Human Factors and Human-Machine Interaction

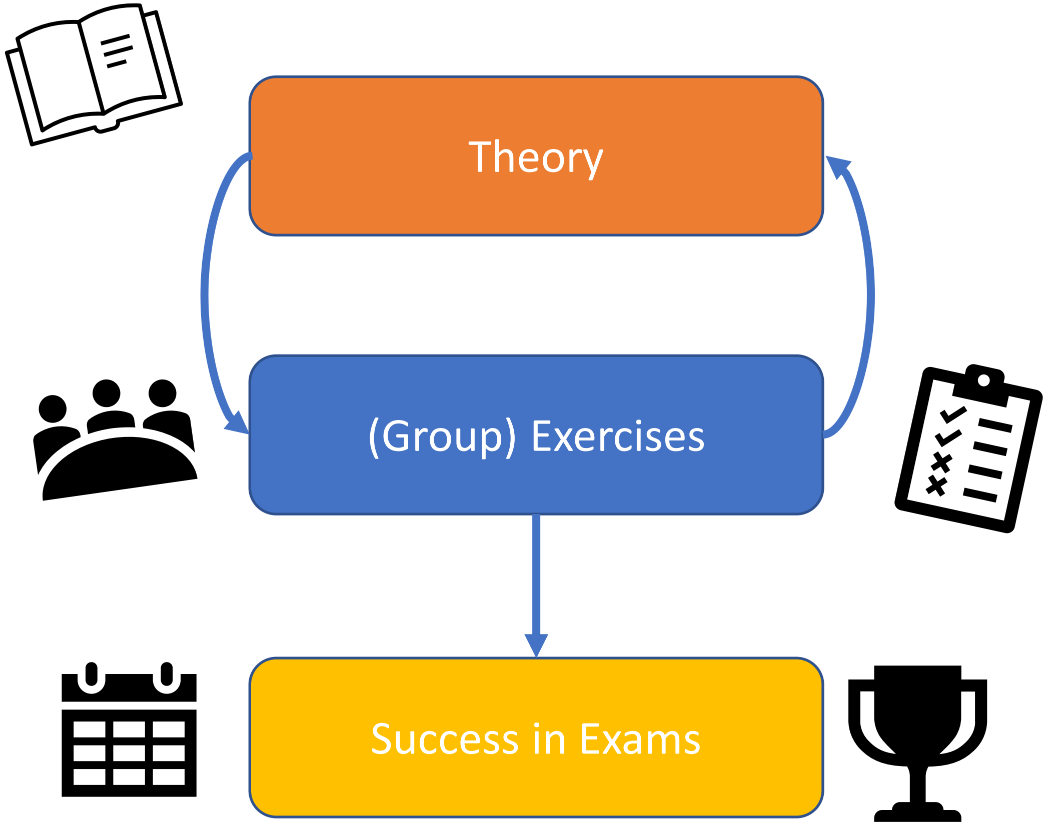
Introduction

FACULTY
OF COMPUTER SCIENCE

DEGGENDORF INSTITUTE OF TECHNOLOGY

COURSE ORGANIZATION

Interactive Lecture



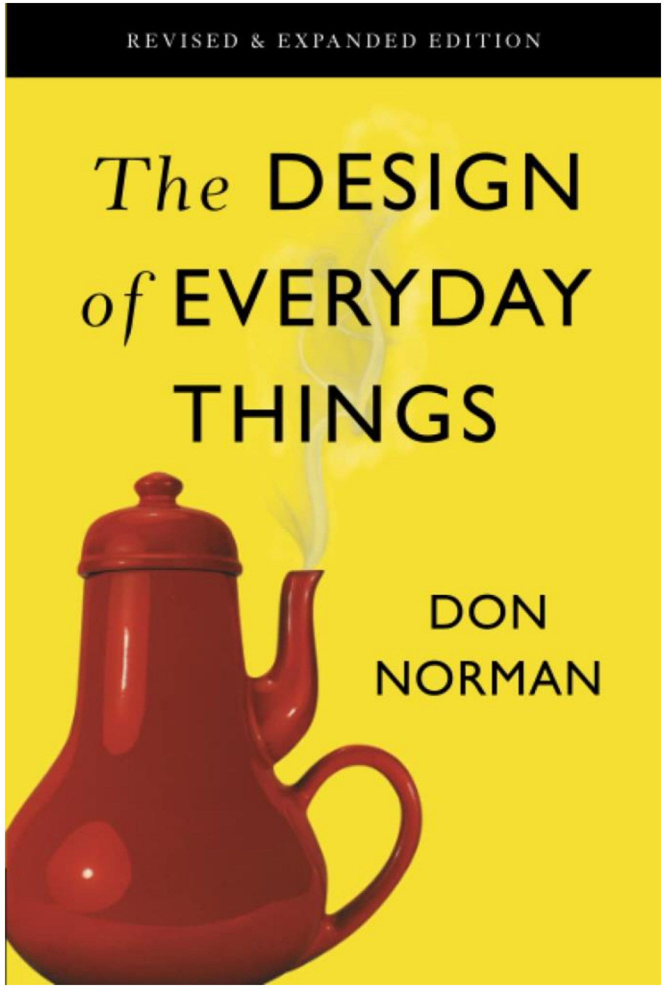
SCHEDULE (PRELIMINARY)

Lecture No.	Date	Topic
1	18.03.2024	Introduction & Design Basics
2	25.03.2024	Design of Everyday Things
	01.04.2024	Holiday
3	08.04.2024	Design of Everyday Things
4	15.04.2024	Cognitive Basics
5	22.04.2024	Cognitive Basics
6	29.04.2024	Information Dashboards
7	06.05.2024	Information Dashboards
8	13.05.2024	Information Dashboards
	20.05.2024	Holiday
9	27.05.2024	Usability Engineering
10	03.06.2024	Usability Engineering
11	10.06.2024	Usability Engineering
12	17.06.2024	Usability Engineering
13	24.06.2024	Usability Engineering Workshop
14	01.07.2024	Usability Engineering Workshop
15	08.07.2024	Exam Preparation (Q&A)

The Bed of Procrustes

taken from Prof. Eichinger's slide

LITERATURE



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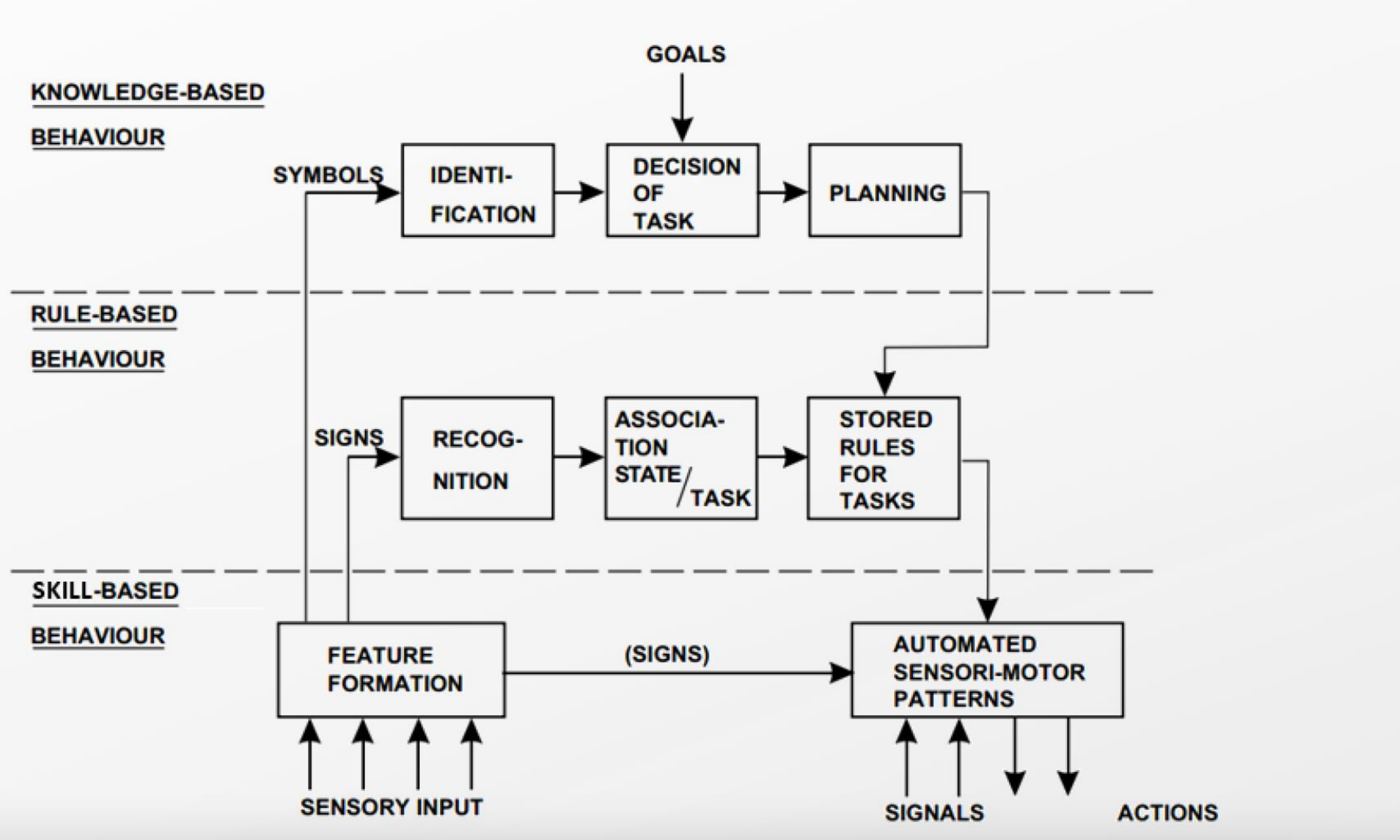
PSYCHOLOGY & DESIGN

- **Psychology**: Underlying mechanisms
- **Design**: universal (from door handle to complex processes)
- **Everyday objects/things**: Principles are universally valid
- **Human Centered Design**: Principles remain valid across different technologies

GOOD VS. BAD DESIGN

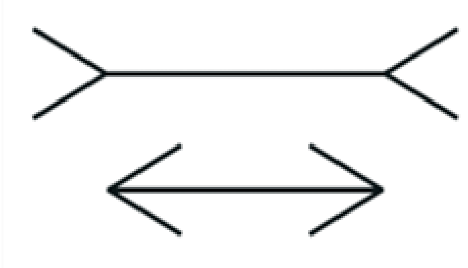
- **Two** cognitive systems:
  - System 1: automatic, fast, intuitive, effortless
  - System 2: slow, strenuous, reflective
- Good Design
  - Is not really „present“
  - Fluent & effortless interaction (System 1)
- Bad Design
  - Requires attention
  - Reflective
  - Strenuous (System 2)

SRK TAXONOMY



PSYCHOPATHOLOGY OF EVERYDAY THINGS

- *„The scientific study of mental disorders, including their theoretical underpinnings, etiology, progression, symptomatology, diagnosis, and treatment […]*" (as defined by the APA)



- Goal: Seamless interaction
- Learning through Trial and Error and system limits
- Analogy:
  - Perception: Visual Illusion vs. Reality
  - Decision behaviour: Heuristics & Biases vs. Rationality

CHARACTERISTICS OF GOOD DESIGNS

Discoverability

- What actions are possible?
- Where and how to perform them?

Understanding

- How is the product supposed to be used?
- What do all the different controls and settings mean?
- What state is the system in?

EXAMPLE: DISCOVERABILITY & UNDERSTANDING

https://www.usability.ch/news/anarchie-der-fernbedienung.html

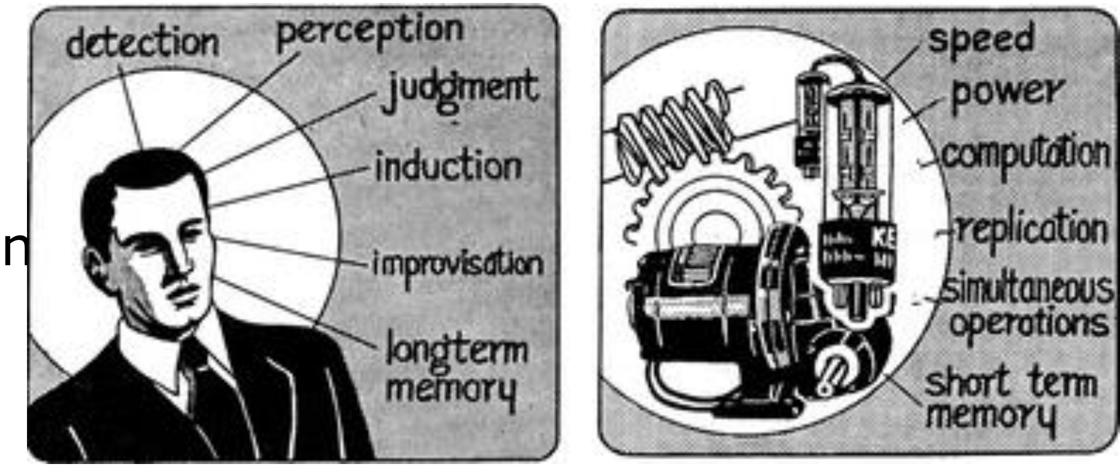

Pull
AUTOMATIC DOOR
Pull
AUTOMATIC DOOR

THE COMPLEXITY OF MODERN DEVICES

- **All artificial things are designed! → Design** is **universal**
- Design does not require physical structure
  - Rules
  - Procedures
  - Organizational structures
- Design: formal & explicit vs. informal & implicit
- Major areas of design:
  - Industrial design
  - Interaction design
  - Experience design

THE COMPLEXITY OF MODERN DEVICES

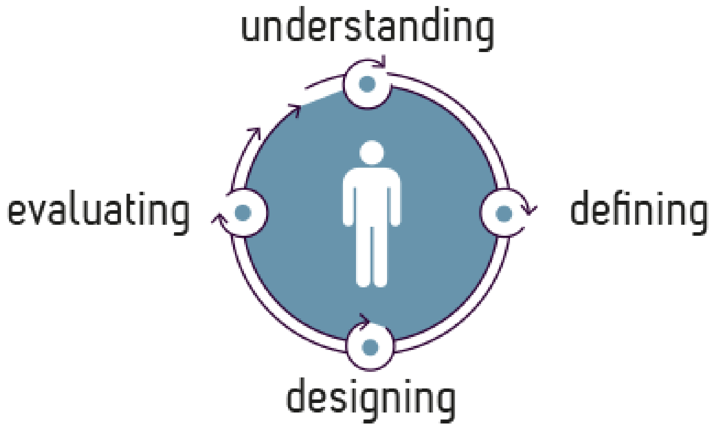
- **Aim** of **good design**:
  - Use people‘s strengths
  - Compensate weaknesses
- **Strengths** and **weaknesses** of Human and Machine
  - Paul Fitts: MABA-MABA-Lists
  - Artificial Intelligence, Automation
- **Reasons** for **bad** Human Computer Interaction (**HCI**)
  - We are all experts for human behaviour?
  - „Rational“ design



https://link.springer.com/article/10.1007/s10111-011-0188-1/figures/2

HCD – HUMAN CENTERED DESIGN

- The „Center“:
  - Human Needs
  - Capabilities
  - Behaviour
- Design to accomodate these needs
- Learn from mistakes → Iterate



EXERCISE

1. Form groups of 4 people

2. Read up on **Discoverability** and **Understanding** (pp. 1-4)

3. **Find things/items** with (in your opinion) **good/bad** design

4. **Why are they good/bad?** Argue with the what we learned about Discoverability and Understanding

5. **Present**

FUNDAMENTAL PRINCIPLES OF INTERACTION

Discoverability & Understanding results from appropriate application of **six** fundamental psychological concepts:

- Affordances
- Signifiers
- Constraints
- Mappings
- Feedback
- Conceptual Models

We talk about these next week!

CREDITS

This presentation/course uses slides provided by Prof. Armin Eichinger.

Thanks!

Human Factors and Human-Machine Interaction

Fundamental Principles of Interaction

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FUNDAMENTAL PRINCIPLES OF INTERACTION

Discoverability & Understanding results from appropriate application of **six** fundamental psychological concepts:

- Affordances
- Signifiers
- Constraints
- Mappings
- Feedback
- Conceptual Models

AFFORDANCES

- **Obviously existing** possible **interactions** between persons and the environment
- Jeff Raskin: „*Each function and the method of operating it would be apparent by merely looking at it.*“
- Make the function and the method of its implementation **transparent**
- Affordance = *Function* + **Perceptibility**

AFFORDANCES

- Affordances are not universal/obvious at all times → result of **interaction experience**
- **Not limited to physical items**
- **Digital interaction experience** as a basis of affordances

SIGNIFIER

- Don Norman: „*I call any physically perceivable cue a signifier, whether it is incidental or deliberate*.“

- Signifiers are – incidental or deliberate – **signals**

- **Affordance**: *what* action is possible (focus on relationship)
- **Signifier**: *where* the action should take place

→ Signifiers must be perceivable

→ Signal how actions are done

SIGNIFIER

- Social Signifier

- Also present in digital environment

- *„Users complete the design"*

- Affordances & Signifier support **discoverability**

AFFORDANCES & SIGNIFIER

AFFORDANCES & SIGNIFIER

Symbol	Funktion der Taste
on/off	Gerät ein- und ausschalten
90	Mikrowellen-Leistung 90 Watt wählen
180	Mikrowellen-Leistung 180 Watt wählen
360	Mikrowellen-Leistung 360 Watt wählen
600	Mikrowellen-Leistung 600 Watt wählen
900	Mikrowellen-Leistung 900 Watt wählen
$\overrightarrow{123}$	Folgebetrieb anwählen
	Gerätetür öffnen

How do you open the microwave?

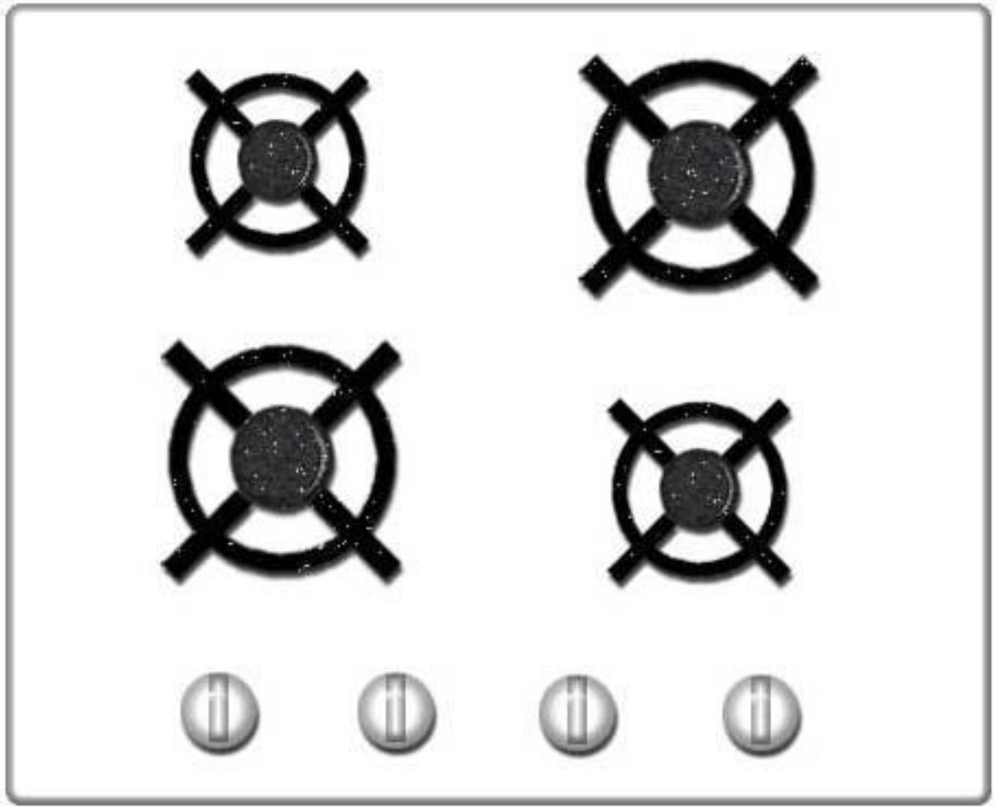
MAPPING

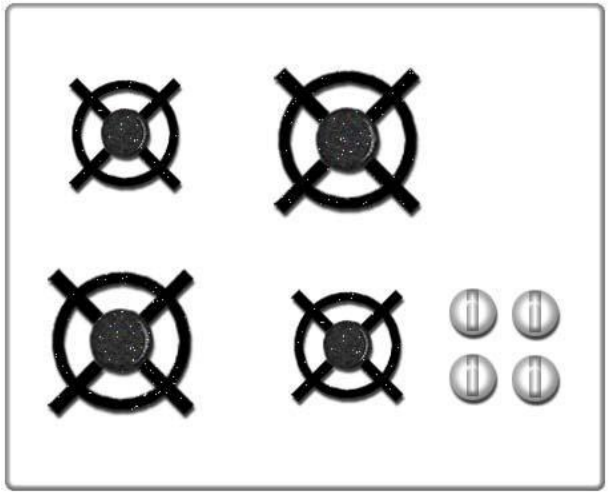
- **Mapping**:
  - Technical term borrowed from mathematics
  - Describes the **relationship** between the elements of two sets of things

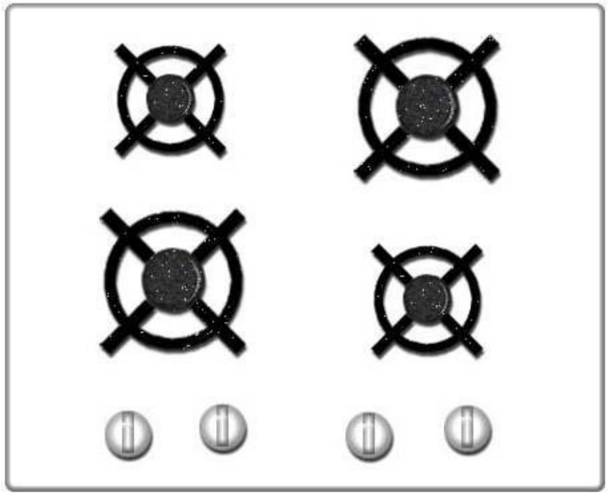
- Spatial **correspondence** between **layout** of the controls and the **devices** being controlled

- **Natural mapping**: taking advantage of spatial analogies

- Good mapping **supports Understanding**







MAPPING

FEEDBACK

- … is **communicating the results of an action** and/or the current system **state**
- … must be **immediate**
- … must be **informative**
- … has to be **planned**
- … must be **prioritized**
- **But**: Too much feedback is annoying

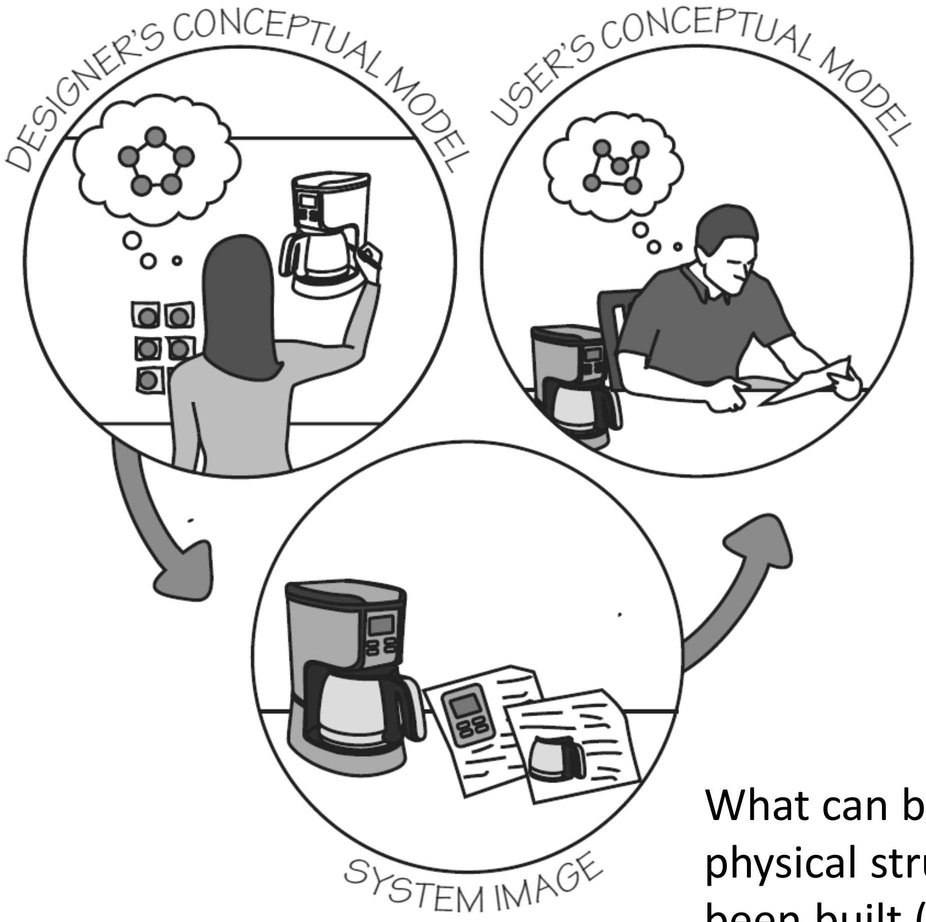
System Interpretation	Response Time Definition	Time (Secs)
Key Response	Key depression until positive response, e.g., "click"	0.1
Key Print	Key depression until appearance of character	0.2
Page Turn	End of request until first few lines are visible	1.0
Page Scan	End of request until text begins to scroll	0.5
XY Entry	From selection of field until visual verification	0.2
Function	From selection of command until response	2.0
Pointing	From input of point to display point	0.2
Sketching	From input of point to display of line	0.2
Local Update	Change to image using local data base, e.g., new menu list from display buffer	0.5
Host Update	Change where data is at host in readily accessible form, e.g., a scale change of existing image	2.0
File Update	Image update requires an access to a host file	10.0
Inquiry (Simple)	From command until display of a commonly used message	2.0
Inquiry (Complex)	Response message requires seldom used calculations in graphic form	10.0
Error Feedback	From entry of input until error message appears	2.0

CONCEPTUAL MODELS

- „A conceptual model is an **explanation**, usually highly **simplified**, of **how something works**.“ (Norman, 2013)
- Can be found in manuals, on the computer (icons, folders, files)
- **Mental Model**: Conceptual model in people‘s mind that represent their understanding of how things work.
- Often inferred from the device itself, some are passed from person to person, some come from manuals
- Don Norman:
  - „A good model allows us to predict the effects of our actions“
  - “As long as things work properly, we can manage. When things go wrong, however, or when we come upon a novel situation, then we need a deeper understanding, a good model.“
- Major clues come from perceived structure, i.e., affordances, signifier, constraints, mappings

CONCEPTUAL MODELS

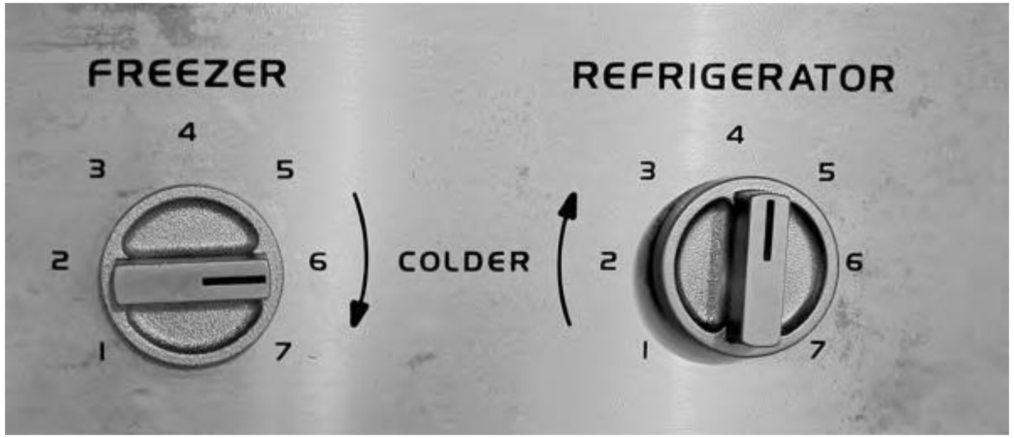
Designer‘s conception of look and feel



Developed through interaction with the product and system image

What can be derived from the physical structure that has been built (+ documentation)

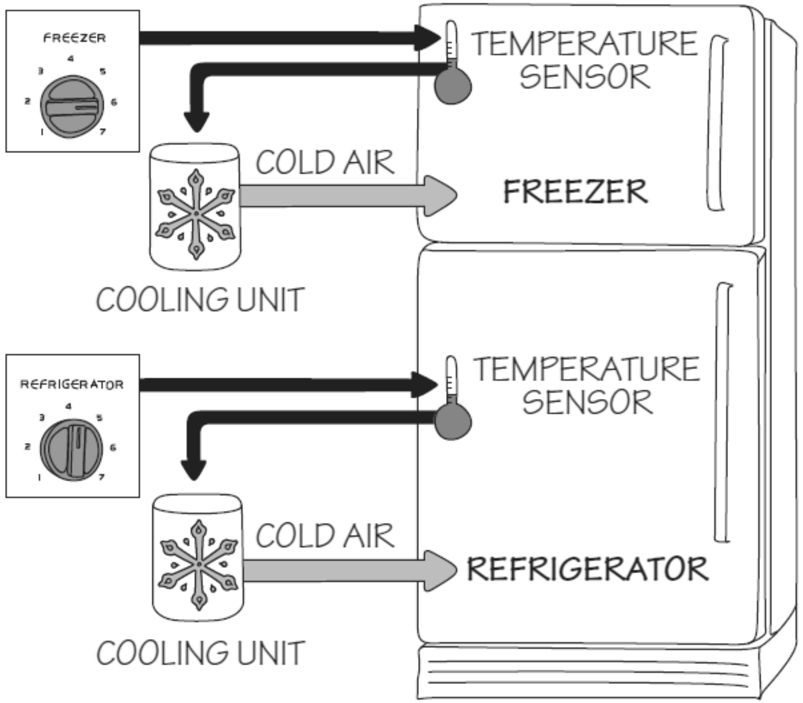
CONCEPTUAL MODEL



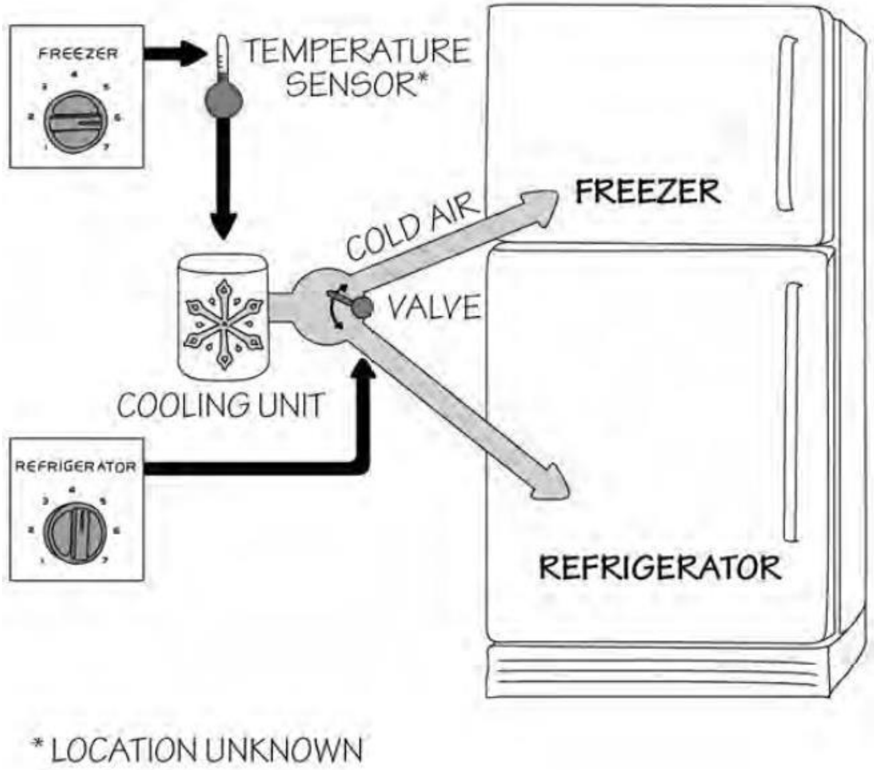
What conceptual model has been developed for this freezer-refrigerator combination?

