IDI | VD

Design Principles and Concepts

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1. Universal Design Principles

There is a large amount of knowledge in different areas of design that may help us when designing user interfaces. In this section we will introduce some of the principles that have arose from many years of practice from different areas. Most of them come from the famous *Universal Principles of Design* book, from where we extracted the ones we found were more notable or useful. Some principles have already been visited, but will be illustrated here with a more detailed explanation or examples.

1.1 The 80/20 Rule

The 80/20 rule asserts that approximately 80 percentage of the effects generated by any large system are caused by only the 20 percentage of the variables in that system.

This rule is observed in all large systems, including economics (i. e. 80% of a company revenue comes from 20% of its products), computer systems (80% of errors are caused by 20% of the components), and so on. In our case, 80% of the usage in an application will be focused on only 20% of its features.

It is a useful rule for focusing resources, that is, we must focus most of our attention to the 20% of the features that are mostly used, to the 20% of the features that are critical, and so on. Focusing on aspects of the system that are beyond the critical 20% rapidly yields diminishing returns.

The rule must be used to assess the value of elements, and determine the target of our efforts in design and optimization.

1.2 Barrier-free design

Accessible or barrier-free designs have four characteristics:

- **Perceptibility:** Everyone can perceive the design, regardless of sensory abilities. This feature is achieved when everyone correctly understands the user interfaces. We must design interfaces with colour-blind friendly designs, with redundant visual indicators (such as text and colour), and so on.
- **Operability:** It indicates that anyone, regardless of physical abilities, is able to work with our system. In User Interface design, this means that we must take care of people with motor inabilities or slower response times (such as for double-click, as a typical case in elder people or children). This can be achieved by facilitating the access to controls (i. e. avoiding key combinations that require the use of two hands).
- **Simplicity:** It is achieved when everyone can understand the design regardless of experience, literacy, or concentration level. Unnecessary complexity must be removed. Designs must be clear, concise, and consistent, and feedback must be provided clearly.
- **Forgiveness:** It is achieved when the design minimizes the occurrence of errors and, in case of error, it also minimizes the errors' consequences. The use of good affordances, constraints, proper input formatting, and confirmations when required help to achieve forgiveness.

1.3 Aesthetic-Usability Effect

Aesthetics play an important role in the way designs are used. Aesthetic designs look easier to use, and encourage its use more than non aesthetic designs. This effect produces the perception that an aesthetic design is easier to use than a non-aesthetic design. However, you can find many examples that indicate the contrary. For example, the iPhone Calendar, though beautifully designed, makes a poor use of space, thus avoiding the visualization of a complete day in our calendar. On the other side, WebOS calendar is able to show a higher amount of information in a smaller space due to some elements such as an intelligent free-time collapsing option (see Figure 2). In use, the iPhone Calendar also requires a higher amount of clicks to generate an appointment, as compared to other calendars such as Android's or WebOS.

Figure 2: Left: iPhone Calendar. Right: Palm's WebOS calendar. WebOS Calendar makes a much smarter use of the space with the collapsing free-space regions and the overlapping of the view changing buttons. All in all, more things are shown in a 3.1-inch screen (right) than the famous 3.5-inch screen of the iPhone (left).

Since aesthetic designs are perceived as easier to use, we must devote important efforts to improving our designs. They are usually more readily accepted and user over time, and also foster positive relationships with people.

1.4 Correct alignment

We have already seen the infamous *butterfly ballot* from the US presidential election in 2000. One of the main problems was alignment.

Elements in a design must be aligned to each other. This creates a sense of unity and cohesion, as well as facilitates reading. When using grid or column-based

alignments, we are also guiding the reading directions of the users. This is important because we may guide the attention, as well as induce the relation between the different elements.
Most common and useful alignments are rows and columns. Although more elaborate designs can exist, it may be necessary to add other visual cues to enforce the alignment direction.

