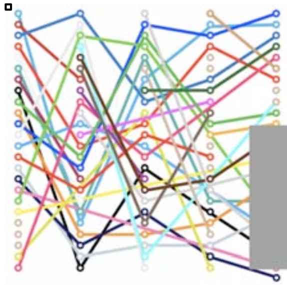
VU 188.305 – VO: 2 hrs. / 3 ECTS



Information Visualization

Visual Perception, Cognition & Visual Encoding

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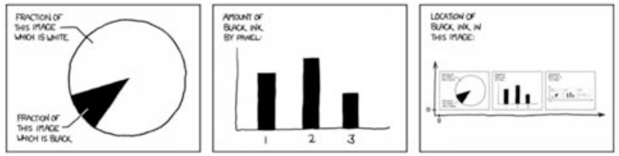


[http://xkcd.com/688/]

Contents

Perception

Perception deals with the human senses that generate signals from the environment through sight, hearing, touch, smell and taste.

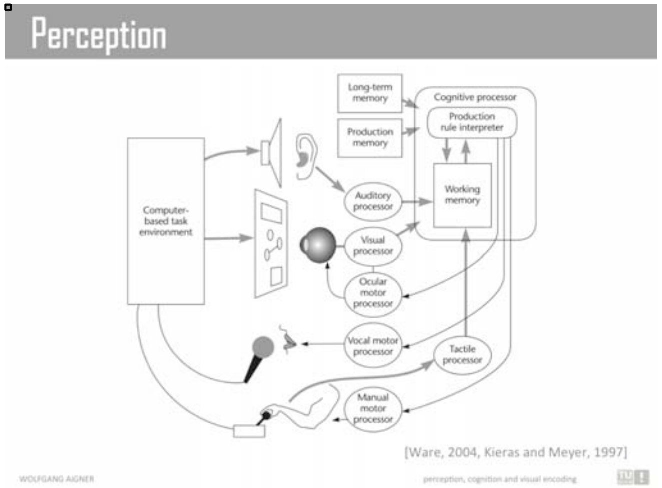
[...] the process of recognizing (being aware of), organizing (gathering and storing), and interpreting (binding to knowledge) sensory information

[Ward et al., 2010]

Simply put, perception is the process by which we
interpret the world around us,
forming a mental representation of the environment.

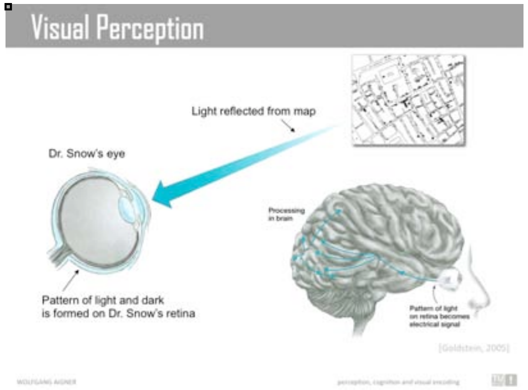
This representation is not isomorphic to the world, but it's subject to many correspondence differences and errors.
The brain makes assumptions about the world to overcome the inherent ambiguity in all sensory data, and in response to the task at hand.

Source: [Ward et al., 2010]



EPIC architecture

Source: [Ware, 2004]



"Conscious experience that results from stimulation of the senses." [Goldstein, 2005]

"Perception is our "window to the world" that enables us to experience what is "out there" in our environment. Thus, perception is the first step in the process that eventually results in all of our cognitions. Paying attention, forming and recalling memories, using language, and reasoning and solving problems all depend--right at the beginning--on perception. Without perception, these processes would be absent or greatly degraded. Therefore it is accurate to say that perception is the gateway to cognition." [Goldstein, 2005]

High bandwidth

Fast screening of a lot of data

Pattern recognition

Visual Problem Solving

- Prevalent in many fields - Engineering, etc
- Faster and less strenuous because visual
- Depends on representation, interaction

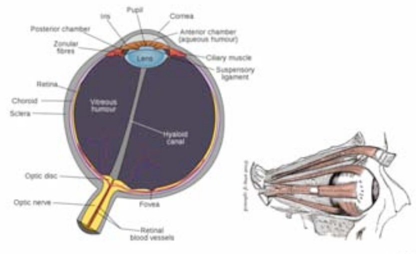
"Perception refers to how information is acquired from the environment, via the different sense organs, e.g. eyes, ears, fingers, and transformed into experiences of objects, events, sounds, and tastes (Roth, 1986). It is complex, involving other cognitive processes such as memore, attention, and language. Vision is the most dominant sense for sighted individuals, followed by hearing and touch. With respect to interaction design it is important to present information in a way that can be readily perceived in the manner intended." [Sharp, Roger, and Preece, Interaction Design, 2nd Edition, p. 99]

ANATOMY OF THE VISUAL SYSTEM

WOLFGANG AIGNER

perception, cognition and visual encoding

Eye



Left figure: horizontal cross-section of the right eye, viewed from above
- the eye is a fluid-filled sphere of light-sensitive cells
- one section open to the outside via a basic lens system
- connected to the head and brain by six motion control muscles and one optic nerve

eye muscles: six muscles are generally considered as motion controllers
- providing the ability to look at objects in the scene
- action of looking at specific areas in the environment involves orienting the eye's optical system to the regions of interest through muscle contractions and relaxations
- Continually making minor adjustments
- eyes are never at rest
- we do not perceive these actions visually

optical system of the eye is similar in characteristic to a doublelens camera system

cornea / Hornhaut: exterior cover to the front of the eye
- protective mechanism against physical damage to the internal structure
- also serves as one lens focusing the light from the surrounding scene onto the main lens

pupil: circular hole in the iris
- similar in function to an aperture stop on a photographic camera

iris: colored annulus containing radial muscles for changing the size of the pupil opening
- determines how much light will enter the rest of the internal chamber of the eye

lens: crystalline structure is similar to onion skin
- the lens can be stretched and compressed
- adjusting the focal length of the optical system
- lens can focus on near and relatively far objects

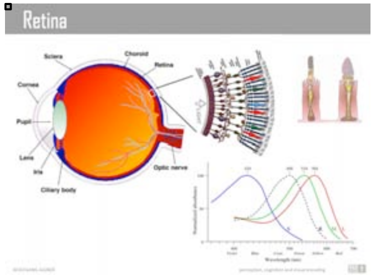
retina / Netzhaut: photoreceptive layer
- process is not as precise as camera optics

blind spot

Source: Ward et al., 2010

Images: Wikimedia commons
http://commons.wikimedia.org/wiki/File:Schematic_diagram_of_the_human_eye_en.svg
http://commons.wikimedia.org/wiki/File:Eyemuscles.jpg

contains the photoreceptors responsible for the visual perception of our external world
two types of photosensitive cells: rods and cones; respond differently to light stimulation



rods / Stäbchen
- intensity perception
- ten times more sensitive to light than cones
- night vision (shades of gray)
- during daylight rods do not contribute to vision
- visible spectrum between approximately 400 and 700 nm

cones / Zäpfchen
- color perception
- day vision
- 3 types of cones
  - S (short) wavelength: red
  - M (medium) wavelength: green
  - L (long) wavelength: blue
- considerably fewer short cones, compared to the number of medium and long wavelength cones

fovea
- small region at the center of the visual axis
- structure of the retina is roughly radially symmetric around the fovea
- contains only cones
- about 147,000 cones per millimeter
- region of sharpest vision
- size: thumb at arm's length

about 120 million rods and 6 million cones

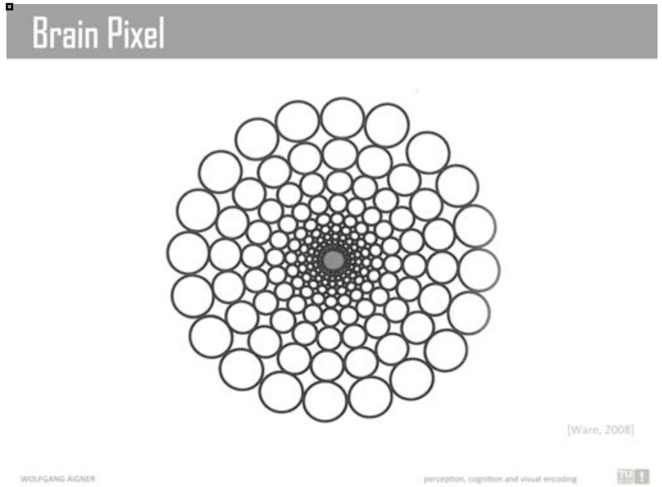
Optic nerve only contains about one million fibers (--> visual processing has to be performed already in the eye)

photosensitive cells are facing away from the light source
- "eyes are actually part of the brain and represent an outgrowth from it,"

The eye contains separate systems for encoding spatial properties (e.g., size, location, and orientation), and object properties (e.g., color, shape, and texture).

retinal processing
- four neuron layers
- initial image processing

Images:
http://commons.wikimedia.org/wiki/File:Cone-response.svg
[Ward et al., 2010]



Unlike pixels of a digital camera, that are uniformly distributed, „brain pixels" of the eye are concentrated around the „fovea".

human vision does not resemble the relatively faithful and largely passive process of modern photography

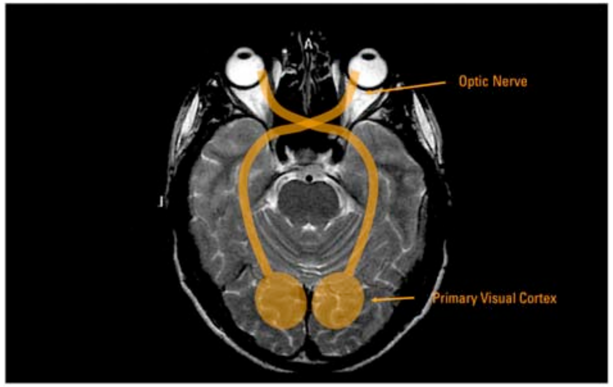
What we see depends as much on our goals and expectations as it does on the light that enters our eyes.

