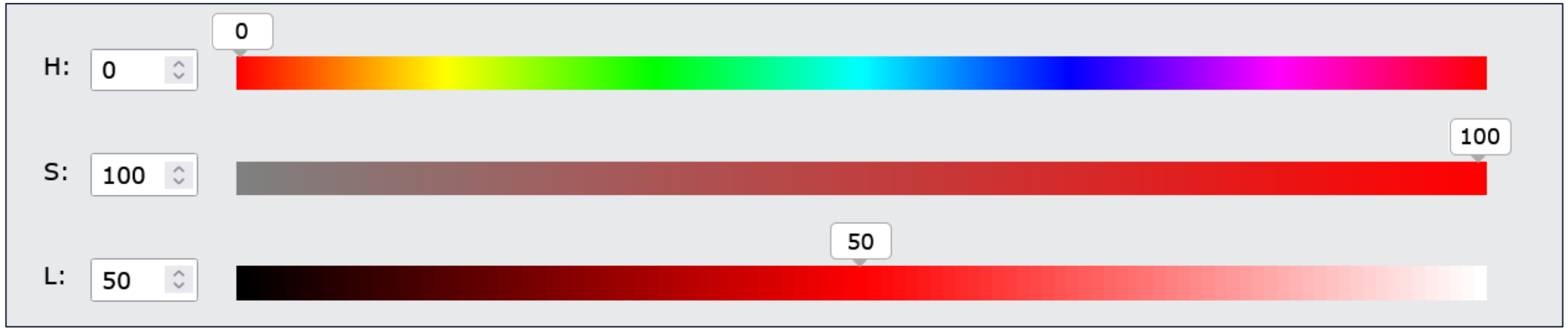
Indicates how «strong» the color is

- Typically it’s a percentage in 0-100
- 100% means the color is bright and pure
- 80% means the color is mixed with 20% gray
- 0% means we only get the gray

Lightness

Lightness indicates how much light the color has

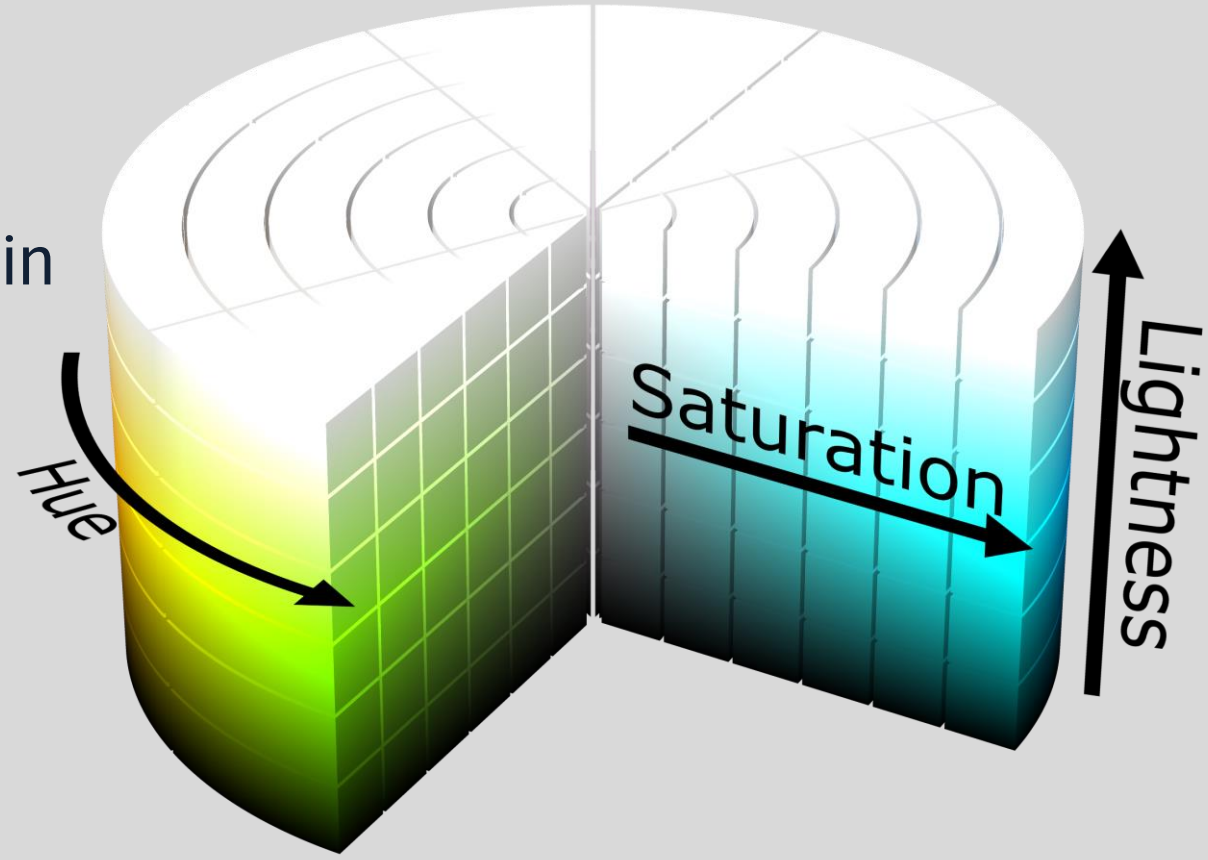
- 0% is very dark (black)
- 50% is in the middle, not too dark or bright
- 100% is very bright (white)



https://www.w3schools.com/colors/colors_hsl.asp

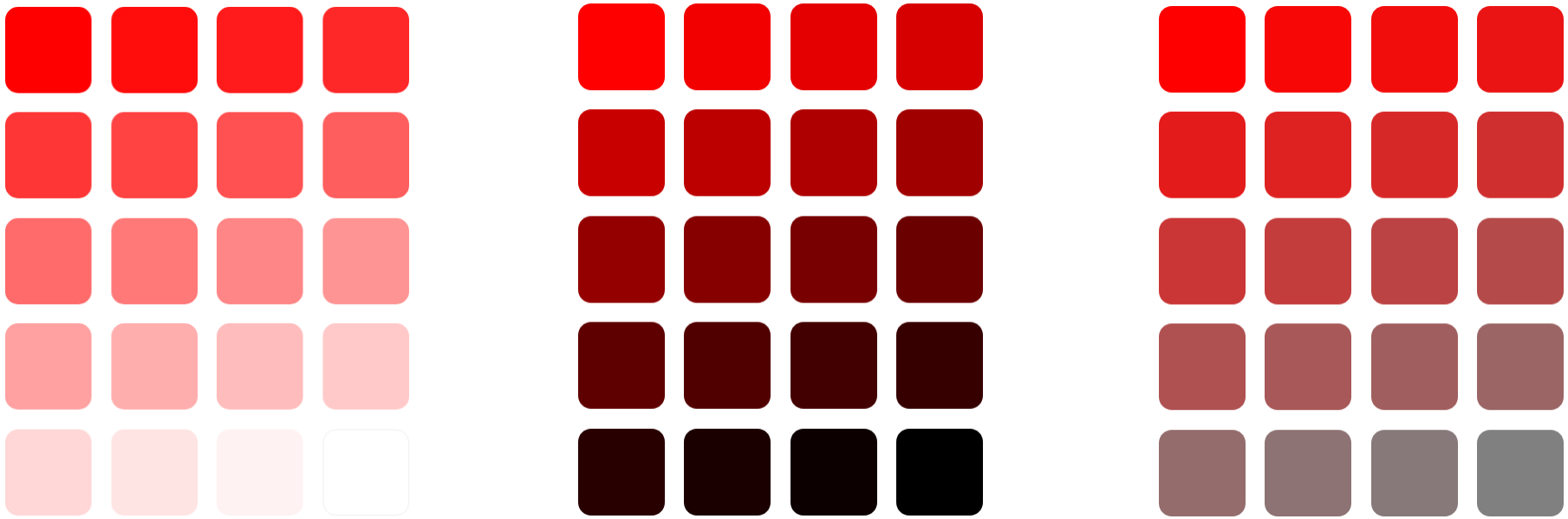
Hsl Color Representation

- HLS is a cylindrical coordinate model
- By defining Hue, Saturation and Lightness, we identify one point in the cylindrical space



Tints, Shades, and Tones

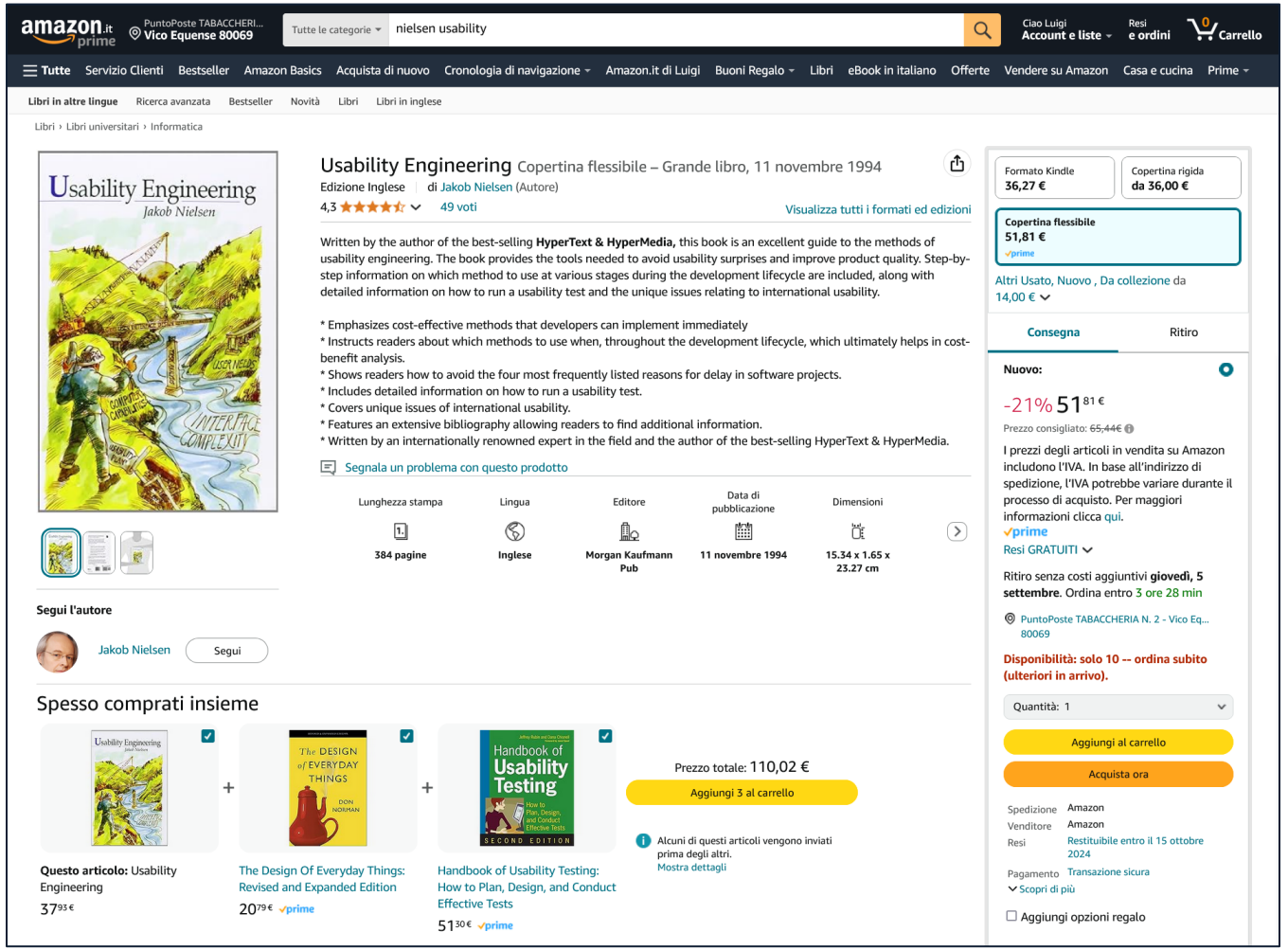
- A **tint** is a mixture of a color with white, incresing lightness
- A **shade** is a mixture with black, decreasing lightness
- A **tone** is a mix with gray



Using Colors in UI Design

- Color is a powerful tool in a UI designer's arsenal
  - Can make some elements stand out (we'll see more about that at the end of the lecture)
  - Can convey meaning (but beware of regional differences!)
- So, the more colors, the better?
  - Not really. UI should generally include no more than 6 different colors.
  - Corollary: pick a palette and **be consistent**!
- A good rule of thumb is to use the 60-30-10 rule
  - 60% primary color
  - 30% secondary color
  - 10% accent color (for parts we want to stand out)