1.5 Chunking

The term chunk is used to refer to a unit of information in short-term memory. Chunking is a technique that seeks to place the information in a way that accommodates to the limits the humans have to process bits of information. The famous paper by George Miller *The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information*, studies the capabilities of human brain in recalling performance. Essentially, smaller chunks are easier to remember than larger lists, for example, most people can remember a list of 5 words for 30 seconds, but few can remember a list of ten words for 30 seconds.
Chunking is a technique that refers to elements that must be memorized, such as menu items, telephone numbers and so on. It is not required to divide all the elements in a screen or page in groups of 5 or so, since this can yield no benefits at all. Tasks such as text scanning do not require recalling the text that has been analysed; therefore, elements such as dictionary pages must not be chunked.

1.6 Cognitive dissonance

Cognitive dissonance is a psychological phenomenon that refers to the discomfort felt at a discrepancy between what you already know or believe, and new information or interpretation. It therefore occurs when there is a need to accommodate new ideas, and it may be necessary for it to develop so that we become "open" to them.
This discomfort is released usually in one of these three ways:

- Changing our behaviour.
- Justifying our behaviour by changing the conflicting cognition.
- Justifying our behaviour by adding new cognitions.

A typical example of cognitive dissonance is smoking. Many smokers feel some discomfort with the fact that smoking will shorten their lives and that they want to have long and healthy lives. There are different ways to reduce cognitive dissonance among smokers:

- Changing the behaviour: Quitting smoking.
- Justifying the behaviour by changing the conflicting cognition: Denying the evidence that smoking produces cancer.
- Justifying the behaviour by adding new cognitions: Rationalizing their behaviour by saying that only a few amount of hard smokers actually become ill.

A typical example of cognitive dissonance is a service that offers a free trial period but that requires a long time and effort to make the service properly work for you. When the free time expires, it will be a hard work to change the system and therefore, the larger the cognitive dissonance that will lead to a large amount of people to accept the price to continue with the service. Cloud services integrated into computers or mobile phones may produce a high cognitive dissonance if we

want to change our system with a different one, since moving all our music, folders, configurations, and so on, may be time costly, and therefore we might prefer to buy a new product from the same company. The larger we are involved (the higher number of services we use), the higher the cognitive dissonance to change the trademark.

1.7 Colour

Colour is an important feature that can make a design more visually pleasing and aesthetic. They can be used to reinforce layout design and the meaning of elements. Some aspects must be taken into account when using colours.

- **Number of colours:** The number of colours must be kept low. Commonly, up to five is enough. Do not rely on the colour to provide information, always use a second cue because there are users with some sort of colour-blindness.
- **Colour combinations:** When using different colours for adjacent elements, we may take different approaches. The most common, and widely accepted are the use of analogous colours (adjacent colours on the colour wheel), complementary colours (opposing colours on the colour wheel), colours at the corners of a symmetrical polygon circumscribed in the colour wheel, triadic (triangle) or quadratic (square), or combinations of colours found in nature (see Figure 3).
- **Saturation:** Attention attraction can be achieved using saturated colours (pure hues), when performance and efficiency are important, the use of desaturated colours may help. Desaturated colours are perceived as more professional, while saturated colours are perceived as more exciting and dynamic.
- **Symbolism:** The meanings of colours may vary among cultures, therefore, one should not try to use a certain colour to produce some feeling (i. e. dark colours are assumed to make people sleepy) without a previous verification of the target audience.

Figure 3: Colour combinations found in nature: The right image shows a portion of Irish coast, and some of its colours have been picked for the Dublin website.

1.8 Consistency

Consistency is a well-known design principle. It may be applied or classified in different ways:

- **Internal consistency:** It refers to how the elements of the application are consistent with each other. It induces trust.
- **External consistency:** It refers to the consistency of the elements of a design with other elements in the environments or other applications. It extends the advantages of internal consistency across multiple systems.
- **Aesthetic consistency:** It refers to the consistency of the style and appearance. The use of logos or trademarks with the same font and colours makes the elements more recognizable than when using different fonts and/or colour combinations.
- **Functional consistency:** It refers to the coherency between expected results and effective results of our actions. If our interface is functionally consistent, the learning curve will be softer, and usability will be improved.

1.9 Five hat racks

Five hat racks refers to the ways of organizing information. There are five ways to organize information: category (similarity relatedness), time (chronological sequence), location (geographical or spatial references), alphabet (alphabetical sequence), and continuum (magnitude; highest to lowest, best to worse).