CONCEPTUAL MODEL

What we expect…



How it actually is…



EXCERCISE

1. Take/find pictures of things with poor design.

2. Read up on the principles learned today (p. 10-30)

3. **Why is the design poor** and **how can it be improved**? Use the **fundamental principles** we‘ve learned today to build your argument.

4. **Present** as posters/slides → explicitly relate to the terms/definitions from the slides/book

Human Factors and Human-Machine Interaction

Constraints and the 7 Stages of Action

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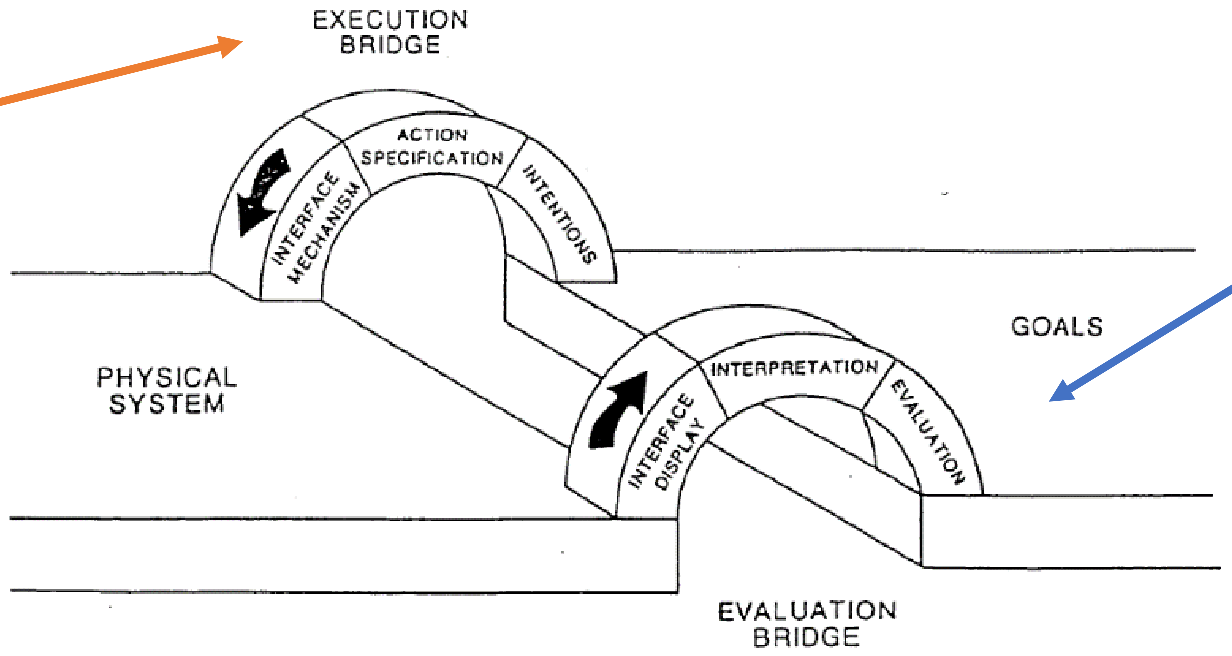
THE GULFS OF EXECUTION/EVALUATION

Gulf of Execution

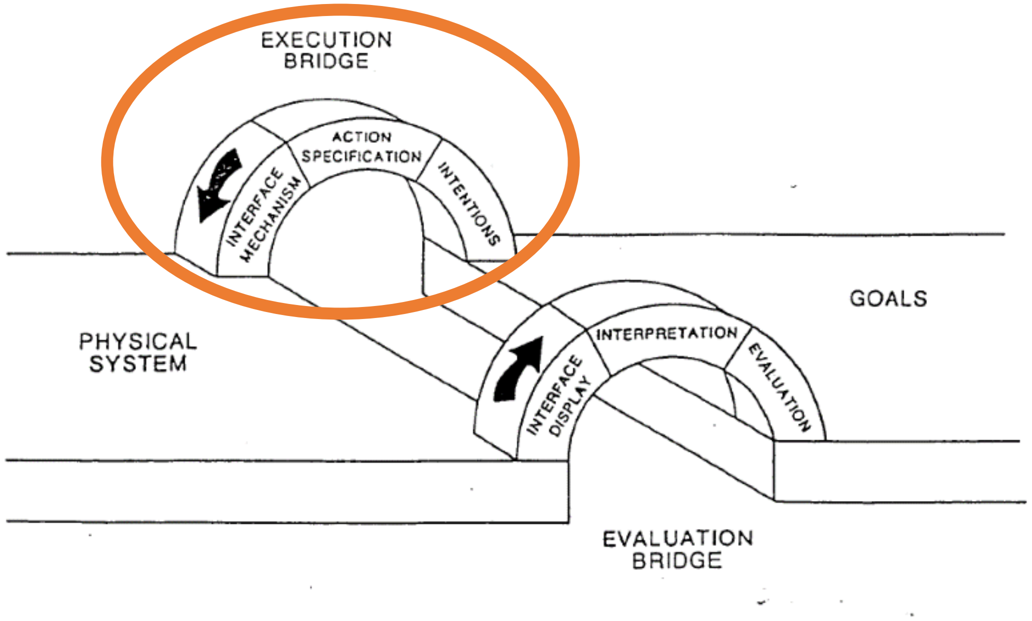
People try to figure out **how something works/operates**



Gulf of Evaluation

People try to figure out **what happened**

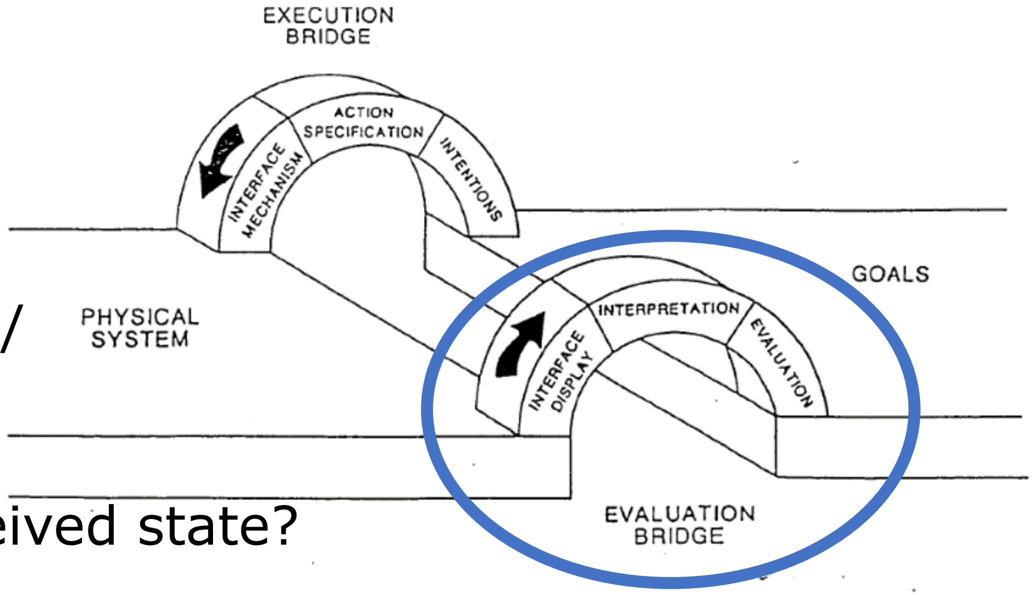
GULF OF EXECUTION



- Starting point of an action: Goal/Task
- How can we achieve this goal?
- Which steps do I need to take? What can I do?
- Are there problems during execution?

→ Bridge with: **signifiers, constraints, mappings, conceptual model**

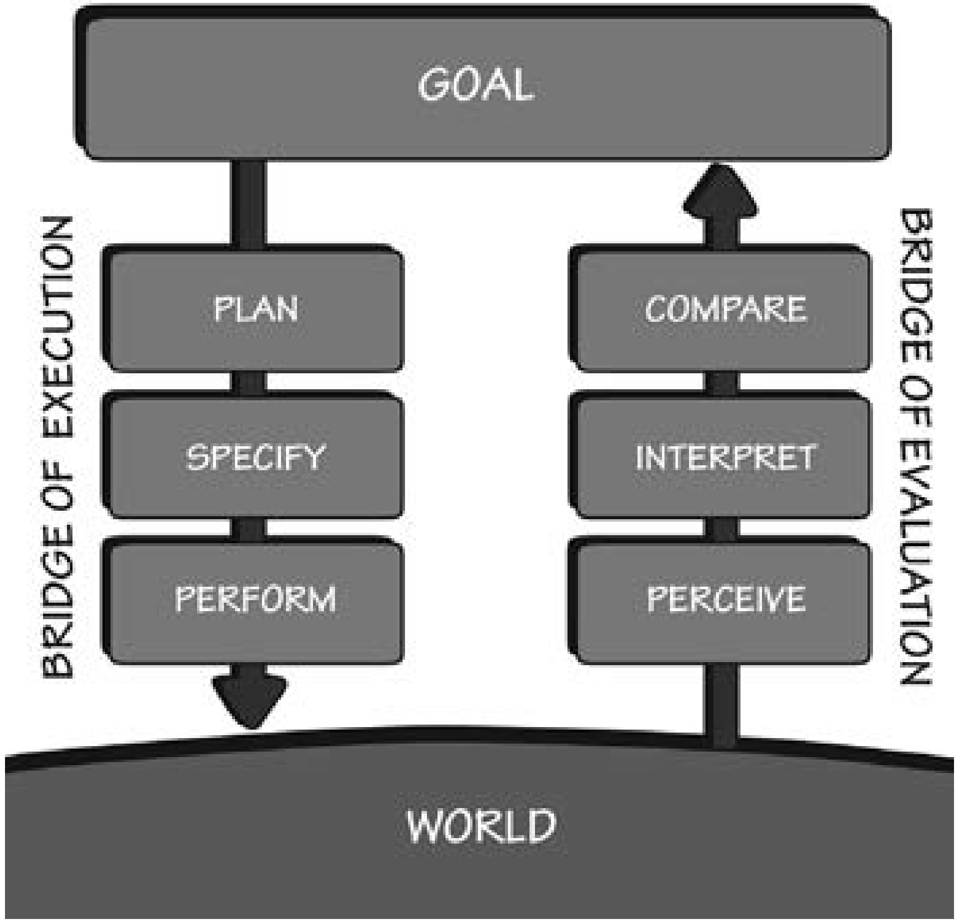
GULF OF EVALUATION



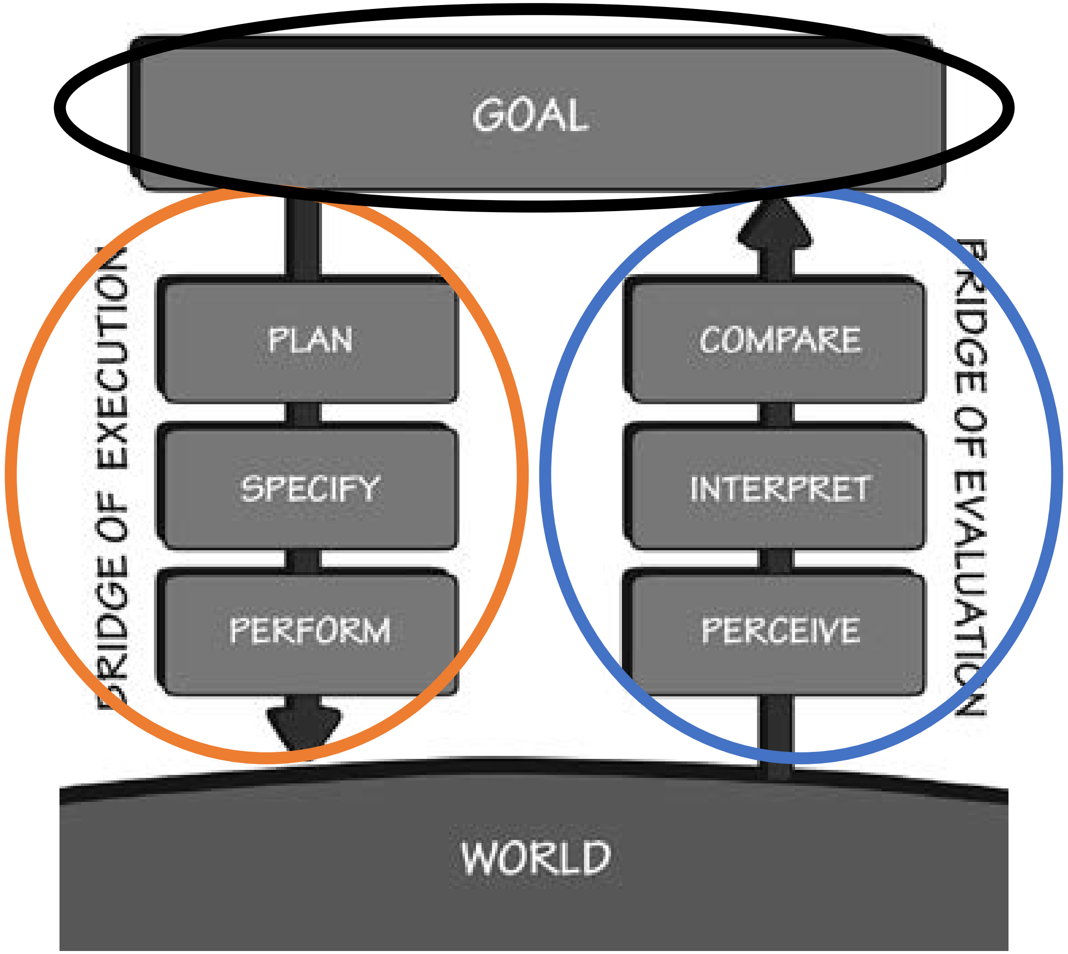
- **Perception**: How does the „world"/interface/ product look like after interaction?
- **Interpretation**: Can I understand the perceived state?
- **Evaluation**: Does the state meet the original goal?
- *„The Gulf of Evaluation reflects the amount of effort that the person must make to interpret the physical state of a device and to determine how well the expectations and intentions have been met."*

→ Bridge with: **feedback** and **conceptual model**

7 STAGES OF ACTION



7 STAGES OF ACTION



1. **Goal**: Form the Goal
2. **Plan** the action
3. **Specify** an action sequence
4. **Perform** the action sequence
5. **Perceive** the state of the world
6. **Interpret** the perception
7. **Compare** the outcome with the goal

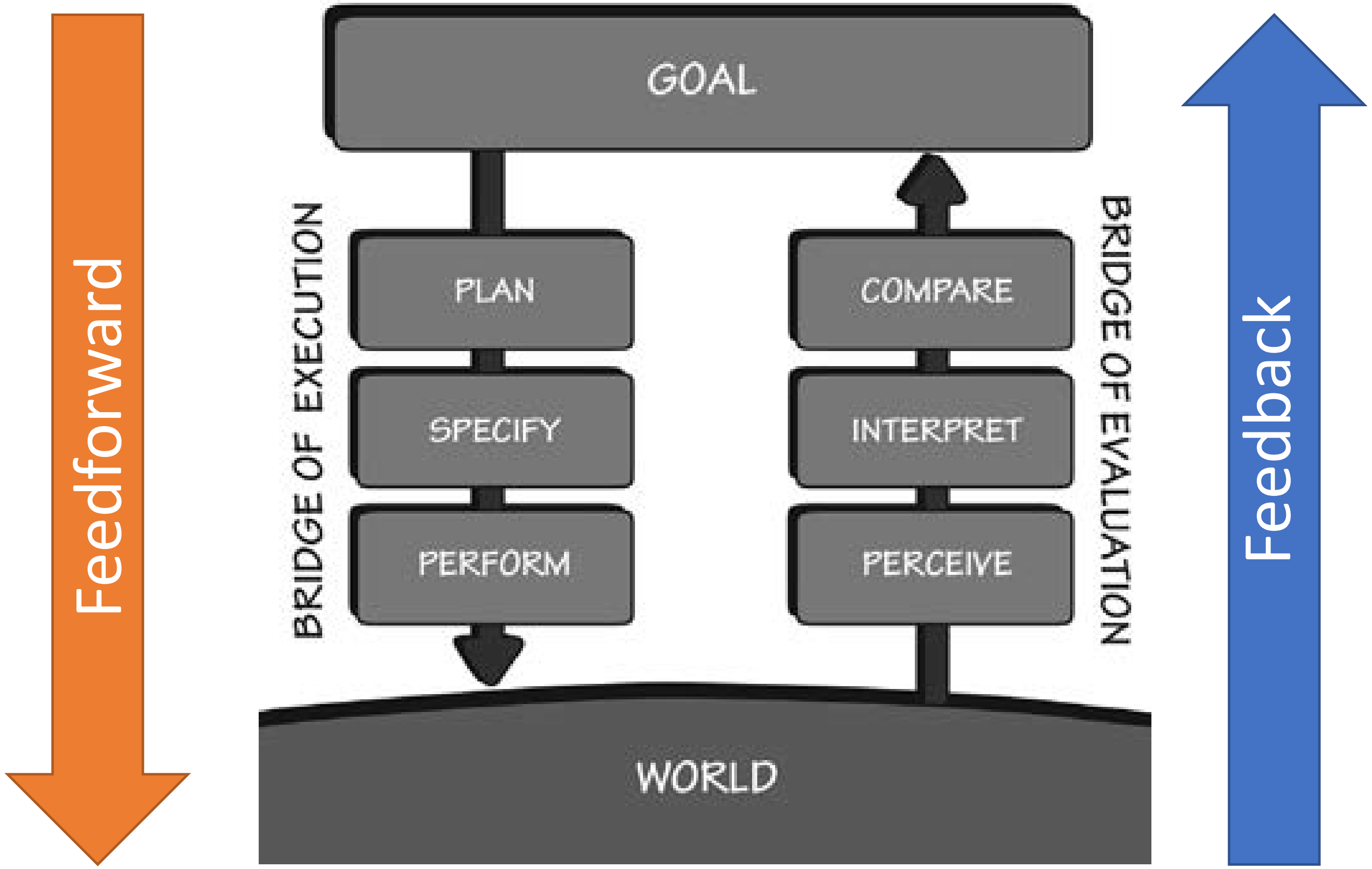
7 STAGES OF ACTION

Signifiers

Constraints

Mapping

Conceputal Model



Feedback

Conceptual Model

(PHYSICAL) CONSTRAINTS

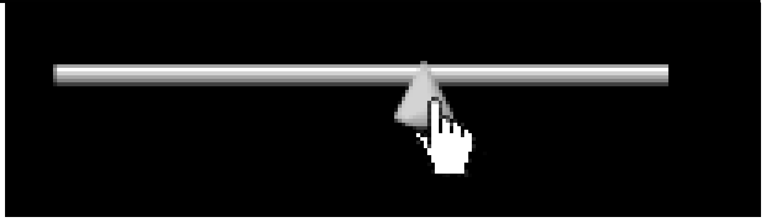
- Constrain possible interactions/operations
- Reduce errors

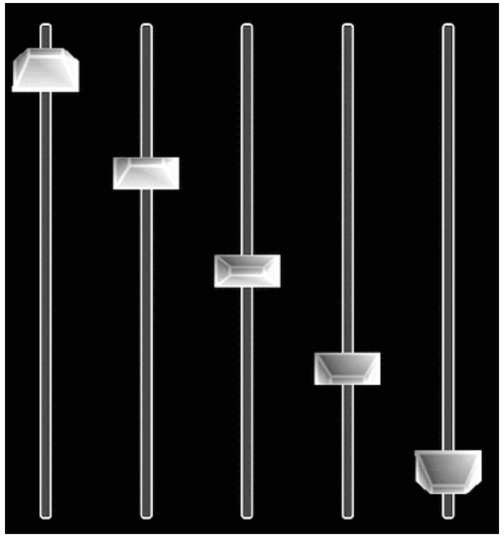
- Guide attention
- Simplify creation of conceptual models

CONSTRAINTS

CULTURAL CONSTRAINTS

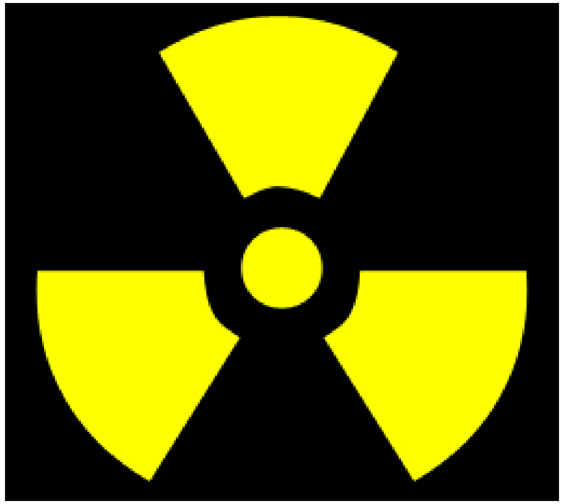
- How to increase something:
  - Clockwise rotation (very clear)
  - Left-right movement (not universally valid)
  - Down-Up movement (problematic)
- Behaviour in social situations (frames, scripts, …)
- Cultural Constraints change over time





CULTURAL CONSTRAINTS

- Use of signal colours
- Use of signal shapes



SEMANTIC CONSTRAINTS

- Based on our knowledge in a situation/in the world

- Lego motor bike
    - Position of the rider
    - Position of the tires
    - Position of the windshield

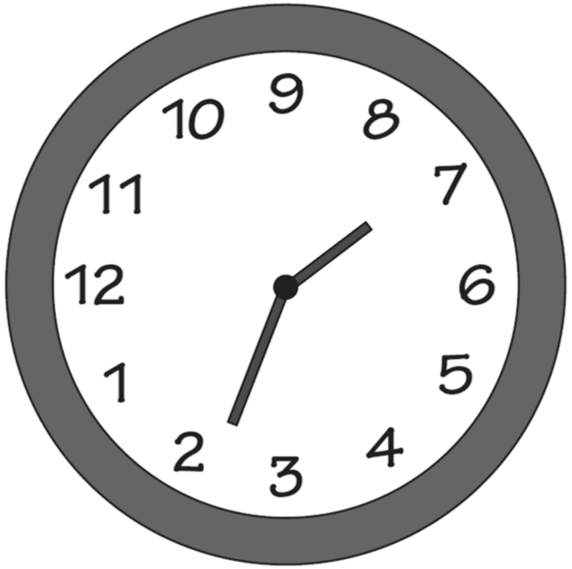
- Semantic constraints can change over time