60-30-10 Rule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di Jakob Nielsen (Autore)
4,3
49 voti
Visualizza tutti i formati ed edizioni
Written by the author of the best-selling HyperText & HyperMedia, this book is an excellent guide to the methods of usability engineering. The book provides the tools needed to avoid usability surprises and improve product quality. Step-by-step information on which method to use at various stages during the development lifecycle are included, along with detailed information on how to run a usability test and the unique issues relating to international usability.
* Emphasizes cost-effective methods that developers can implement immediately
* Instructs readers about which methods to use when, throughout the development lifecycle, which ultimately helps in cost-benefit analysis.
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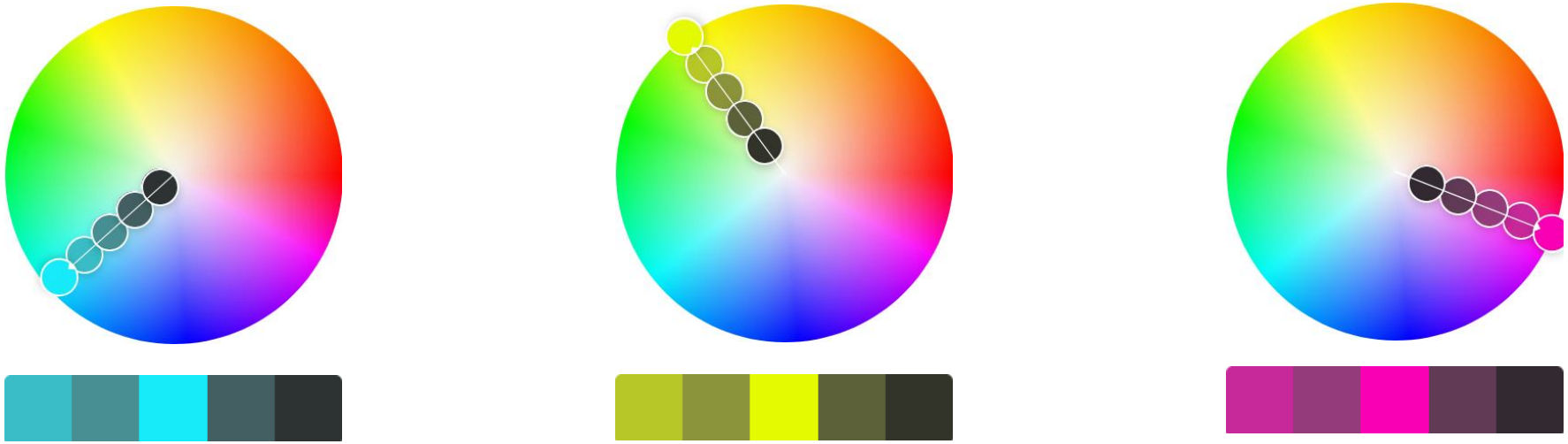
Color Theory

- Not all colors «go well» togheter
  - Remember red text on a blue background?
  - That’s not the only clashing colors!
- We can use **color armonies** to build palettes (sets of colors) for our UI that do not clash with each other
  - Monochromatic
  - Analogous
  - Complementary
  - Split-complementary
  - Triadic

Monochromatic Color Armonies

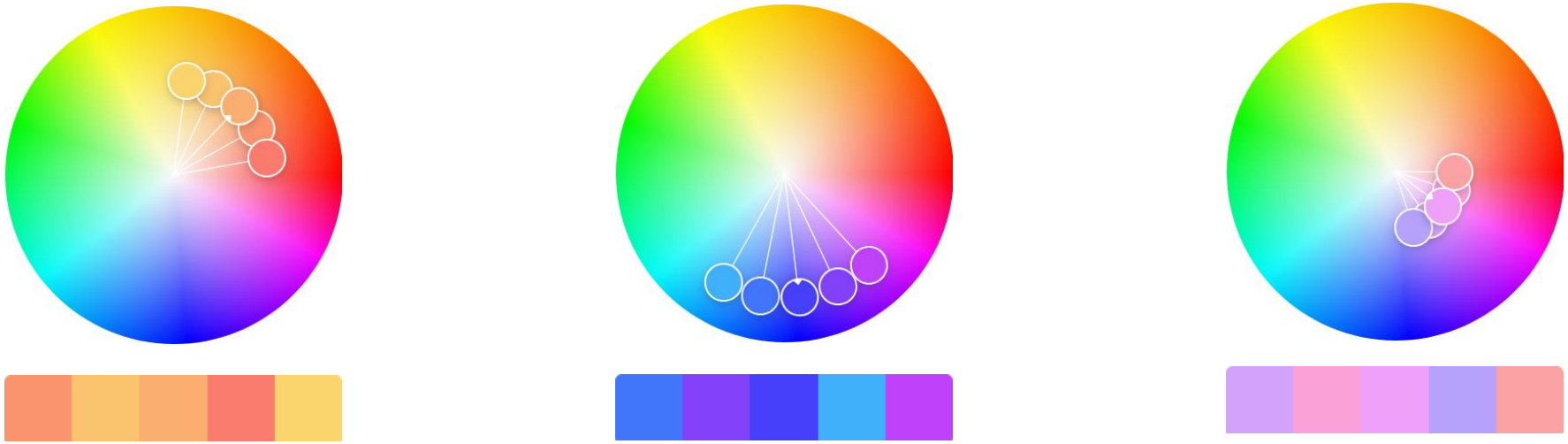
- Select one main color and generate others as different tints, tones, or shades of that single hue



Palettes generated at https://color.adobe.com/create/color-wheel

Analogous Color Armonies

- Pick adjacent colors on the color wheel
- Leads to color schemes with reduced contrast



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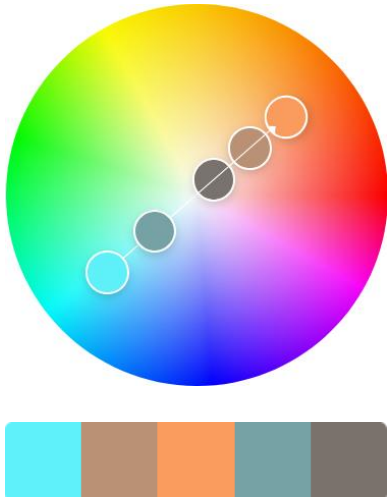
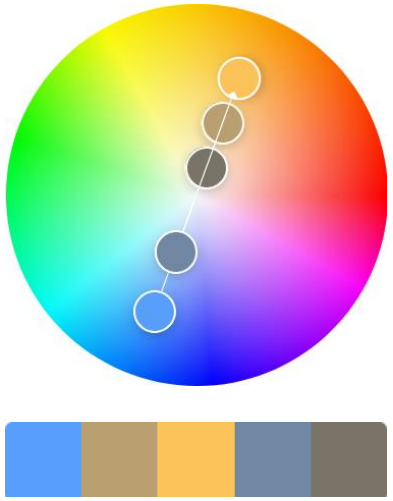
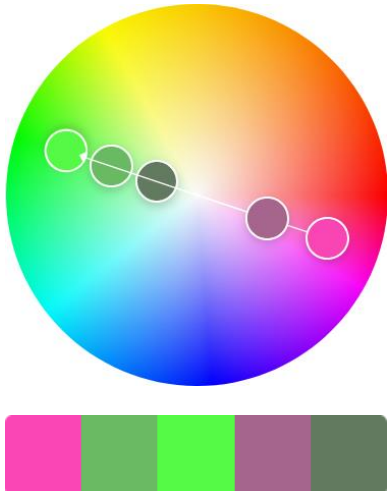
Complementary Color Armonies

- Pick colors that are opposite on the color wheel
- Produces color scheme with higher contrast



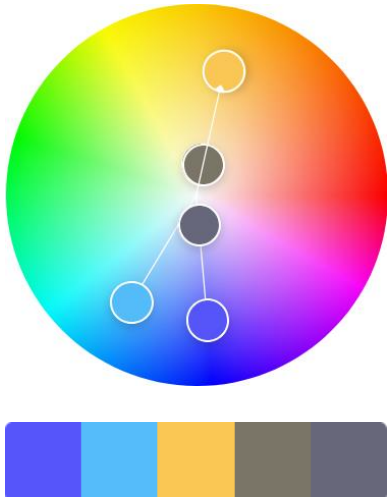


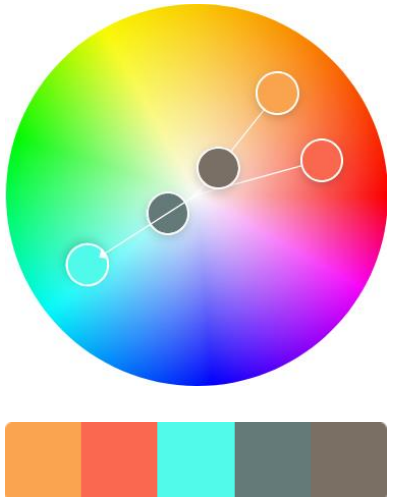


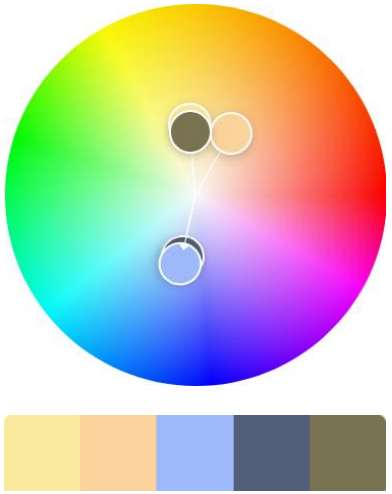
Palettes generated at https://color.adobe.com/create/color-wheel

Split-complementary Color Armonies

- Pick one color and combine with colors from either side of its complementary color
- Softens contrast w.r.t. complementary armonies



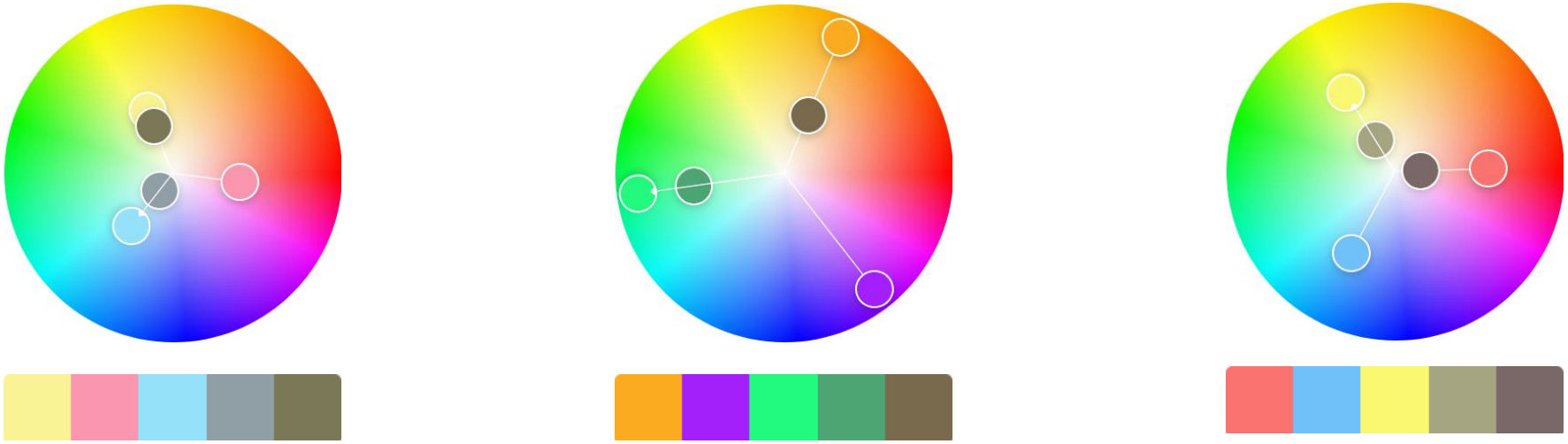




Palettes generated at https://color.adobe.com/create/color-wheel

Triadic Color Armonies

- Pick three colors equidistant on the color wheel (120° apart)
- Softens contrast w.r.t. complementary armonies

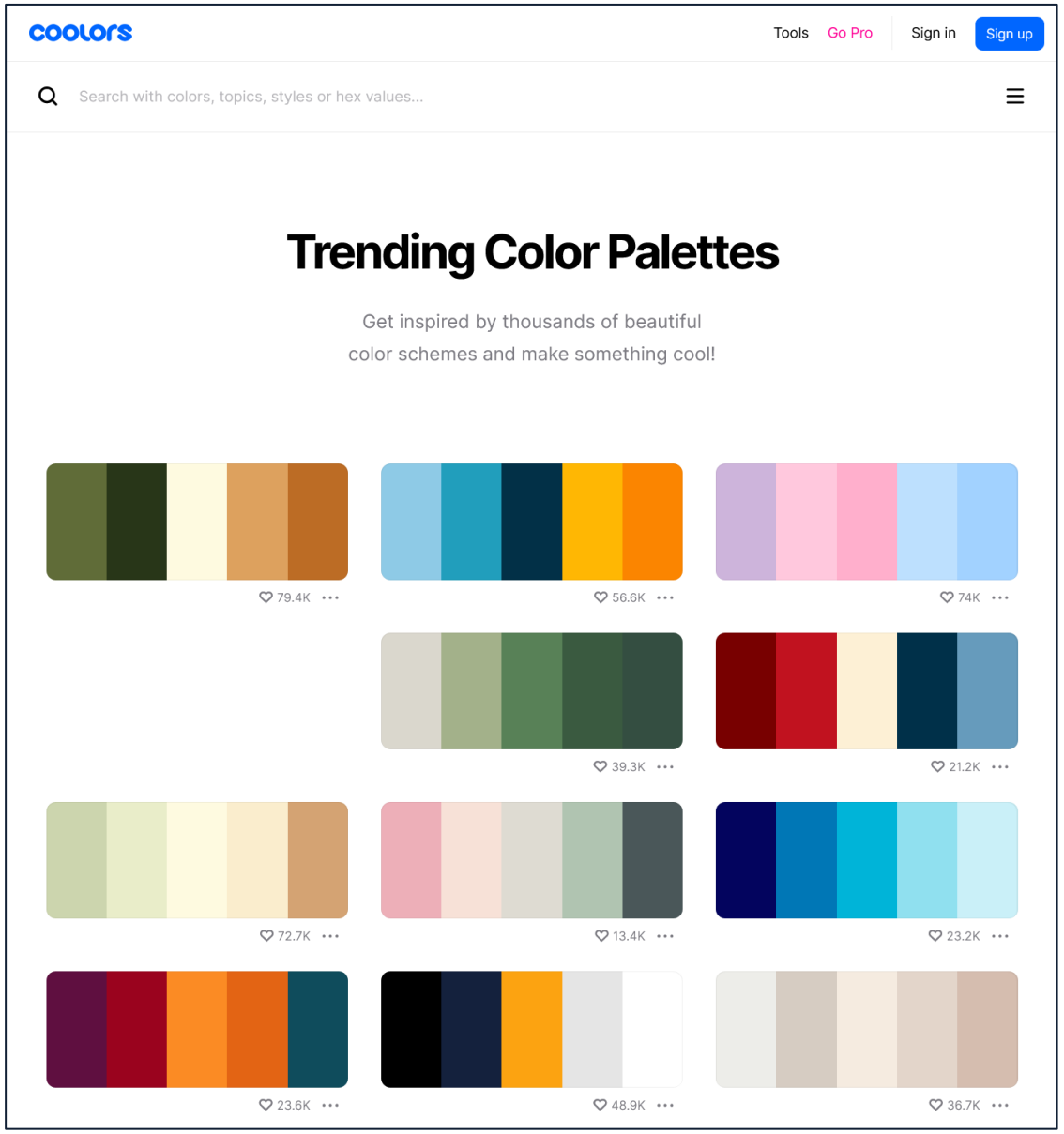


Palettes generated at https://color.adobe.com/create/color-wheel

Color Armonies

You can explore palettes made by others at:

- https://coolors.co/palettes/trending
- https://color.adobe.com/explore

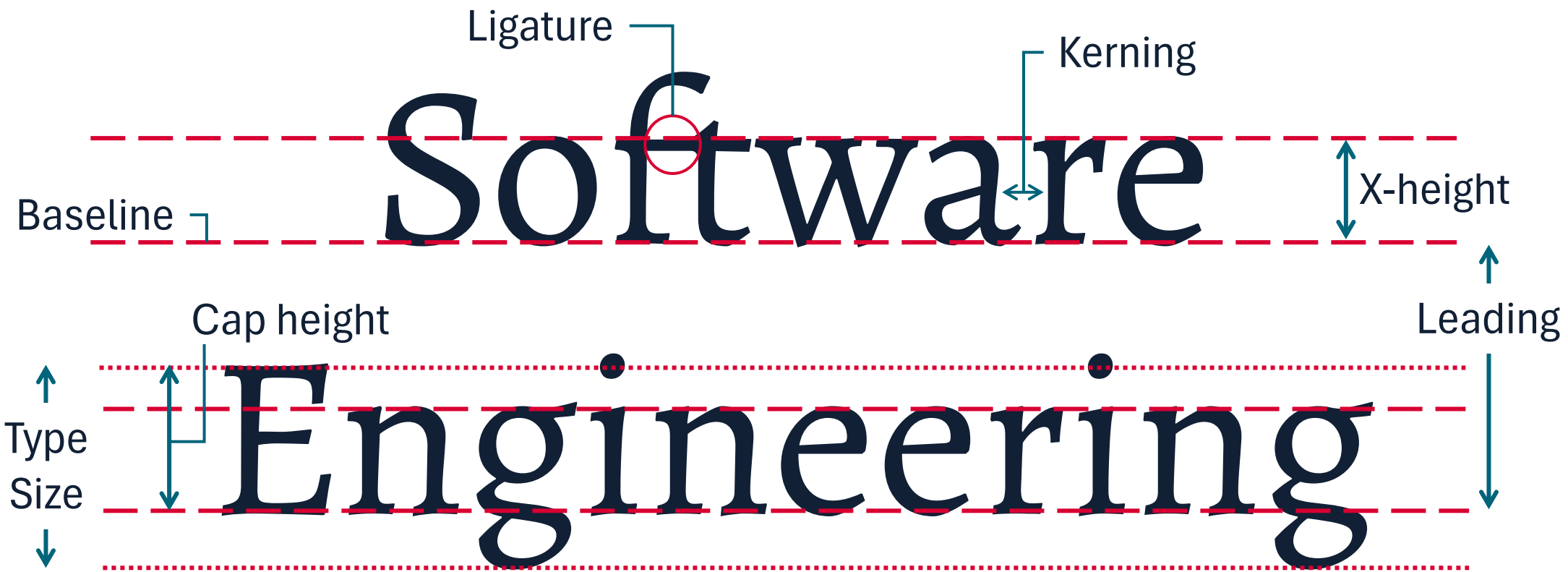


Color Psychology

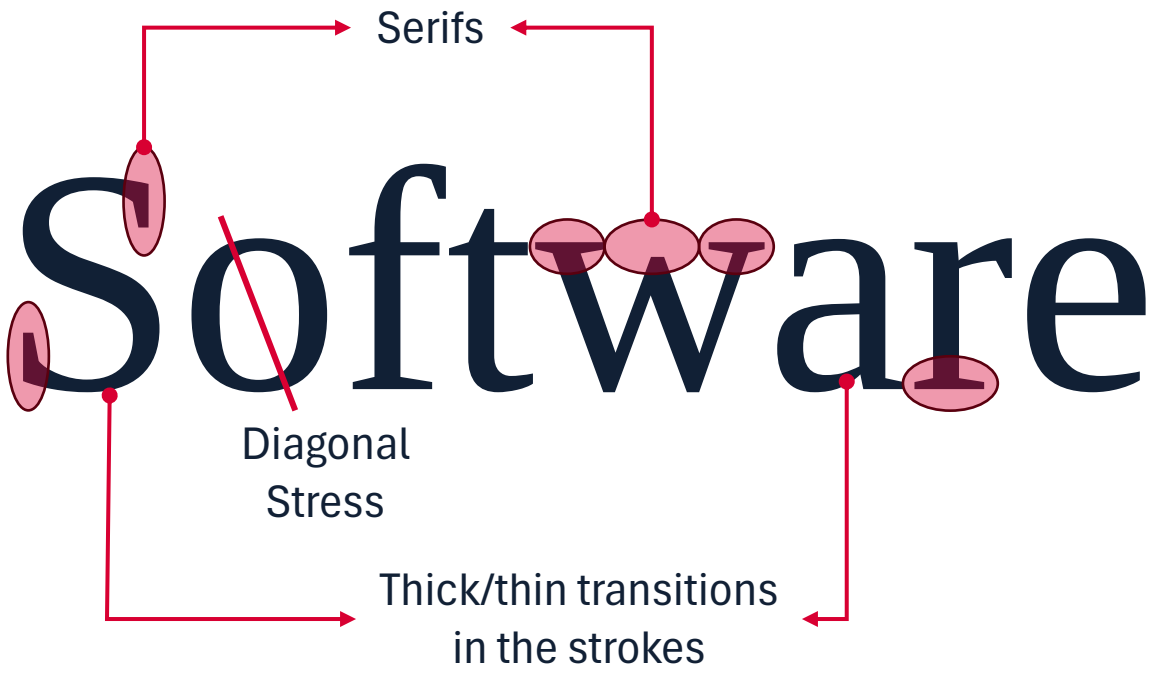
- Human mind may subconsciously react to colors (color psychology)
  - Black is associated with elegance, power and authority
  - Blue is perceived as authoritative, dependable, trustworty
  - Red may be associated with passion, desire, love, energy, danger
  - Green may be associated with nature, freshness, serenity, health, money
- There is not much research that demonstrated the actual effect of a particular color on emotions
- Also, keep in mind that regional differences exist!
  - In China, red is the color associated with money. In the US, it’s green..

Typography

Typography: Some Terminology

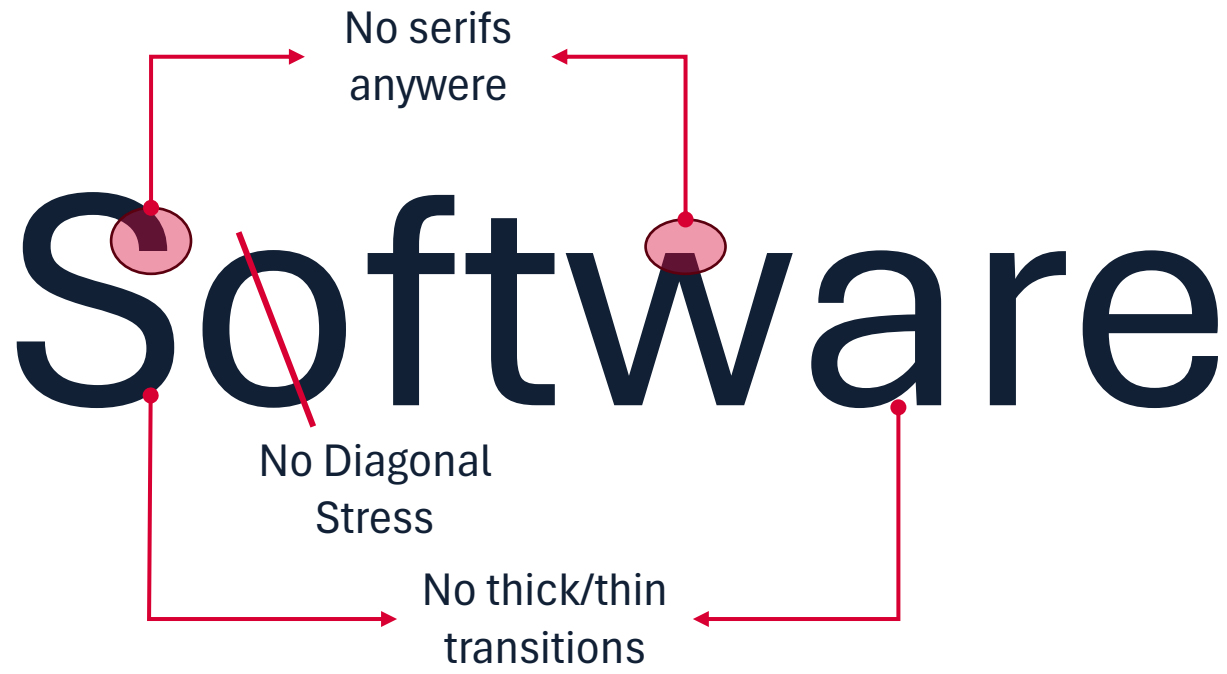


Typography: Serif Fonts



Times Alegreya Baskerville Palatino Libertine

Typography: Sans Serif Fonts



Aptos Comic Sans Gill Sans Alegreya Sans **Futura**

The Serif Hypothesis

- Serif typefaces **are easier to read** – and thereby preferable for long stretches of text – because the serifs provide anchors that guide the reader's eye.
- Sans serif fonts lack these anchors and are therefore inappropriate for long stretches of text.
- In practice, individual differences dwarf any effect of the presence/absence of serifs
  - I.e., some people read faster than others..

Impact of Types in UIs

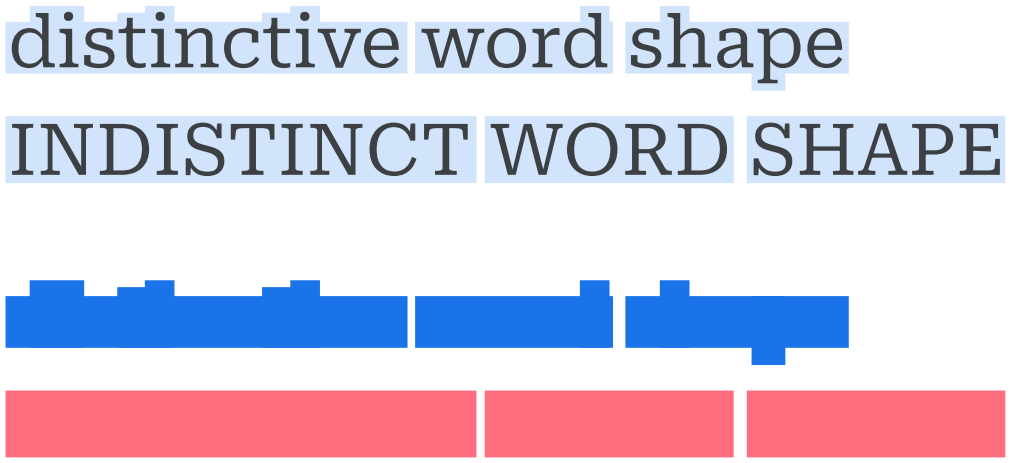
- Types can be a good way to vehiculate messages in Uis
  - Reading is more than just recognizing sequences of letters
  - Typography can convey additional messages:
    - «This is meant to be easy to read»
    - «This is a playful message»
    - «This may be perceived as source code»
- **Readability** is an important aspect of **usability**
  - Users need to read labels and information from our UIs
  - Typography plays an important role in how easy it is to do so
    - The appearance of words can be important as well

Types and Accessibility

- Some typefaces are harder to read for people affected by dyslexia:
  - Papyrus (lorem ipsum dolor sit amet)
  - Chiller (lorem ipsum dolor sit amet)
  - ONYX (lorem ipsum dolor sit amet)
- If you want to learn more about typeface accessibility:
  - Rello, L., & Baeza-Yates, R. (2016). The effect of font type on screen readability by people with dyslexia. ACM Transactions on Accessible Computing. https://www.superarladislexia.org/pdf/2016-Luz%20Rello-Fonts-taccess.pdf
  - https://numberdyslexia.com/best-and-worst-fonts-for-dyslexia/

Word Superiority Effect

- Sometimes, readers recognize a word by its shape, before they even recognize the letters in that word
  - This is called «**Word Superiority Effect**» in cognitive psychology
- People generally read lowercase latin text faster than uppercase
  - Do not use uppercase for long stretches of text!



Pic from https://fonts.google.com/

Combining Types: Concordant

Usability

From Wikipedia, the free encyclopedia

Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In *Software Engineering*, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.

Aptos, bold, 40pt

Aptos, 24pt

Aptos, 24pt

Combining Types: Conflicting

Usability

From Wikipedia, the free encyclopedia

Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In *Software Engineering*, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.

Aptos, bold, 40pt

Alegreya Sans, 24pt

Gill Sans, 24pt

Combining Types: Contrasting

Usability

From Wikipedia, the free encyclopedia

Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In *Software Engineering*, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.