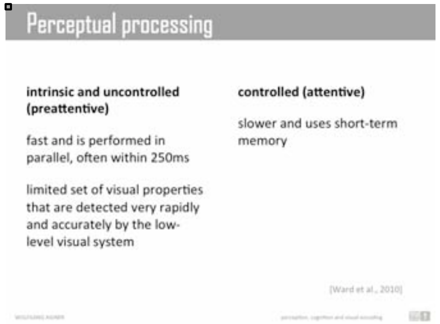
--> both, bottom up & top down

[Ward, Grinstein, Keim, 2010]

VISUAL PROCESSING

Visual Perception





intrinsic and uncontrolled (preattentive) or controlled (attentive).

preattentive perception is fast and is performed in parallel, often within 250ms

limited set of visual properties that are detected very rapidly and accurately by the low-level visual system

Attentive perception is slower and uses short-term memory

Source: Ward et al., 2010

Immediate perception

Immediate understanding - no learning necessary

Behaviour can't be forgotten

Optical illusions are seen even when knowing that they are illusions

Sensual immediacy

Certain phenomena are perceived very quickly because they are not learned but „hardwired" in the brain

Studied by brain research

Effective and stable

Mostly innate and cultural invariant

Phenomena of immediate perception (e.g., color and pattern perception) can be generalized to mankind

But also learned differentiations of the brain: most perceptual processes are based on a combination of innate and learned mechanisms

Conventional representations

Hard to learn

e.g., script

Easy to forget

But there are visual representations that can't be forgotten easily (e.g., numbers)

Embedded within cultural context

Powerful form of representation

e.g., mathematical symbols

Easy to change

Studied by e.g., psychology, sociology, HCI

Stage 1: Parallel Processing to Extract Low-Level Properties of the Visual Scene
Stage 2: Pattern Perception
Stage 3: Sequential Goal-Directed Processing

Stage 1: Parallel Processing to Extract Low-Level Properties of the Visual Scene

Visual information is first processed by large arrays of neurons in the eye and in the primary visual cortex at the back of the brain.

Individual neurons are selectively tuned to certain kinds of information, such as the orientation of edges or the color of a patch of light.

billions of neurons work in parallel, extracting features from every part of the visual field simultaneously

proceeds whether we like it or not, and it is largely independent of what we choose to attend to

Important characteristics

Rapid parallel processing

Extraction of features, orientation, color, texture, and movement patterns

Transitory nature of information, which is briefly held in an iconic store

Bottom-up, data-driven model of processing

Stage 2: Pattern Perception

rapid active processes divide the visual field into regions and simple patterns, such as continuous contours, regions of the same color, and regions of the same texture.

Patterns of motion are also extremely important

pattern-finding stage of visual processing is extremely flexible

influenced both by the massive amount of information available from Stage 1 parallel processing and by the top-down action of attention driven by visual queries

increasing evidence that tasks involving eye–hand coordination and locomotion may be processed in pathways distinct from those involved in object recognition

two–visual system hypothesis

one system for locomotion and action, called the "action system,"

one system for symbolic object manipulation, called the "what system."

Important characteristics

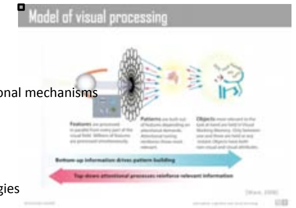
Slow serial processing

Involvement of both working memory and long-term memory

More emphasis on arbitrary aspects of symbols

In a state of flux, a combination of bottom-up feature processing and top-down attentional mechanisms

Different pathways for object recognition and visually guided motion



Stage 3: Sequential Goal-Directed Processing

objects held in visual working memory by the demands of active attention

we construct a sequence of visual queries that are answered through visual search strategies

only a few objects can be held at a time

constructed from the available patterns providing answers to the visual queries

For example, if we use a road map to look for a route, the visual query will trigger a search for connected red contours (representing major highways) between two visual symbols (representing cities).

Source: Ware, 2004

There are two fundamental ways in which visualizations support thinking:

by supporting visual queries on information graphics

For visual queries to be useful, the problem must first be cast in the form of a query pattern that, if seen, helps solve part of the problem.

For example, finding a number of big red circles in a GIS display may indicate a problem with water pollution. Finding a long, red, fairly straight line on a map can show the best way to drive between two cities.

by extending memory

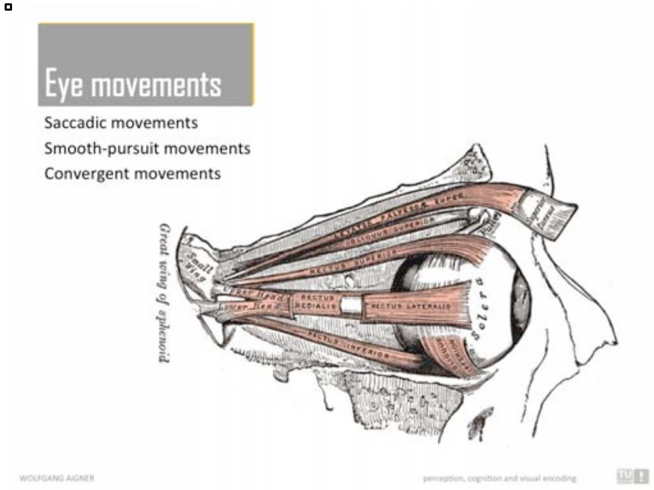
Memory extension comes from the way a display symbol, image, or pattern can rapidly evoke nonvisual information and cause it to be loaded from long-term memory into verbal- propositional processing centers.

Source: Ware, 2004

Postattentive Processing

The preattentive visual perception doesn't save any information about the scene

Source: Mazza, 2009



We constantly make eye movements to seek information.

three important types of eye movement:

Saccadic movements

In a visual search task, the eye moves rapidly from fixation to fixation.

During the course of a saccadic eye movement, we are less sensitive to visual input than we normally are

Smooth-pursuit movements

When an object is moving smoothly in the visual field, the eye has the ability to lock onto it and track it.

Convergent movements

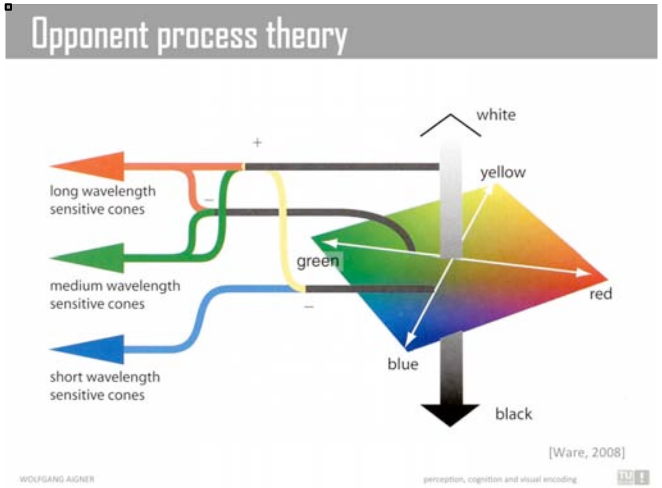
When an object moves toward us, our eyes converge.

Long-Term Memory

can be usefully characterized as a network of linked concepts

Long-term memory and working memory appear to be overlapping, distributed, and specialized.

Source: Ware, 2004

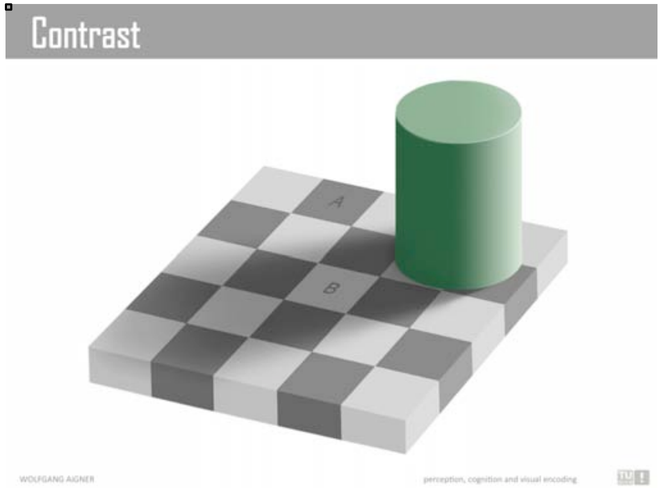


Color-opponent channels

- red-green (difference between mid and long wavelength cones)
- yellow-blue (difference between luminance and short wavelength)
- black-white (luminance – combines long and mid wavelength cones)

Transformation is performed in V1 (primary visual cortex)

Source: [Ware, 2008]



distortion of a patch of color in a way that increases the difference between a color and its surroundings

often thought of as an illusion, but helps to see surface colors in the real world

visual system is better at determining differences than absolute values

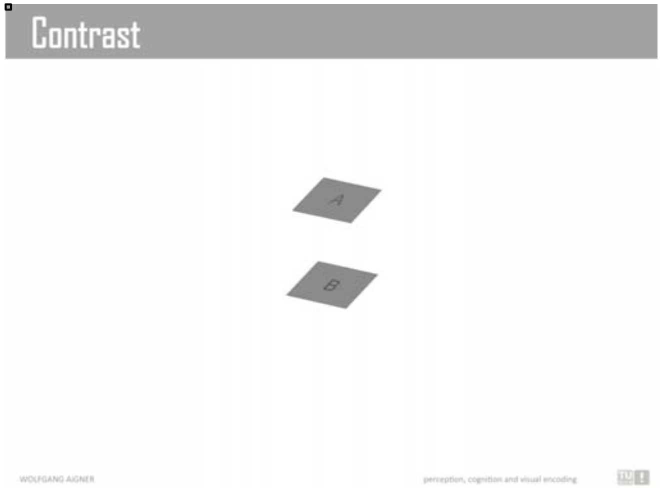
Source: Ware, 2008

ability to ignore the color of the ambient light in order to zero in on the true color of a surface.