CONSTRAINTS

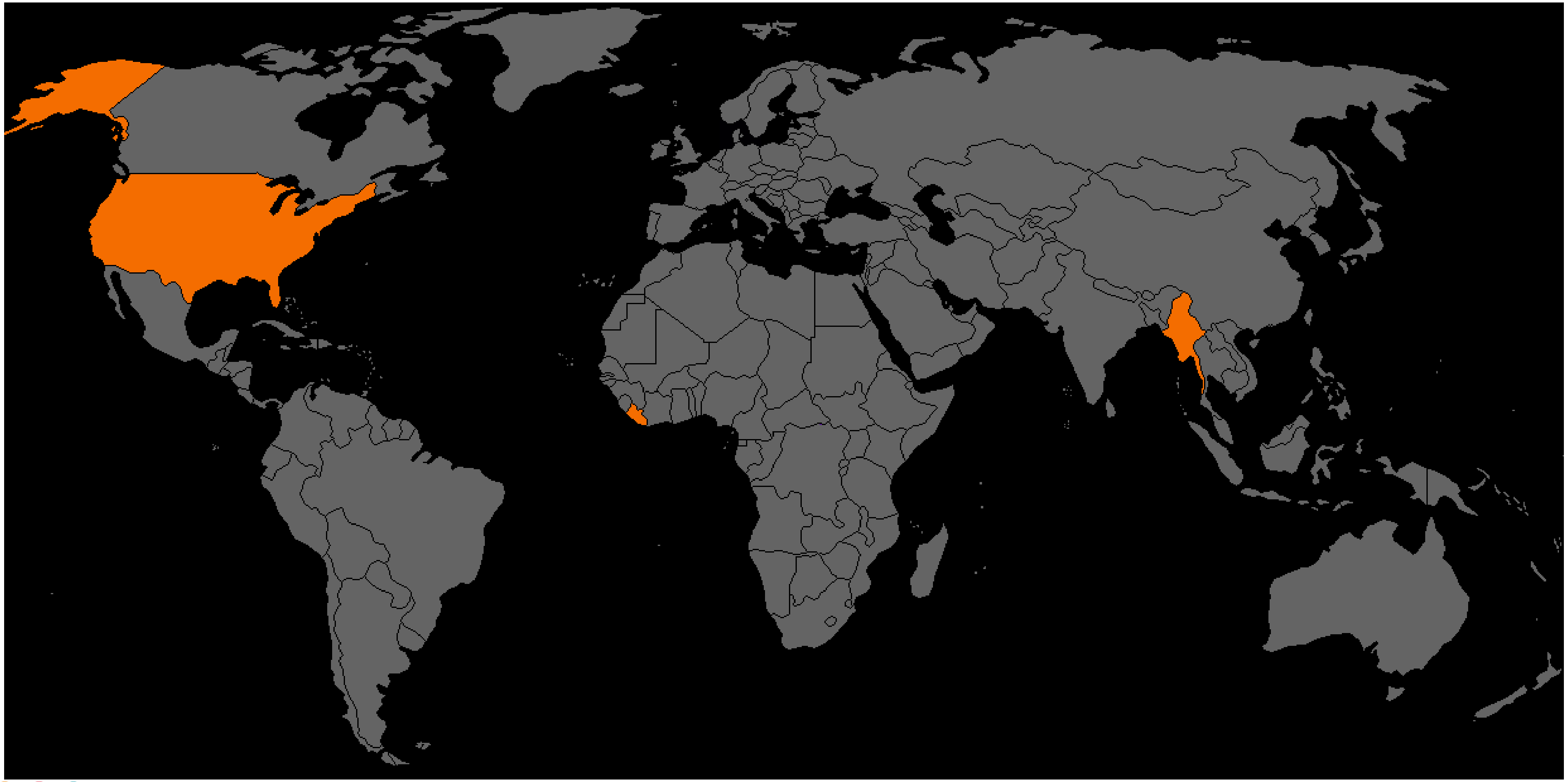
STANDARDS

- Precursor: Conventions
- **Advantage**: Facilitation by limiting the scope of action (variant of mostly cultural constraints).
- Standards often **formalized** and **legally binding**
- **Examples**:
    - Time: What time is it?
    - Right/left division in road traffic
    - positioning of steering wheel, indicator lever, gear shift, ...
    - charging socket for smartphones

https://live.staticflickr.com/2007/2243896940_eca8c620ab_b.jpg



STANDARDS



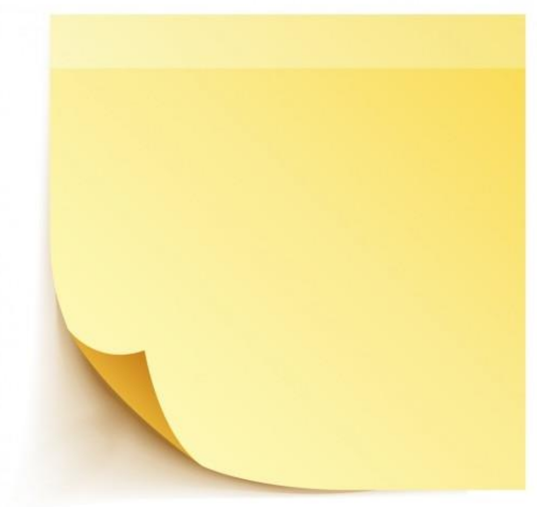
STANDARDS

Source: Wikipedia

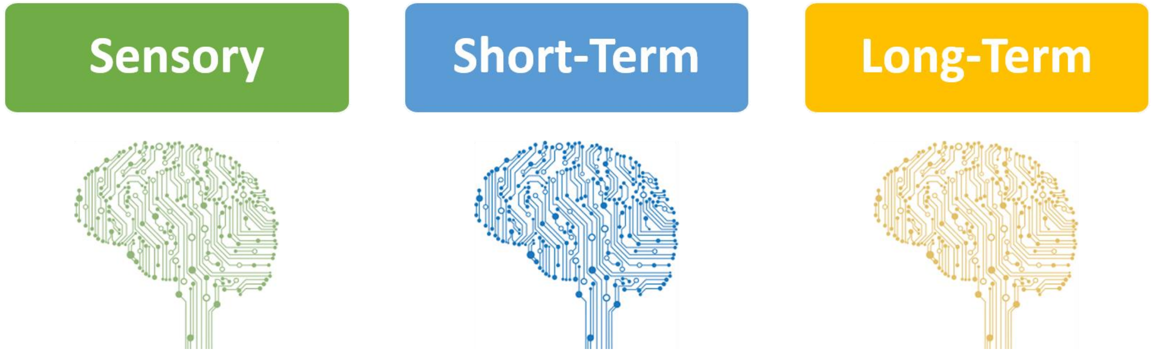
KNOWLEDGE IN THE WORLD

- Knowledge in the world is externalised knowledge
- Environment provides support…
  - …to remember things
  - …to perform actions

- Right timing is important
- Effort required by learning to interpret the information
- When time & place are right: effective and efficient
- Realized by signifiers, constraints, mappings
- Aesthetics



KNOWLEDGE IN THE HEAD



- Memory is knowledge in the head

- **(Classic) Stucture of memory**:
  - **Sensory**: ultra short-term memory
  - **Short-term or working memory (STM)**: Capacity limited („Miller's magical number 7"), easily disturbed ,easily retrieved, different sensory modalities.
  - **Long-term memory (LTM)** : no known capacity limit,recall may be strenuous, declarative procedural, episodic

- **Prospective memory** : memory for the future, "I must not forget that tomorrow I will ...", signal vs. message

Image source: https://media.licdn.com/dms/image/C4E12AQHJyqS4PJLsJg/article-cover_image-shrink_600_2000/0/1521817180143?e=2147483647&v=beta&t=0Xn5QGKs4iHkK2UM9mNTHKvYxbwBp7cuhyHvJytbzPA

KNOWLEDGE IN THE HEAD

- Requires effort (for storage and/or retrieval)
- Reduces demands on designer
- Immediately available in working memory; may require time-consuming search in LTM
- With automatisms: very efficient

KNOWLEDGE IN THE WORLD AND IN THE HEAD

Source: Wikipedia

EXCERCISE: IMPROVE THE DESIGN!

1. Read up on Constraints (Chapter 4) and the 7 Stages of Action/the Gulfs (p. 38 - 44)

2. Find items with **a bad design**

3. **Analyse:** Why is the design bad? Explain with the *7 Stages of Action* model where the interaction fails. How does this relate to the fundamental principles we have heard about?

4. **Improve** the design

5. Present your analysis

Human Factors and Human-Machine Interaction

Cognitive Basics

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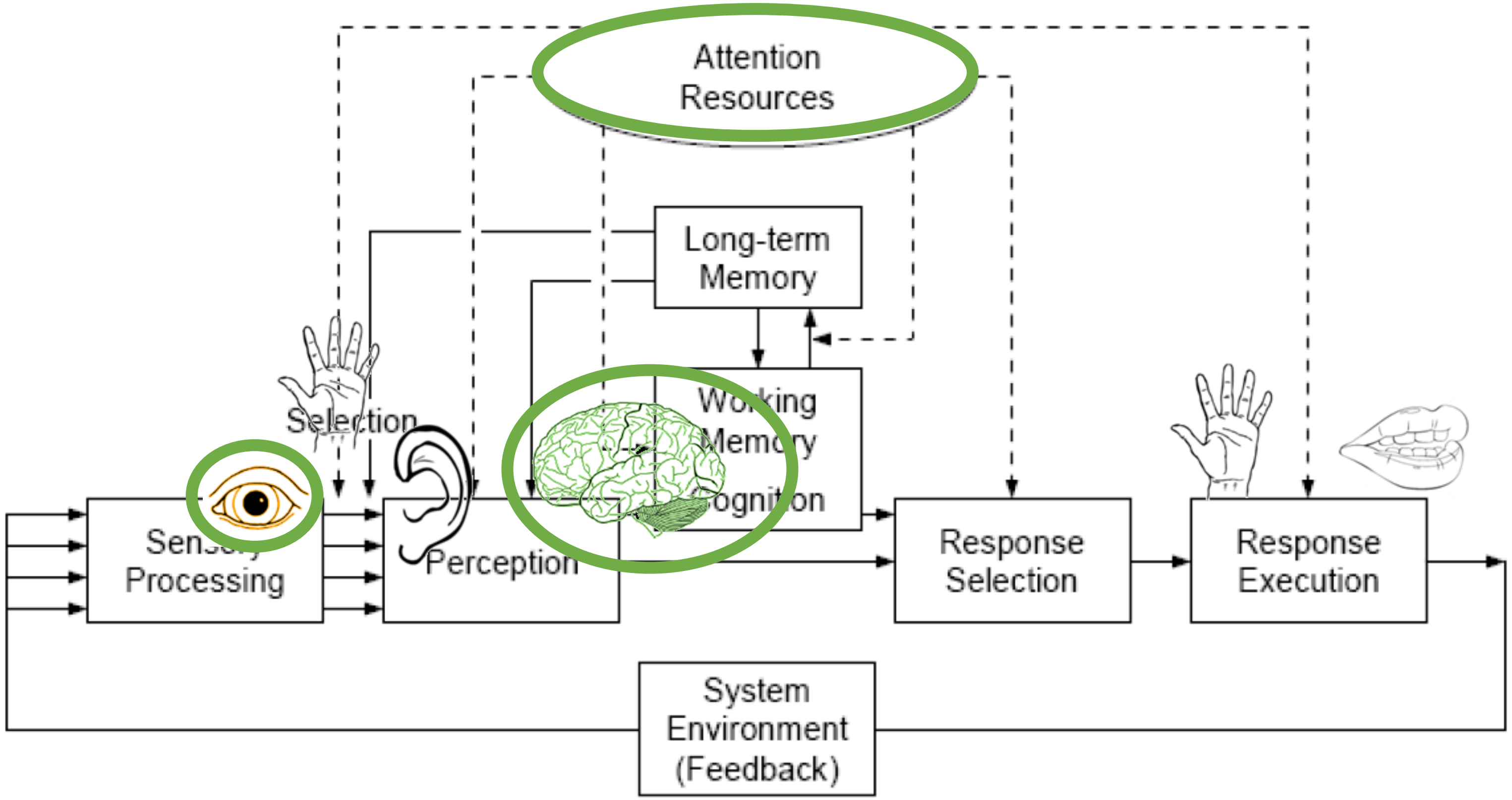
OVERVIEW

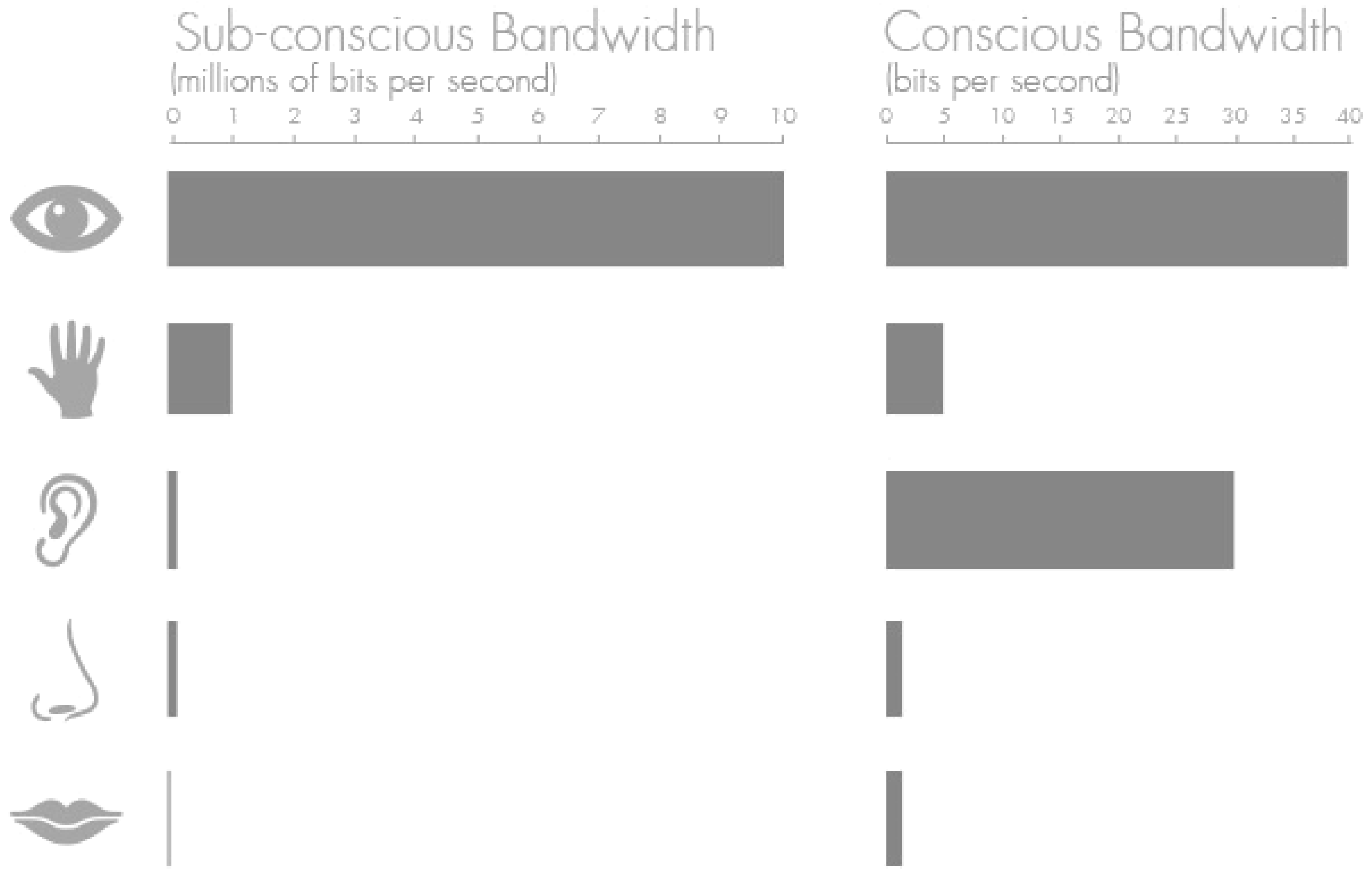
- Information Processing
- Visual Perception
- Attention
- Applied cognitive phenomena

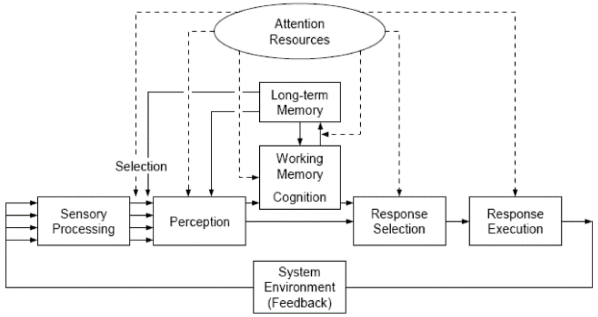
INFORMATION PROCESSING MODEL



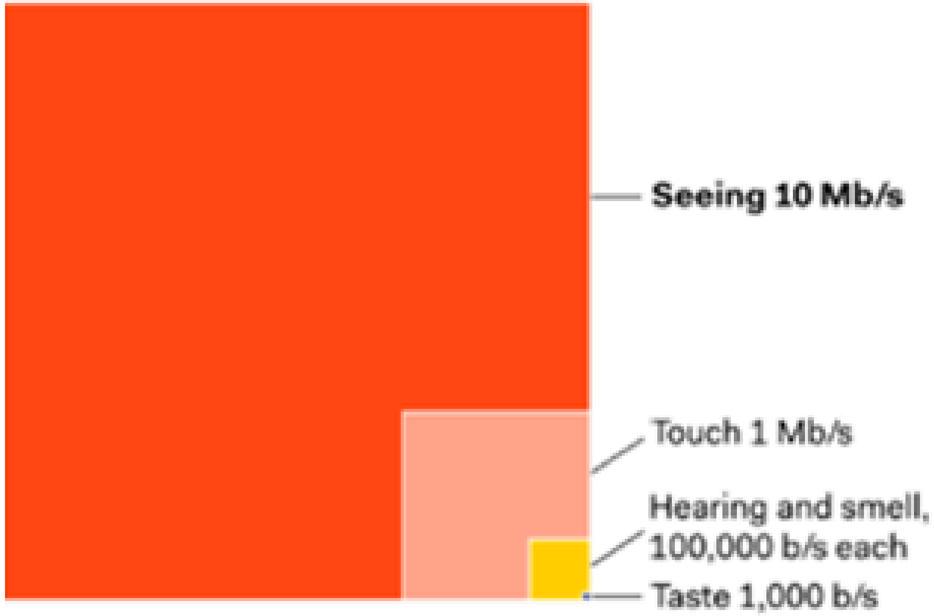
(Wickens, C. & Carswell, C. (2006). Information Processing. In G. Salvendy(Hrsg.), Handbook of Human Factors and Ergonomics (S. 111-149). Hoboken: John Wiley.)

INFORMATION PROCESSING



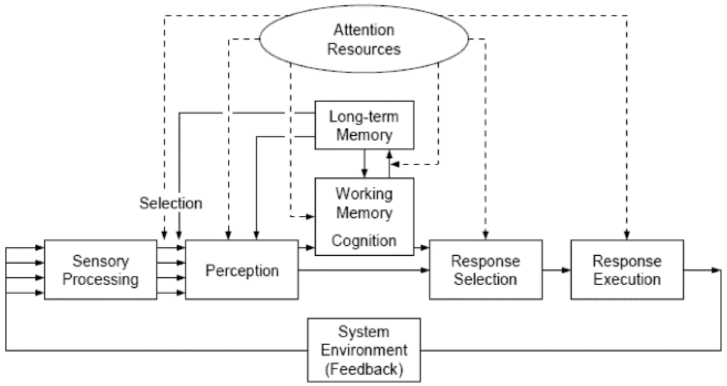


INFORMATION PROCESSING



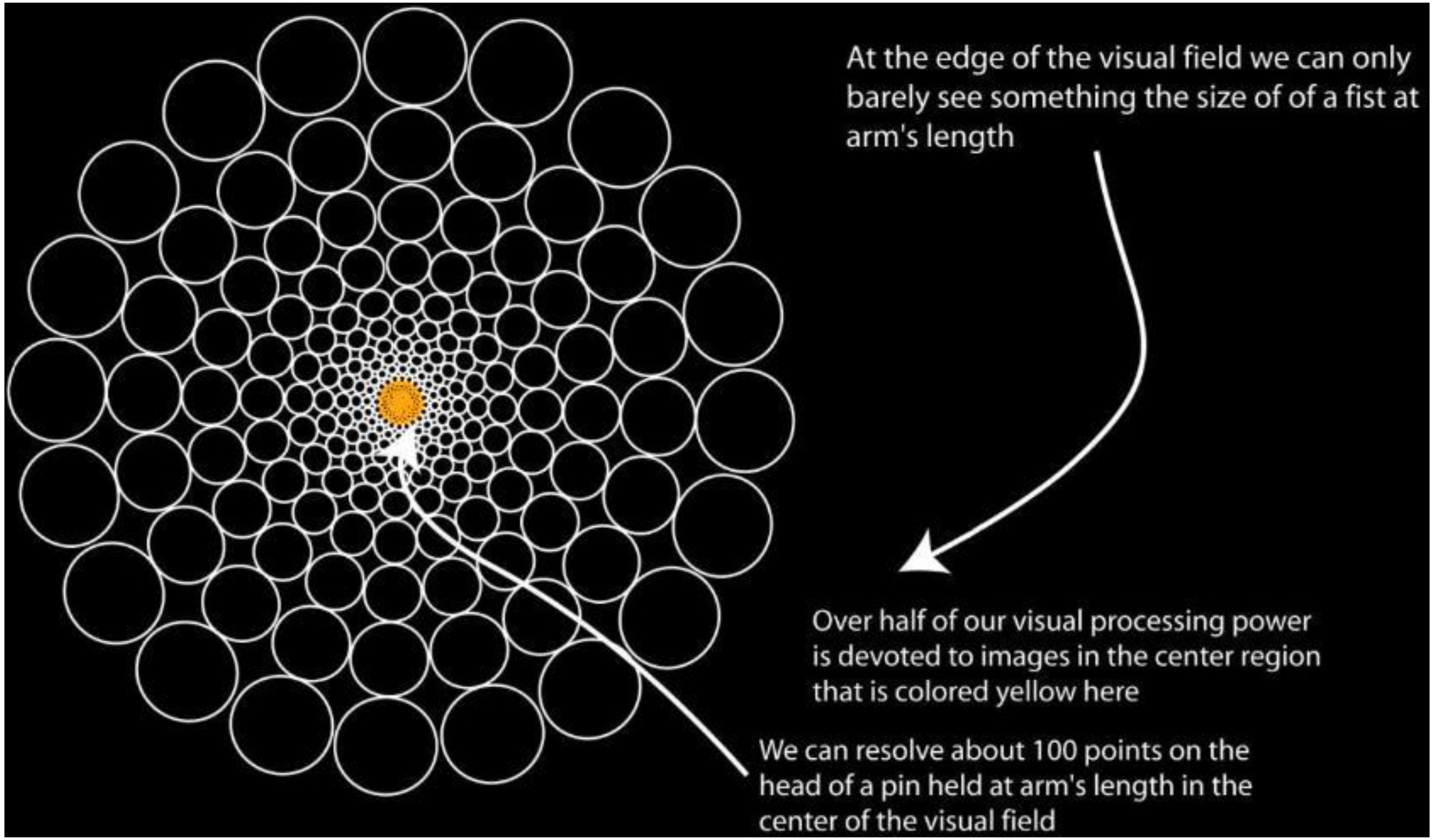
Koponen, J., & Hildén, J. (2019). Data visualization handbook. Espoo: Aalto Arts Books.

We are able to visually perceive our environment, and changes in it considerably more quickly and precisely than using other senses.
It is estimated that, each moment, our visual system sends our brains around eight times more information than all the other senses combined. (p. 21)



INATTENTIONAL BLINDNESS

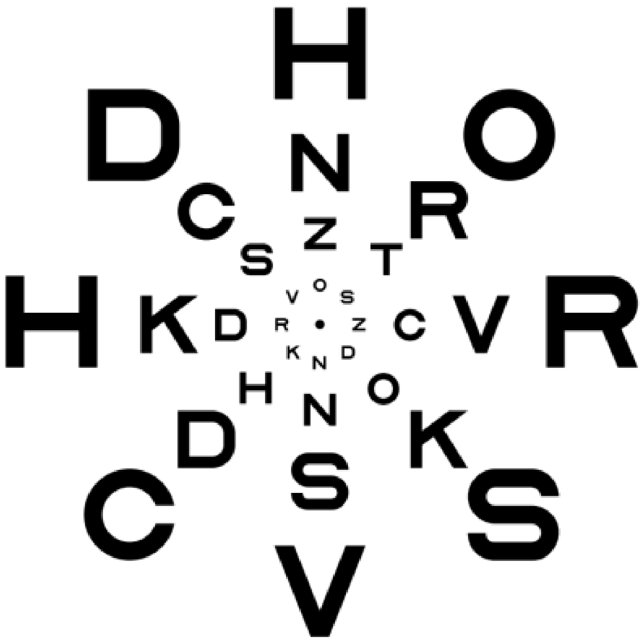
PERCEPTION: BRAIN PIXELS



Ware, C. (2008). Information Visualization: Perception for Design. San Francisco: Morgan Kaufmann.

PERCEPTION: BRAIN PIXELS

ANSTIS' PERIPHERAL ACUITY CHART



Koponen, J., & Hildén, J. (2019). Data visualizationhandbook. Espoo: Aalto Arts Books.

The so-called Anstischart, created by UC San Diego professor Stuart Anstis (Anstis, 1972) demonstrates how rapidly visual acuity decreases towards the periphery of the visual field. When the gaze is fixated at its center all the letters should be equally readable.(p. 48)

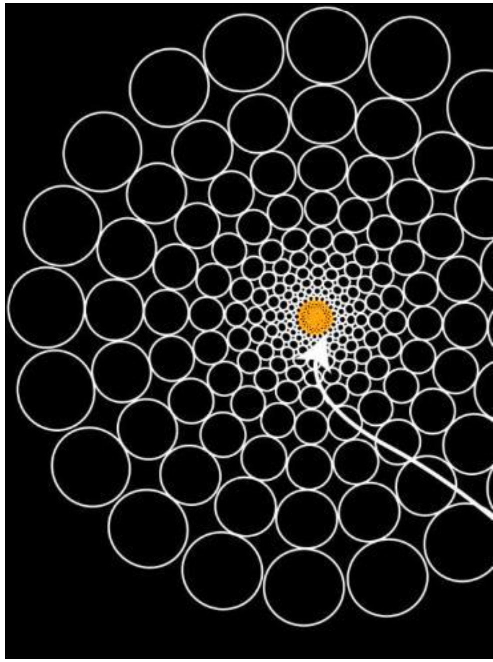
STRUCTURE → SACCADES

- The visual information from **100 million receptors** is compressed and transported via **a million nerve tracts** to the responsible brain areas.

- 50% of the **processing power** (area of the parafovea) corresponds to 5% of the visible environment.

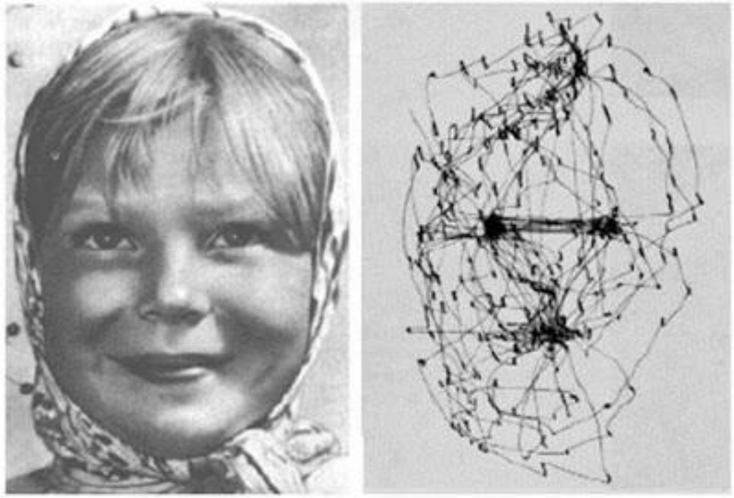
- Consequence: fast eye movements (**saccades**) are necessary to capture interesting and necessary details: saccade speed up to 900°/sec.

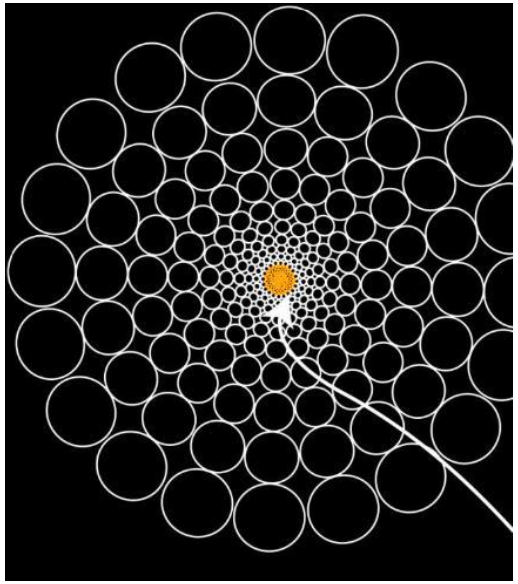
- The eyes move in a series of jumps, but we do not perceive them as such. I.e.: We do not perceive what the first stages of visual information acquisition offer us, but a coherent whole.