The organization of information is a powerful way to improve understanding as well as influencing the way people think. The LATCH principle (Location, Alphabet, Time, Category, Hierarchy) is a slight redefinition of the *Five Hat Racks*. The five organization modes are described next.

Location

Location is chosen when the information you are comparing comes from several different sources or locales. Doctors use different locations of the body to group and study medicine. Concerning an industry you might want to know where on the world goods are distributed.

Alphabet

Alphabet is best used when you have enormous amount of data. For example words in a dictionary or names in a telephone. As usually everybody is familiar with the Alphabet, categorizing by Alphabet is recommendable when not all the audience is familiar with different kind of groupings or categories you could use instead.

Time

Time is the best form of categorization for events that happen over fixed durations. Meeting schedules or our calendar are examples. The work of important persons might be displayed as timeline as well. Time is an easily framework in which changes can be observed and comparisons made.

Category

Category is an organization type often used for goods and industries. Shops and services in the yellow pages are easy to find by category. Retail stores that sell clothing have separated parts for men, woman, and children clothing. This mode works well to organizing items of similar importance.

Hierarchy

Hierarchy organizes by magnitude. From small to large, least expensive to most expensive, by order of importance, etc. Hierarchy is to be used if you want to assign weight or value to the ordered information.

1.10 Garbage In – Garbage Out

This principle refers to the long-time experience of computer scientists that have found out that good input produces good output while bad input often produces bad output. It is often abbreviated GIGO. This metaphor refers to two common input problems:

- **Problem of type:** This problem appears when the incorrect type of input is provided to a system. Sometimes the type problem can be detected, but may produce the high level of garbage if it goes undetected. Elements such as numerical fields that can be fed with a phone number or a credit card number are examples of this type problem.
- **Problem of quality:** It occurs when the correct type of input is fed into a system but it has some defects. This type of errors may often be caused accidentally, and one way to minimize problems is the use of previews and confirmations.

The best way to avoid garbage out is to properly avoid garbage in: Type checks, input formatting, default values, or example inputs may help to reduce the input of garbage data.

1.11 Iconic Representation

It is the use of images to represent objects, actions and concepts. There are four types of iconic representations:

- **Similar:** They try to represent the action or object by an image that is visually similar to the element they try to represent. It is often useful for simple objects or actions (right turn) but less effective when trying to represent complex concepts.
- **Example:** They use elements that can be related with the object or action that they represent, such as a plane to indicate an airport.
- **Symbolic:** Images have a high level of abstraction. They are more effective when the symbol is well-established (such as the unlock icon with an open lock).
- **Arbitrary:** They are icons that use images with no relationship with the element or action, such as the male/female symbols.

1.12 Law of Prägnanz

The word *prägnanz* is a German term meaning "good figure." The law of Prägnanz is sometimes referred to as the law of good figure or the law of simplicity. It is referred to as one of the Gestalt Principles of perception.

This law holds that objects in the environment are seen in a way that makes them appear as simple as possible.

We tend to order our experience in a manner that is regular, orderly, symmetric, and simple. Some of the Gestalt Laws relevant for visual design are:

- **The law of closure:** The mind may experience elements it does not perceive through sensation, in order to complete a regular figure (that is, to increase regularity).
- **The law of similarity:** The mind groups similar elements into collective entities or totalities. This similarity might depend on relationships of form, colour, size, or brightness.
- **The law of proximity:** Spatial or temporal proximity of elements may induce the mind to perceive a collective or totality.
- **The law of symmetry:** Symmetrical images are perceived collectively, even in spite of distance.
- **The law of continuity:** The mind continues visual, auditory, and kinetic patterns.
- **The law of common fate:** Elements with the same moving direction are perceived as a collective or unit.

Some examples of these laws are shown in Figure 4.