Source: Enns, 2004

Image:

http://commons.wikimedia.org/wiki/File:Grey_square_optical_illusion.PNG



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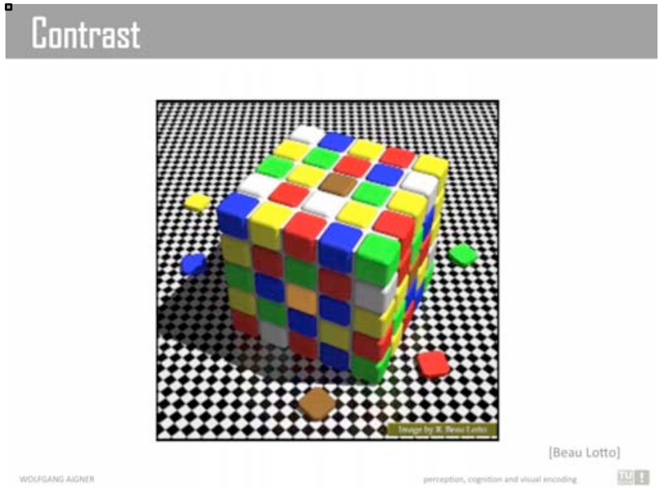
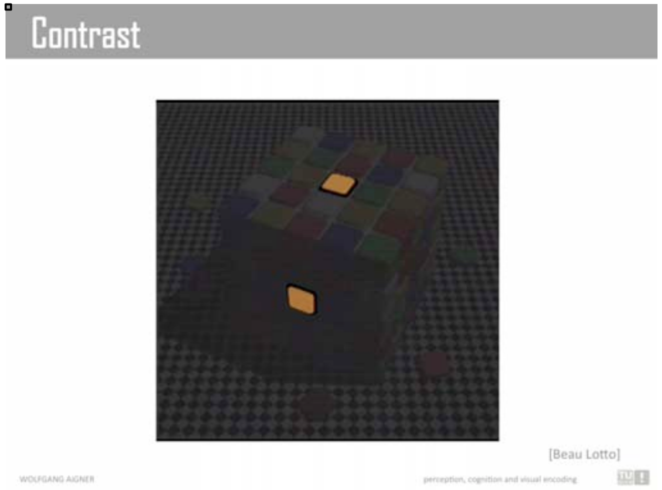
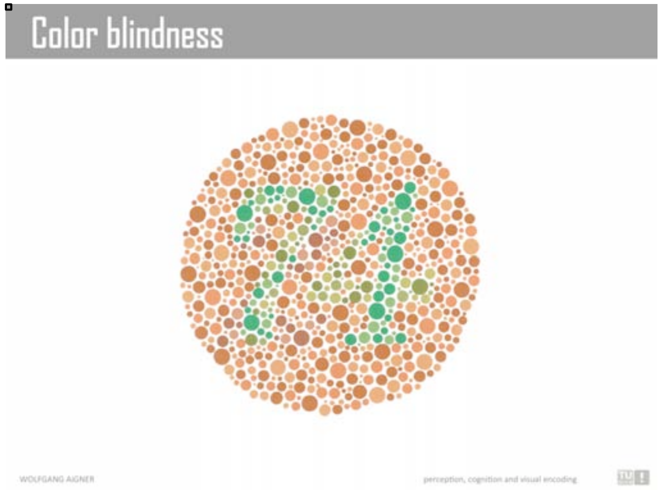






8 percent of males

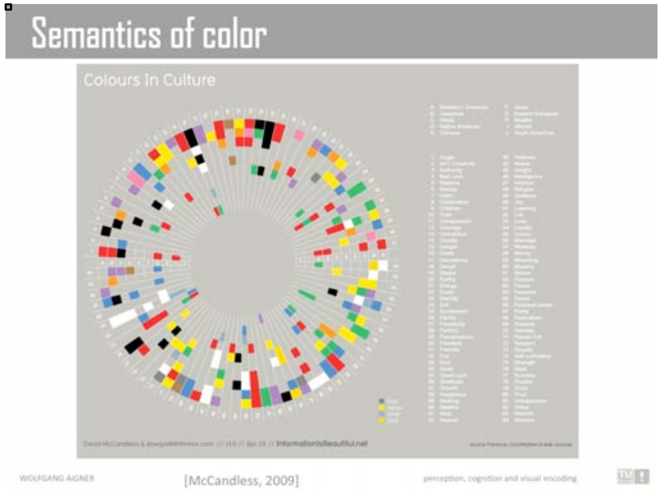
mostly missing red-green channel

Source: Ware, 2008

The numeral "74" should be clearly visible to viewers with normal color vision. Viewers with dichromacy or anomalous trichromacy may read it as "21", and viewers with achromatopsia may not see numbers.

Image:

http://en.wikipedia.org/wiki/Color_blindness



Colors have different meanings in different cultures

Sources: [Ward et al., 2010, McCandless, 2009]

"automatically" - below the level of consciousness

It sometimes happens that certain elements of a graphic representation, maybe a colour or an icon "pop out". We detect them instantaneously.

make elements stand out / pop out

These phenomena, whose visual identification is performed in a very short time lapse (typically between 200 and 250 miliseconds or less) are called pre-attentive since they occur without the intervention of consciousness. There's no need to focus on the search task. Even when they are hidden among many other objects they are identified immediately.

the conjunction of several pre-attentive elements can reduce its effect and limit its pre-attentive processing

A target made up of a combination of non-unique features (a conjunction target) normally cannot be detected preattentively.

Immediate perception

Immediate understanding - no learning necessary

Behaviour can't be forgotten

Optical illusions are seen even when knowing that they are illusions

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Preattentive Processing

1561321203658413076510374 6274
17312752732759273299070974217
03707774179527931749270973401
974321790937094517927941 7

15613212036584130765103746274
17312752732759273299070974217
03707774179527931749270973401
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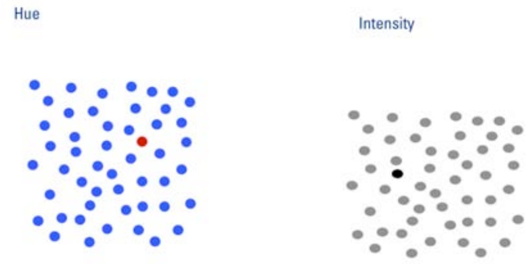
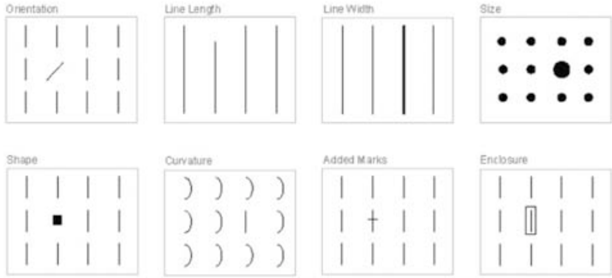
Example uses preattentive attribute "color"

Color



[Dürsteler, 2006]

Form



Applet:
http://www.csc.ncsu.edu/faculty/healey/PP/index.html

[Few, 2004]

Line orientation. A line with a different orientation of that of the surrounding distractors.

Line length. A change in the length of the line compared to those of the surrounding distractors.

Line width. The same as before but with width.

Size. An object of different size of the distractors.

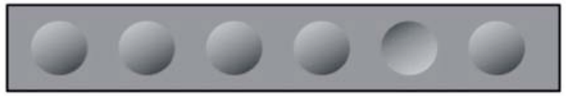
Shape.

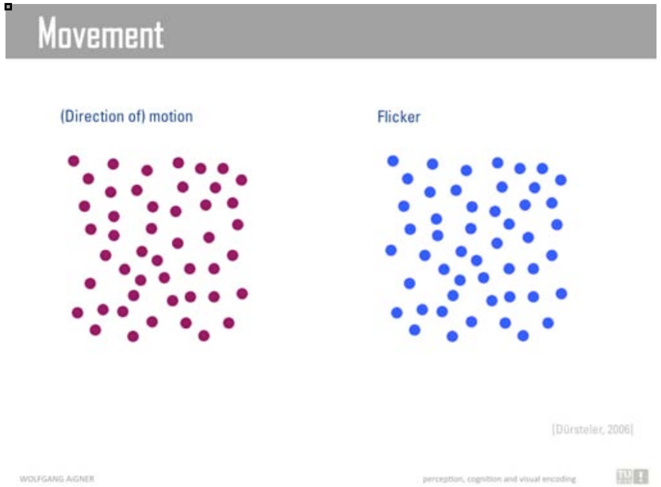
Curvature. A straight line is clearly perceived if surrounded by curved ones.

Added marks. making a mark, like circling around an object makes it "pop out".

Spatial position

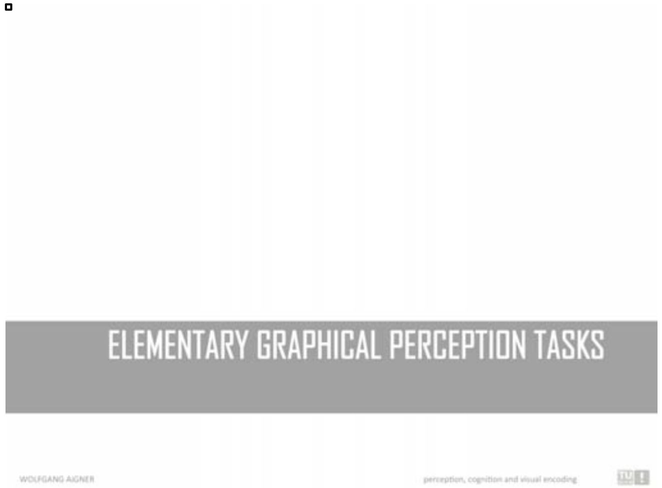
2D position
Stereoscopic depth
Concavity convexity





Direction of motion. An object moving against a still background or in relation with a homogeneously moving background in a different direction is detected immediately.