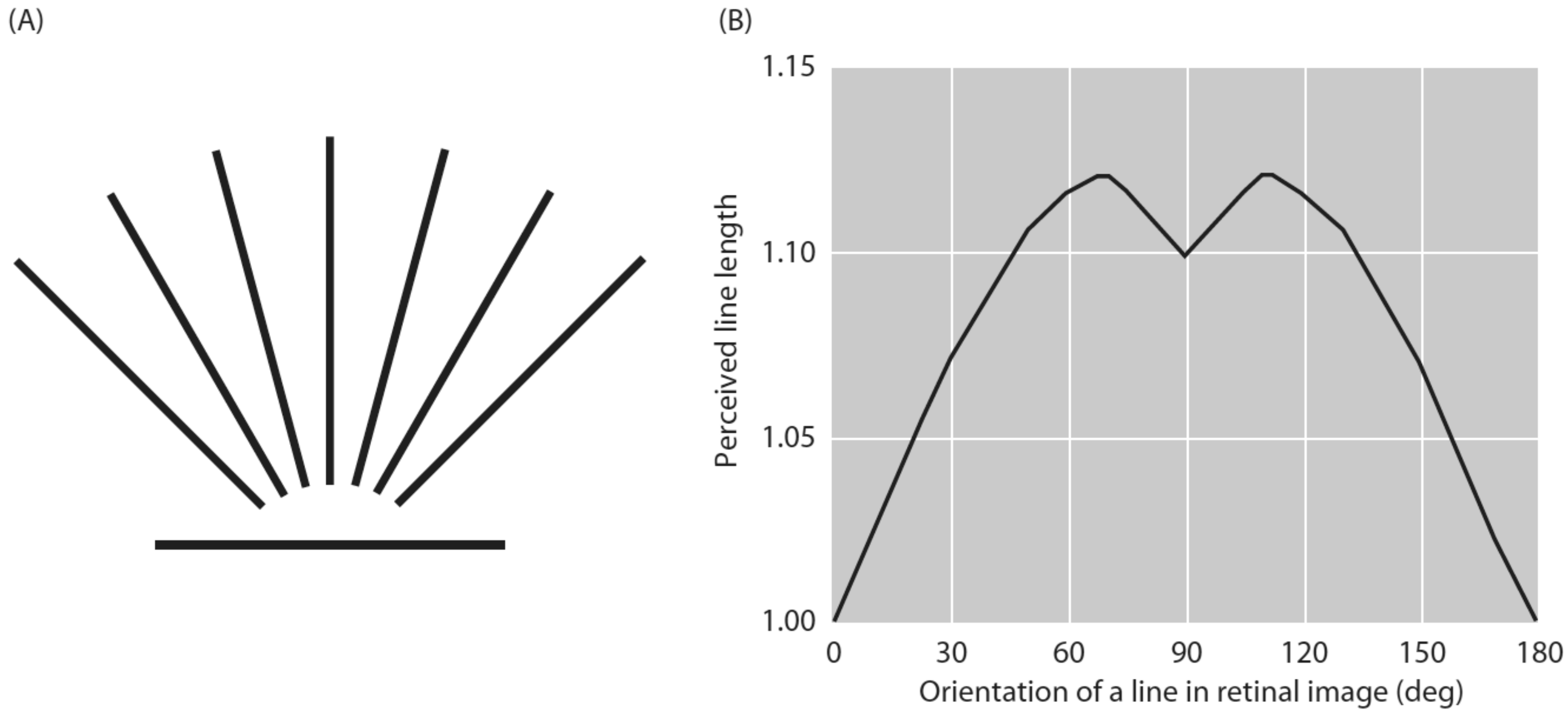
SACCADES

- We **do not perceive a stable image** of the environment
- **Saccade jumps**: 3/sec
- **Goal**: centering interesting parts on the fovea
- **Consequence**: effects of selective perception

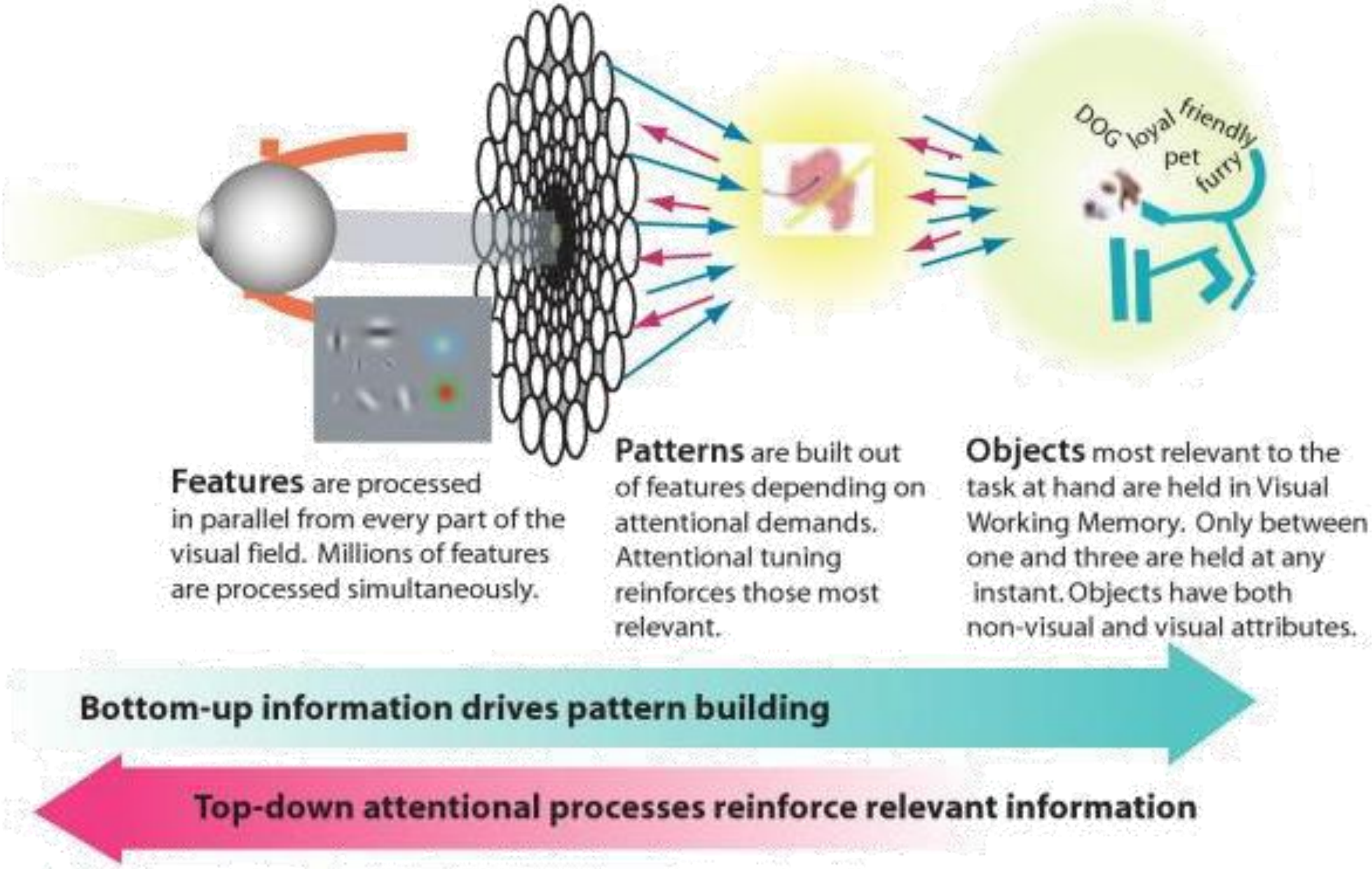




PERCEPTION OF LENGTH

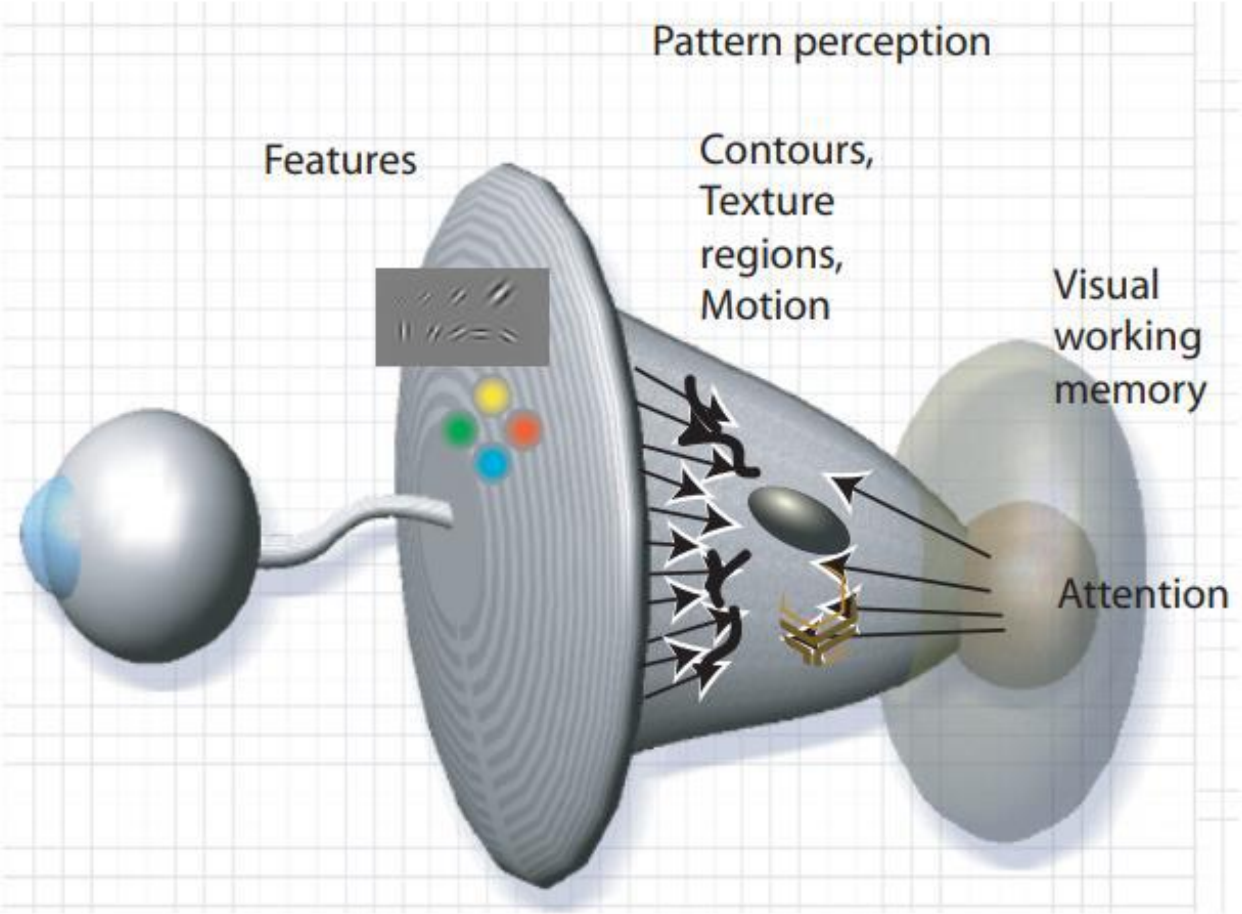


VISUAL PERCEPTION: BOTTOM UP



Ware, C. (2008). Information Visualization: Perception for Design.San Francisco: Morgan Kaufmann.

3 STAGES OF VISUAL PERCEPTION



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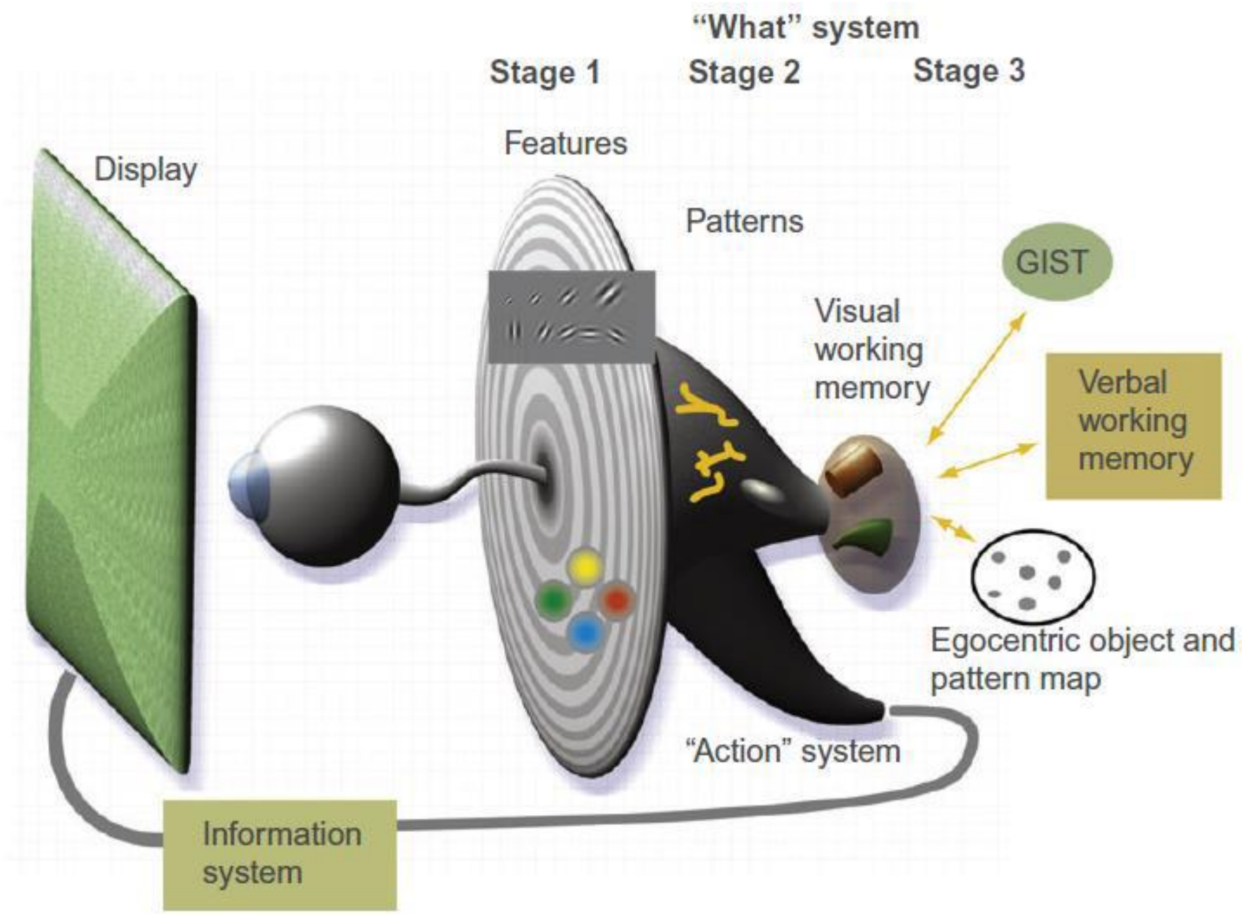
3 STAGES OF VISUAL PERCEPTION



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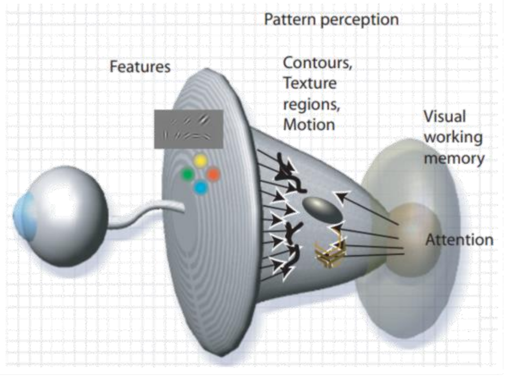
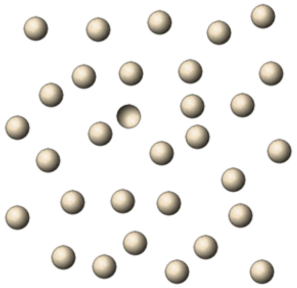
VISUAL PERCEPTION: BOTTOM UP

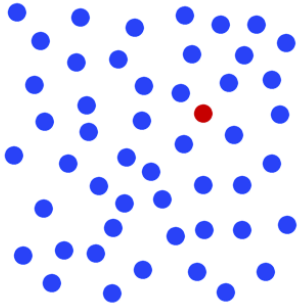


- Five billion neurons form a parallel processor that processes the information provided by a million neural pathways.
- Specialized brain areas take care of **the recognition of features**: size, color, shape, movement,
- In **pattern recognition**, visual space is divided and organized into regions, contours, boundaries of the same texture or color (Gestalt laws).
- The last stage of information compression is the **formation of visual objects**, which are stored in the visual working memory.
- Number: 3 - 5 objects; duration 0.1 - 2 sec. The capacity of visual working memory is severely limited. Therefore, it is dependent on external visual support.

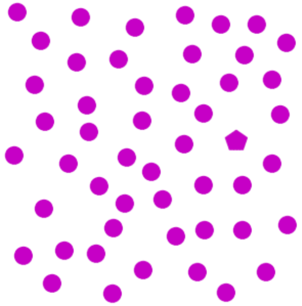
VISUAL PERCEPTION: FEATURES

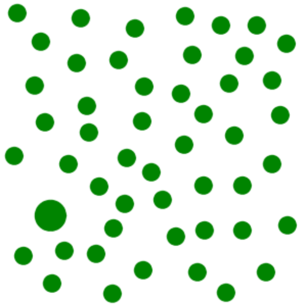
=**preattentive cues**; can be used to control eye movements (e.g., to support search processes).

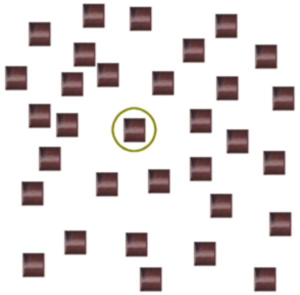

convex/concave

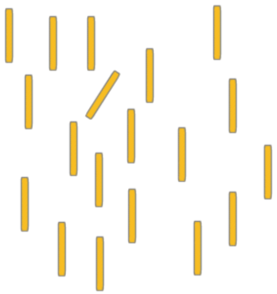

color

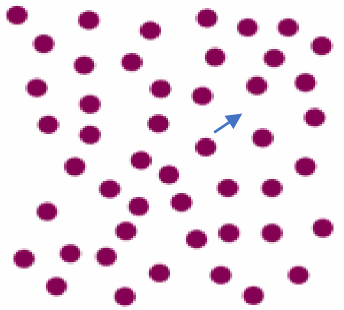

intensity


shape

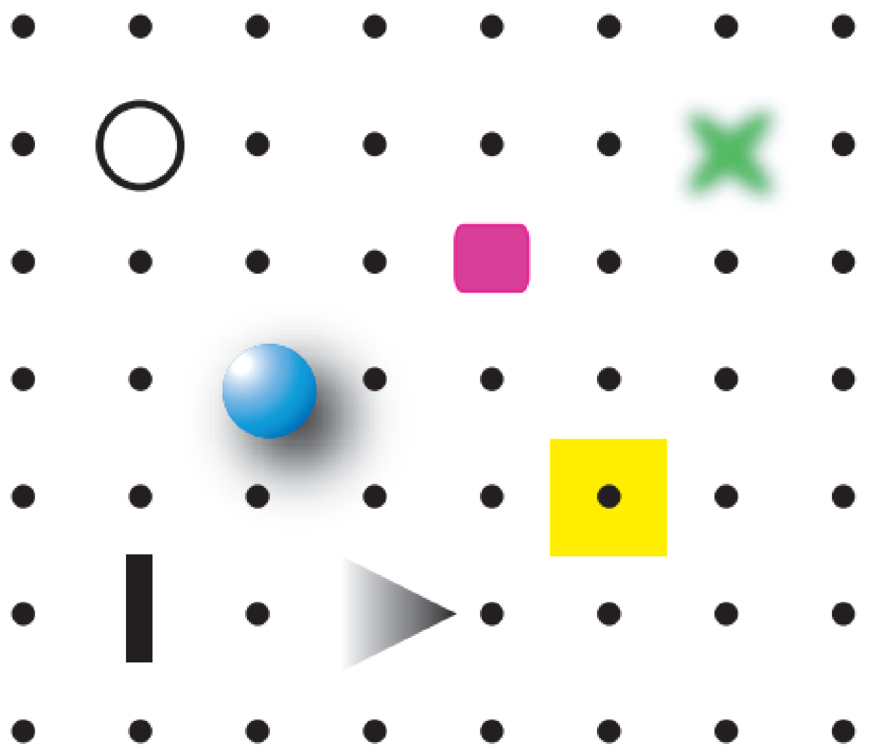

size


marker


orientation


movement

VISUAL PERCEPTION: FEATURES



A set of symbols designed so that each would be independently searchable.

Each symbol differs from the others on several channels. For example, there is only one green symbol; it is the only one with oblique lines and it is the only one with no sharp edges.

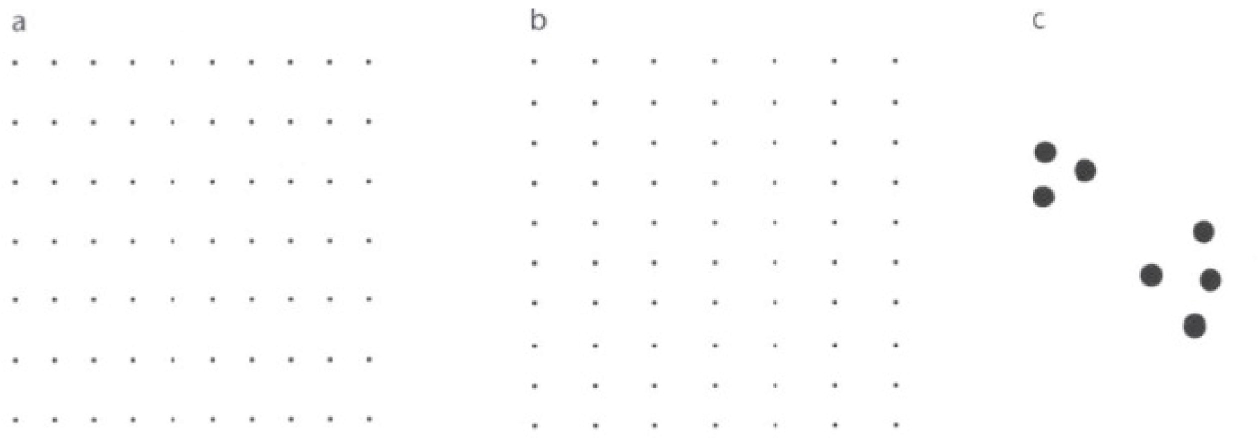
Ware, C. (2008). Information Visualization: Perception for Design. San Francisco: Morgan Kaufmann.

VISUAL PERCEPTION: FEATURES

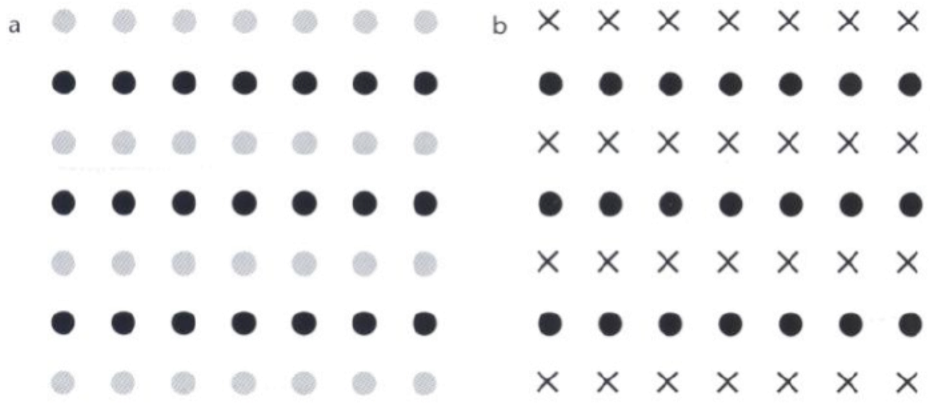
In this scatter plot, two different kinds of points are easy to find. It is easy to visually query those data points representing countries with a high level of literacy. These use color coding. It is also easy to visually query the set of points representing countries with a low urban population. These are distinct on the orientation channel because these symbols are made with **X**s containing strong oblique lines.

Ware, C. (2008). Visual Thinking for Design. Burlington: Elsevier.

ORGANISE PATTERNS: GESTALT PRINCIPLES/LAWS



Proximity



Similarity

GESTALT PRINCIPLES

- Similarity
- Proximity
- Closure
- Simplicity or good figure
- Continuity and completion
- Common destiny
- Familiarity

GESTALT PRINCIPLES

- **Similarity**
- Proximity
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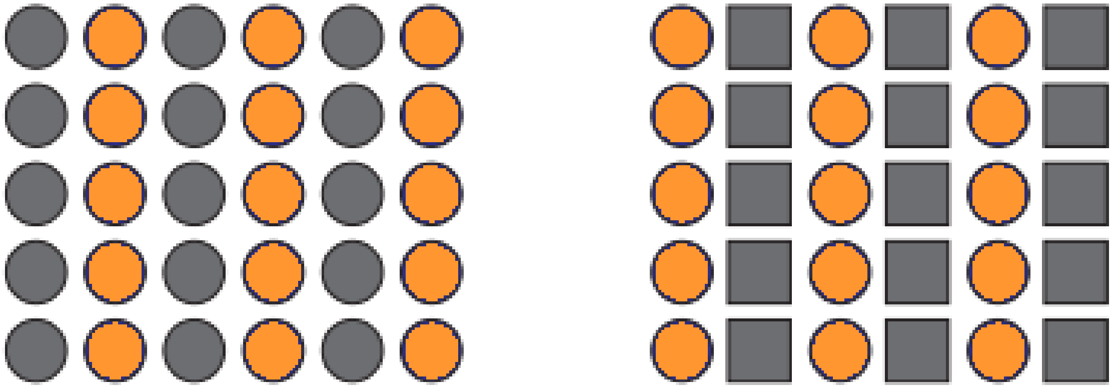

GESTALT PRINCIPLES

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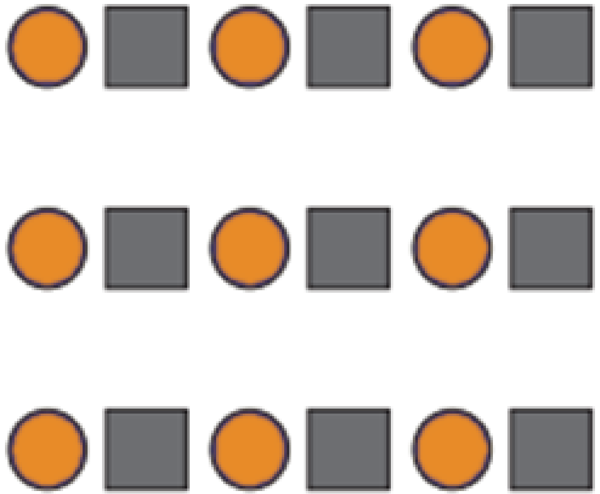

GESTALT PRINCIPLES

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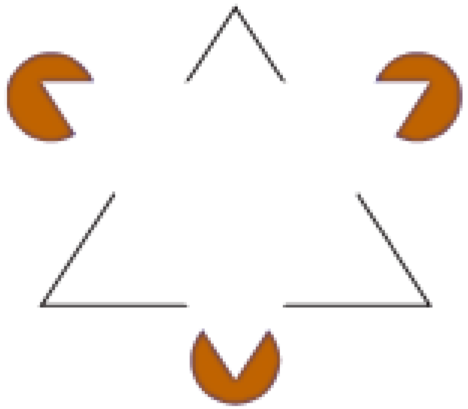

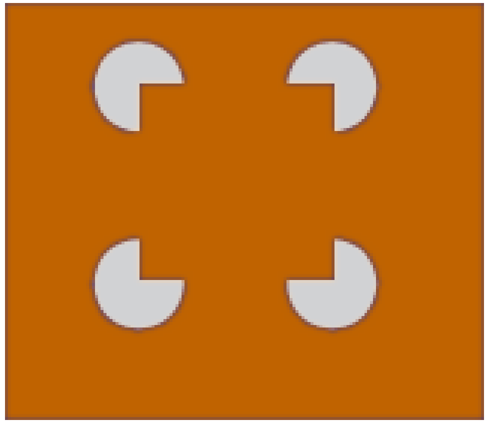

GESTALT PRINCIPLES

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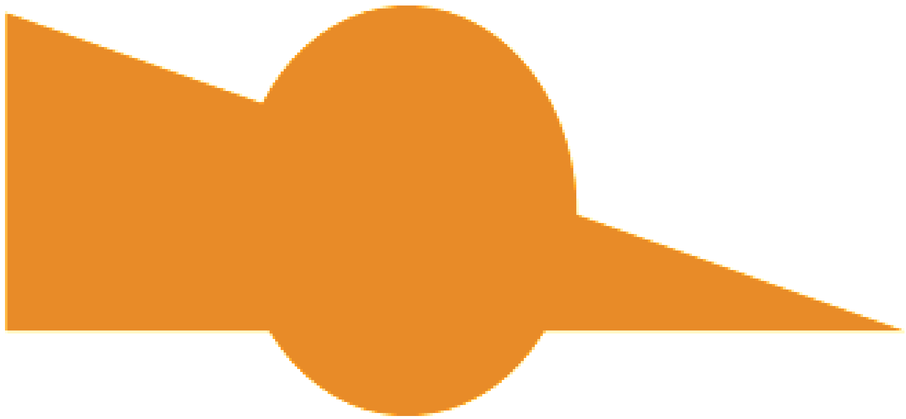

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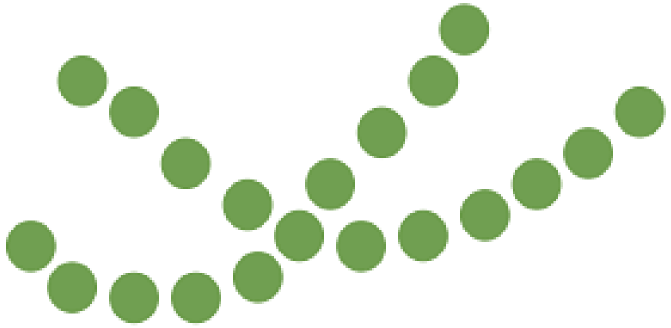

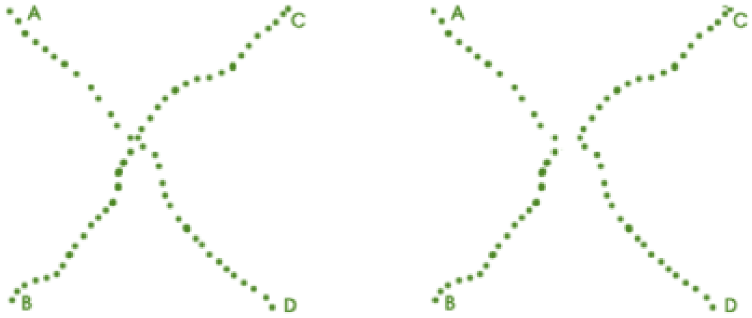

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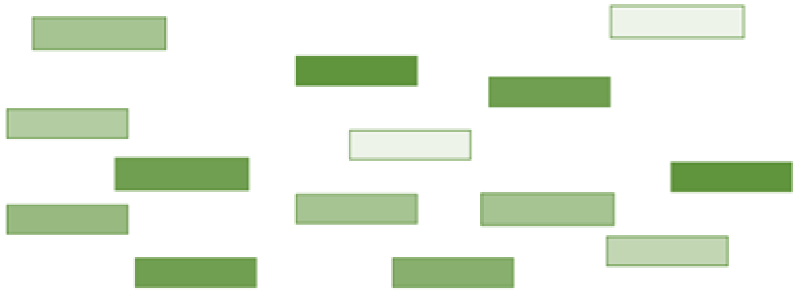