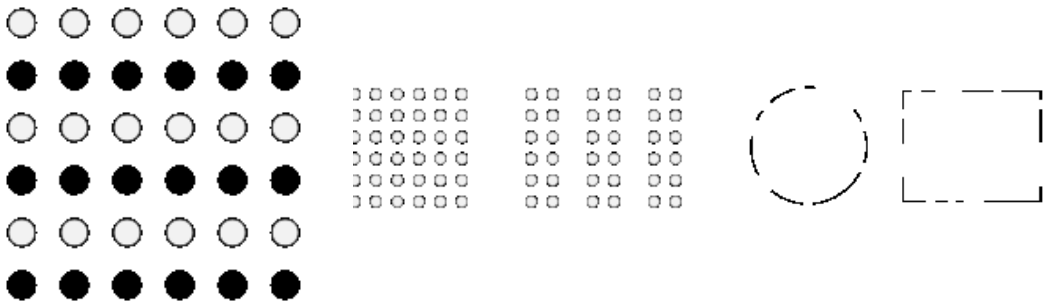


Figure 4: Examples of the Gestalt principles of similarity (left), proximity (centre) and closure (right).

1.13 Occam's Razor

Occam's Razor (also Ockham's Razor) is sometimes expressed in Latin as *lex parsimoniae* (the law of parsimony, economy or succinctness). It is a principle that generally recommends selecting from among competing hypotheses the one that makes the fewest new assumptions. In design it is applied to indicate that it is preferred the simplicity over the complexity.

Occam's original statement was "Entities should not be multiplied without necessity". Albert Einstein's formulation was: "Everything should be made as simple as possible, but not simpler".
Unnecessary elements decrease design's efficiency. If we compare Yahoo's search page with Google's search page, we should prefer the second to the former. However, we should not forget that Yahoo's webpage also provides other services than search.

1.14 Orientation Sensitivity

The efficiency with which we can perceive the orientation of lines is limited. Humans easily distinguish or can judge vertical or horizontal orientations while oblique orientations are more difficult to distinguish. Usually 30 degrees is the minimum recommended difference in orientation for the users to perceive it properly. This is due to two main phenomena in visual perception:

- **Oblique effect:** The relative deficiency in perceptual performance for oblique contours as compared to the performance for horizontal or vertical contours. It is caused by a greater sensitivity of neurons to vertical and horizontal stimuli than to oblique stimuli.
- **Pop-out effect:** It is the tendency of certain elements in a display to pop out as figure elements, and therefore be easily detectable. For instance, in a set of lines, targets are more easily detectable if they differ a minimum of 30 degrees over the other background of lines. When combined with the oblique effect, it becomes stronger: it is easier to distinguish a line with a subtle difference in orientation if it is close to a vertical or a horizontal line rather than close to a set of oblique lines.

1.15 Pictorial superiority effect

Concepts are much more likely to be remembered experientially if they are presented as pictures rather than as words. In many cases, information recall is superior when the information is presented in pictures. However, this happens after thirty seconds, that is, when the information is recalled before 30 seconds, the same amount of information can be recalled in text than in pictures. However, after 30 seconds, it is easier to recall pictorial information.
This also happens when the time of exposure is small, images can be better recalled than text.

1.16 Progressive Disclosure

It is an interaction design technique that sequences information and actions across several screens in order to reduce feelings of overwhelm for the user. It keeps displays clean and uncluttered. By disclosing information progressively, you reveal only the essentials and help the user manage the complexity of feature-rich sites or applications to reduce confusion, frustration, or disorientation. Progressive disclosure is not just about displaying abstract then specific information, but rather about getting the user's attention by going from simple to more complex actions.
Sometimes, designers present too much information in order to reduce kinematic load. Since not all the elements in an interface will be equally used, progressive

disclosure will move complex and less frequently used options out of the main user interface and into secondary screens.

1.17 Rule of thirds

The rule of thirds is a compositional rule of thumb in visual arts such as painting, photography and design. The basic principle behind the rule of thirds is to imagine breaking an image down into thirds (both horizontally and vertically) so that you have 9 parts. With this grid in mind the *rule of thirds* identifies four important parts of the image that you should consider placing points of interest in as you frame your image: the two central vertical edges, and the two horizontal edges of the grid. Then, important compositional elements should be placed along these lines or their intersections.