Flicker. An element that appears and disappears, the blinking of a car signal or the flashes of the anti collision lights of the planes are detected pre-attentively. For this reason they are used as safety elements in aviation, populating planes, antennas and potentially dangerous obstacles.



Mapping Data to Preattentive Attributes

preattentive attributes are very powerful, as they are immediately perceived without the need for conscious attention

C. Ware: “the most important contribution that vision science can make to data visualization”

the number of preattentive attributes that can be used in a single representation, and the number of visual distinctions of a single attribute, are limited

Ware [65] suggests limiting to no more than eight different hues, four different orientations, four different sizes, and all the other visual preattentive attributes to less than 10 distinct values.

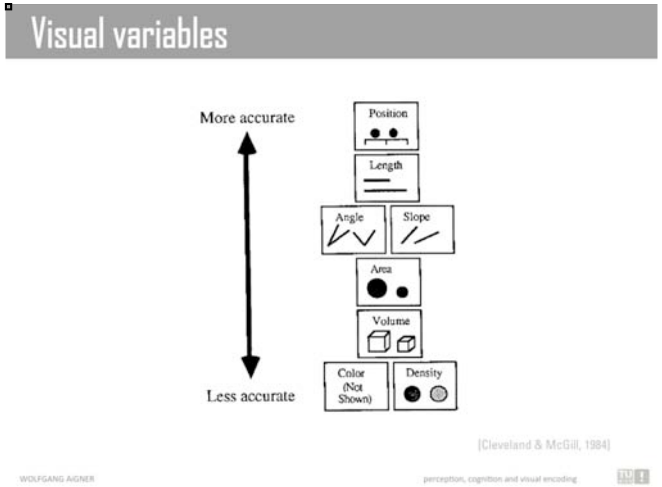
Few [19] instead chooses a more prudent approach and suggests limiting the number of distinctions, for any attribute, to no more than four.

the combination of particular preattentive attributes cannot usually be detected preattentively

Cleveland and McGill & Mackinlay

studies & ranking

Source: Mazza, 2009

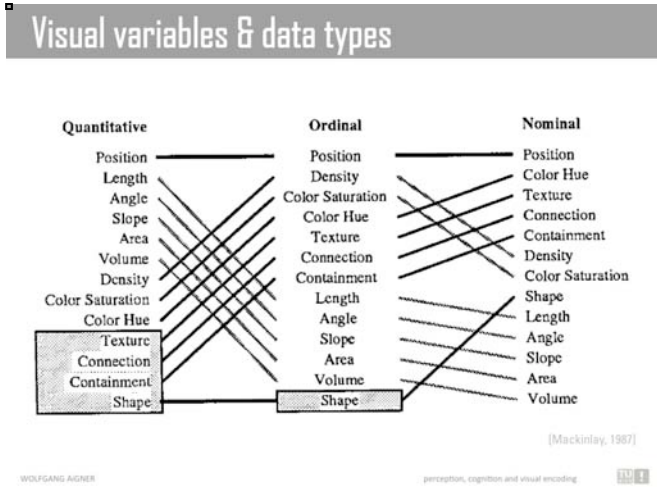


Perceptual principles - preattentive processing, Gestalt laws
Appropriateness of visual variables dependent of scale type.

Cleveland & McGill

how well humans gauge differences

detection of differences, rather than extracting a numeric value



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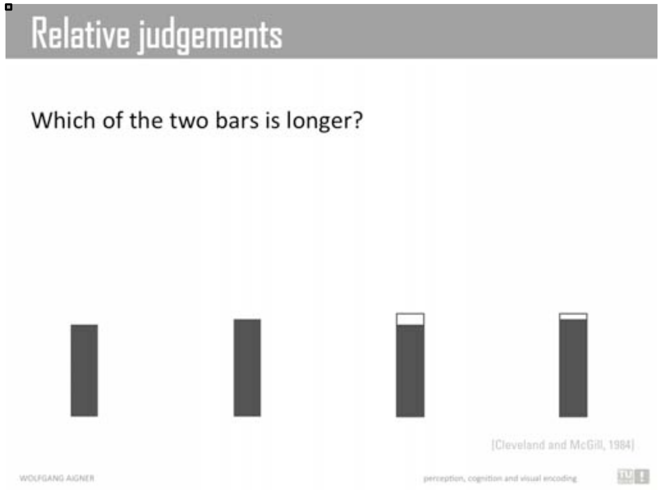


Obey perceptual principles

Preattentive features

Gestalt Laws

[Cleveland and McGill, 1984]

Weber's Law

the likelihood of detecting a change is proportional to the relative change, not the absolute change, of a graphical attribute

[Ward et al., 2010]

Steven's Law

As the dimension of an attribute increases, the degree at which we underestimate it increases

[Ward et al., 2010]

[Ward, Grinstein, Keim, 2010, p. 123]

GESTALT PRINCIPLES

[Max Wertheimer, Kurt Koffka, and Wolfgang Kohler (1912)]

Laws of perceptual organization

- mind groups patterns according to rules
- reflect things we know from long experience in our environment and because we are using them unconsciously all the time
- more "heuristics" than "laws" because they might also be misleading
- Gestalt school of psychology - began in 1912

Gestalt Laws are Useful as Design Guidelines

Gestalt's basic principle is that the whole (the picture of the house) is not the simple sum of its parts (the triangle and rectangles) but has a greater meaning than its individual components.

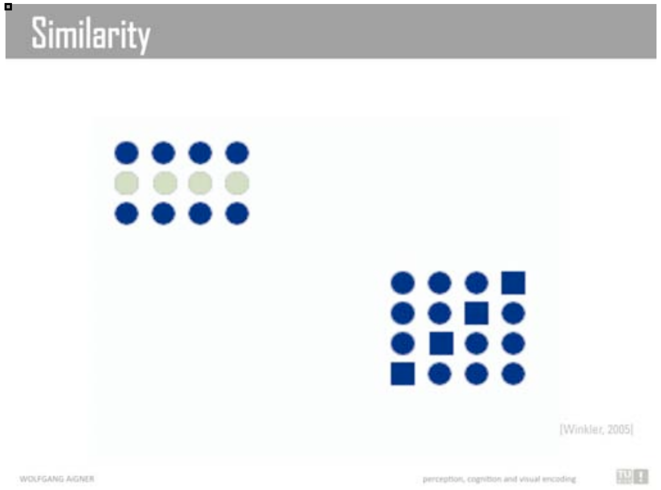
Gestalt principles aim to define the rules according to which human perception tends to organize visual elements into a "unified whole," also referred to as groups (from which the German term gestalt derives.)

Source: Mazza, 2009

Proximity

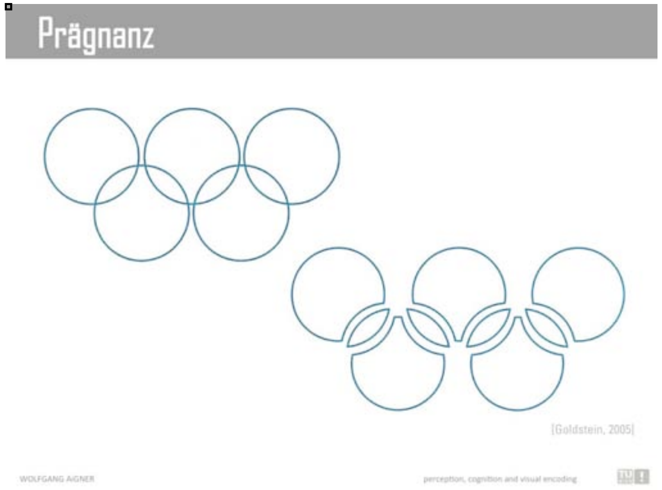
[Winkler, 2005]

Things that are near to each other appear to be grouped together.



Similar things appear to be grouped together.

If several stimuli are presented together, there is a tendency to see the form in such a way that the similar items are grouped together.



also: law of simplicity

Every stimulus pattern is seen in such a way that the resulting structure is as simple as possible.

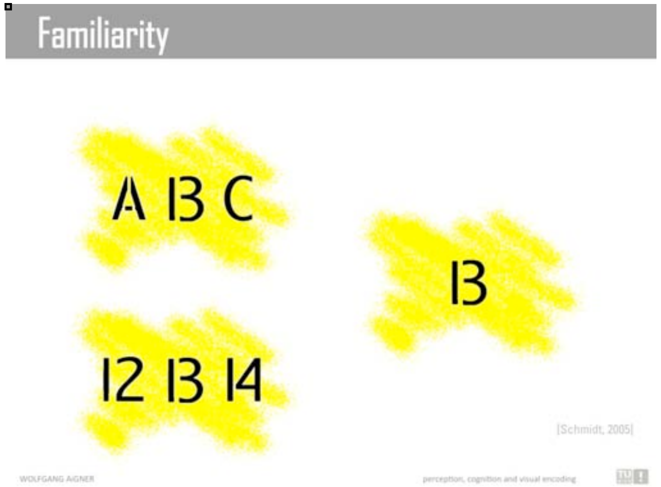
Good Continuation

Points which, when connected, result in straight or smoothly curving lines, are seen as belonging together, and the lines tend to be seen as following the smoothest path.

Visual Entities Tend to be Smooth and Continuous

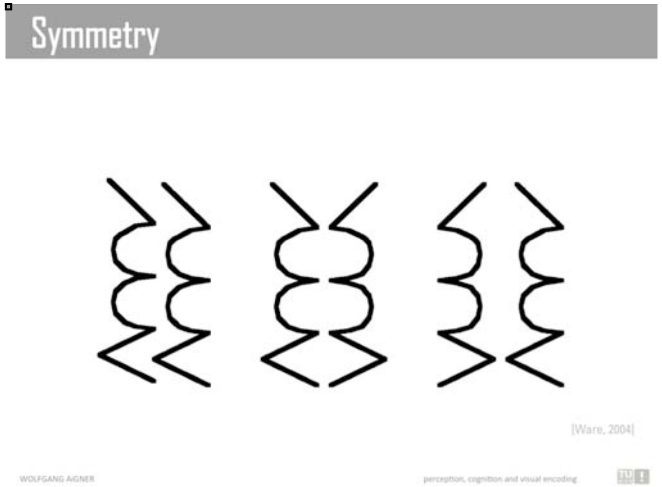
Common Fate

Things that are moving in the same direction appear to be grouped together.