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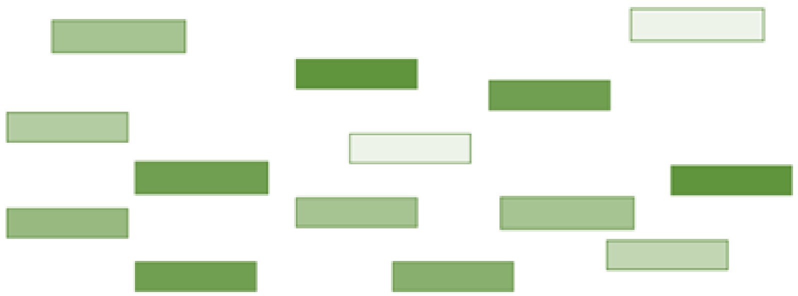

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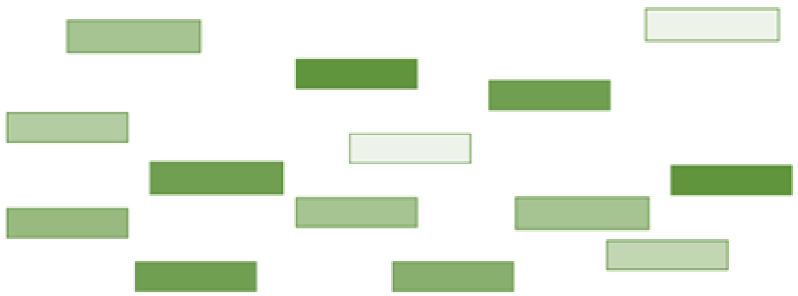

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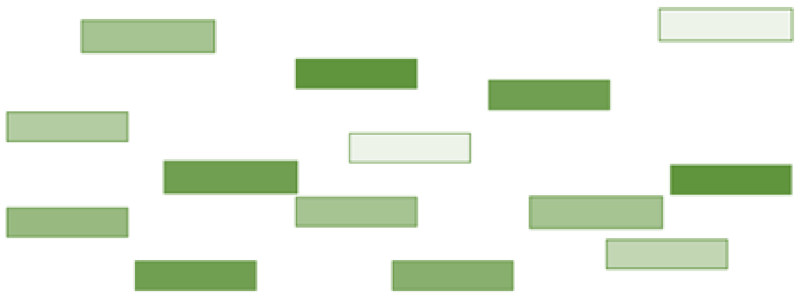

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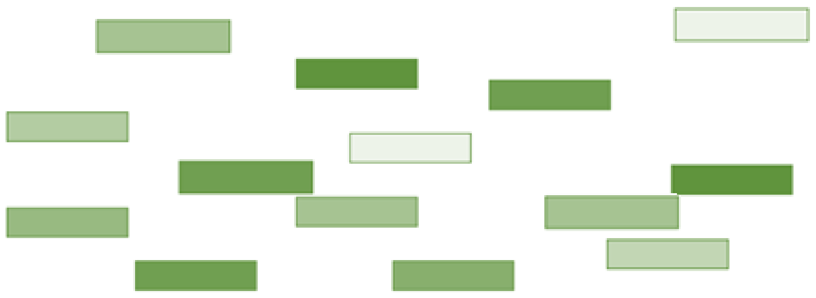

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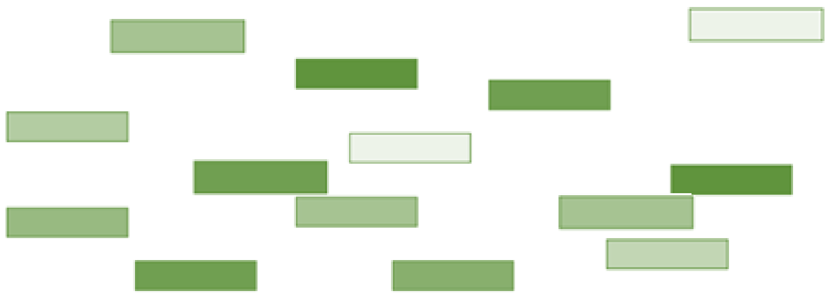

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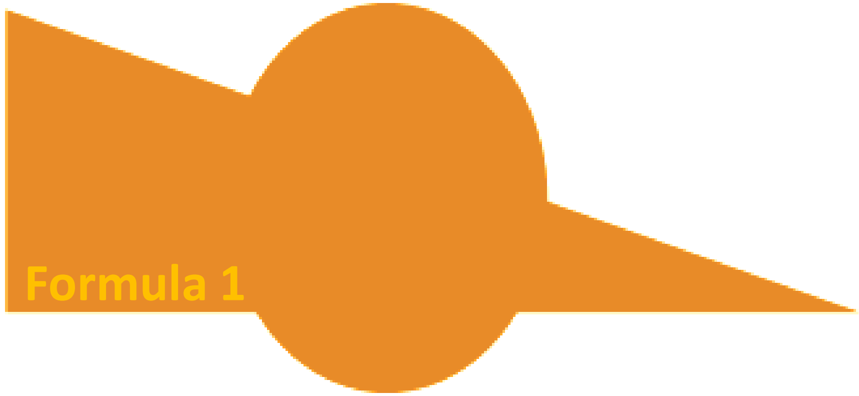
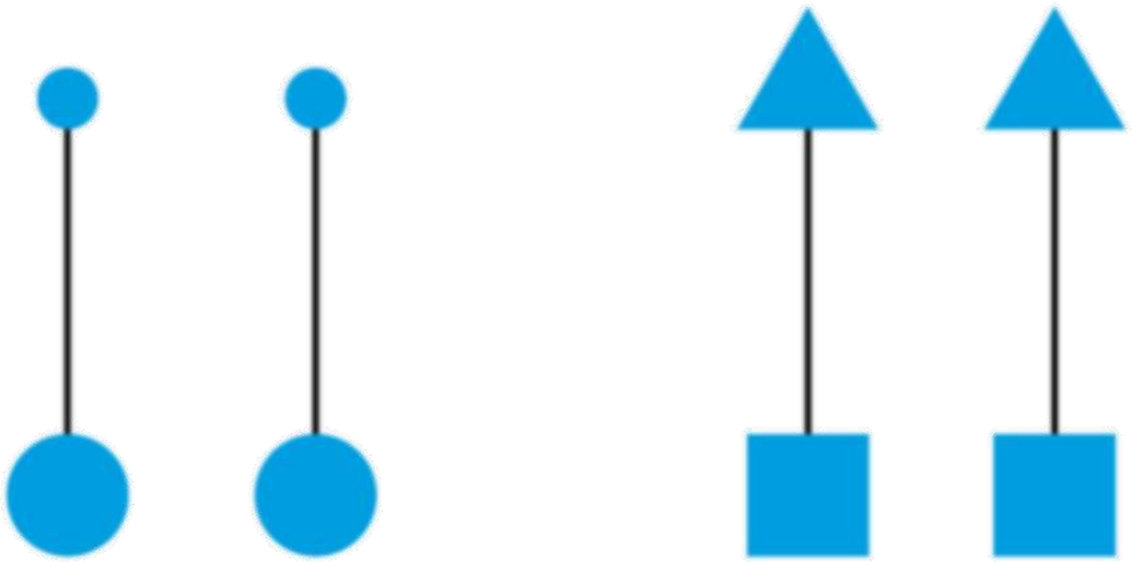
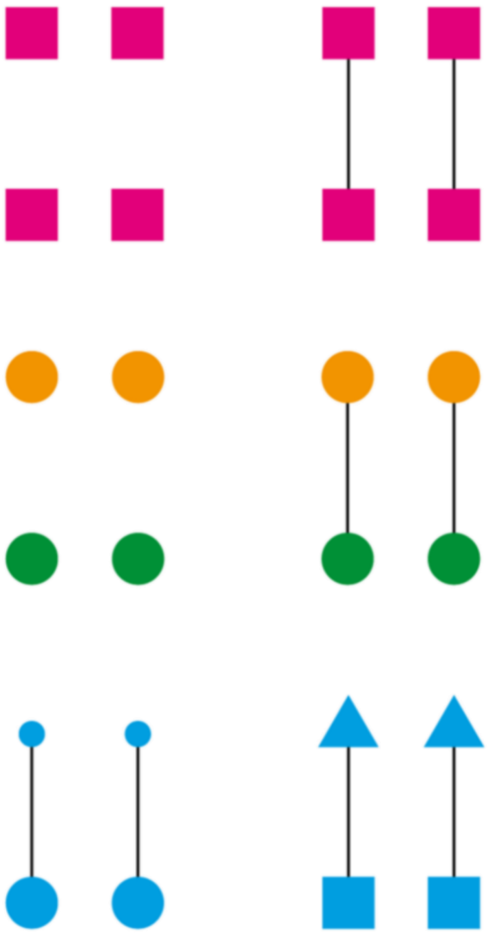


LAW OF CONNECTIONS



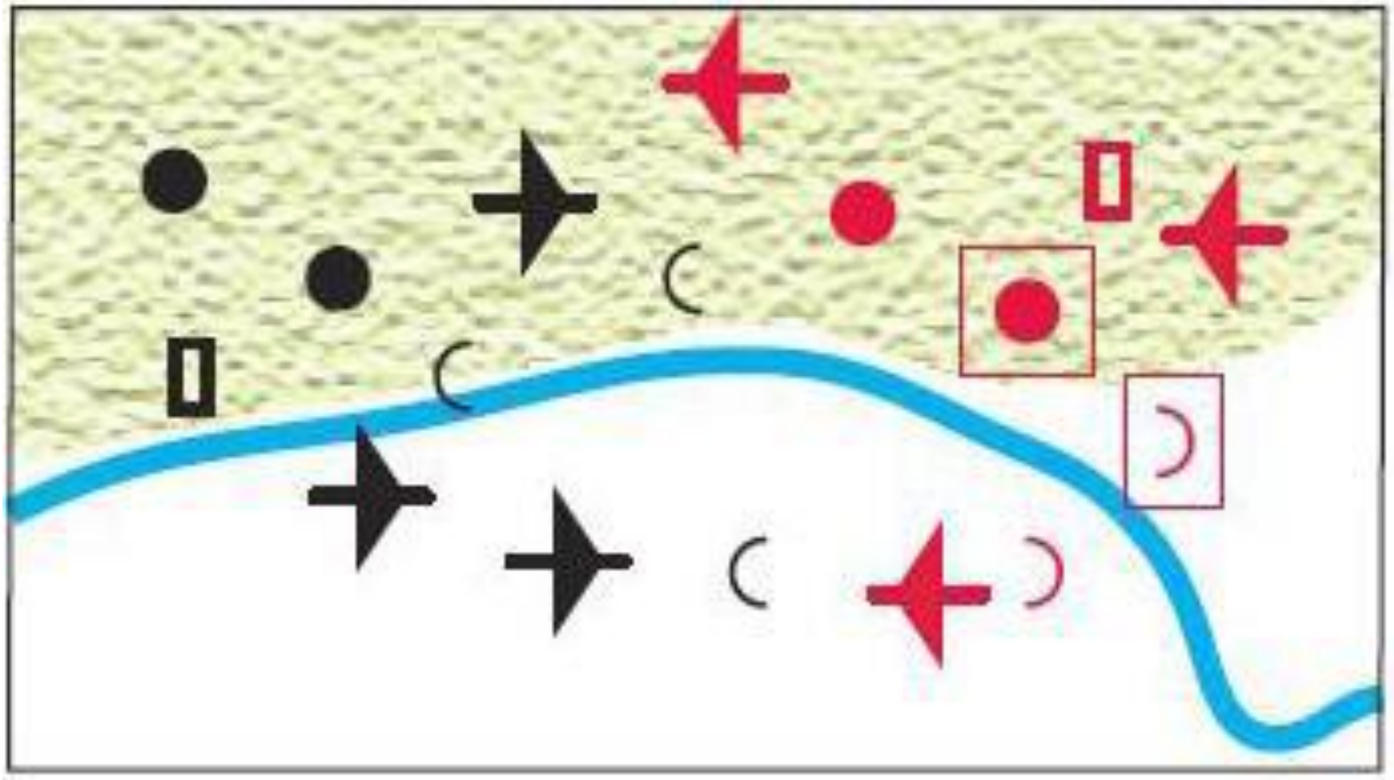
LAW OF CONNECTIONS




1446
Pizza
Kartoffel
Fleisch
Gemüse
Fisch
Pasta
Suppe
Breispeise
Mikrowelle
Grill /Kombi
Aufwärmen
Auftauen
Uhr/Timer
Stop
Start
–
+

1447

FEATURES AND GESTALT LAWS

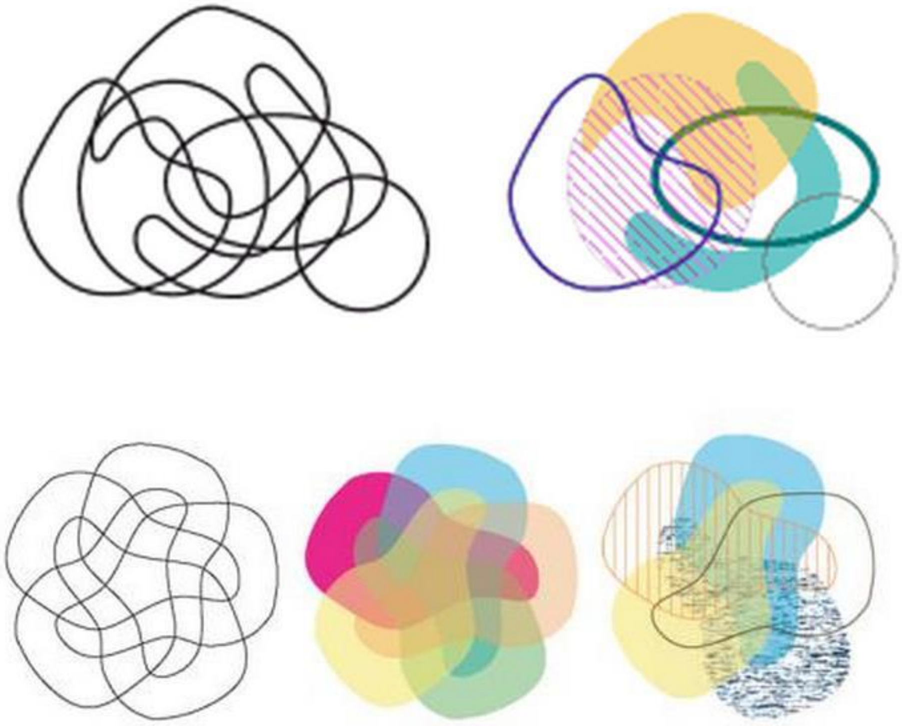


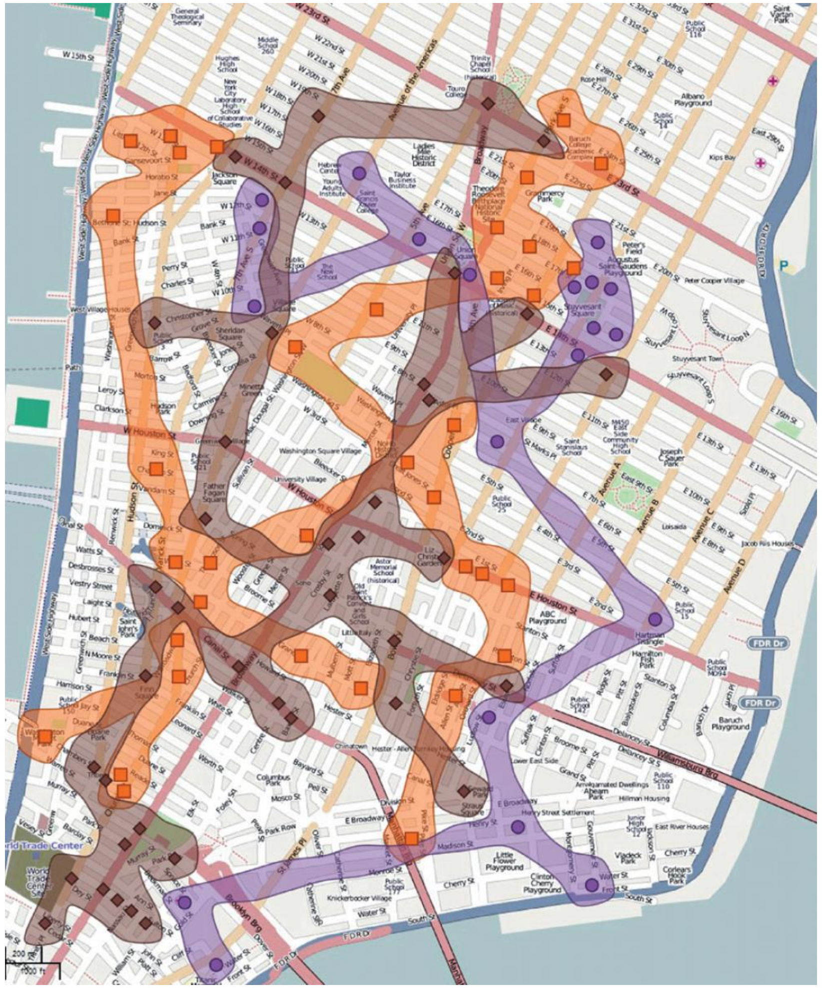
Ware, C. (2013). Information Visualization: Perception for Design. Elsevier

FEATURES + GESTALT LAWS: FEATURE LEVEL TUNING

Ware, C. (2008). Visual thinking for Design. Elsevier.

FEATURES AND GESTALT LAWS





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EXCERCISE: APPLYING THE GESTALT PRINCIPLES

1. Find bad design of everyday thing (see microwave) and interface that misuse the Gestalt Principles

2. Why is the interaction misleading? Which laws are hurt? Explain with what you know about Gestalt Laws and visual features

3. Re-design. Use a sketching app (e.g., excalidraw/draw.io/…) to improve the interaction design. Employ your knowledge of Gestalt Principles and visual perception.

4. Present.

Human Factors and Human-Machine Interaction

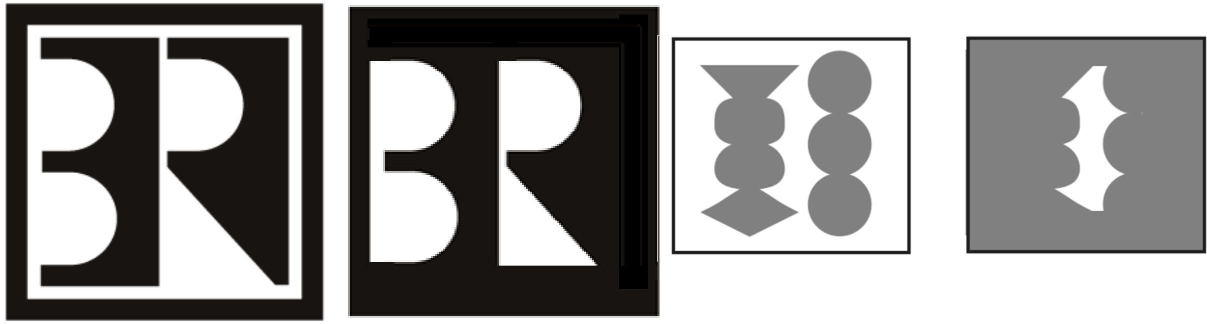
Cognitive Basics – Part 2

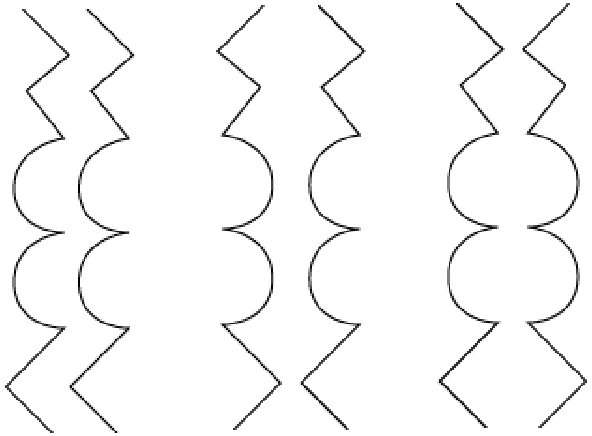
FACULTY OF COMPUTER SCIENCE

DEGGENDORF INSTITUTE OF TECHNOLOGY

PERCEPTUAL STRUCTURE

- **Objects** are perceived as separate from the **scenery**
- Problem of the **figure-ground** separation
- Decisive factors for the perception of a **figure**
    - symmetry - symmetrical objects
    - size - smaller objects
    - Orientation – vertical/horizontal objects
    - Meaning - meaningful representations
    - Outward curved shapes

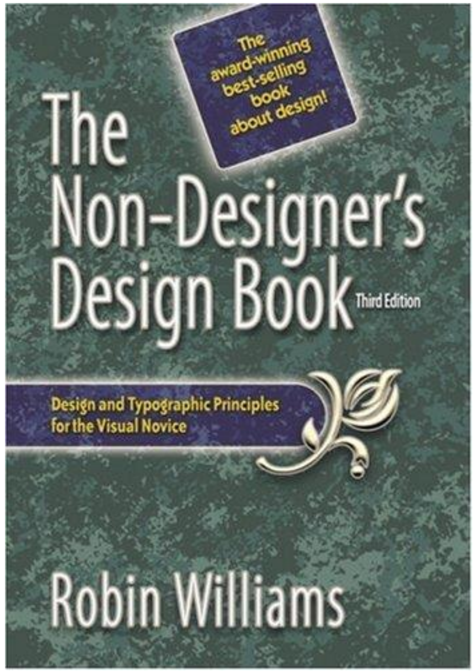




C.R.A.P.

Today you will learn about C.R.A.P.

- C.R.A.P. : The 4 basic principles of design.
- **C**ontrast
- **R**epetition
- **A**lignment
- **P**roximity
  - "...the basic principles of design that appear in every well-designed piece of work."
    - - Robin Williams,
  - *The Non-Designer's Design Book*



C.R.A.P. & GESTALT LAWS

- C.R.A.P. : The 4 basic principles of design.
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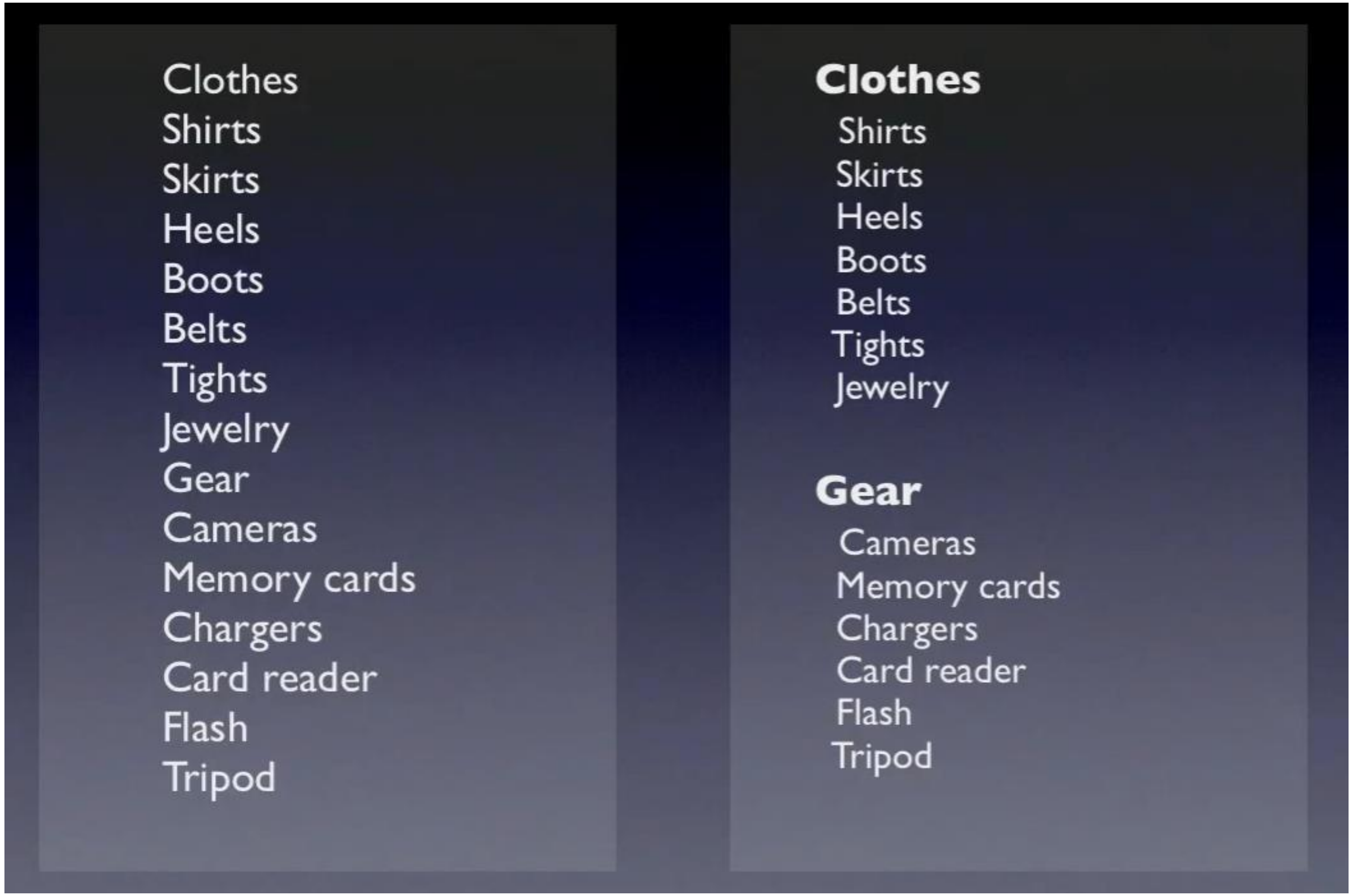
C.R.A.P. & GESTALT LAWS



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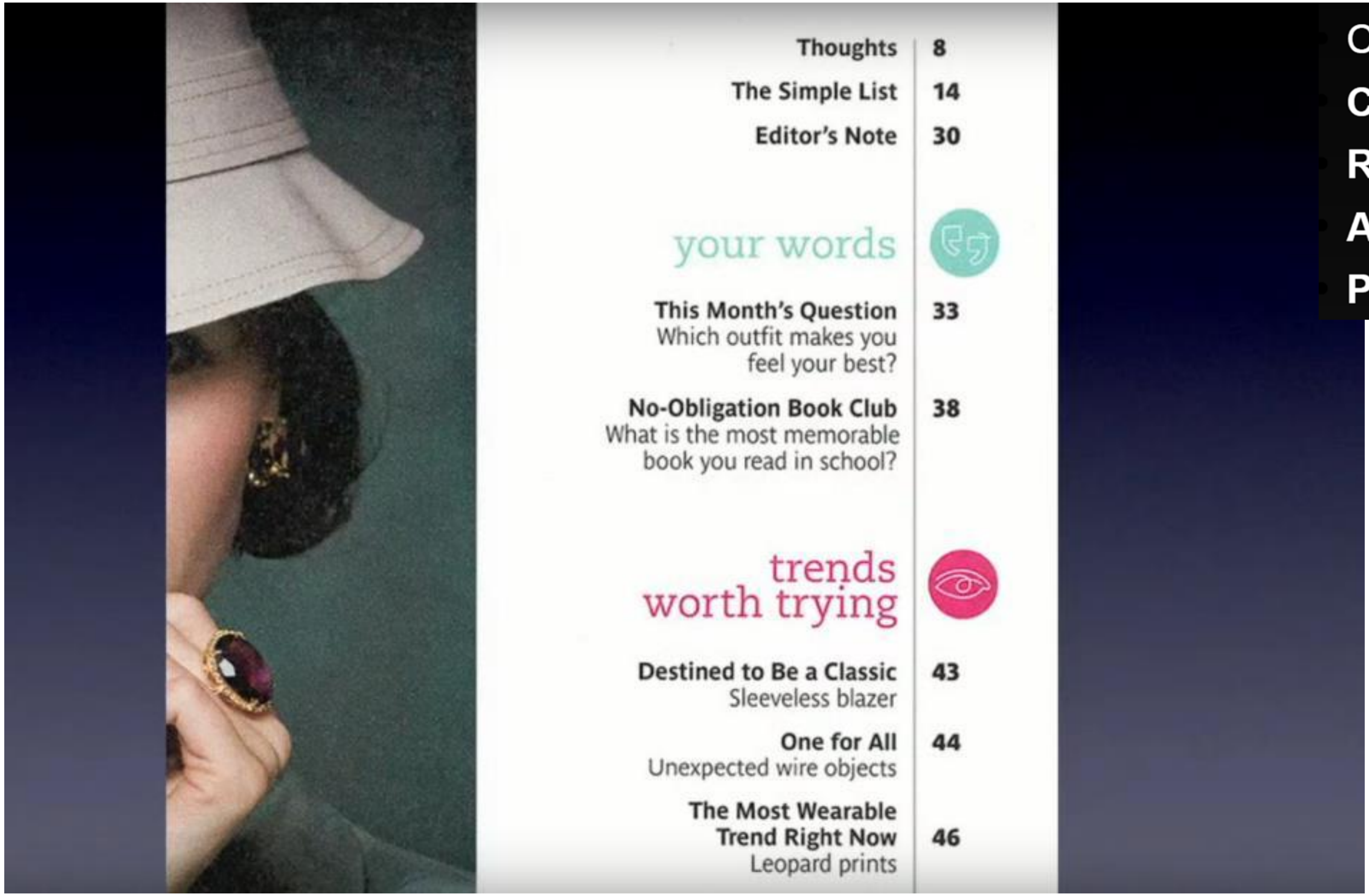
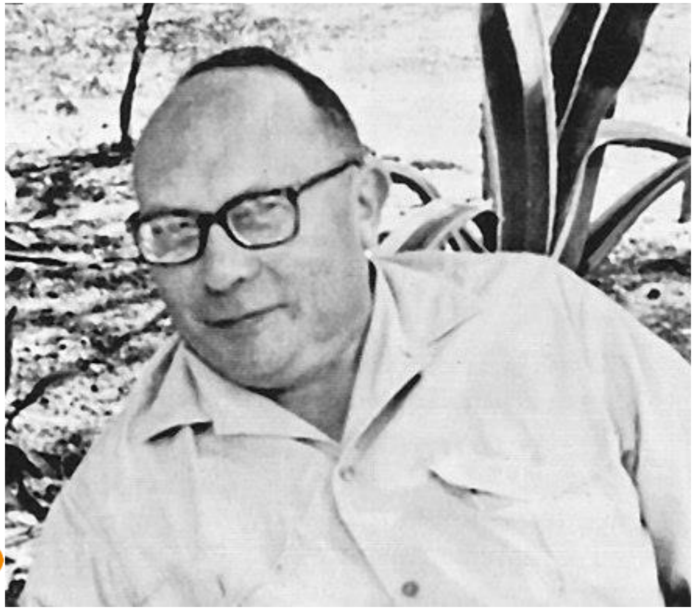
C.R.A.P. & GESTALT LAWS