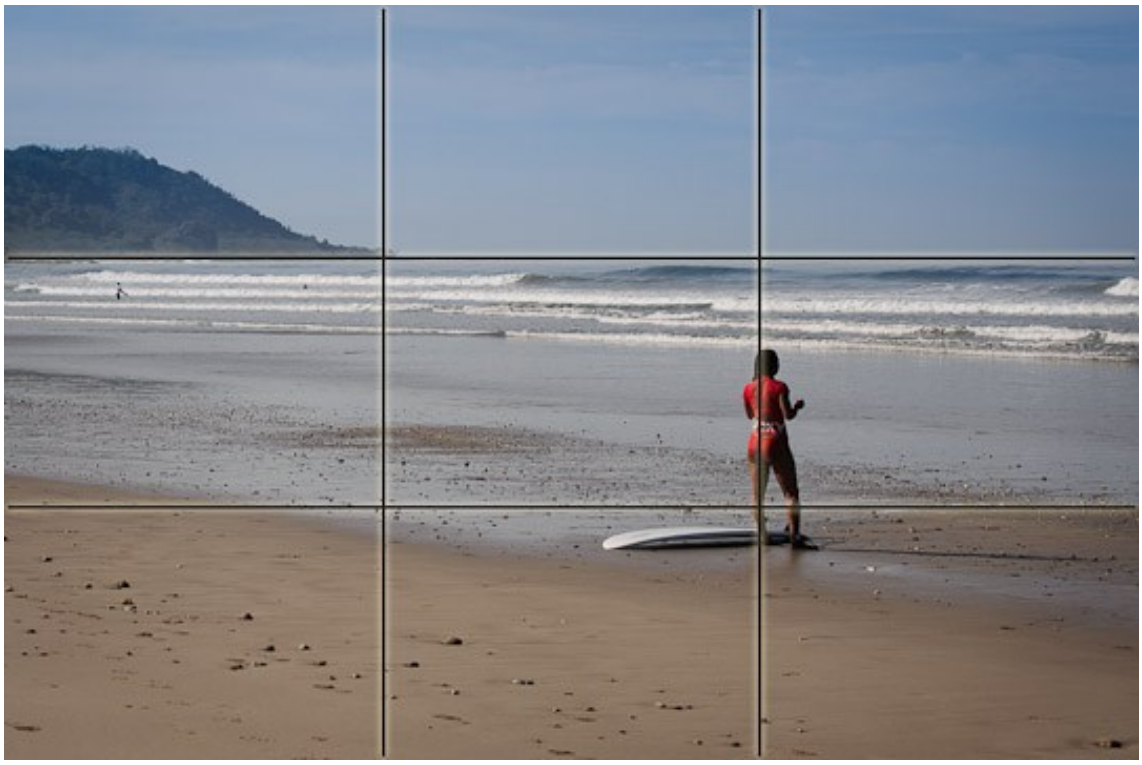


Figure 5: Example image following the rule of thirds.

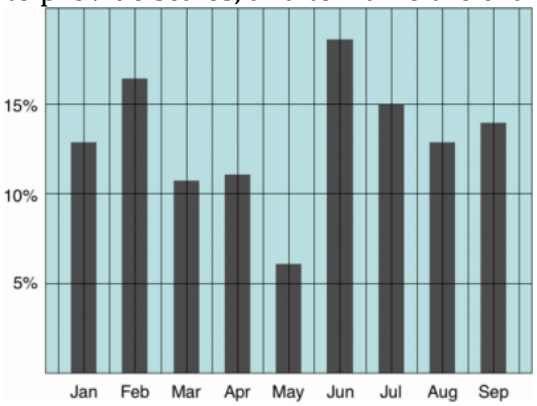
1.18 Signal to noise ratio

Signal-to-noise ratio is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise. The goal of communication is maximizing signal and minimizing noise.
We can improve the signal to noise ratio in our designs by keeping them simple. We can enhance information by using redundant coding and highlighting, and we can remove noise by eliminating unnecessary elements. For tabular data, for example, lines may sometimes be removed if proper alignment or other background solid colours are used to enhance alignments. Bar charts, for instance must avoid textures.