Things are more likely to form groups if the groups appear familiar or meaningful.

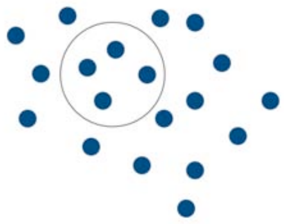
Effect of Past Experience



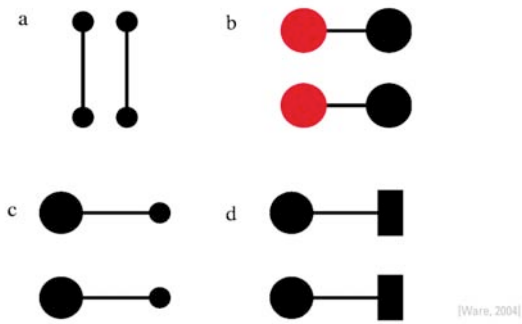
Symmetry Create Visual Whole

Prefer Symmetry

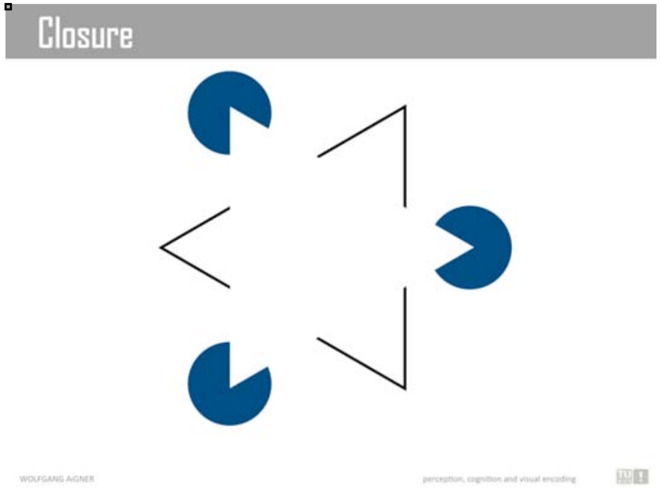
Enclosure



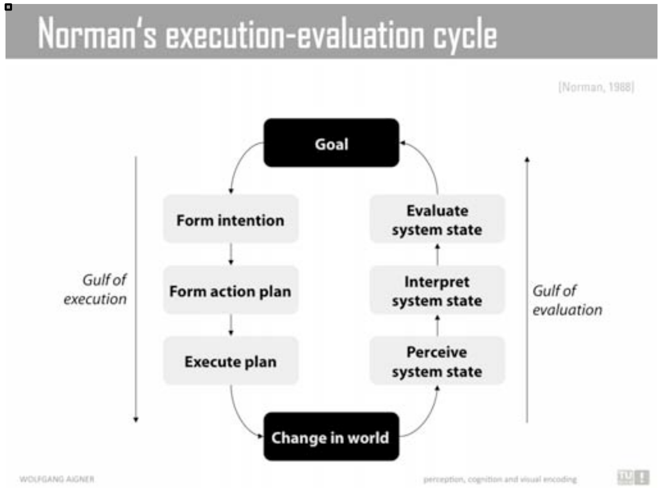
Connection

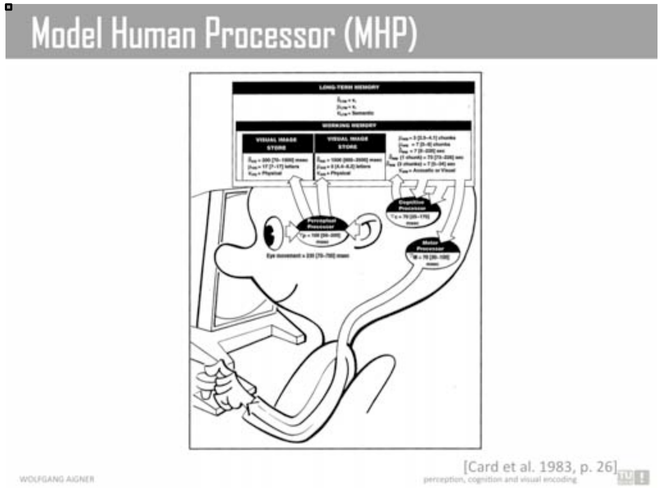


Stronger than other principles



The tendency to unite contours that are very close to each other.



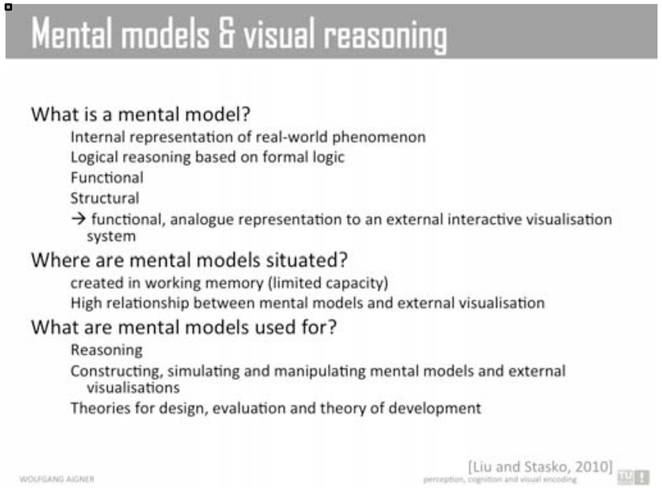


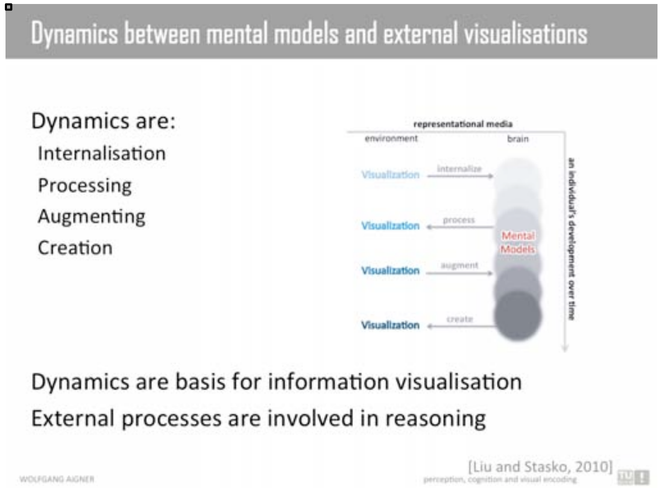
MHP

- Model Human Processor
- system of different types of memories and processors

GOMS

- Framework for task analysis
- Goals, Operators, Methods, Selection rules
- describes hierarchical procedural knowledge needed to complete a task





Internalisation:
Internalisation is getting the visualisation into the brain
Includes encoding of information abstracted from perception
Visualisation and underlying data without connection makes no sense

Processing:
Internalized models can create new visualisations
Structural properties are preserved in the mental model

Augmentation:
After the process step the changed external visualisation augment internal visual models
This models are basis for reasoning using visualisations
internalized visualisation and simulations help in reasonmaking and sensemaking

Creation:
Mental models as basis for novel visual design
Cognitive basis for creativity and innovation
Creation and simulation of mental models can rise new concepts, designs

Cognitive Offloading

Create

Creating stable representations of internal structures

Save/Load

Save the state of a visualisation

Bookmark the state for later retrieval

Automatically logging of visualisation state

External Anchoring

Project

Projection is done when eye fixation and movements

Project mental structures onto visual forms

InfoVis has material anchors like text labels

Reasoning process requires stable representation

Locate

Locating is generated by eye scanning across the screen when visual item is labeled

User creates conceptual structure and needs external representation to anchor it

Locate the appropriate representational anchors for external coupling

Information Foraging

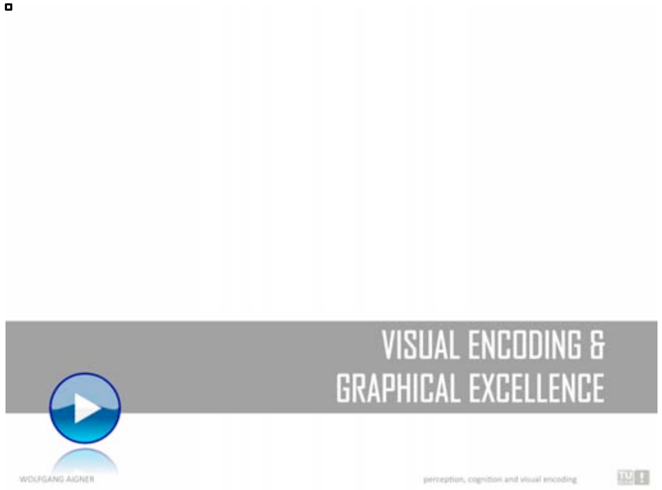
Restructure

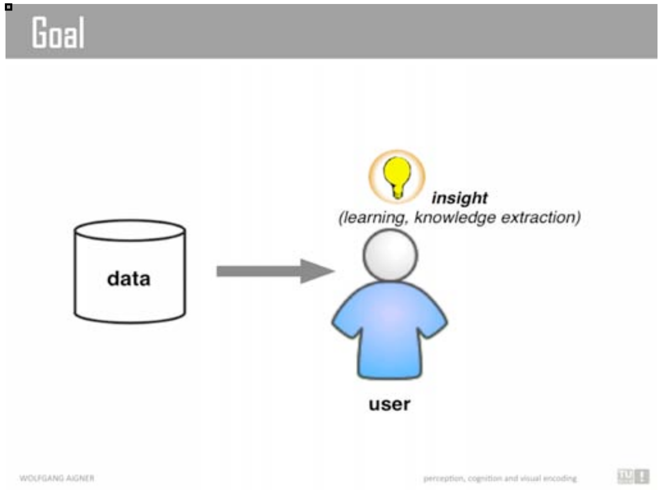
Data restructure leads to new information about data when sorting or color mapping or new visual representation (sometimes randomly done)