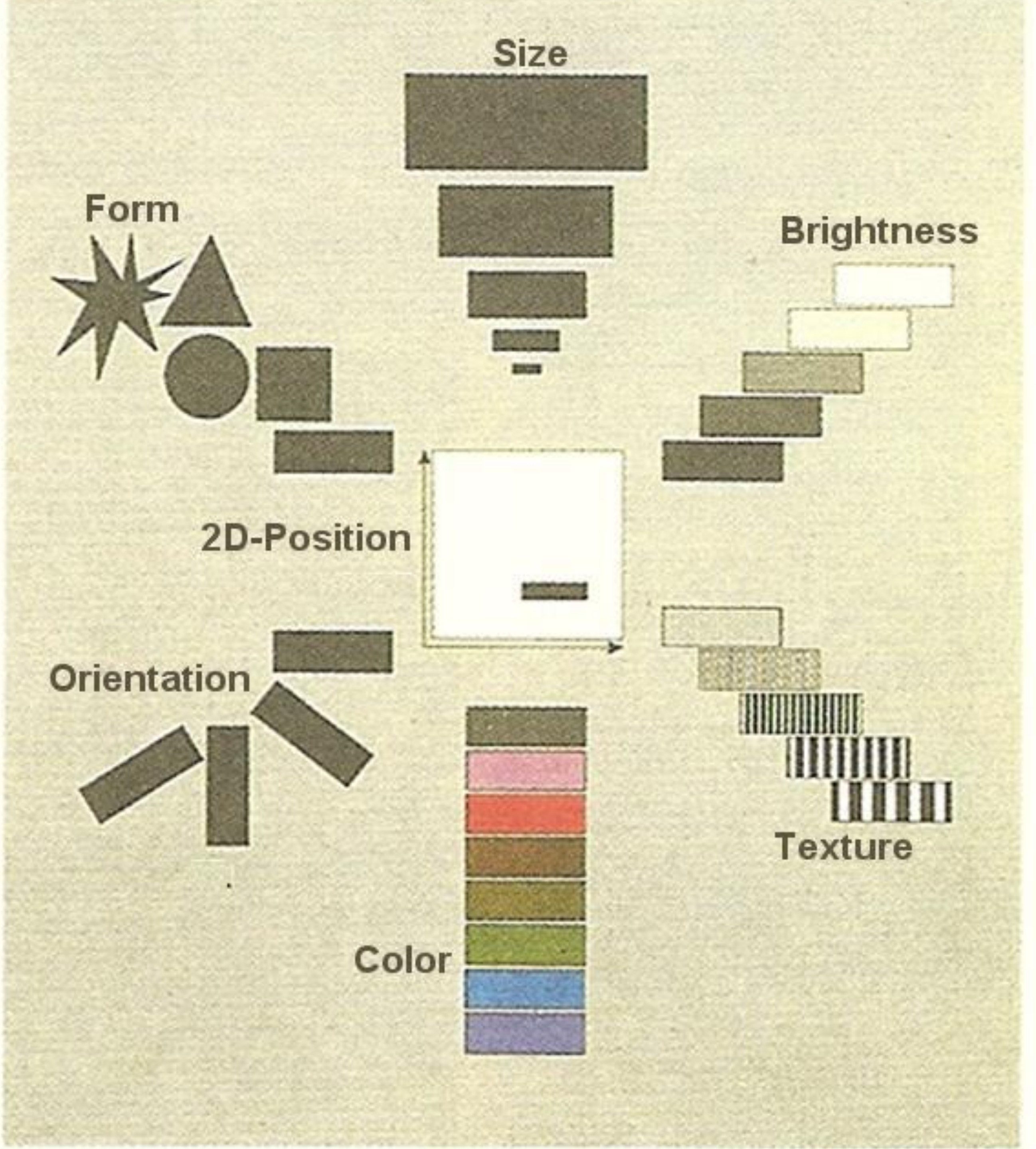


- C.R.A.P. : The 4 basic principles of design.
- **C**ontrast
- **R**epetition
- **A**lignment
- **P**roximity

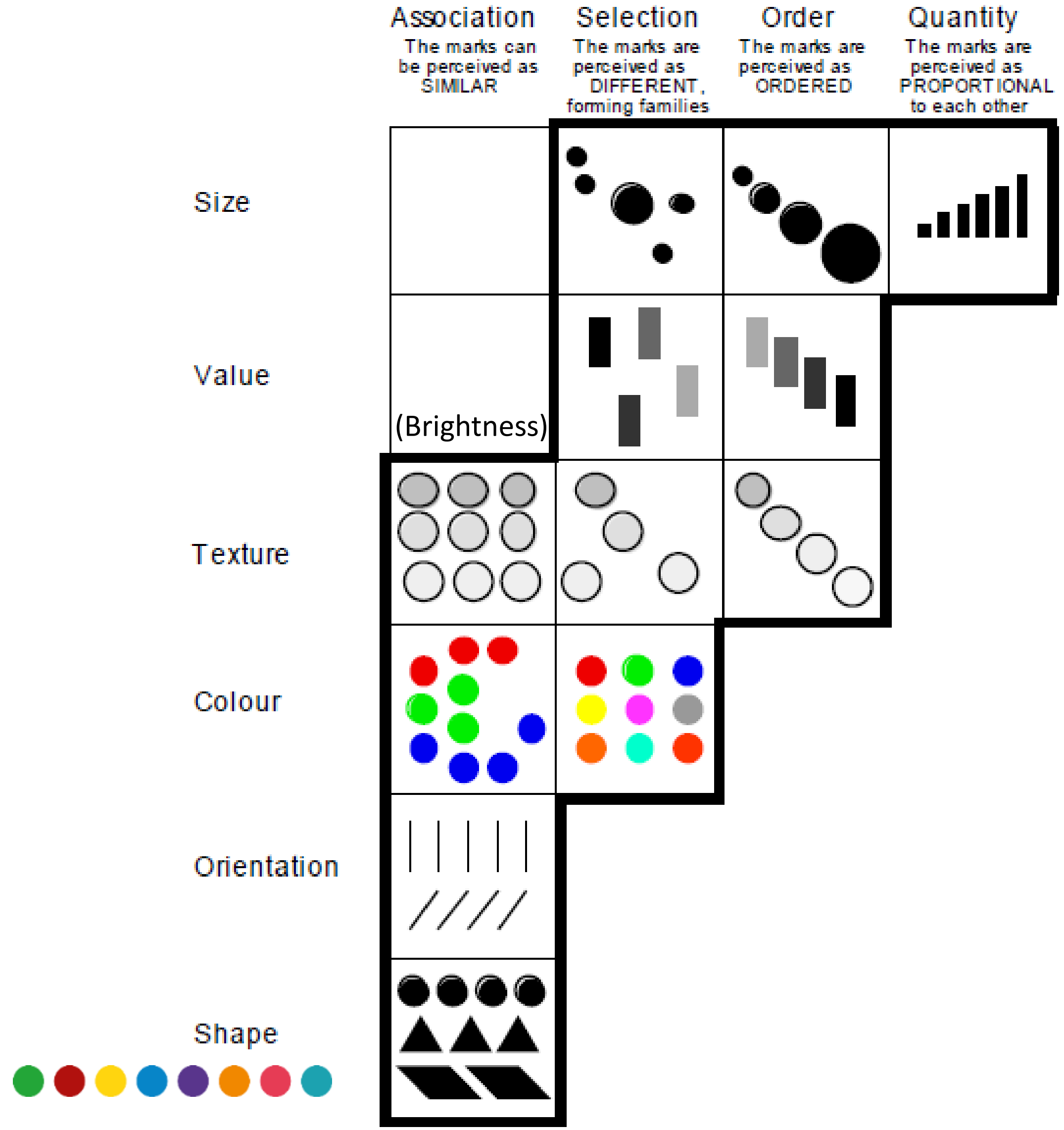
GRAPHIC VARIABLE

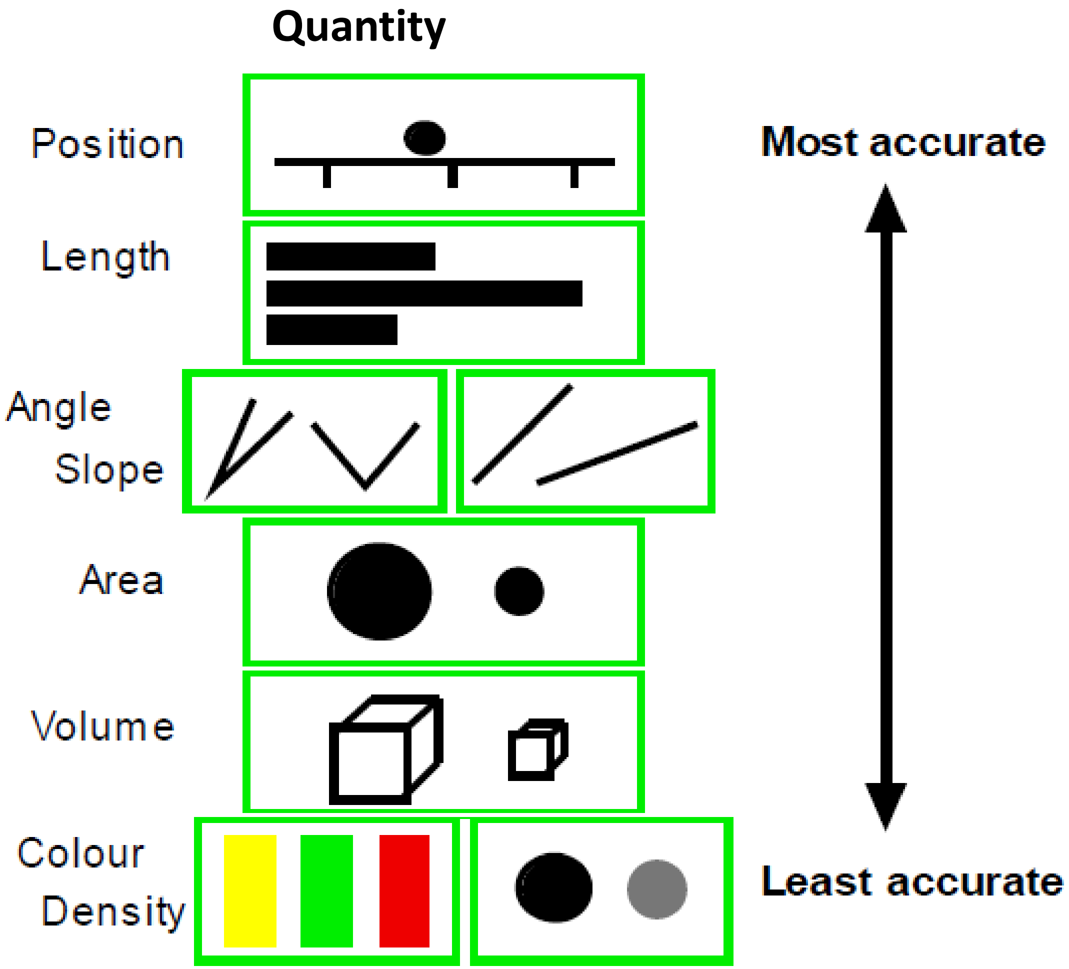
Jacques Bertin



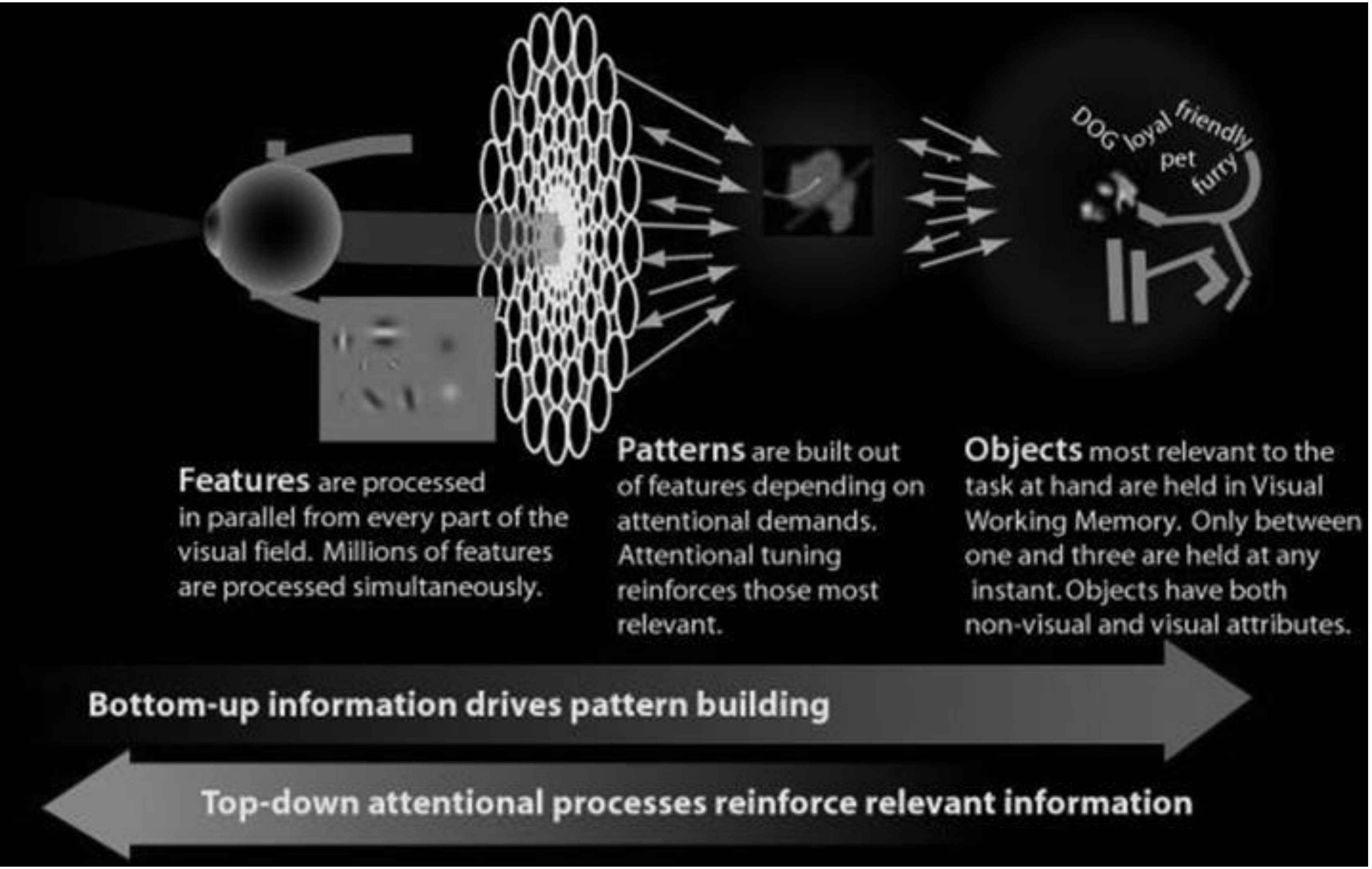


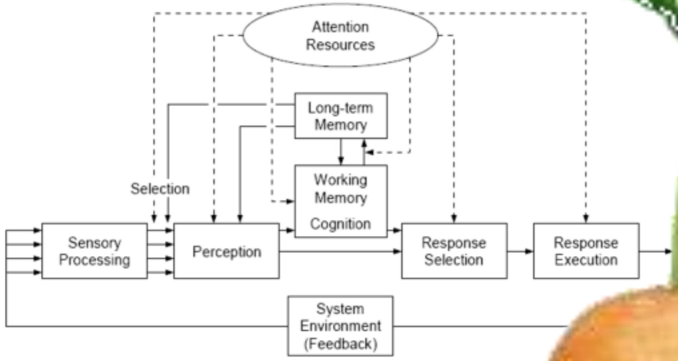
APPLICATION: INFORMATION VISUALIZATION

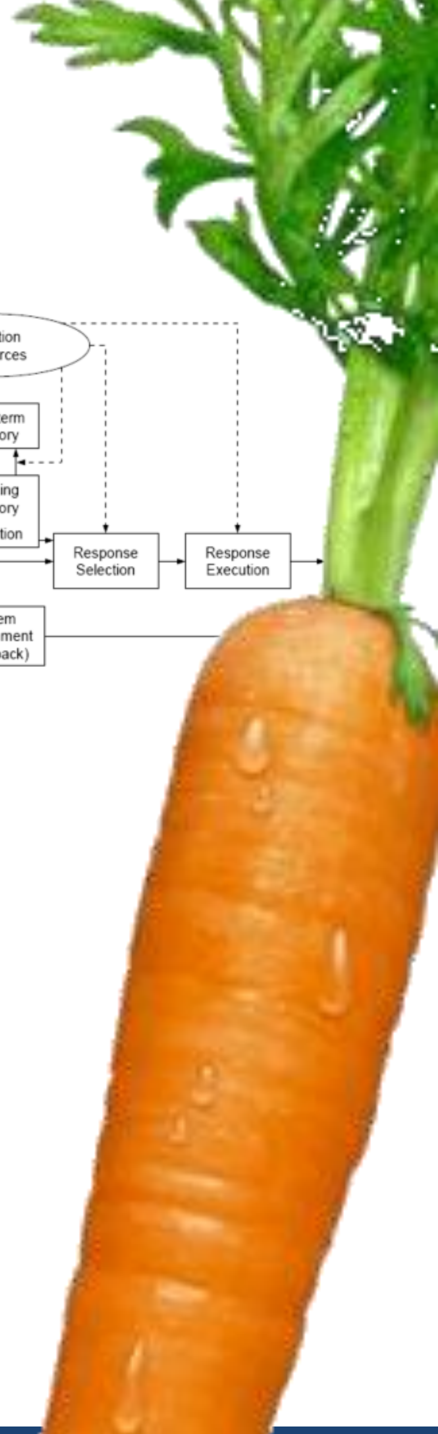




VISUAL PERCEPTION: TOP DOWN







Ware, C. (2008). *Information Visualization: Perception for Design.* San Francisco: Morgan Kaufmann.

VISUAL PERCEPTION: TOP DOWN

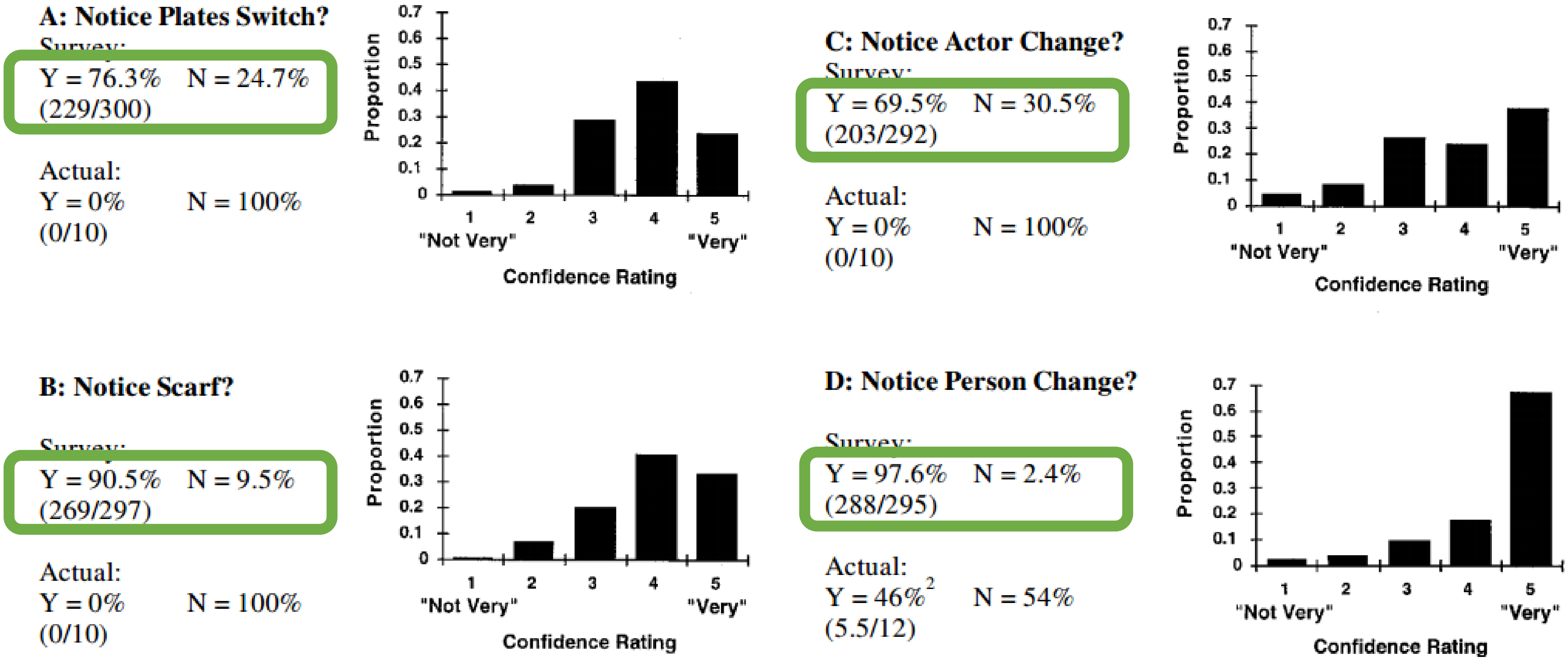
- stage 2-3: proto-object flux
- Stage 3: Ongoing **linking** of visual and non-visual information
- **Attention** influences feature and pattern analysis. It **reinforces** signals we are looking for. The receptors "shout‟
- This amplification **occurs at every stage** of information processing.
- Influence increasing from left to right (**1 < 2 < 3**)
- Consequence: what we see is strongly influenced by what we want to achieve (**goals**)

→ Attentional Tuning

VISUAL PERCEPTION: TOP DOWN

CHANGE BLINDNESS

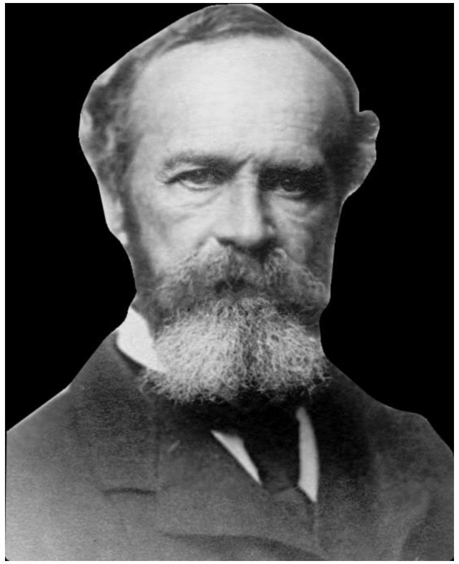
CHANGE BLINDNESS BLINDNESS



Levin, D. T., Momen, N., Drivdahl, S. B. & Simons, D. J. (2000) Change blindness blindness: The metacognitive error of overestimating change-detectionability. *Visual Cognition*7:397–412.