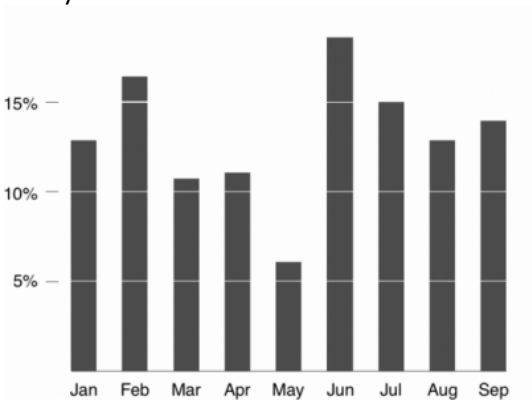
1.20 Ink Ratio

It is the ratio of ink used to frame the graphic with respect to the ink used to represent the actual data.

The ink used to provide scales, axes, labels, and so on, should be less dominant than the used to show the actual data. Otherwise, we are making a poor usage of the ink that will be finally printed (whether this corresponds to a paper or not, does not matter).
The following example shows a bad usage of the ink, because we wasted a lot of ink to provide scales, and to frame the chart with a background colour and a box.

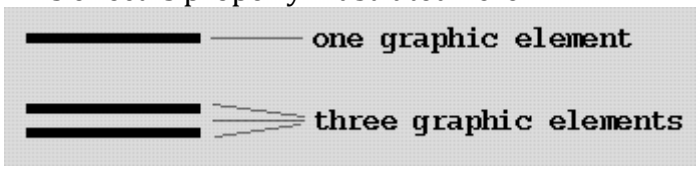


The following example is a modification of the previous chart with a better ratio of data/ink.



1.20 1+1 = 3

Since all the elements in a design are perceived together, some of them, although not designed initially this way, interact. This may create non-information patterns and texture.
This effect is properly illustrated here:



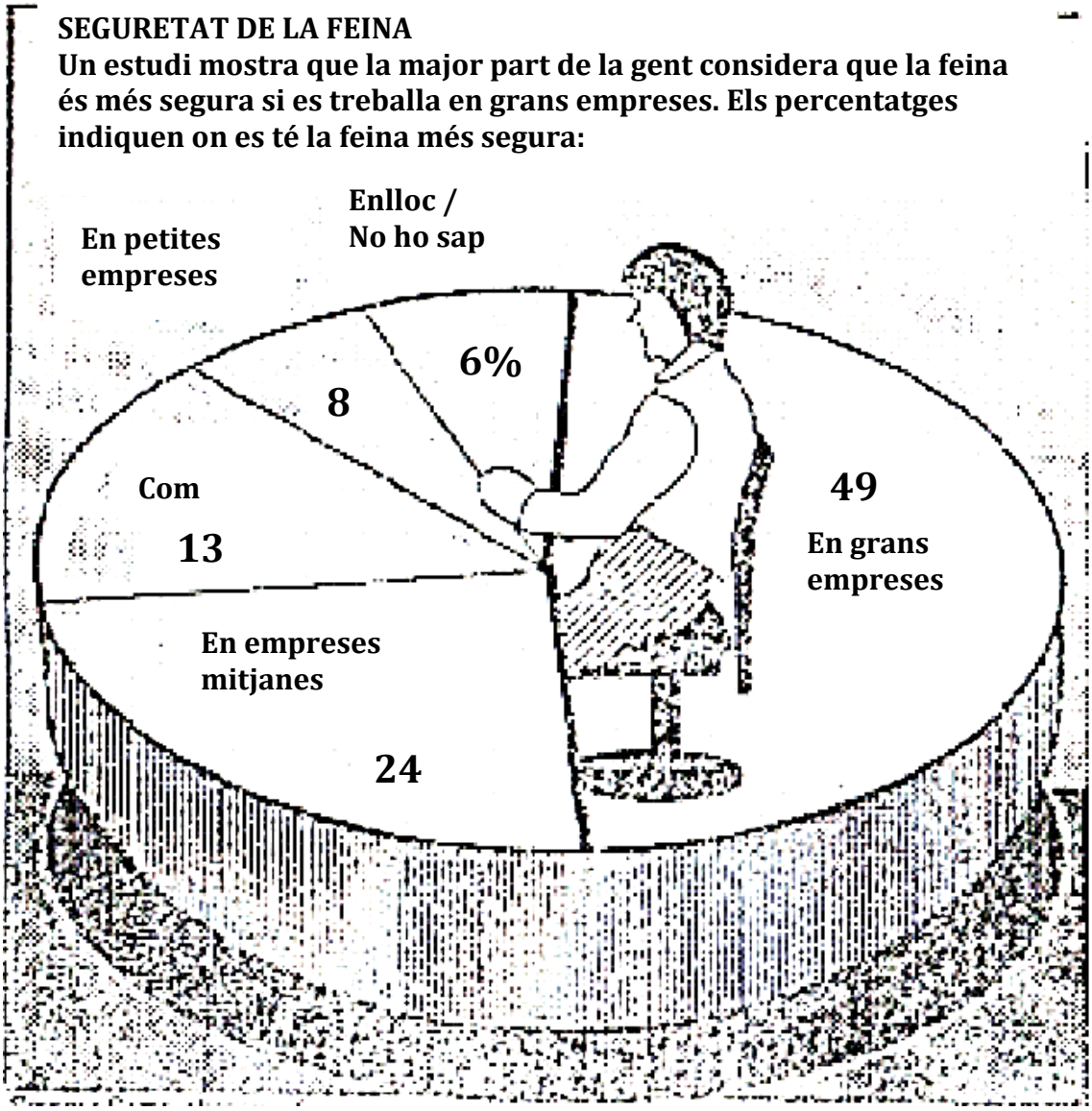
The single line is clearly a single graphic element, while when we add a second line, the empty space lying in between creates a third visual element although it was not intended to. As a consequence, we have three graphical elements, each of the lines and *the space between them*.
This effect is called 1 + 1 = 3. The general result of this effect is that there is an extra effort of the visual system processing something that is not information, but noise and clutter. The noise produced by the 1+1=3 effect is directly proportional to the contrast in value (light/dark) between figure and ground. Therefore, different contrast colors might alleviate the incidental clutter.