Libertine, bold, 40pt

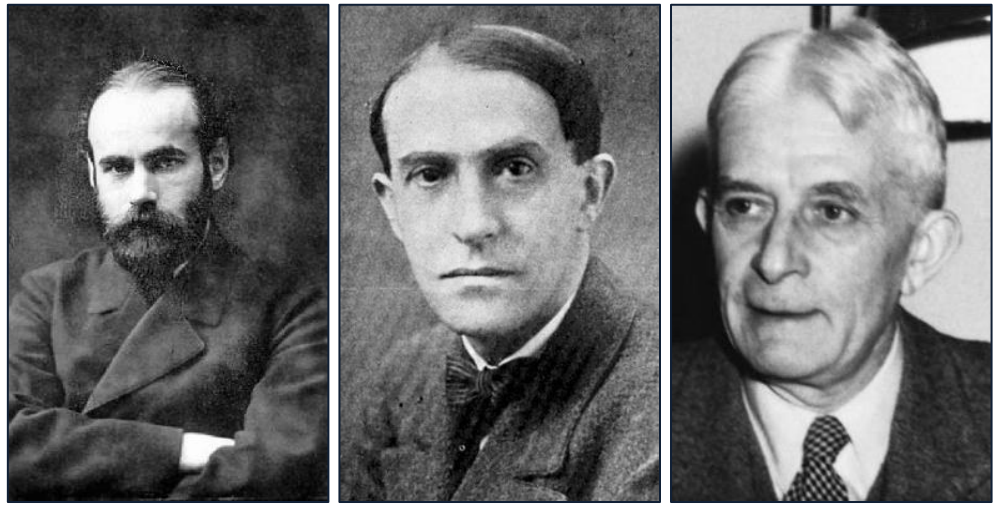
Libertine Caps, 24pt

Aptos, 24pt

Gestalt Theory of Perception

Gestalt Theory of Perception

- We've seen how people biologically perceive visual information
  - And we derived some useful guidelines for our UIs
- How do people process and interpret visual information?
- The **Gestalt Theory of Perception** (a.k.a. **Gestalt Psychology**) focuses on how the human mind processes visual information



From left to right, the three fathers of Gestalt Psychology: **Max Wertheimer** (1880-1943)**, Kurt Koffka** (1886-1941) and **Wolfgang Köhler** (1887-1967).

Gestalt

- Gestalt is a german term literally translating to «form» or «shape»
- Gestalt psychology refers to the idea of **unified whole**
  - We generally perceive **something different** than the mere sum of the individual elements we see
  - We draw meaning from the sum of all parts rather than individual elements

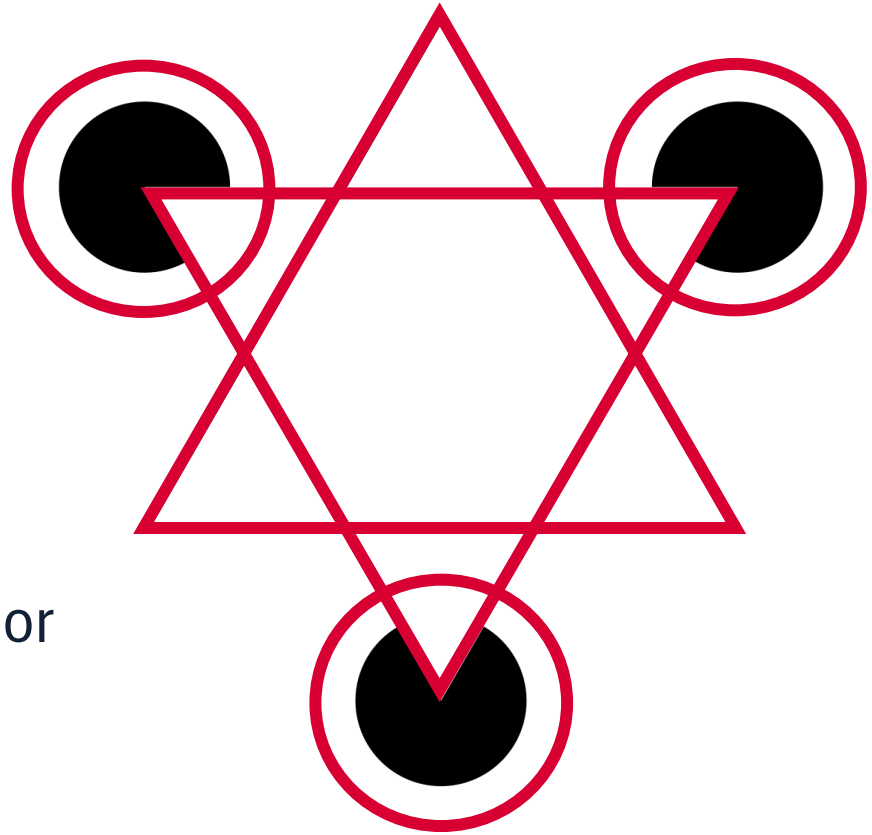
Gestalt in Action

So, what do you see in the image on the right?

- A white triangle on top
- A triangle with black borders below
- Three black partially-covered circles

Why don’t we see just a bunch of lines and splodges?

- Our mind has tendencies to fill in incomplete objects, and see connections between elements based on their relative appearence or position



Gestalt Psychology

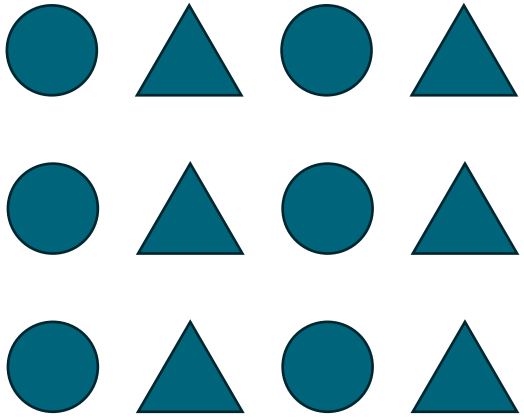
- Gestalt psychology studies these tendencies of our mind and how they manifest
- These tendencies as sometimes referred to as «**laws of perception**»
  - Not actually laws, but important principles or heuristics
  - In the next slides, we'll see some of these principles
  - By understanding them, we can use them to make our UIs more intuitive
  - We want our UIs to work with and not against how the brain processes visual stimuli

GESTALT PRINCIPLES

We’ll see some of the Gestalt principles that we may exploit in UIs

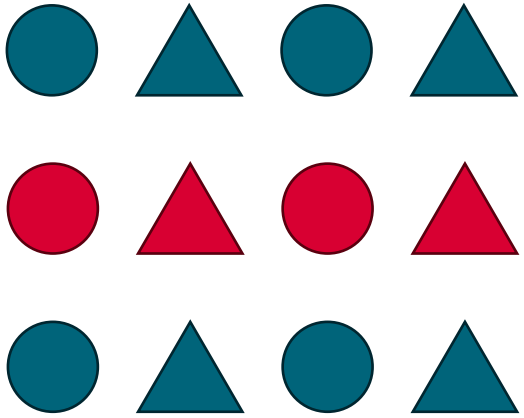
- Similarity
- Proximity
- Connectedness
- Common region

Principle of Similarity



- I bet you interpreted the above image as four columns and not three rows
- Items that share a visual trait are perceived as more related than items that are dissimilar
  - Visual traits can be shapes, sizes, colors, font, movement, orientation…

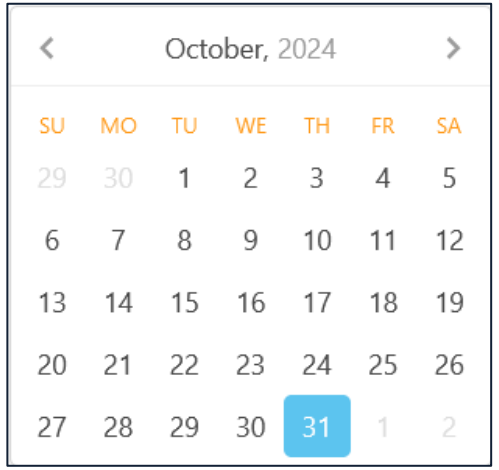
Principle of Similarity

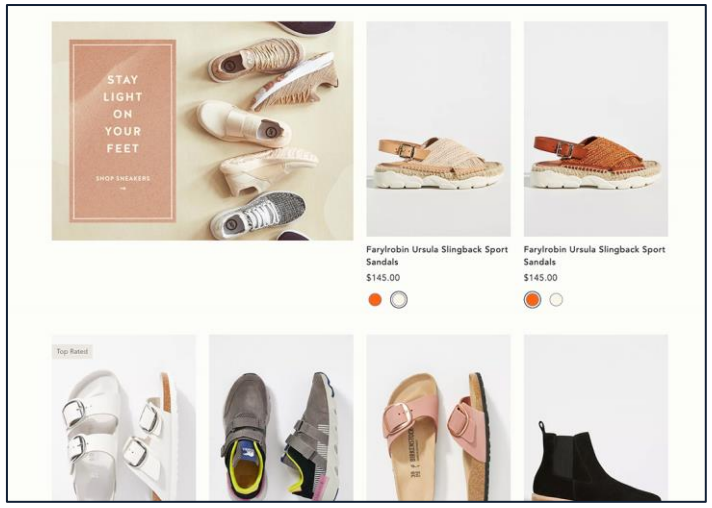


- By adding another visual trait (color), your perception may change
- You’re likely to see three rows now
- Color similarity often overrides other visual traits

Similarity in UI

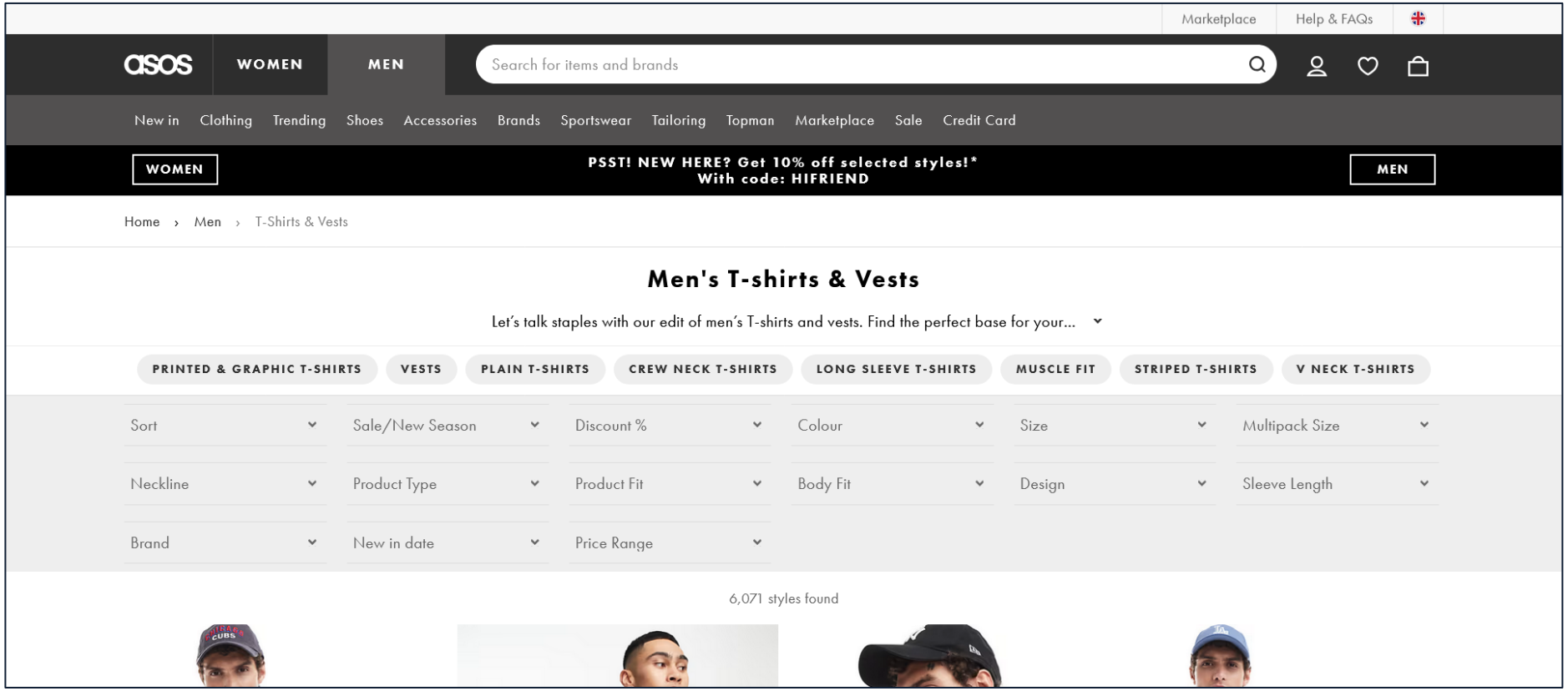
- Similarity can be used to **group related items**
  - If you want different items to be perceived as grouped and related, you may make them share one or more visual trait
  - It can be used to communicate common functionality (e.g.: think of colors to signal links on web pages)
- Similarity can also be used to emphasize differences





On Anthropologie.com, promotions for product collections were displayed at double the size of an individual product listing.
Pic from https://www.nngroup.com