Explore

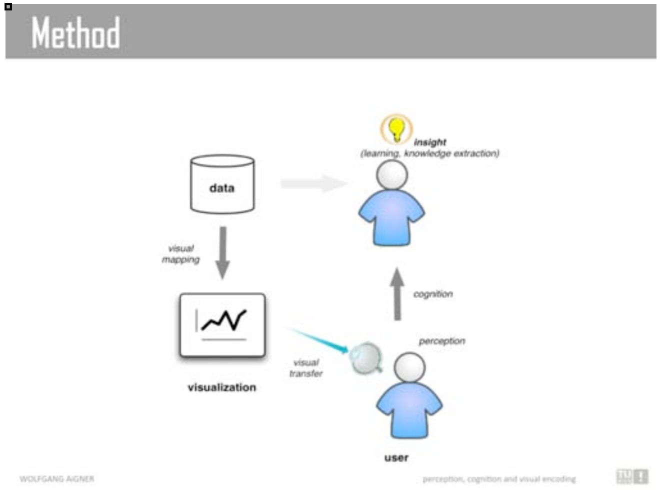
Explore environment to find information

Locating has a target – exploring not





“The purpose of computing is insight not numbers.” - Richard Hamming (1961)

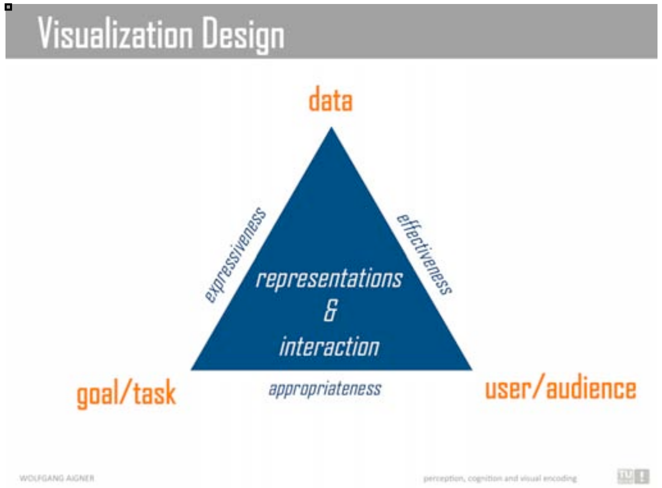


How do we convert abstract information into a visual representation?

Giving form to information so it can be understood

- Example Movie DB
- While still preserving the underlying meaning
- And at the same time providing new insight?

"A general design principle is that information needs to be represented in an appropriate form to facilitate the perception and recognition of its underlying meaning." [Sharp, Roger, and Preece, Interaction Design, 2nd Edition, p. 99]



Kind of representations?

graphical representation

text

table

animation

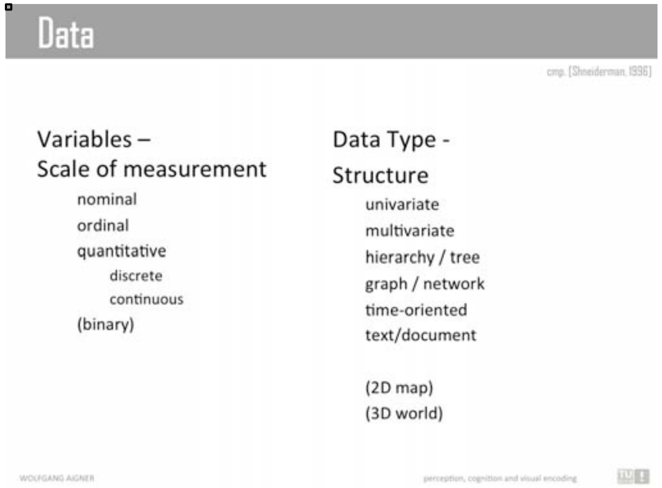
...

Medium?

Magazine

Webpage

...



Data: Example

FilmID	230	105	540	…
Title	Goldfinger	Ben Hur	Ben Hur	…
Director	Hamilton	Wyler	Niblo	…
Actor	Connery	Heston	Novarro	…
Actress	Blackman	Harareet	McAvoy	…
Year	1964	1959	1926	…
Length	112	212	133	…
Popularity	7.7	8.2	7.4	…
Rating	PG	G	G	…
Film Type	Action	Action	Drama	…

Data: Example

Nominal Ordinal Quantitative

FilmID	230	105	540	…
Title	Goldfinger	Ben Hur	Ben Hur	…
Director	Hamilton	Wyler	Niblo	…
Actor	Connery	Heston	Novarro	…
Actress	Blackman	Harareet	McAvoy	…
Year	1964	1959	1926	…
Length	112	212	133	…
Popularity	7.7	8.2	7.4	…
Rating	PG	G	G	…
Film Type	Action	Action	Drama	…

Data type / structure: multivariate

Tasks

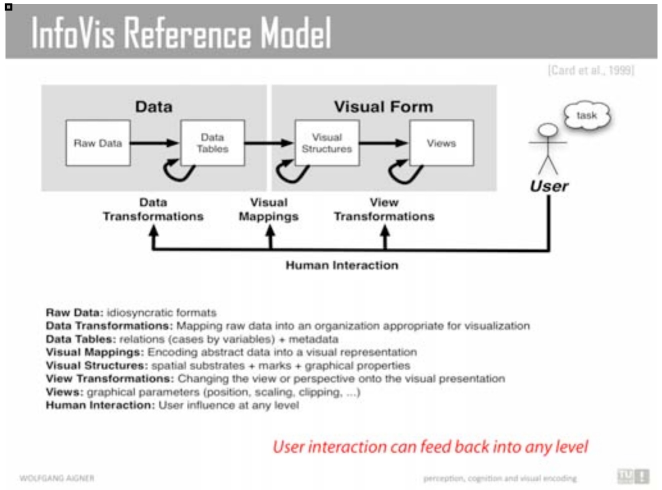
[Shneiderman, 1996]

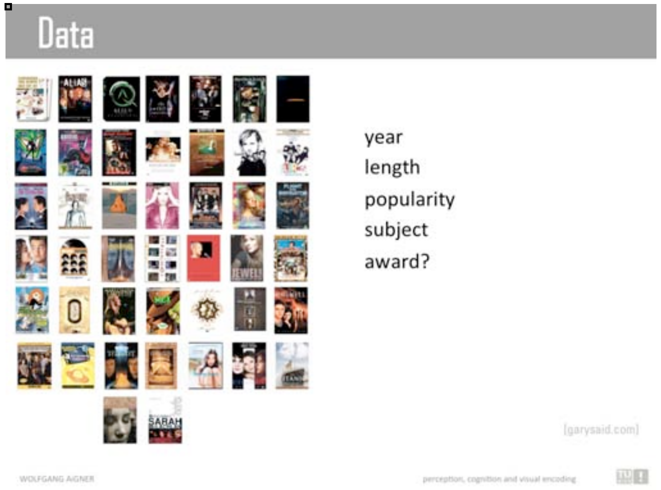
1	overview	gain an overview of the entire set of data
2	zoom	adjust the size of items of interest
3	filter	remove uninteresting items
4	details-on-demand	select one or more items and get details
5	relate	identify relationships between items
6	history	keep a history of actions to support undo/redo
7	extract	extract subsets of items for separate analysis

Visual Information Seeking Mantra

[Shneiderman, 1996]

overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand



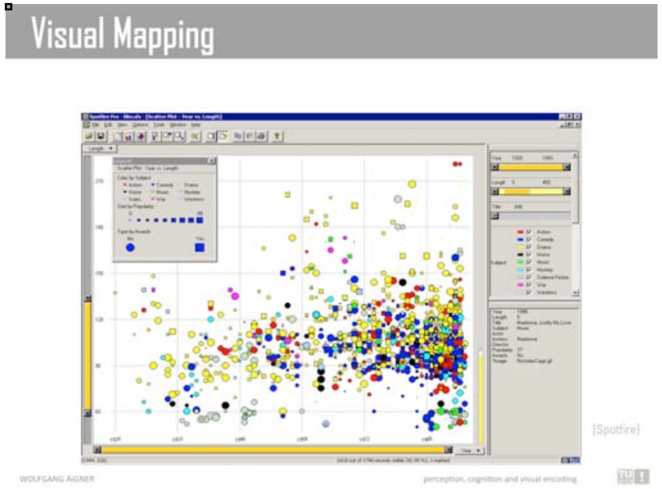


variables

- year
- length
- popularity
- subject
- award?

Demo: Tableau

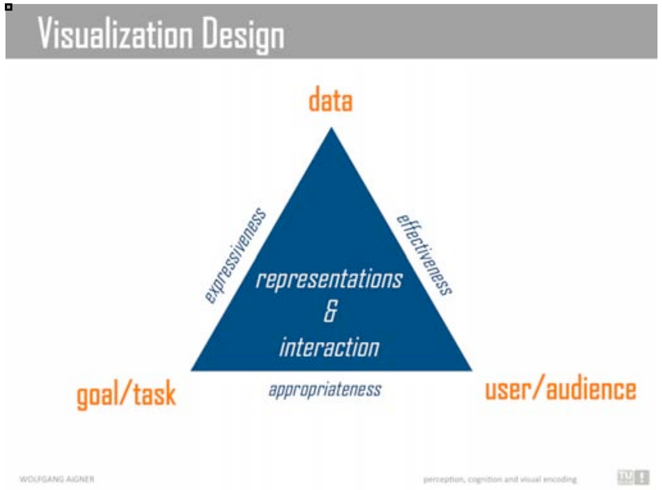
www.**tableausoftware**.com



visual mapping

- films --> visual mark
- year --> x
- length --> y
- popularity --> size
- subject --> color
- award? --> shape

Task dependency



Kind of representations?