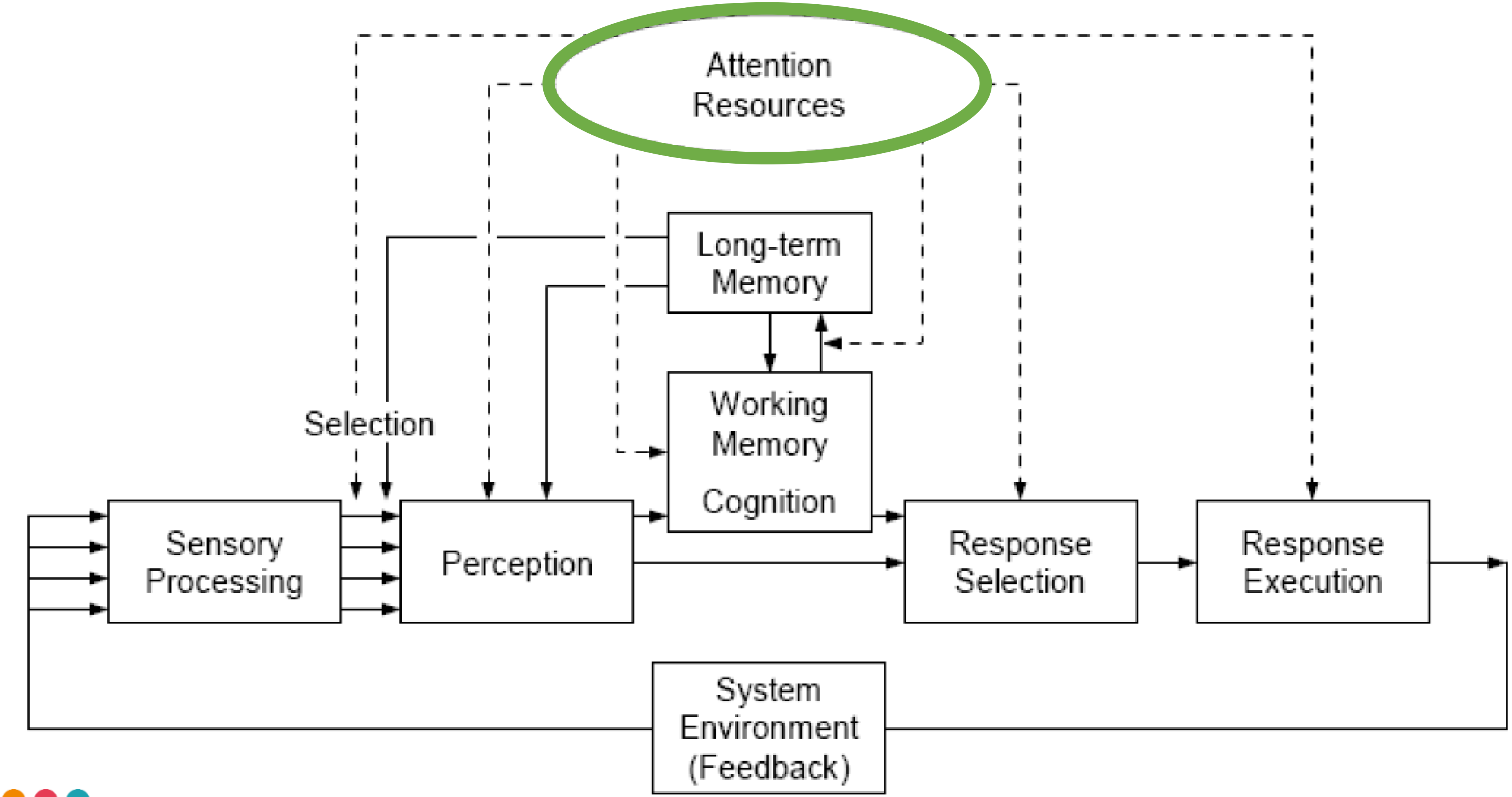
ATTENTION

William James (1890): »***Everyone knows what attention is***«

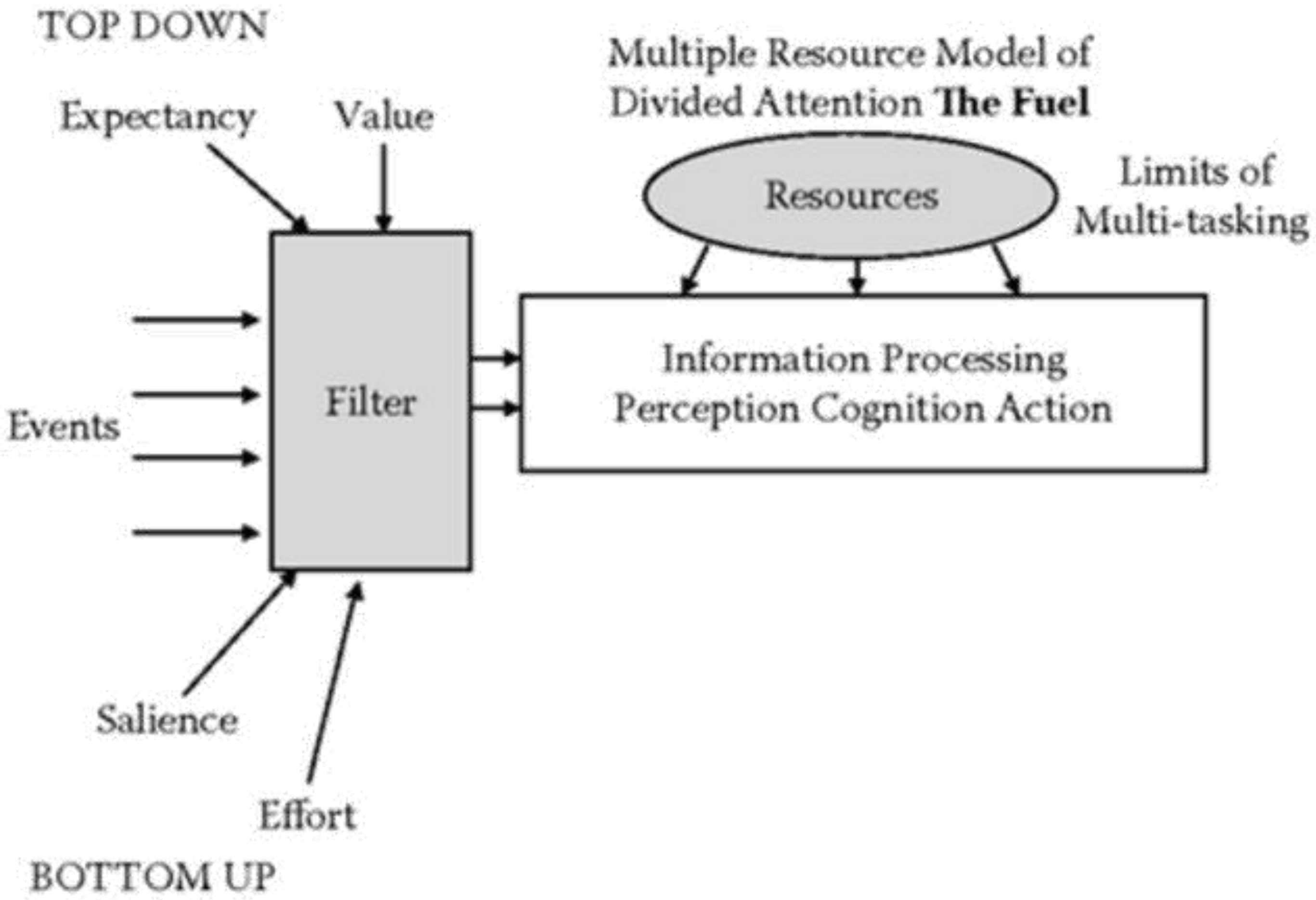


Elizabeth Styles (2006): *»Despite William James's often-quoted remark it would be closer to the truth to say that ›**Nobody knows what attention is**‹ or at least not all psychologists agree«*

INFORMATION PROCESSING

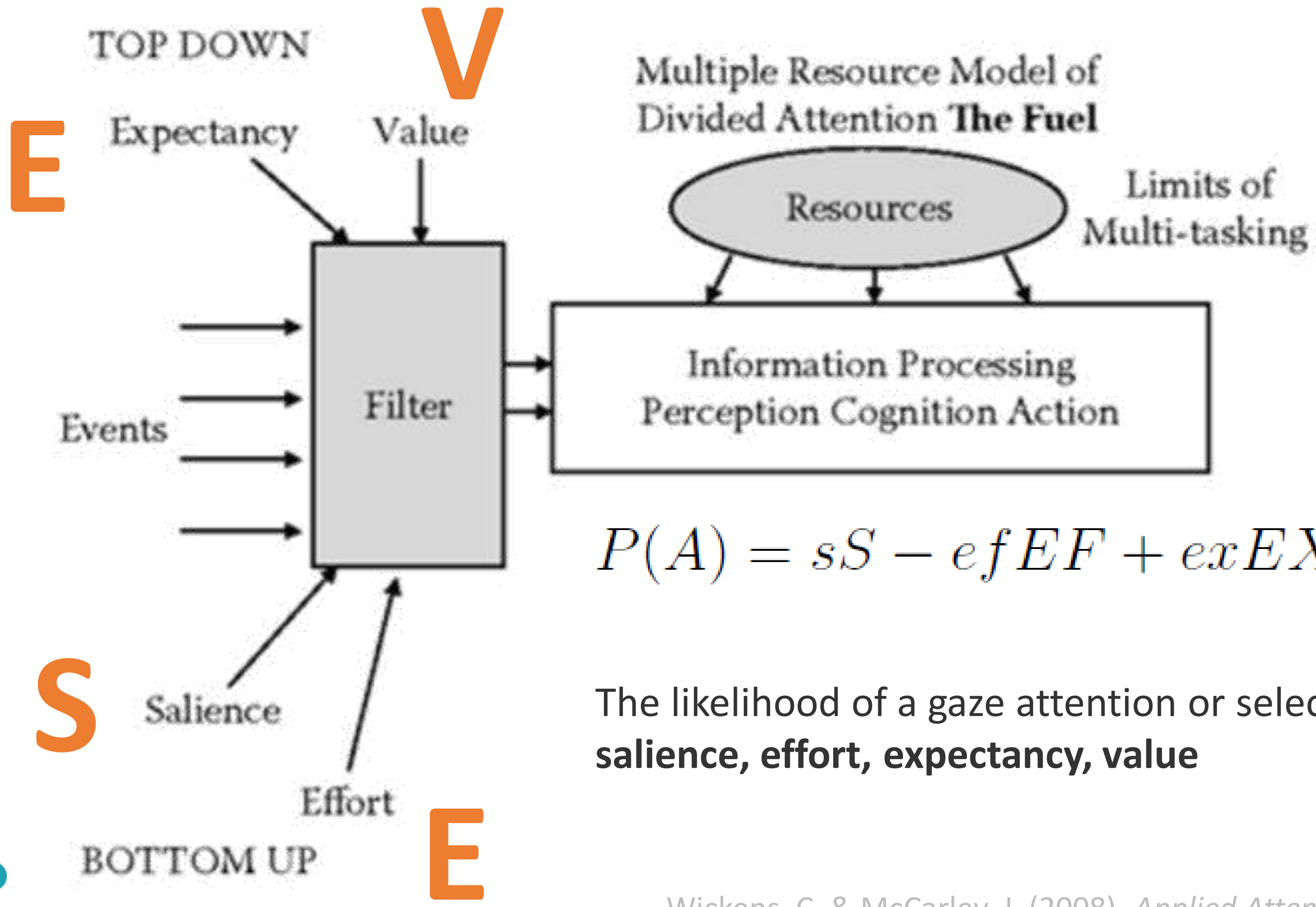


ATTENTION: FILTER & FUEL



Wickens, C. & McCarley, J. (2008). *Applied Attention Theory.* Boca Raton: CRC Press.

SELECTIVE ATTENTION: SEEV-MODEL

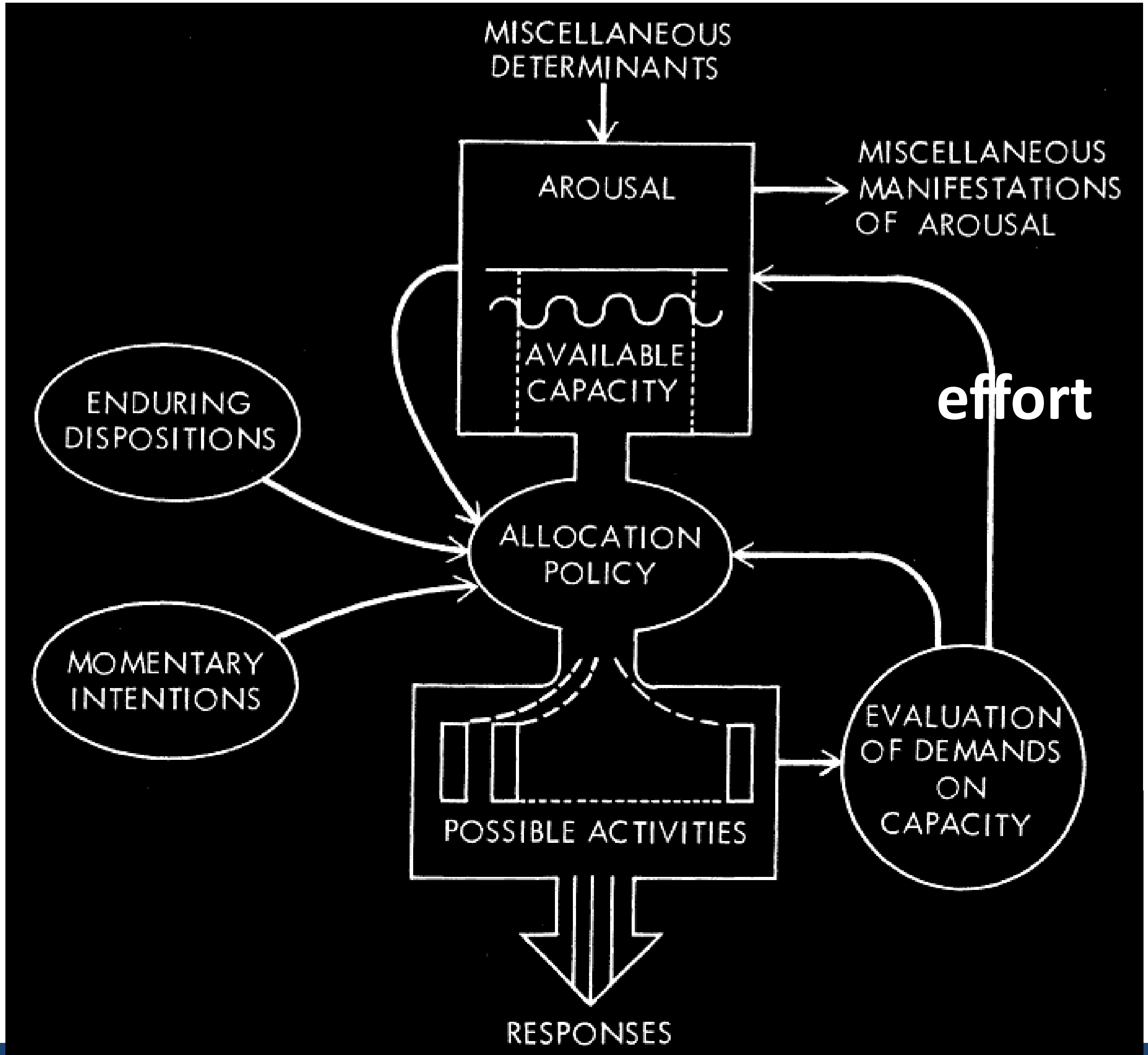


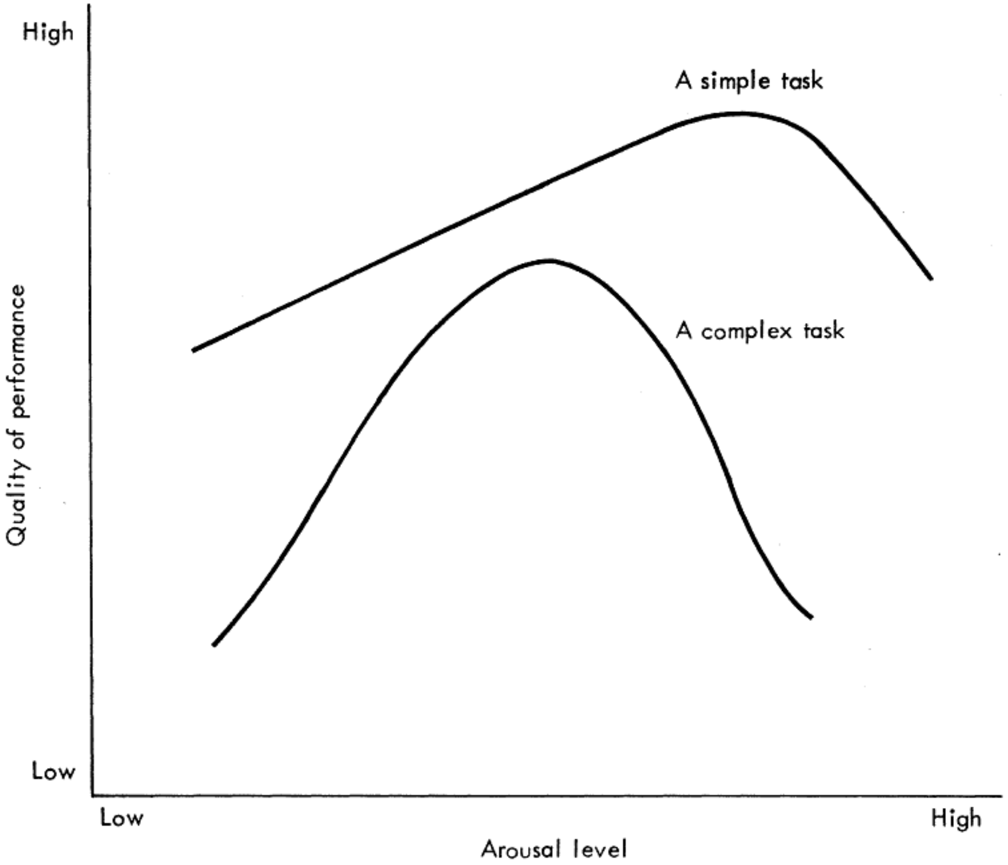
$$P(A) = sS - efEF + exEX + vV$$

The likelihood of a gaze attention or selection is determined by **salience, effort, expectancy, value**

Wickens, C. & McCarley, J. (2008). *Applied Attention Theory.* Boca Raton: CRC Press.

CAPACITY MODEL





Yerkes & Dodson

Workload

WORKLOAD


... und wer fährt?
BG
DVR
Bundesministerium
für Verkehr, Bau-
und Wohnungswesen

WORKLOAD

WORKLOAD DEFINITIONS

Workload is a general term used to describe the cost of **accomplishing task requirements** for the human element of man-machine systems

Hart, S. G., & Staveland, L. E. (1988). Development of NASA TLX (Task Load Index): Results of experimental and theoretical research. In P.A. Hancock & N. Meshkati(Eds.), Human mental workload(pp. 139–183). Amsterdam: North-Holland.

Workload is a hypothetical construct intended to capture **limitations on the operator's information processing apparatus** as these are viewed from the perspective of some assigned task

Gopher, D. & Donchin, E. (1986). Workload –An examination of the concept. Handbook of Perception and Human Performance, 2, 1–49.

Workload is the specification of the amount of **information processing capacity** that is used for task performance

De Waard, D. (1996). The Measurement of Drivers' Mental Workload. Haren, Traffic Research Centre VSC: University of Groningen, Ph.D. Thesis.

MEASURING WORKLOAD

- **Why?**
  - Relation to performance
  - Identification of processing **bottlenecks**
  - **Evaluation** of new designs

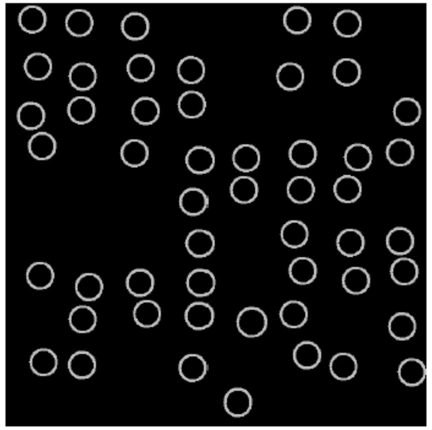
- **How?**
  - Behaviour
  - Physiology
  - Subjective

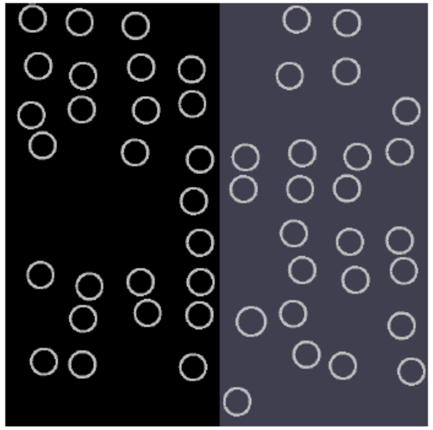
MEASURING WORKLOAD: BEHAVIOUR

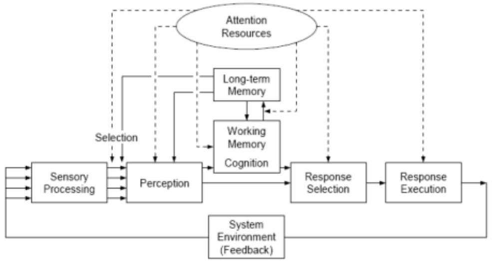
- Deviation from a standard course
- RMSE: Root Mean Square Error
- Artificial driving task: **Lane Change Task**

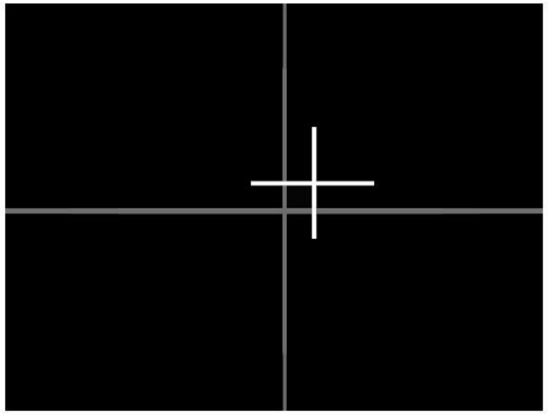
MEASURING WORKLOAD: BEHAVIOUR

- **Additional task**
  - Second task
  - Loading task
- **Visual** task
- **Motor** task
- **Cognitive** task





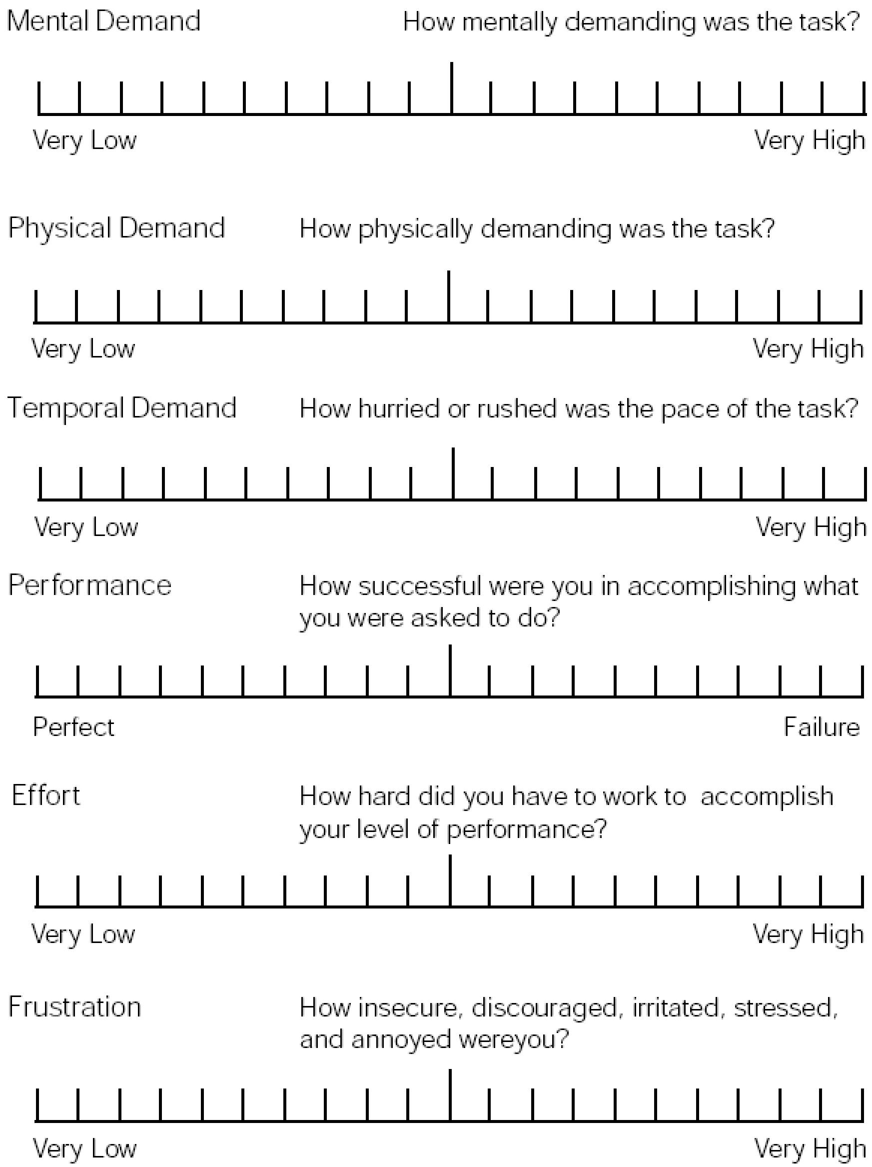


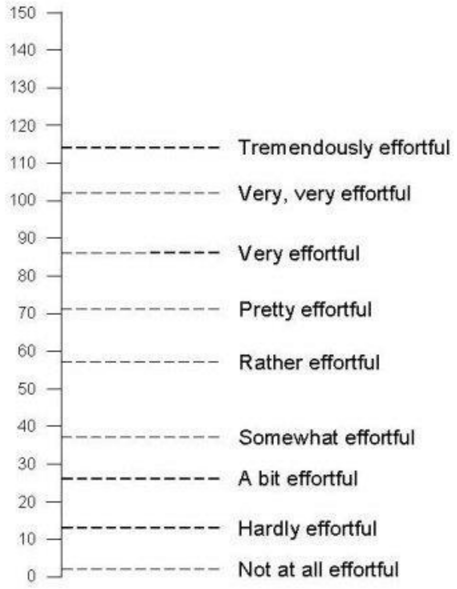


MEASURING WORKLOAD: SUBJECTIVE

Questionnaires

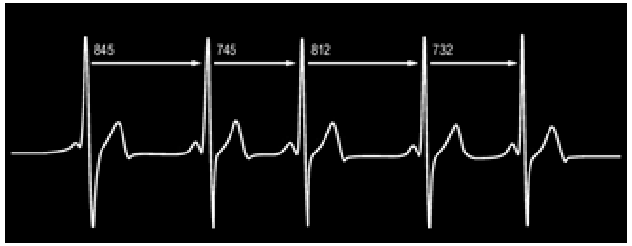
- NASA TLX
- **R**ating **S**cale **M**ental **E**ffort - RSME



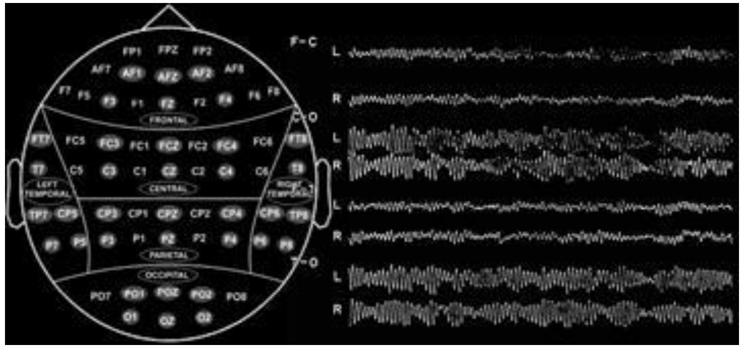


MEASURING WORKLOAD: PHYSIOLOGY

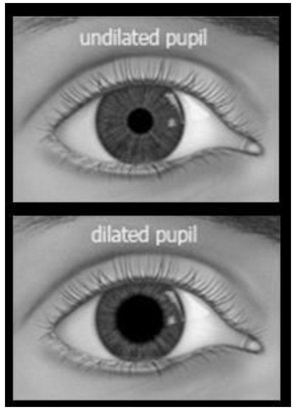
Heart rate variability



EEG



Pupil diameter



EXCERCISE: C.R.A.P.

1. Is your app C.R.A.P.? Select at least three apps installed on your smartphone and analyse, how the C.R.A.P. principles are implemented.

2. Is there room for improvement concerning the principles?

3. Report and present.

DEGGENDORF INSTITUTE OF TECHNOLOGY

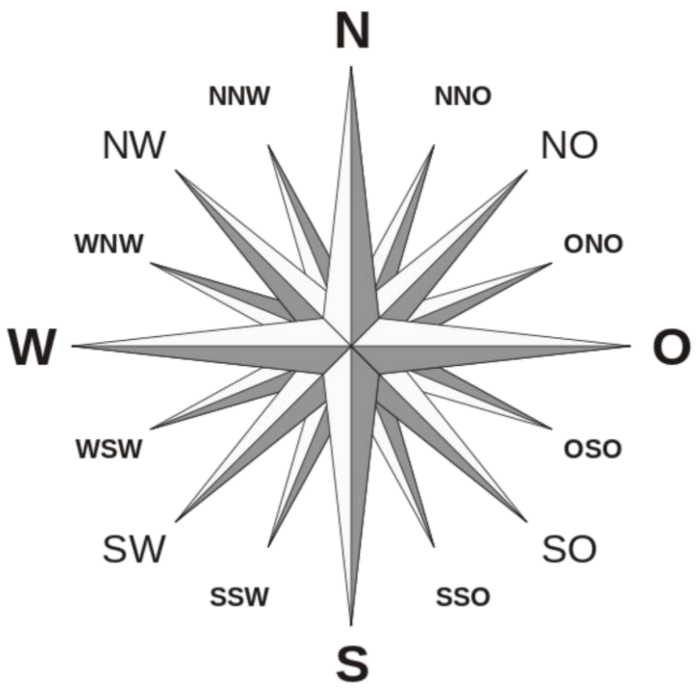
Human Factors and Human-Machine Interaction