Similarity in UI

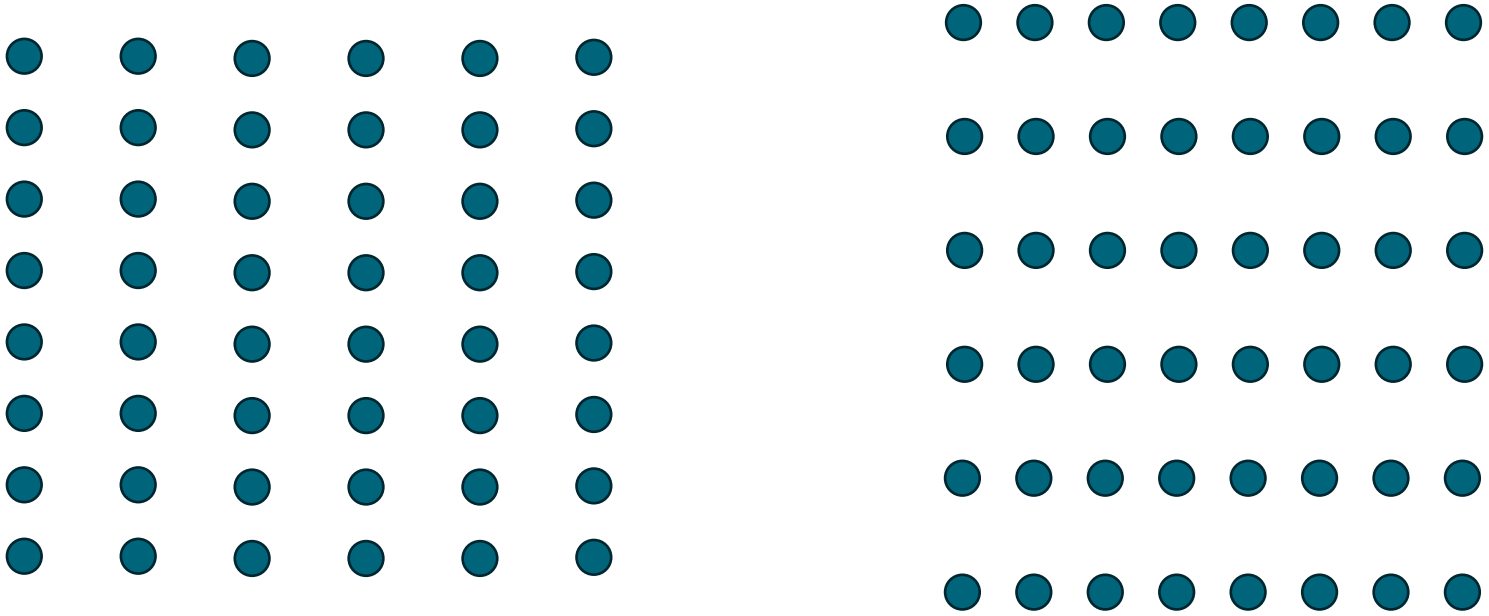


Subcategories

Filters

Principle of Proximity

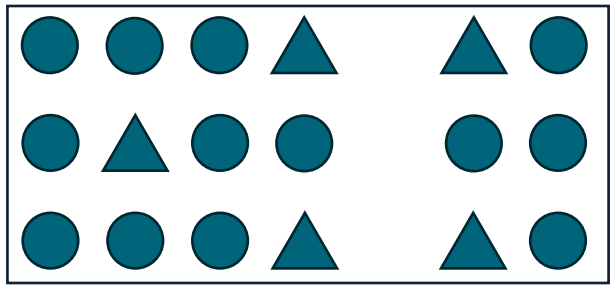
What pattern are you seeing in this image?



- Chances are you saw **six columns** on the left, and **six rows** on the right!

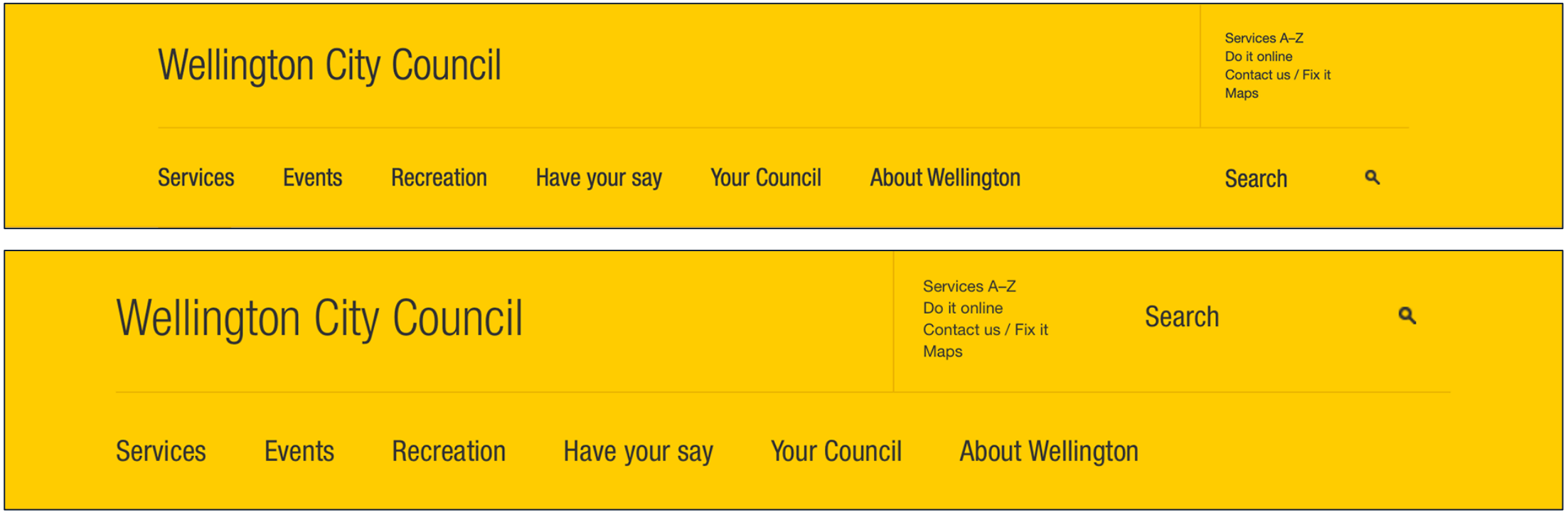
Proximity

What about in this picture?



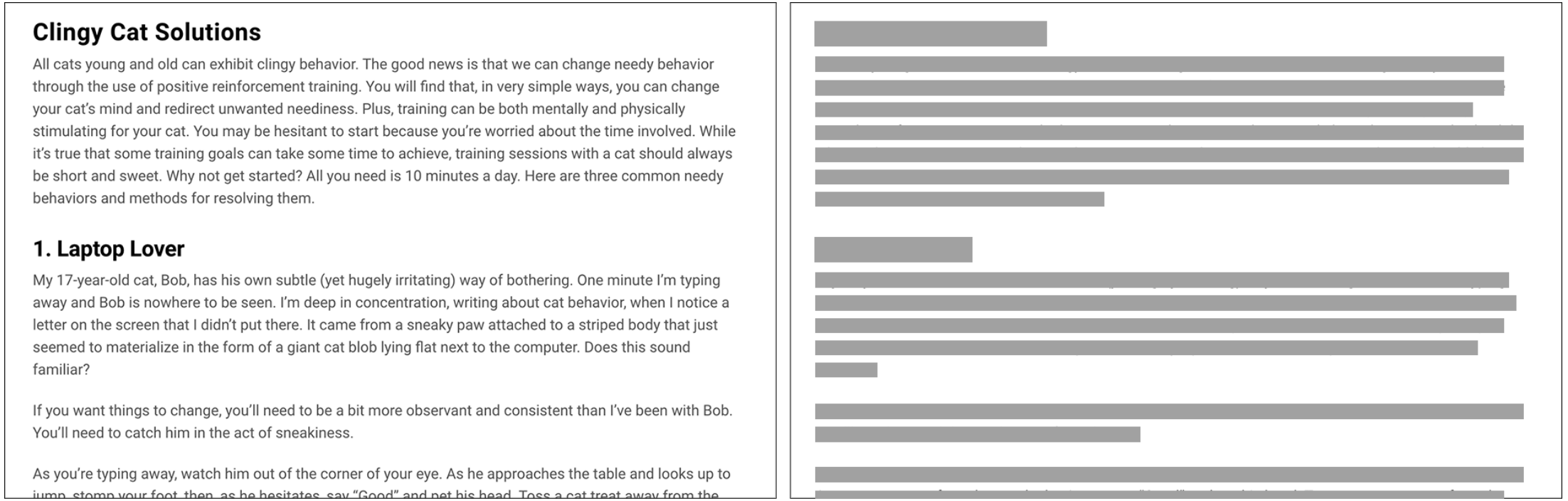
- You probably see **two groups** of shapes (even though we included different shapes in them!)
- Whitespace is a powerful tool for making some elements appear to be related or unrelated
- When designing a UI, the spacing between elements is used in a way that helps users achieve their goals, and not misguides them

Proximity: example



*Wellington City Council website, as seen on a desktop monitor (top) and tablet (bottom): The "*Search *control" is separated from the rest of the main navigation, which suggest it's a different type of functionality.*
Pics from https://www.nngroup.com/

Proximity: text



Clingy Cat Solutions

All cats young and old can exhibit clingy behavior. The good news is that we can change needy behavior through the use of positive reinforcement training. You will find that, in very simple ways, you can change your cat's mind and redirect unwanted neediness. Plus, training can be both mentally and physically stimulating for your cat. You may be hesitant to start because you're worried about the time involved. While it's true that some training goals can take some time to achieve, training sessions with a cat should always be short and sweet. Why not get started? All you need is 10 minutes a day. Here are three common needy behaviors and methods for resolving them.

1. Laptop Lover

My 17-year-old cat, Bob, has his own subtle (yet hugely irritating) way of bothering. One minute I'm typing away and Bob is nowhere to be seen. I'm deep in concentration, writing about cat behavior, when I notice a letter on the screen that I didn't put there. It came from a sneaky paw attached to a striped body that just seemed to materialize in the form of a giant cat blob lying flat next to the computer. Does this sound familiar?

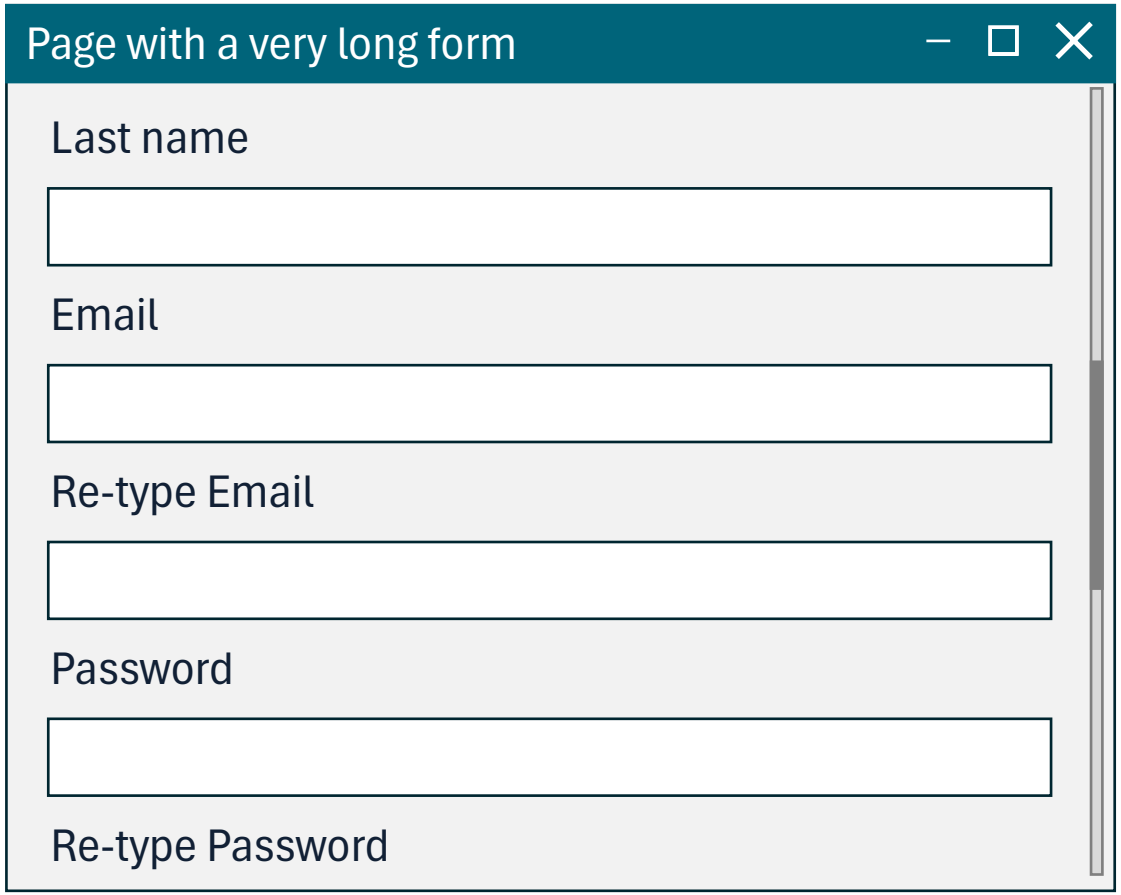
If you want things to change, you'll need to be a bit more observant and consistent than I've been with Bob. You'll need to catch him in the act of sneakiness.