- graphical representation
- text
- table
- animation
- ...

Medium?

- Magazine
- Webpage
- ...

Expressiveness

A visualization is considered to be **expressive** if the relevant information of a dataset (and only this) is expressed by the visualization. The term "relevant" implies that expressiveness of a visualization can only be assessed regarding a **particular user** working with the visual representation to achieve **certain goals**.

*„A visualization is said to be expressive **if and only if** it encodes **all the data relations** intended and **no other** data relations.“* [Card, 2008, p. 523]

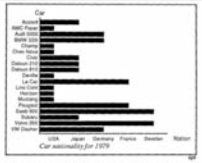


Fig. 11. Incorrect use of a bar chart for the *Nation* relation. The lengths of the bars suggest an ordering on the vertical axis, as if the USA cars were longer or better than the other cars, which is not true for the *Nation* relation.

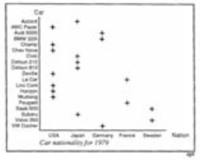


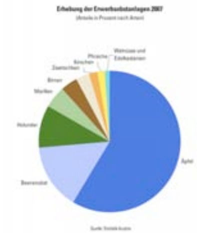
Fig. 12. Correct use of a plot chart for the *Nation* relation. Since bar charts encode ordered domain sets, plot charts are conventionally used to encode nominal domain sets. The ordering of the labels on the axes is ignored.

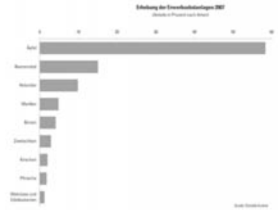
[Mackinlay, 1986]

Effectiveness

A visualization is effective if it **addresses the capabilities of the human visual system**. Since perception, and hence the mental image of a visual representation, varies among users, effectiveness is **user-dependent**. Nonetheless, some general rules for effective visualization have been established in the visualization community.

„Effectiveness criteria identify which of these graphical languages [that are expressive], in a given situation, is the most effective at exploiting the capabilities of the output medium and the human visual system.“ [Mackinlay, 1986]





Appropriateness

[Schumann and Müller, 2000]

Appropriateness regards the tradeoff between efforts required for creating the visual representation and the benefits yielded by it. If this tradeoff is balanced, the visualization is considered to be appropriate.

Model of Van Wijk:

- *n* users use visualization *V* to visualize a data set *m* times each where each session takes *k* exploratory steps and time *T*
- C_i ... Initial development costs
- C_u ... Initial costs per user (e.g., selection, acquisition, learning, tailoring)
- C_s ... Initial costs per session (e.g., data conversion, specification)
- C_e ... Perception and exploration costs (e.g., spend time to view and understand, modify, and tune)
- $W(\Delta K)$ ... Value of acquired knowledge $\Delta K = K(T) - K(0)$

Total costs:

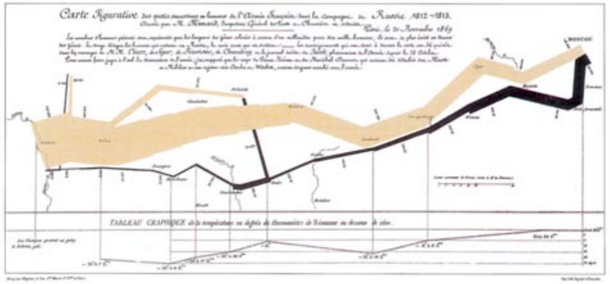
$$C = C_i + n*C_u + n*m*C_s + n*m*k*C_e$$

Overall profit:

$$F = n*m*(W(\Delta K) - C_s - k*C_e) - C_i - n*C_u$$

[Van Wijk, 2006]

Graphical Excellence



Charles Joseph Minards famous map of Napoleons Russian campaign

6 variables: the *size* of the army, its *two-dimensional location* (latitude and longitude), the *direction* of the army's movement, and *temperature* on various *dates* during the retreat from Moscow.

"A good graph is quiet and lets the data tell their story clearly and completely." [Wainer, 1997]

Expressiveness

- Encodes all data
- Encodes only the data
- A visualization is considered to be expressive if the relevant information of a dataset (and only this) is expressed by the visualization. The term "relevant" implies that expressiveness of a visualization can only be assessed regarding a particular user working with the visual representation to achieve certain goals.

Effectiveness

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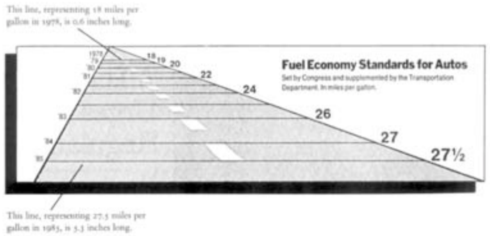
Appropriateness

- Appropriateness regards the tradeoff between efforts required for creating the visual representation and the benefits yielded by it. If this tradeoff is balanced, the visualization is considered to be appropriate.

Tell the truth about the data



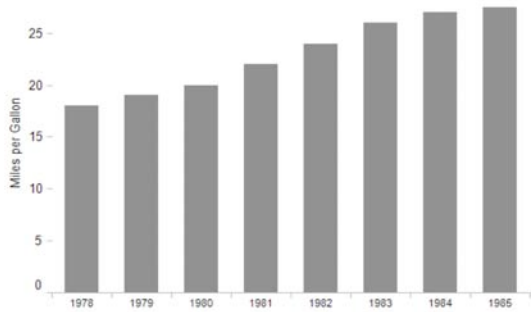
$$\text{Data Effect} = \frac{27.5 - 18}{18} = 0.53, \qquad \text{Graph Effect} = \frac{5.3 - .6}{.6} = 7.83,$$

[Tufte, 1983]

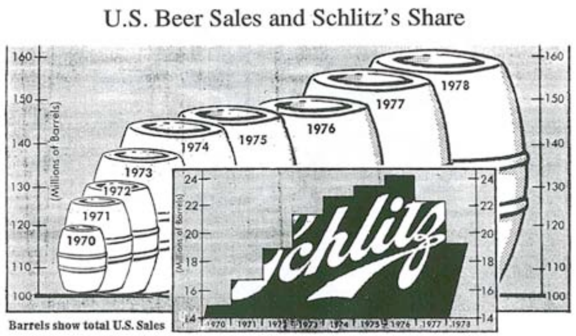
$$\text{Lie Factor} = 14.8$$

Visual attribute value should be directly proportional to data attribute value
Lie factor = Size of effect shown in graphic / Size of effect in data

Fuel Economy Standard Redesign



Lie Factor



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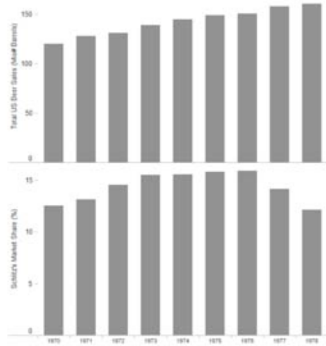
r=3 r=12

Effect in the data: (160-120)/120 = 0,33

Effect in the graphic: (27*142,6 - 565,5)/565,5 = 47

Lie Factor = 47/0,33 = 141

Beer Sales Redesign



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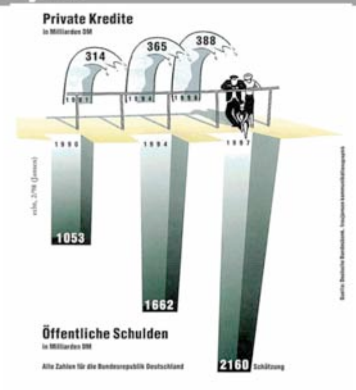
Avoid Chartjunk



[Jansen & Scharfe, 1999]

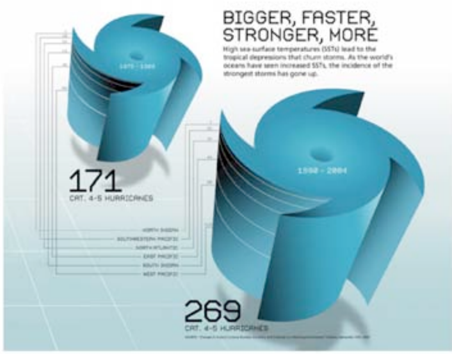
Extraneous visual elements that detract from message.

Tufte Design Principles

1. Above all else show the data.
2. Maximize the data-ink ratio.
3. Erase non-data-ink.
4. Erase redundant data-ink.
5. Revise and edit.

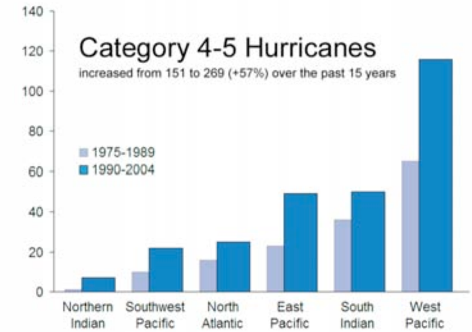
[Tufte, 1983]

Example



[Seed, 2006] Edit Staff, State of the Planet - Bigger, Faster, Stronger, More, Seed - seedmagazine.com, Created at: April 20, 2006, Retrieved at: June 21, 2006. http://www.seedmagazine.com/news/2006/04/state_of_the_planet.php

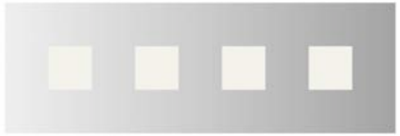
Redesign



[Weber et al., 2006] Sonja Weber, Christof Kopfer, Matteo Savio, Nicole Brosch, Category 4-5 Hurricanes, Created at: November 14, 2006, Retrieved at: November 3, 2009. http://www.infovis-wiki.net/index.php?title=Image:Verbessert3.jpg