A particularly common example is caused by the use of boxes around text, which are commonly discouraged.

1.21 Typical Chart crimes

One of the typical crime is to use pie charts at all.

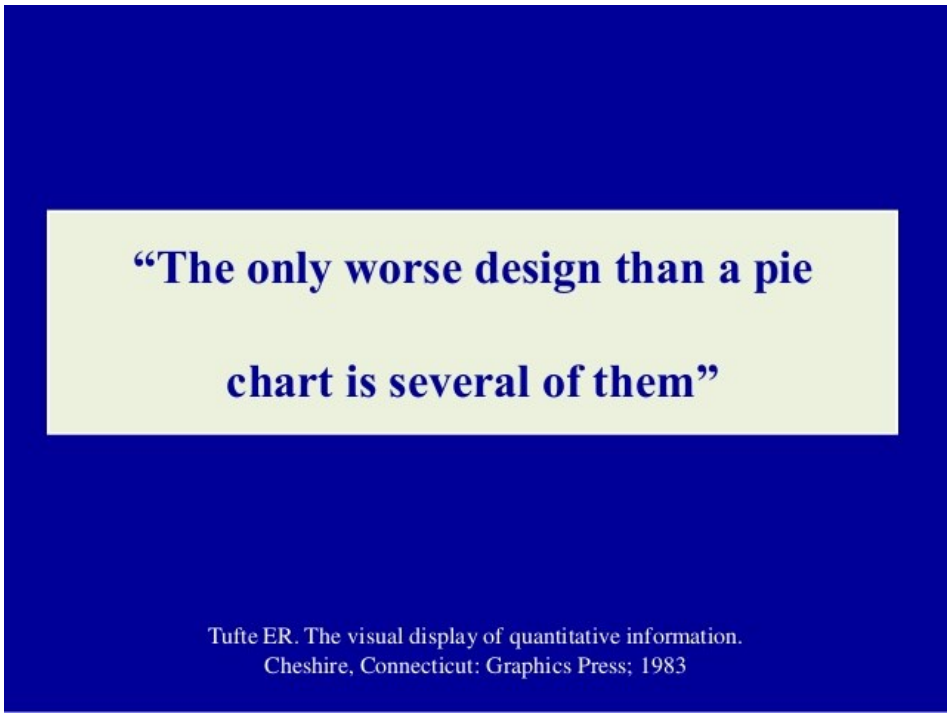
From last year's exam:



There are some major problems here:

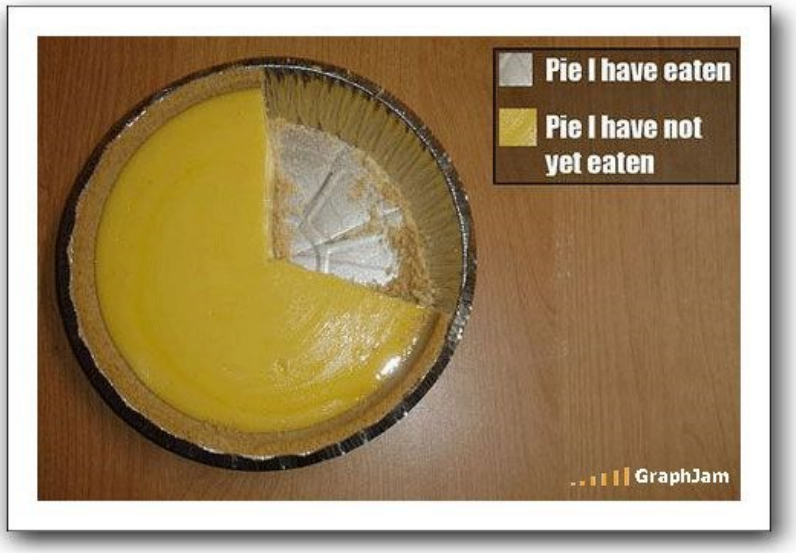
- Note the wrong sizes of pieces representing percentages 8 and 6.
- Note the space occupied in screen by the front pieces, because the projection is perspective, this makes the reader to infer its size is larger than it is, despite the proper percentages being printed.
- The "duck" in the middle of the map.
- Finally, using pie charts is almost never right, since the perception of 2D relative sizes is very difficult for the human eye.

As E. Tufte says:

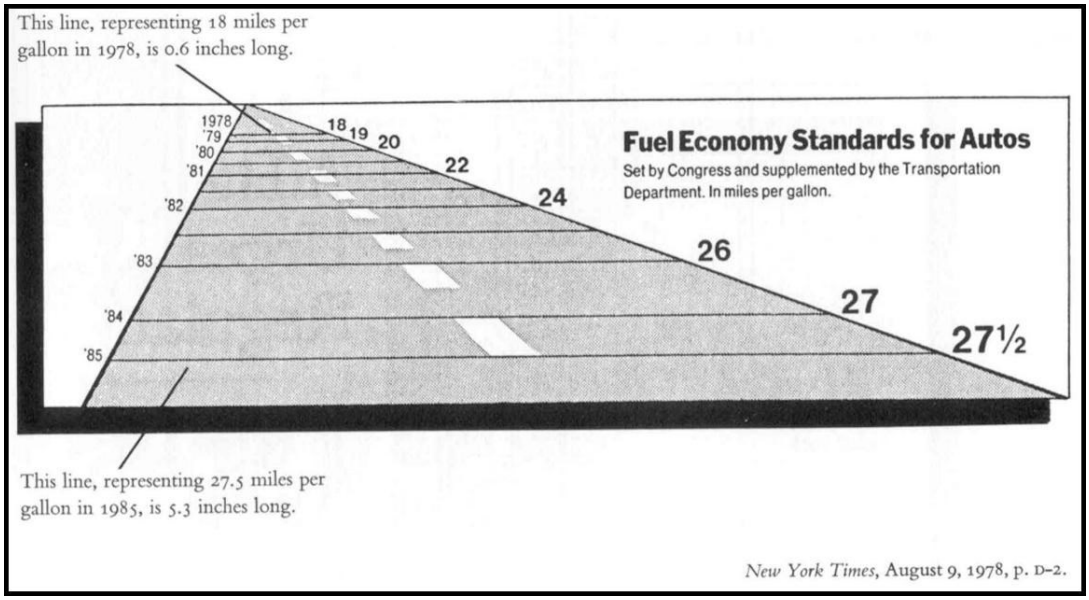


And I put it here with big letters to ensure you do not forget this.

The only time it makes sense to use a pie chart is this:



Another bad example:



Already commented in the chart…

And another, take your measures yourselves…