As you're typing away, watch him out of the corner of your eye. As he approaches the table and looks up to

(Left) Proximity defines groups of related text (paragraphs and sections) and helps scanning. (Right) These groupings are discernible even without viewing the actual text
Pics from https://www.nngroup.com/

Proximity: forms

The principle of proximity is especially useful in forms



- In the example on the left, it's not entirely clear to which field each label corresponds
- Labels are equi-distant from fields

Proximity: forms

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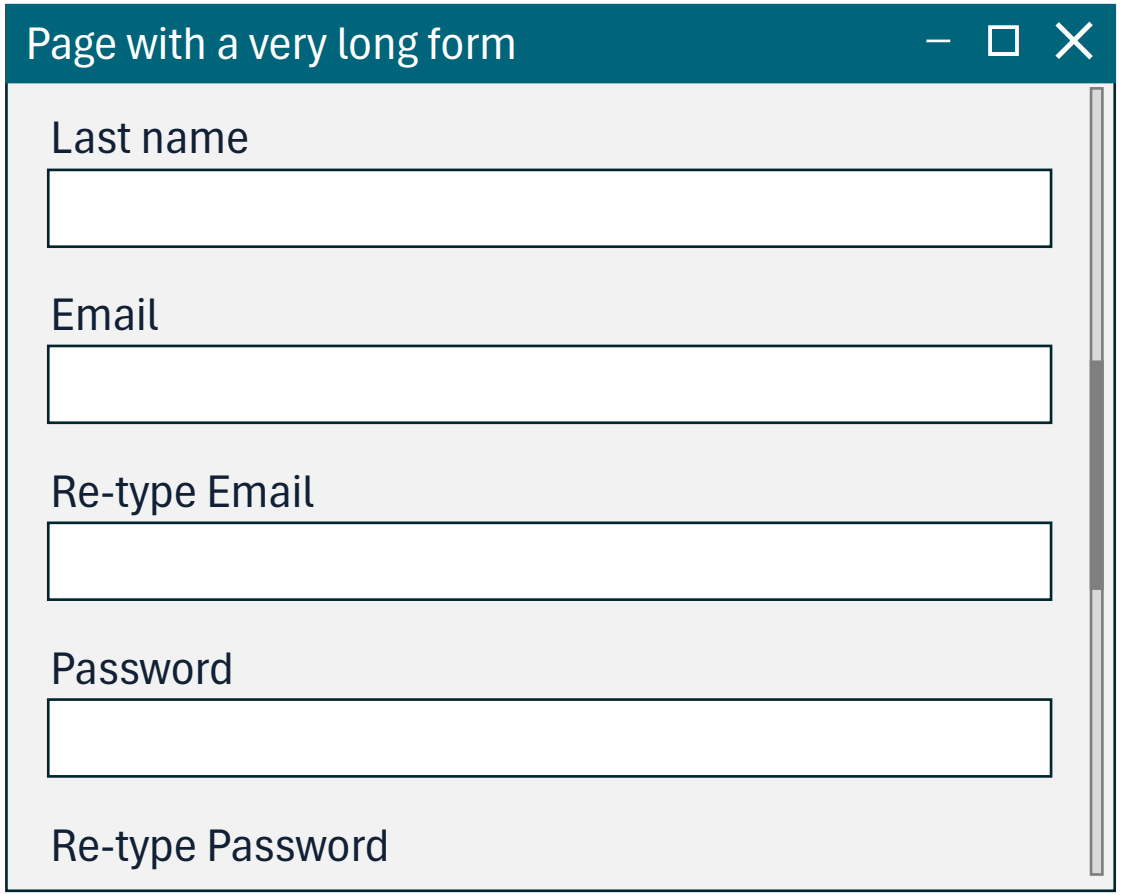
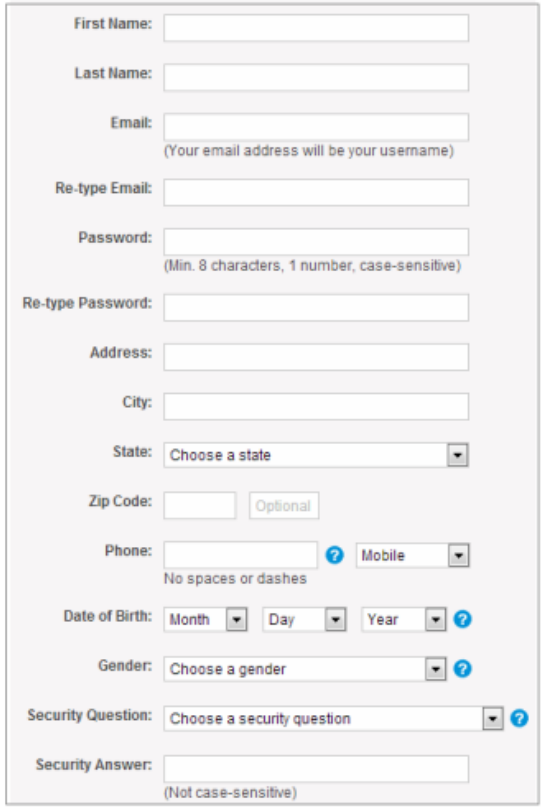
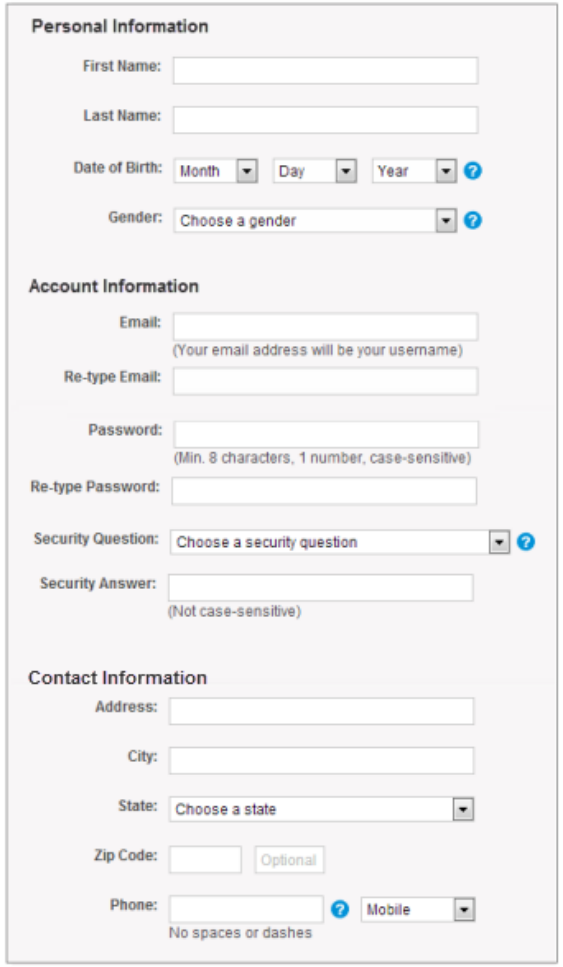


- Using spacing better can help us make a more intuitive form!

Proximity: forms

- Long forms with many input fields can feel **overwhelming**
- Grouping related fields together helps users make sense of the information they must fill in
- Spacing is one way to help group related fields

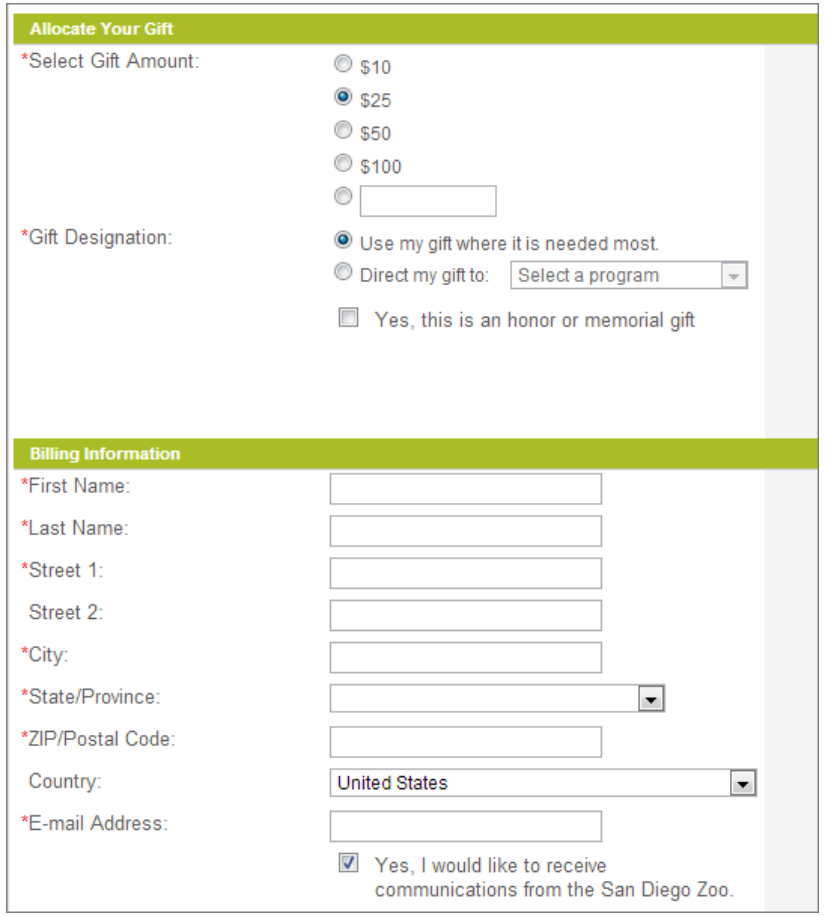




Pic from https://www.nngroup.com/

Proximity: label placement in forms

- The safest approach is to position labels above the input fields
- If you want more compact forms, consider placing labels to the left of input fields
  - Labels should have similar length, and should not be too far from the input fields
  - Right-aligned labels are known for hindering scannability
- In the example on the right, field labels are placed too far from the corresponding text field.

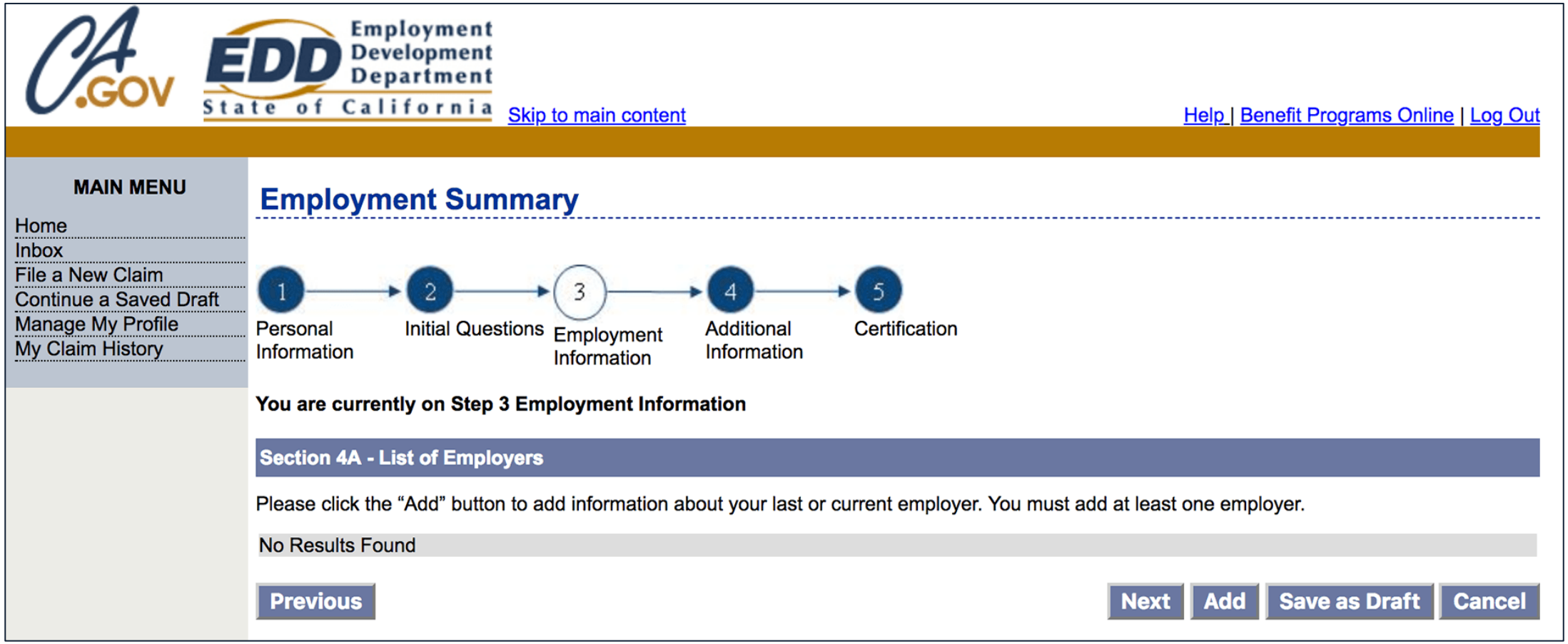


San Diego Zoo donation form.
Pic from https://www.nngroup.com/

Proximity can backfire

- Beware of grouping together unrelated elements
- It can camouflage unrelated elements, making them less noticeable!