Using Color

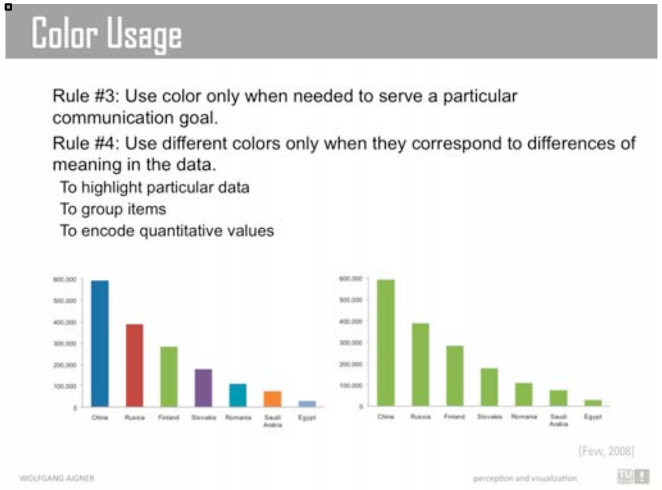
Color Context



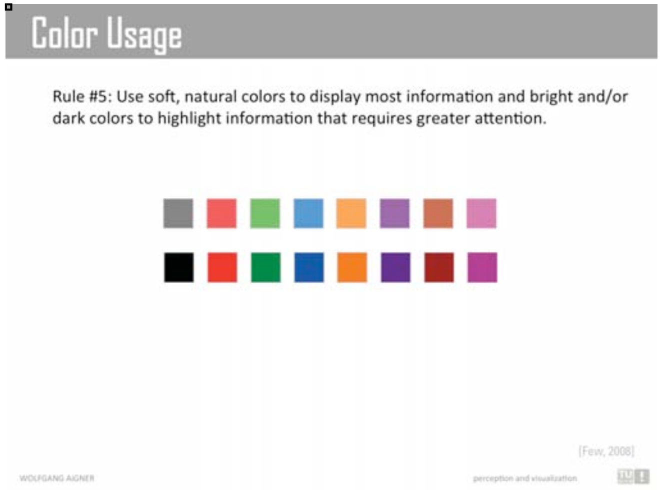
Rule #1: If you want different objects of the same color in a table or graph to look the same, make sure that the background--the color that surrounds them--is consistent.

Rule #2: If you want objects in a table or graph to be easily seen, use a background color that contrasts sufficiently with the object.

[Few, 2008]



We should only add color to an information display to achieve something in particular−−something that serves the goal of communication. Don’t use color to decorate the display. Dressing up a graph might serve a purpose in advertising, but it only distracts people from what’s important--the data--in an information display.



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Palette Types

Categorical

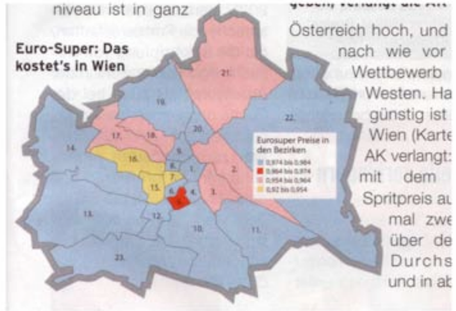
Sequential

Diverging

Rule #6: When using color to encode a sequential range of quantitative values, stick with a single hue (or a small set of closely related hues) and vary intensity from pale colors for low values to increasingly darker and brighter colors for high values.

[Few, 2008]

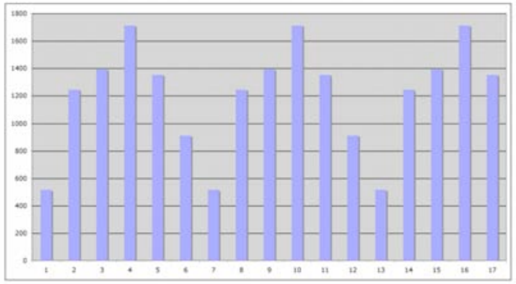
Example



Quelle: AK Für Sie, Mitgliederzeitschrift der AK Wien,

De-emphasize non-data components

Rule #7: Non-data components of tables and graphs should be displayed just visibly enough to perform their role, but no more so, for excessive salience could cause them to distract attention from the data.



[Few, 2008]

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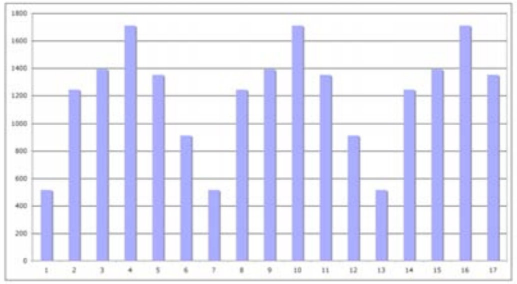

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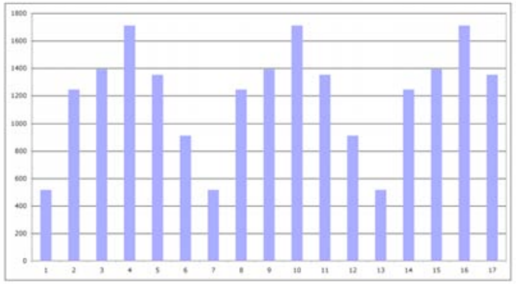

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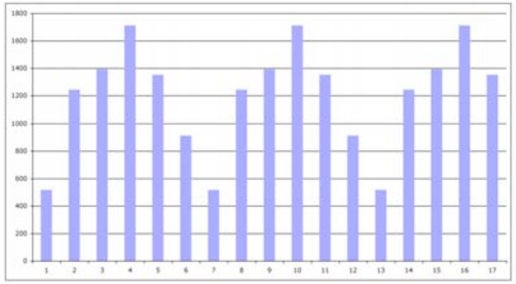

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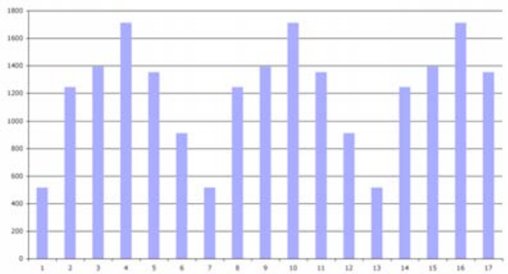

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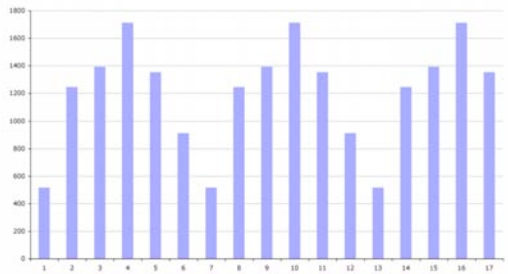

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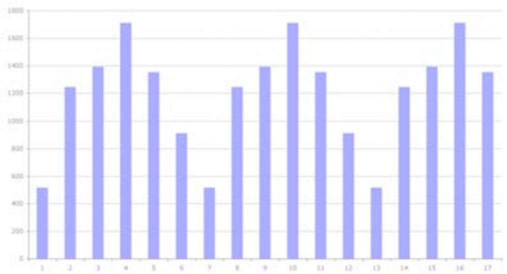

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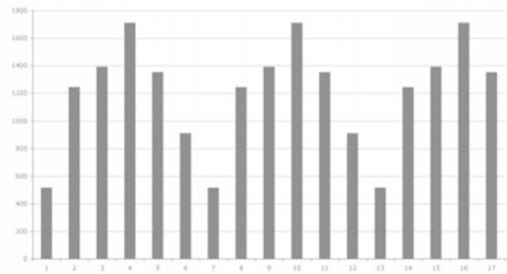

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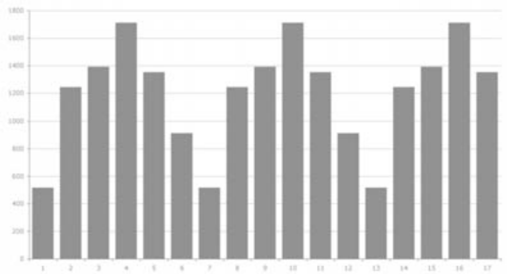

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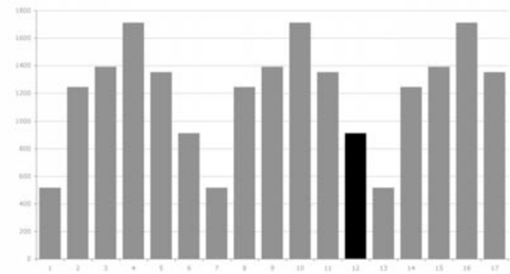

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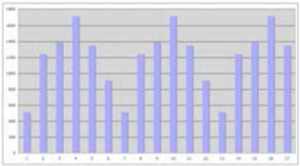
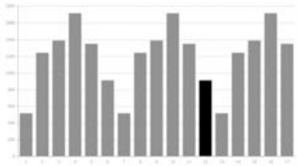
De-emphasize non-data components

Rule #7: Non-data components of tables and graphs should be displayed just visibly enough to perform their role, but no more so, for excessive salience could cause them to distract attention from the data.





[Few, 2008]

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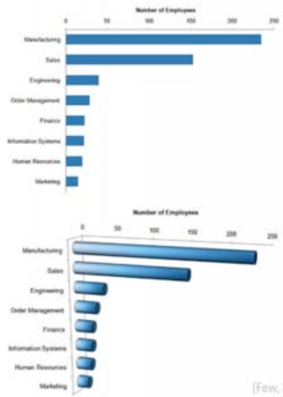
Avoid Red-Green

Rule #8: To guarantee that most people who are colorblind can distinguish groups of data that are color coded, avoid using a combination of red and green in the same display.

[Few, 2008]

WOLFGANG AIGNER perception and visualization

Rule #9: Avoid using visual effects in graphs.



[Few, 2008]

Summary: InfoVis...

... is a very complex task

... can help to get insight into data more quickly

... requires preparation and sensible handling of the information

... should make use of the properties of human visual perception

... requires sensible handling, relative to the task

... is a big challenge, if you want to do it good

»Die Umwelt, so wie wir sie wahrnehmen, ist unsere Erfindung.«

Heinz von Foerster

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