Proximity can backfire: example

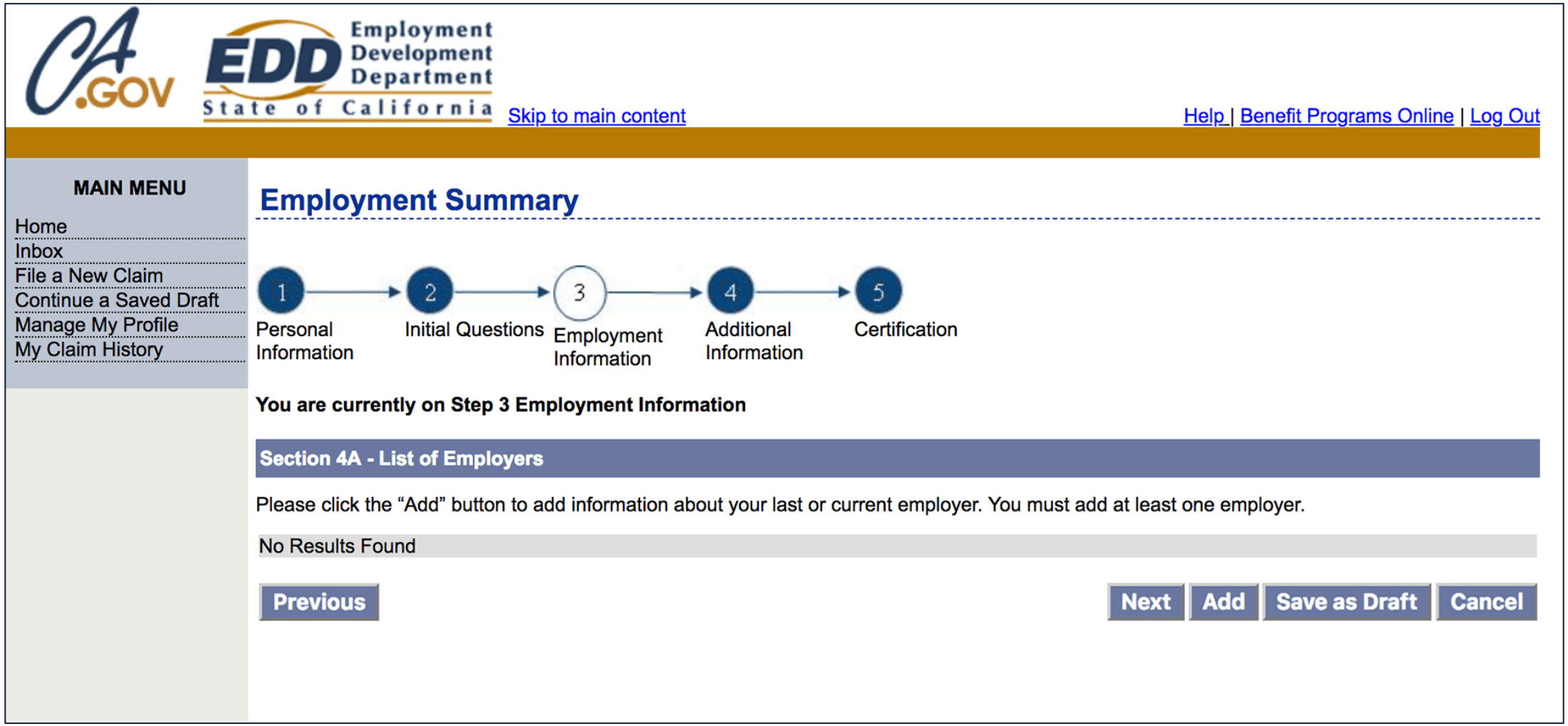


CA.gov website. Pic from https://www.nngroup.com/

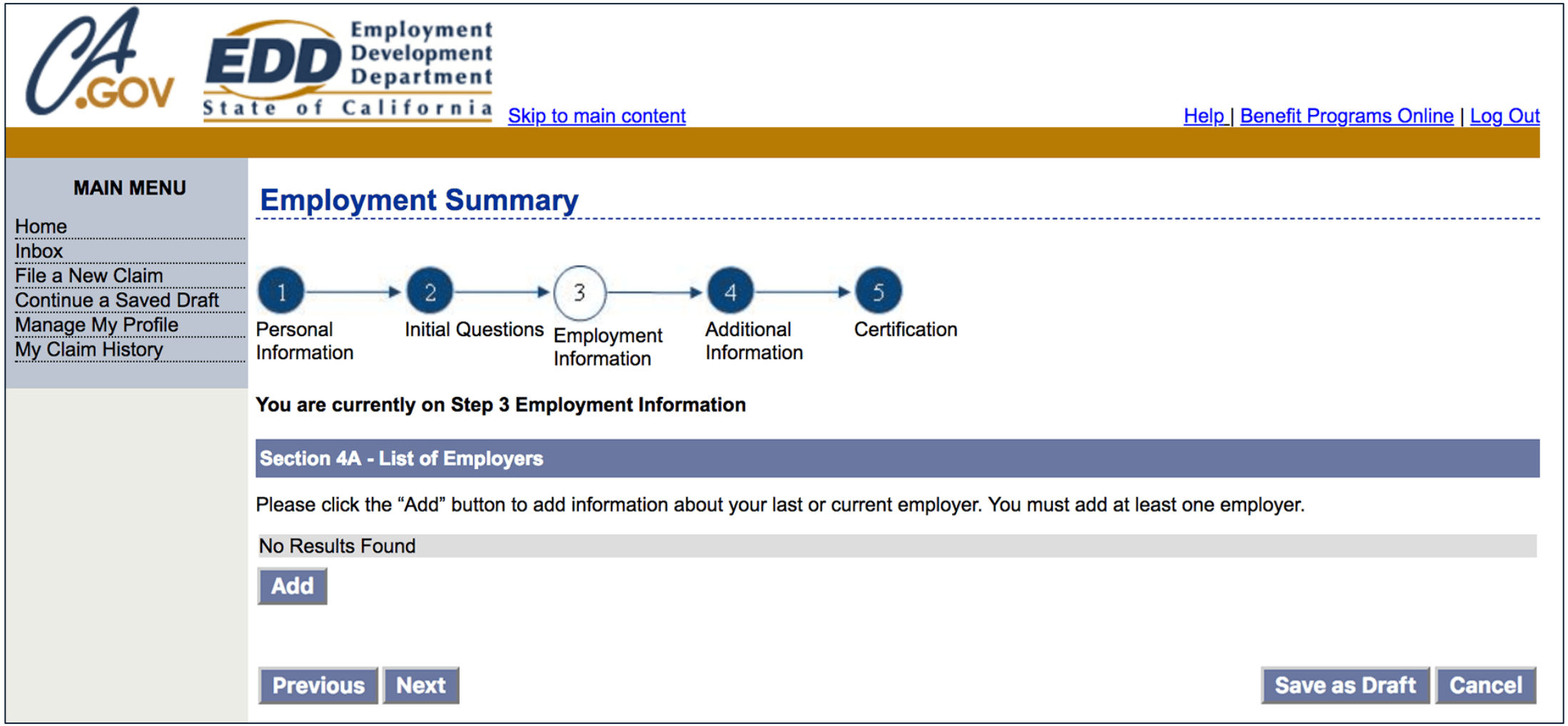
Proximity can backfire: example

- In the CA.gov website page, the «add» button, required to add employment information, is placed near unrelated buttons (move to the next step, save submission as draft, and cancel).
- When looking around the page, users may **only look at one item within a perceived grouping and use that to make a judgement about what the other items in that group must be**.

Proximity can backfire: example



Proximity can backfire: fixing the example



Principle of Connectedness

- Elements that are connected (or share a border) are perceived as related or part of the same group
- How many groups do you see in the shapes below?

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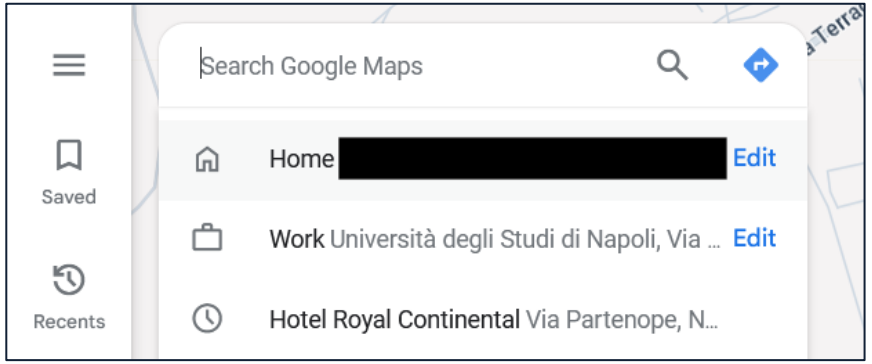
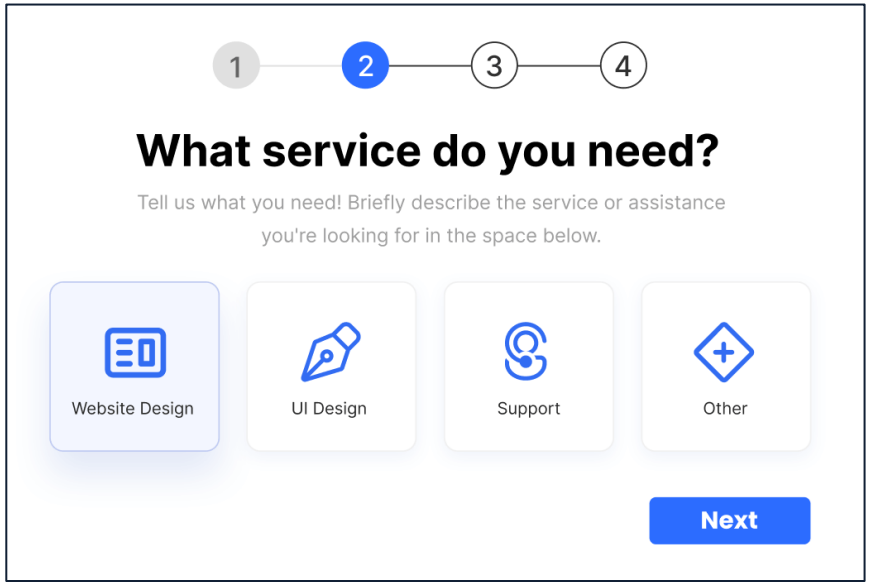
- Connectedness **overrides** proximity and similarity

Principle of Connectedness in UI Design

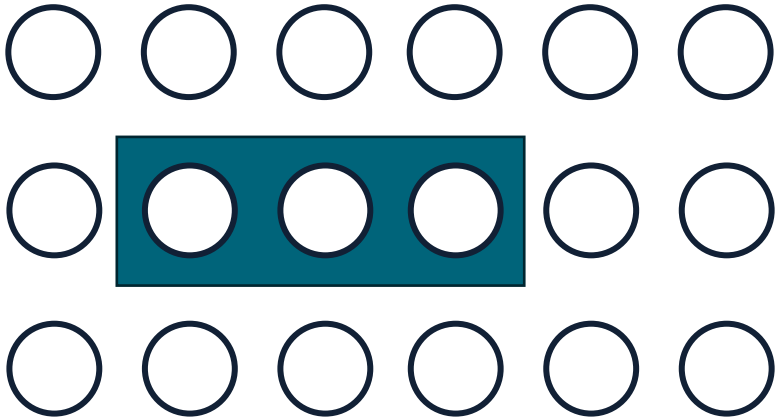
- In Google Maps (web version) the search box is connected (share a border) to recent queries and saved locations
  - This suggests that those features are related
- Long forms can also be split in multiple phases or steps. The steps in the indicator on top of the figure (from fluentforms.com) are connected
  - This conveys the fact that these step belongs to the same, larger process





Principle of Common Region

- Items within a boundary are perceived as a group and assumed to share common characteristics or functionality



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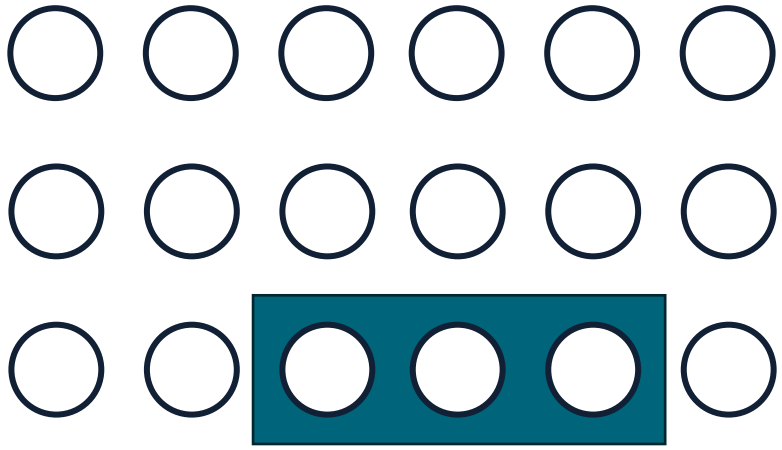

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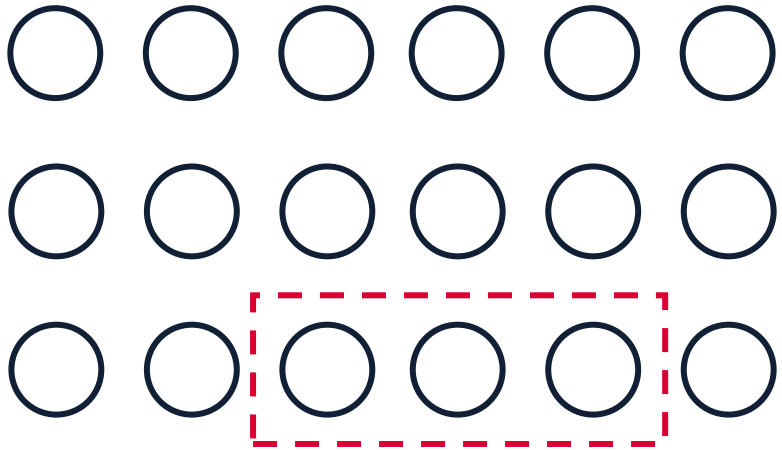
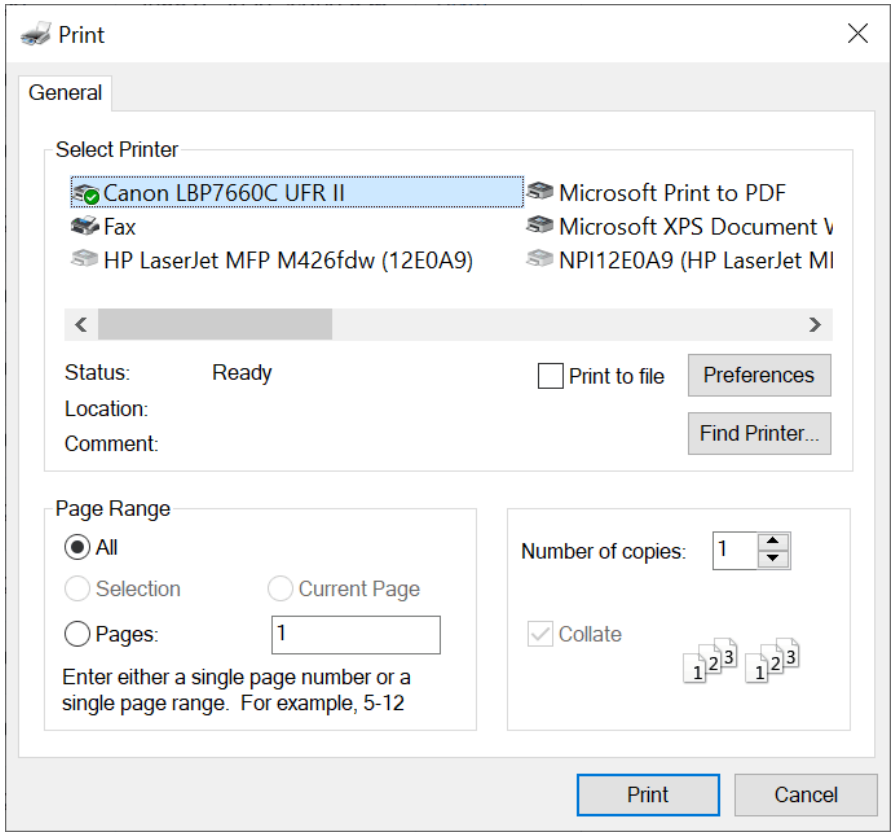


Principle of Common Region: examples



Printing dialog on Windows 11.
Pic from https://www.nngroup.com

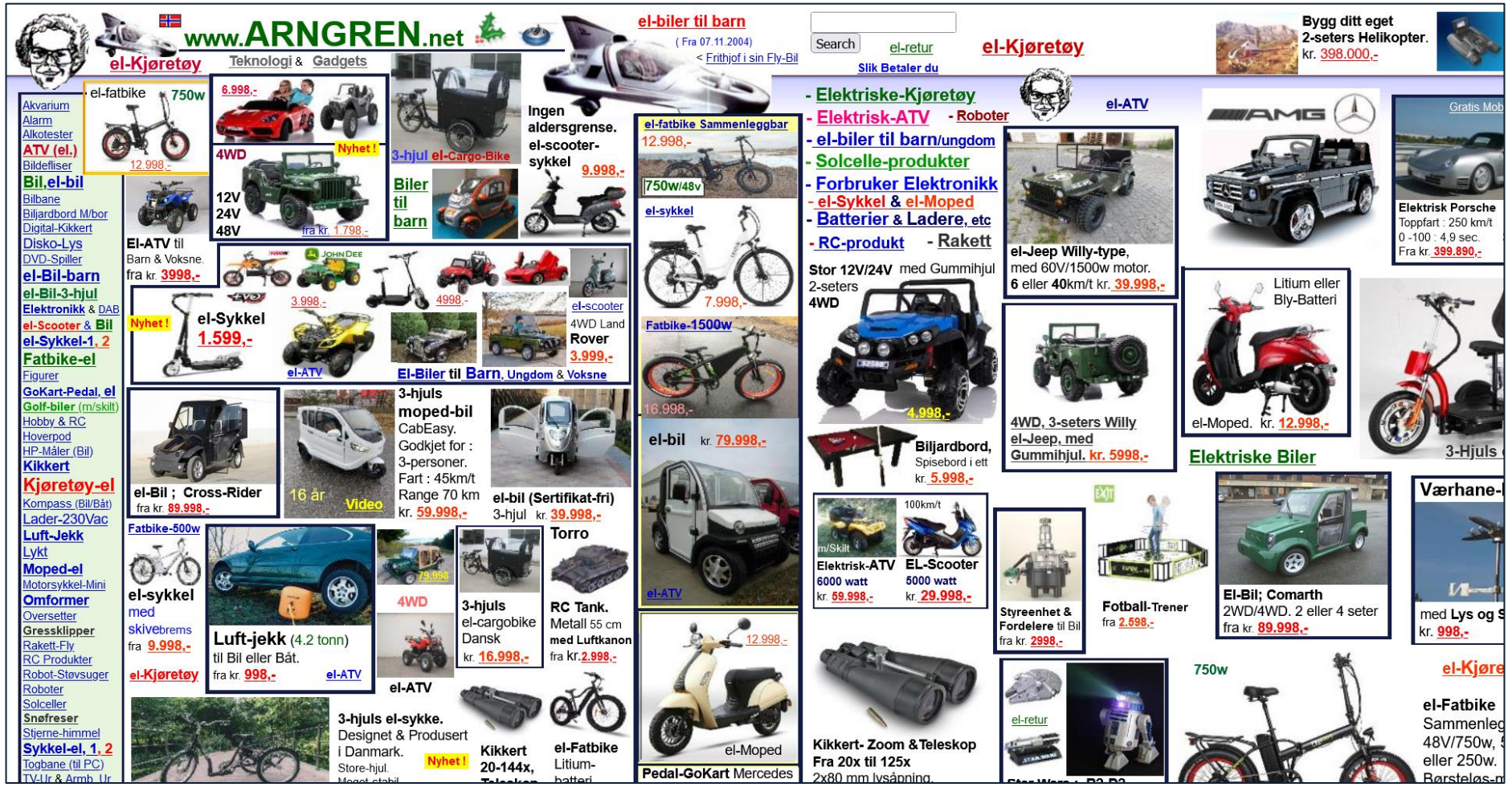
Principle of Common Region: examples

Footer in the teacher's personal website: https://luistar.github.io

Visual Hierarchy in UI Design

- Have you ever seen a website or an app presenting a screen full of information, and you don’t even know where to start looking?
- When that happens, it’s likely that the layout is missing a clear **visual hierarchy**
- **Visual hierarchy** (of a 2D layout) refers to the organization of the design elements on the screen/page so that the eye is guided to consume each design element in the order of intended importance.

Lack of a Visual Hierarchy on arngren.net

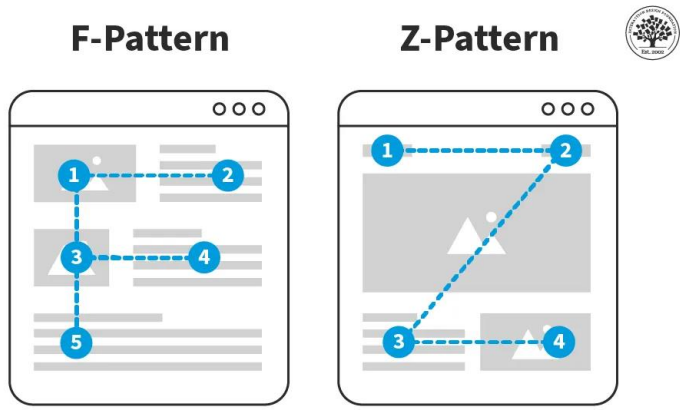


Lack of a Visual Hierarchy (SPSB website)

https://www.scuolapsb.unina.it/programmi-di-internazionalizzazione/

Creating a Visual Hierarchy

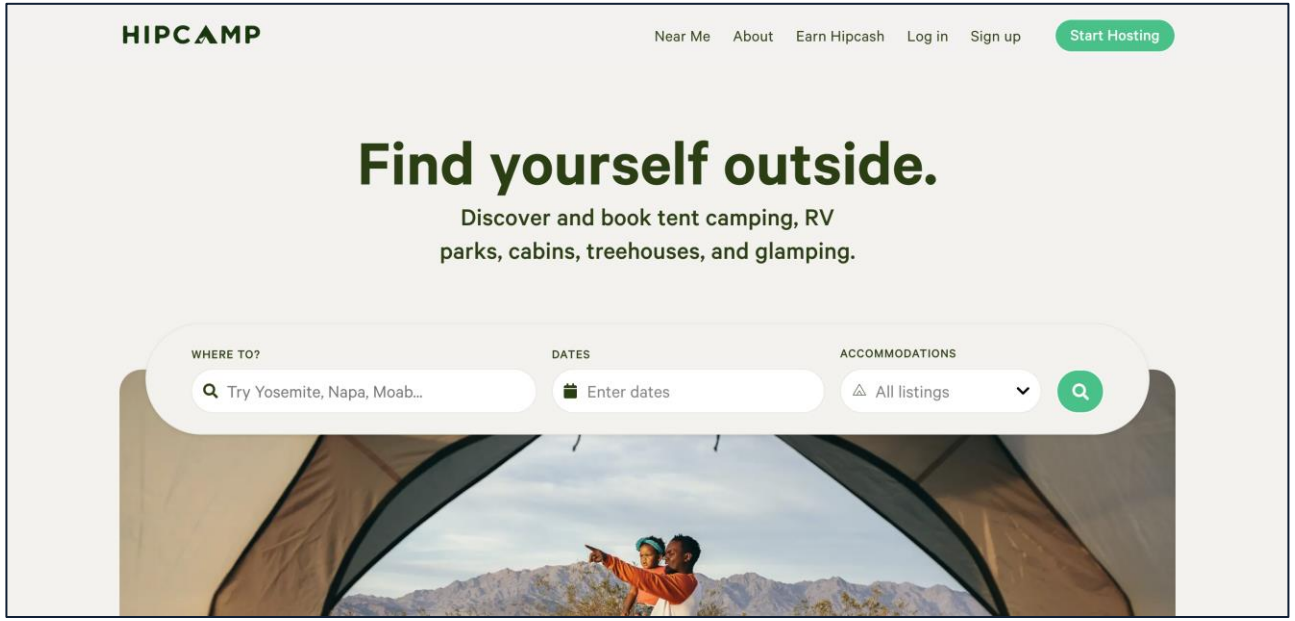
- You should use what you learned about colors, typography, and Gestalt principles to ensure that your designs have a clear visual hierarchy
- Designs should guide users so that they consume contents in the desired order
- Keep in mind that western users typically scan a UI using a **F-** and **Z-pattern**
  - You can reinforce these natural patterns
- **Scale**, **colors** and **groupings** are powerful tools to create a visual hierarchy



Interaction Design Foundation
interaction-design.org

Creating a Visual Hierarchy: Scale

- Users pay more attention to big things than to small things
- More important elements should be larger than less important ones
- Users will notice larger elements first

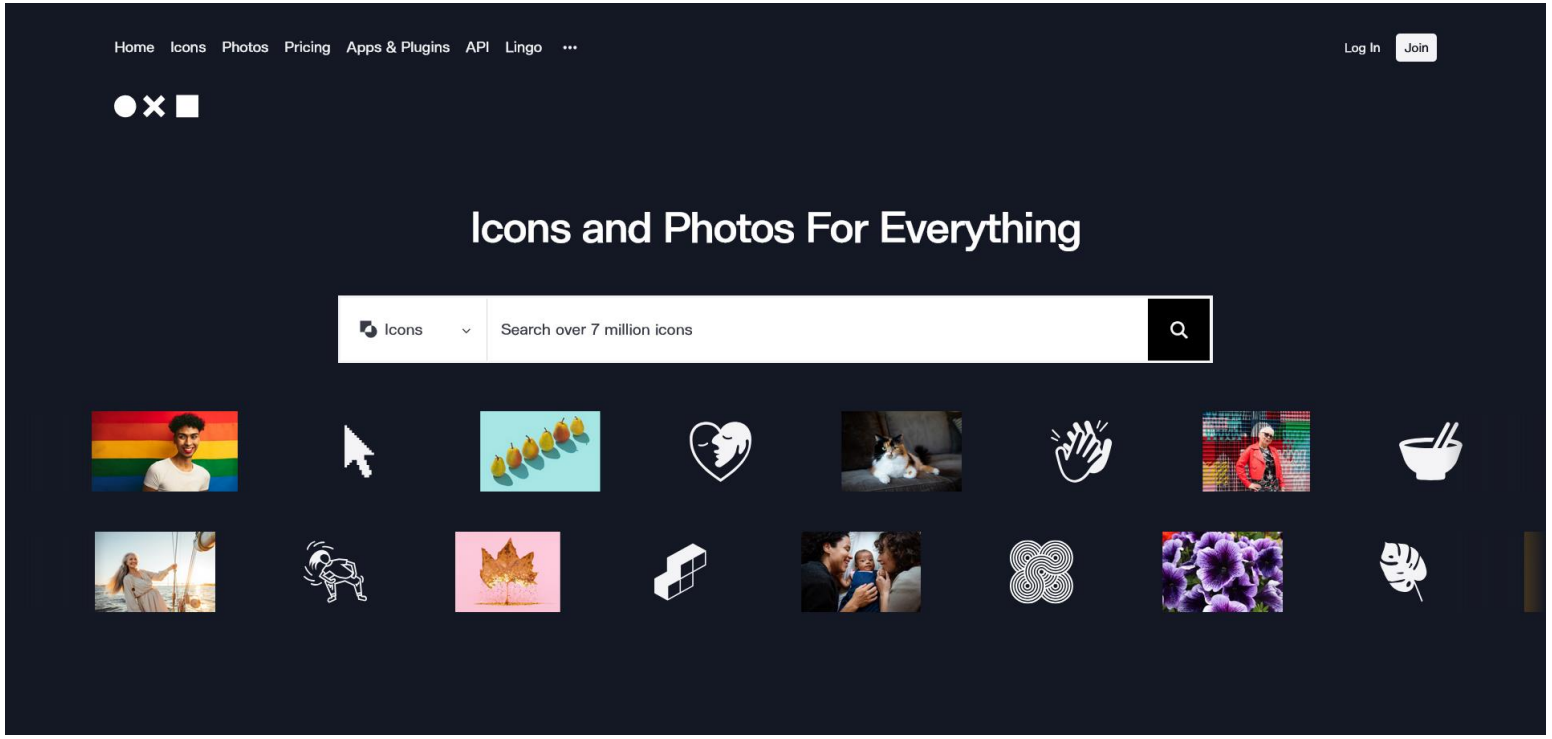


Hipcamp.com: *The visual hierarchy is communicated through font size. The eye is drawn first to the* "Find yourself outside" *text due to its large, bolded size. This text gives you a general idea of what you can do on this website.*

From https://www.nngroup.com/

Creating a Visual Hierarchy: Color / Contrast

- Color and contrast is a good way to make some elements appear in advance while others recede



In thenounproject.com, attention is drawn to the search field both because of its size and because of its high contrast w.r.t. the dark background.

Creating a Visual Hierarchy: Grouping

- Implicit and explicit groupings help us see the bones or the structure of a layout and allow us to direct attention to those areas of the screen that are likely to be relevant to our goal
- Gestalt principles (proximity, similarity, common region) can help convey groupings
- In the Spotify app (pic from nngroup.com), we immediately see 3 different groupings.