Information Visualisation

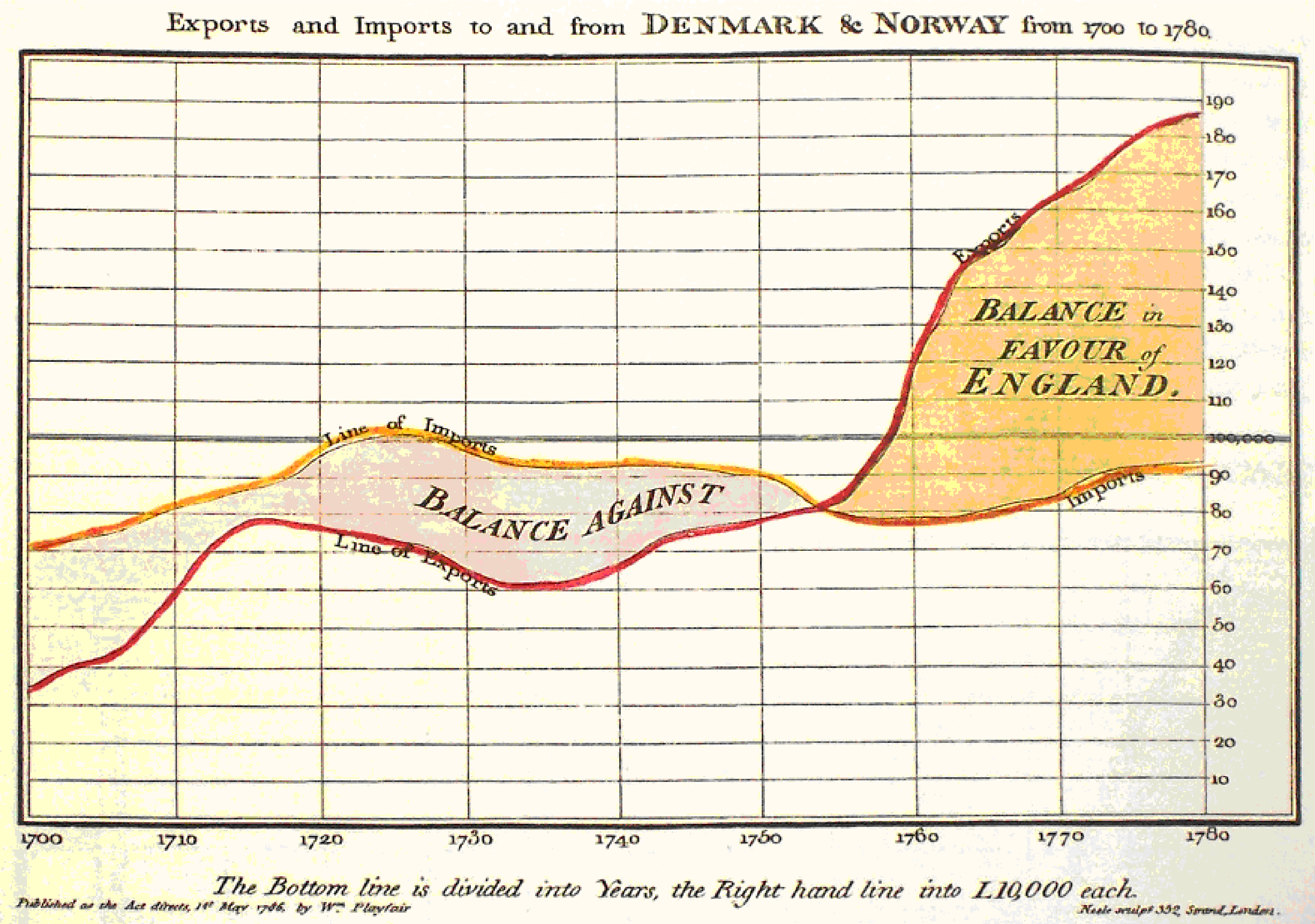
FACULTY OF COMPUTER SCIENCE

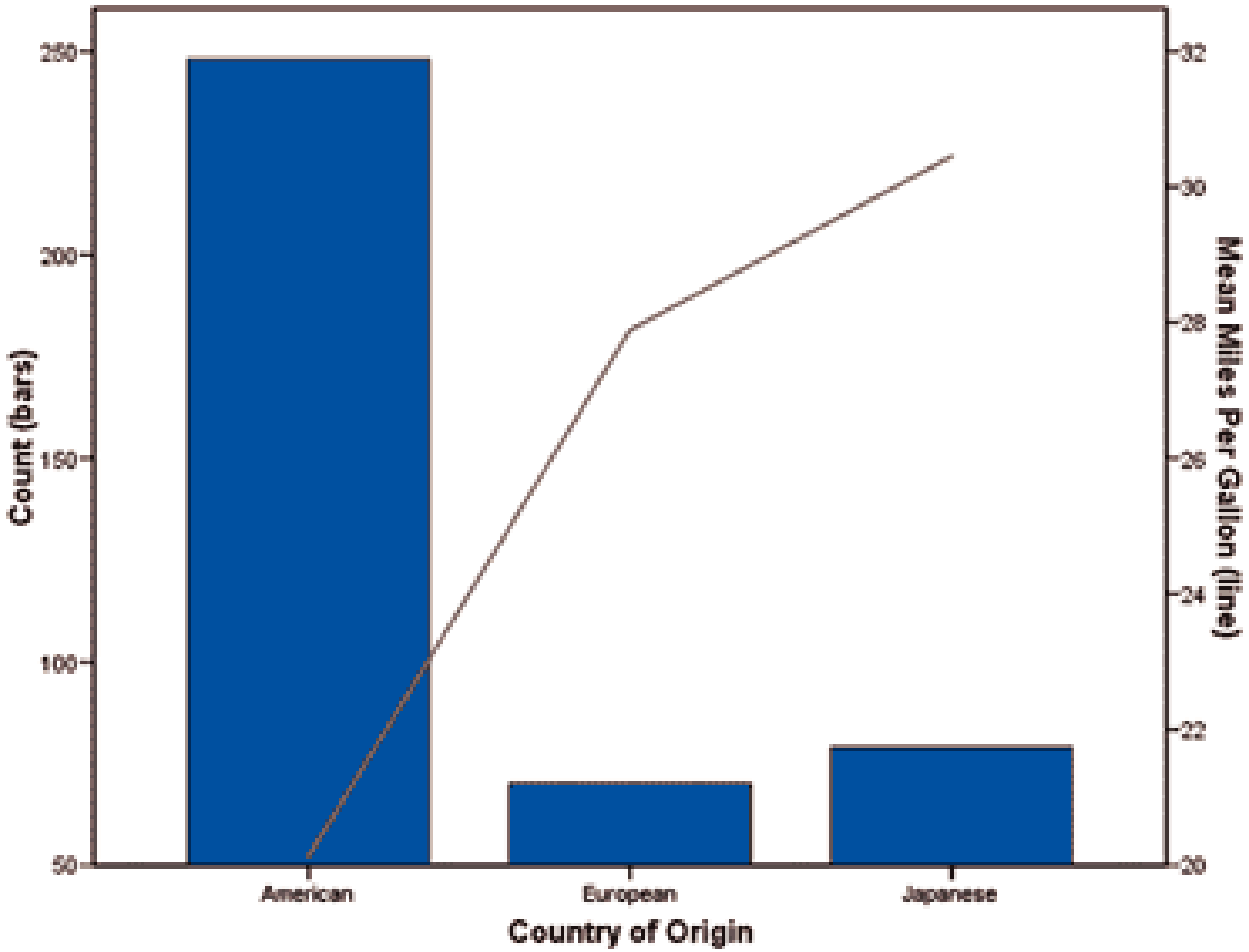
OVERVIEW

- (Historical) Examples
- Edward Tufte : Chart Junk, Lie Factor, Small Multiples
- No Good Ideas: The third dimension, pie charts
- Visual characteristics from head to toe: Bertin, Cleveland
- Examples: before & after

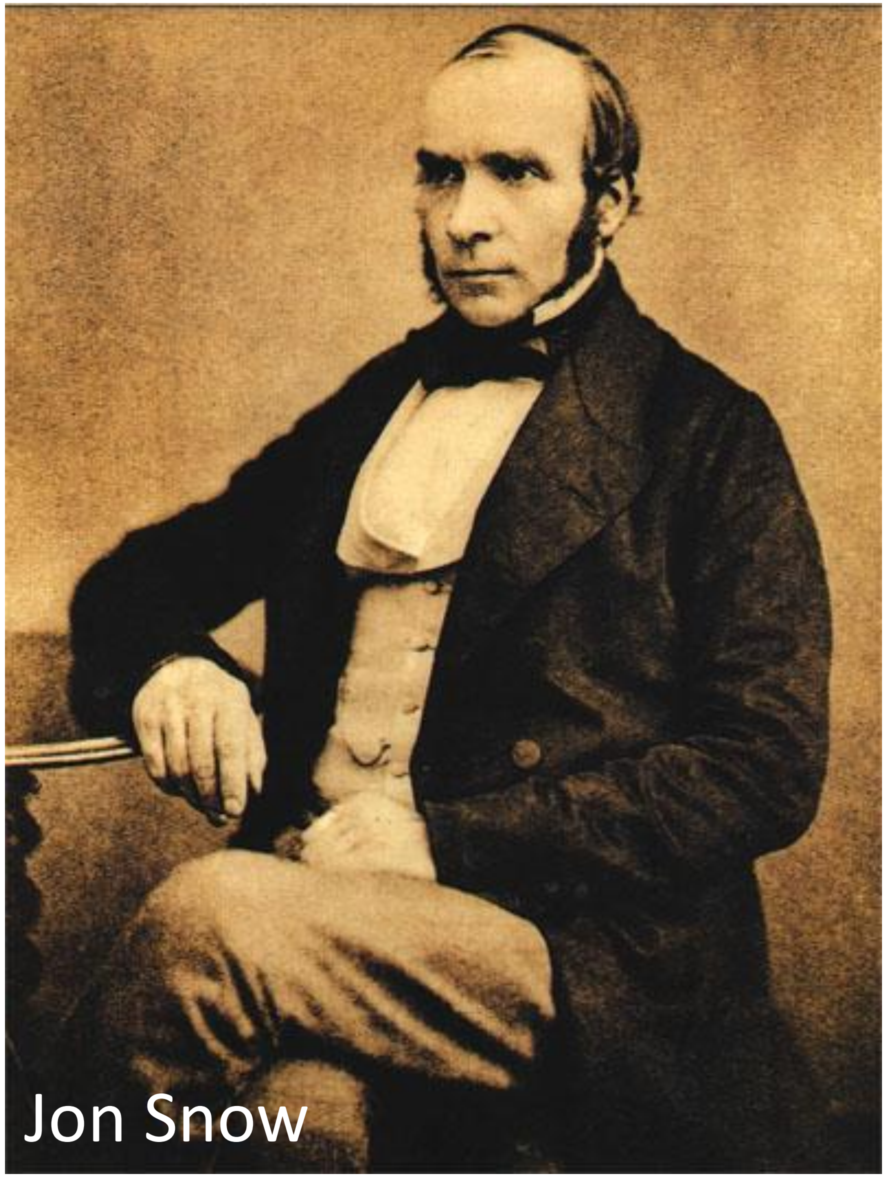


(NOT ONLY HISTORICAL) EXAMPLES


Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.
Line of Imports
BALANCE AGAINST
Line of Exports
Exports
BALANCE in FAVOUR of ENGLAND.
Imports
190
180
170
160
150
140
130
120
110
100,000
90
80
70
60
50
40
30
20
10
1700
1710
1720
1730
1740
1750
1760
1770
1780
The Bottom line is divided into Years, the Right hand line into L10,000 each.
Published as the Act directs, 1st May 1786, by Wm. Playfair
Neele sculpt 352, Strand, London.

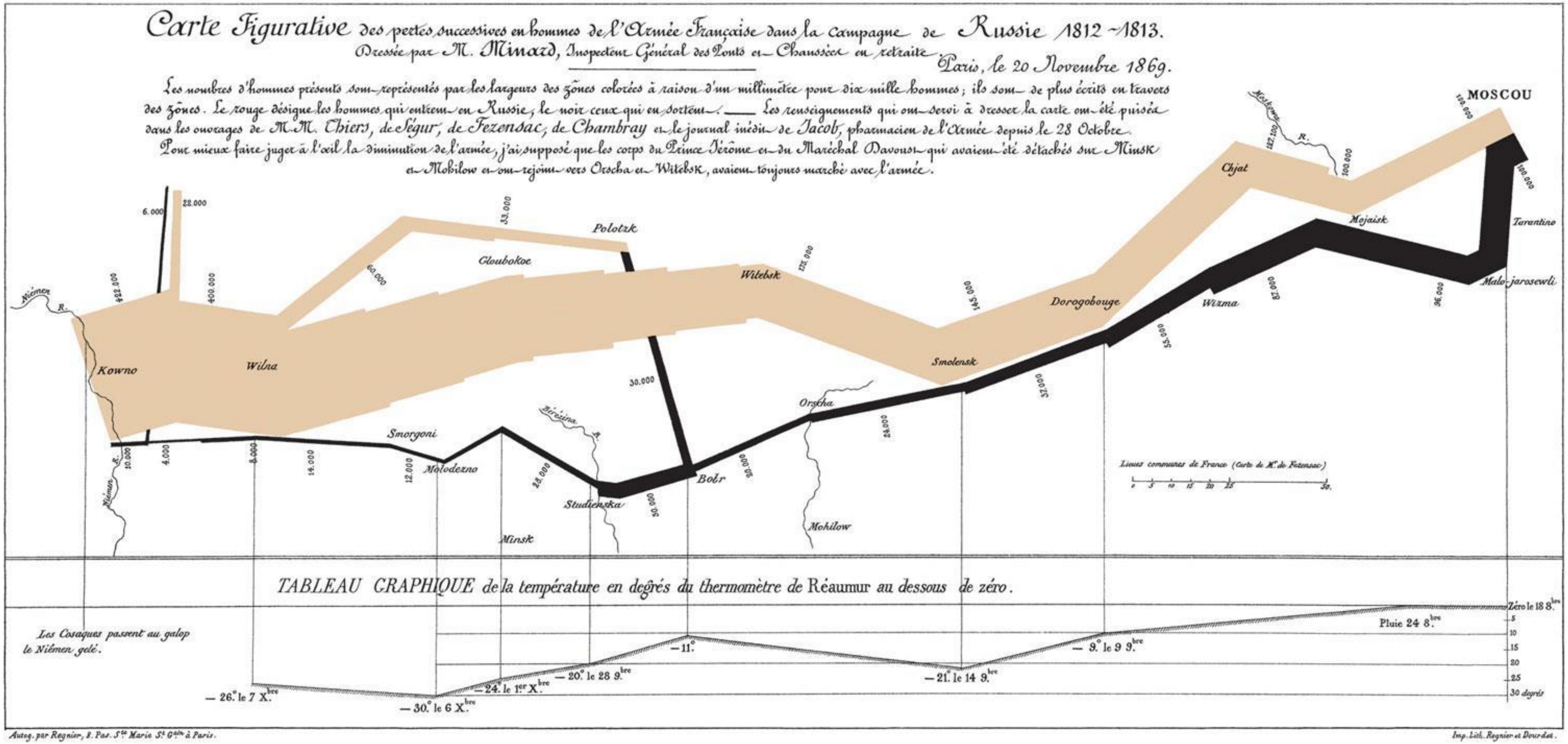


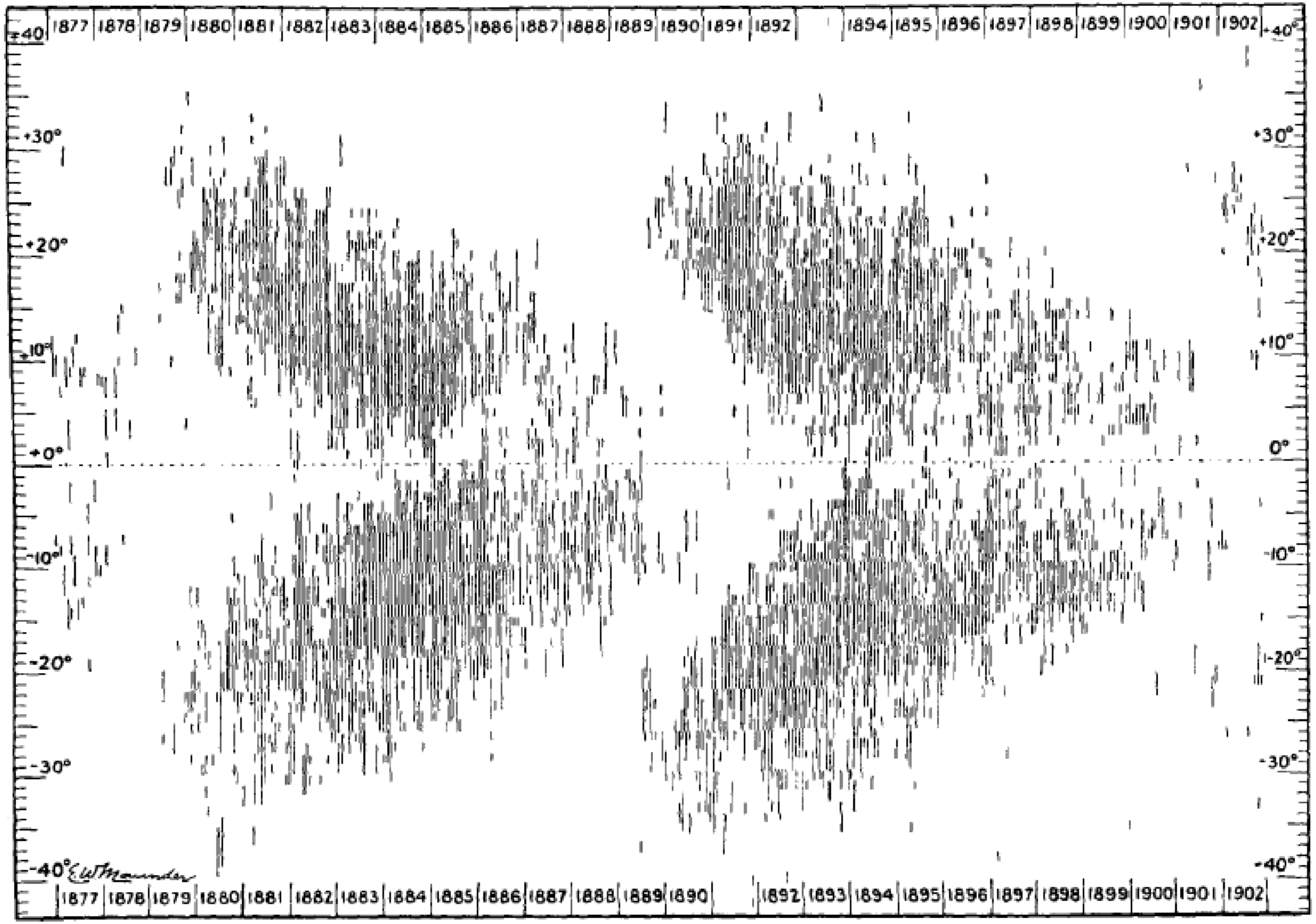
Count (bars)
250
200
150
100
50
Mean Miles Per Gallon (line)
32
30
28
26
24
22
20
American
European
Japanese
Country of Origin



Jon Snow

Yards
50 0 50 100 150 200
× Pump
• Deaths from cholera
OXFORD STREET
DEAN STREET
REGENT STREET
GT. MARLBOROUGH ST.
WARDOUR STREET
BROAD STREET
KING STREET
CONDUIT STREET
GOLDEN SQUARE
BREWER STREET
SAVILLE ROW
NEW BOND STREET
REGENTS QUADRANT
PICCADILLY


Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.
Paris, le 20 Novembre 1869.
Les nombres d'hommes présents sont représentés par les largeurs des zônes colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zônes. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. —— Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de MM. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.
Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mobilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.
MOSCOU
Niémen R.
Kowno
Wilna
Gloubokoe
Polotzk
Witebsk
Smolensk
Dorogobouge
Wizma
Chjat
Mojaisk
Tarantino
Malo-jarosewli
Smorgoni
Molodezno
Studienska
Minsk
Bobr
Orscha
Mohilow
Bérézina R.
Moskowa R.
422.000
400.000
22.000
6.000
60.000
33.000
30.000
175.000
145.000
127.100
100.000
100.000
96.000
87.000
55.000
37.000
24.000
20.000
50.000
28.000
12.000
14.000
8.000
4.000
10.000
Lieues communes de France (Carte de M. de Fezensac)
TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.
Les Cosaques passent au galop le Niémen gelé.
Zéro le 18 8.bre
Pluie 24 8.bre
— 9.° le 9 9.bre
— 11.°
— 21.° le 14 9.bre
— 20.° le 28 9.bre
— 24.° le 1.er X.bre
— 30.° le 6 X.bre
— 26.° le 7 X.bre
30 degrés
Autog. par Regnier, 8. Pas. S.te Marie S.t G.ain à Paris.
Imp. Lith. Regnier et Dourdet.



1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1894 1895 1896 1897 1898 1899 1900 1901 1902
+40
+30°
+20°
+10°
+0°
-10°
-20°
-30°
-40°
0°
E W Maunder

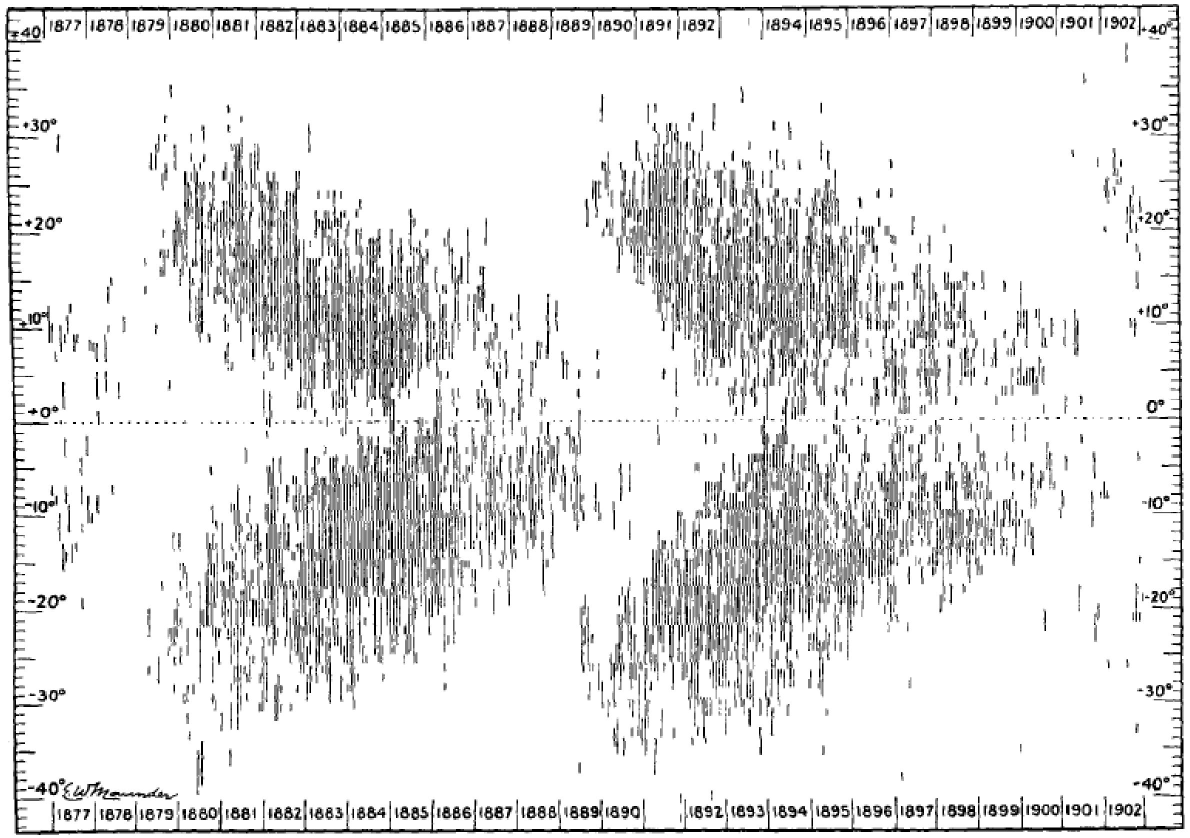
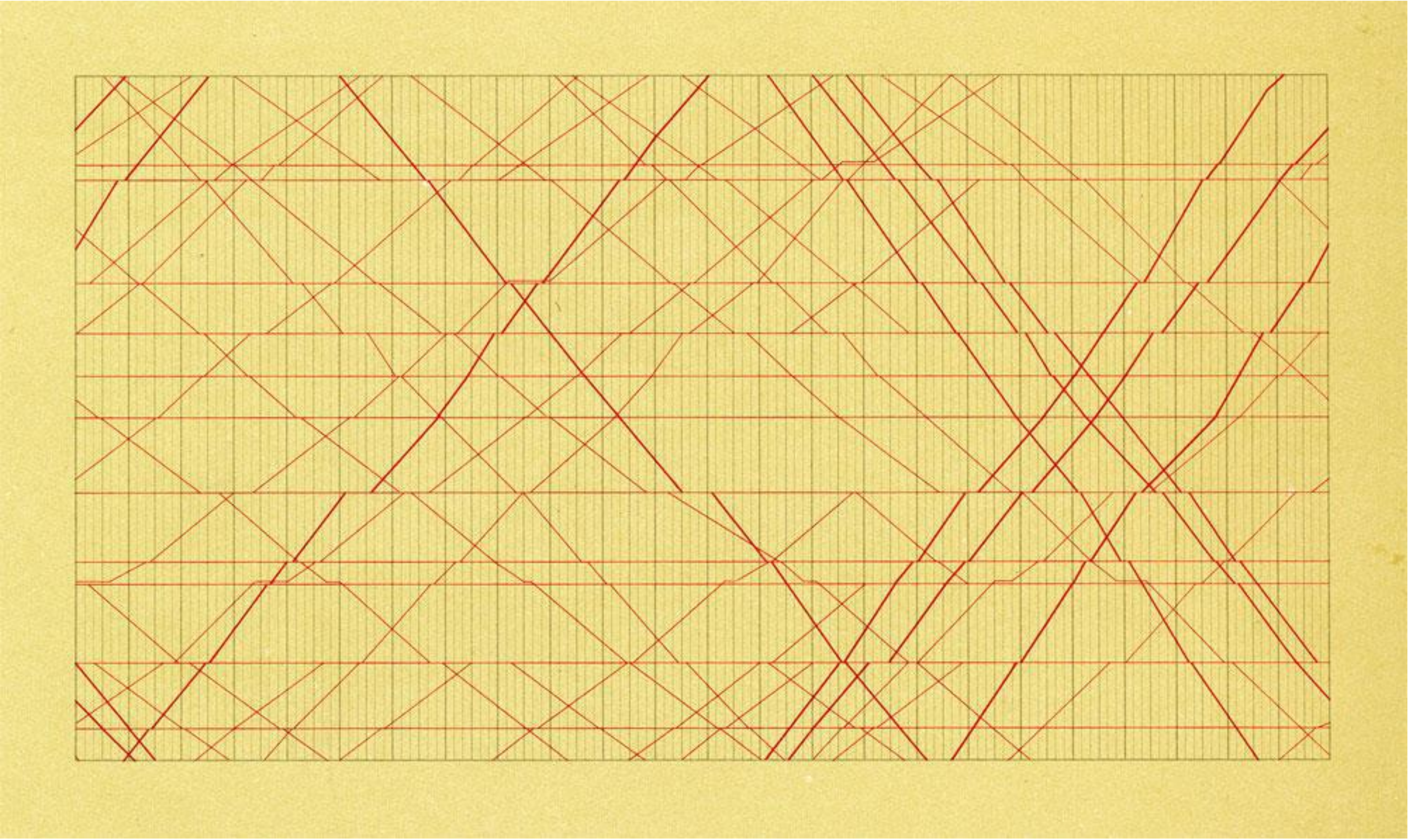
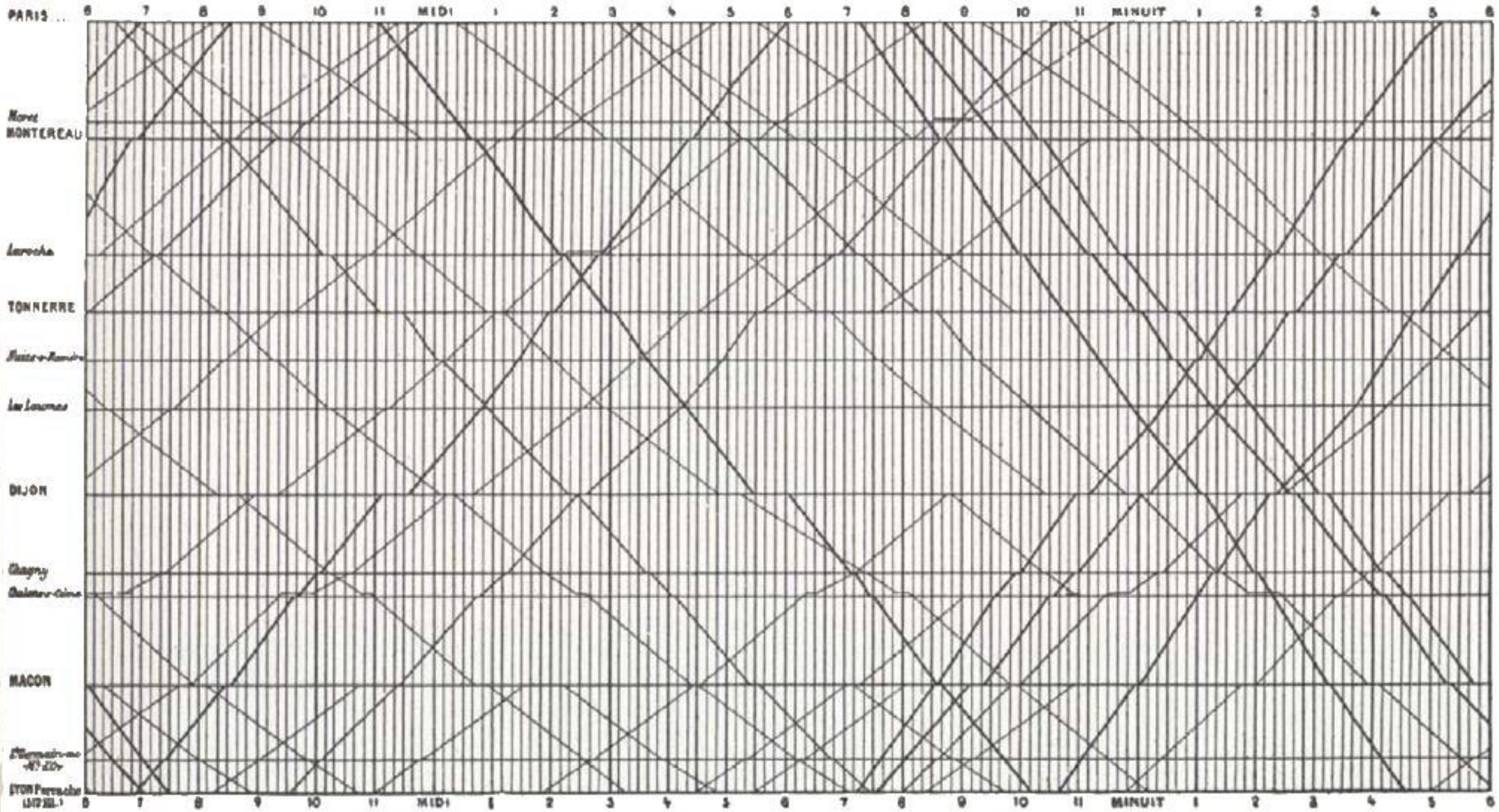
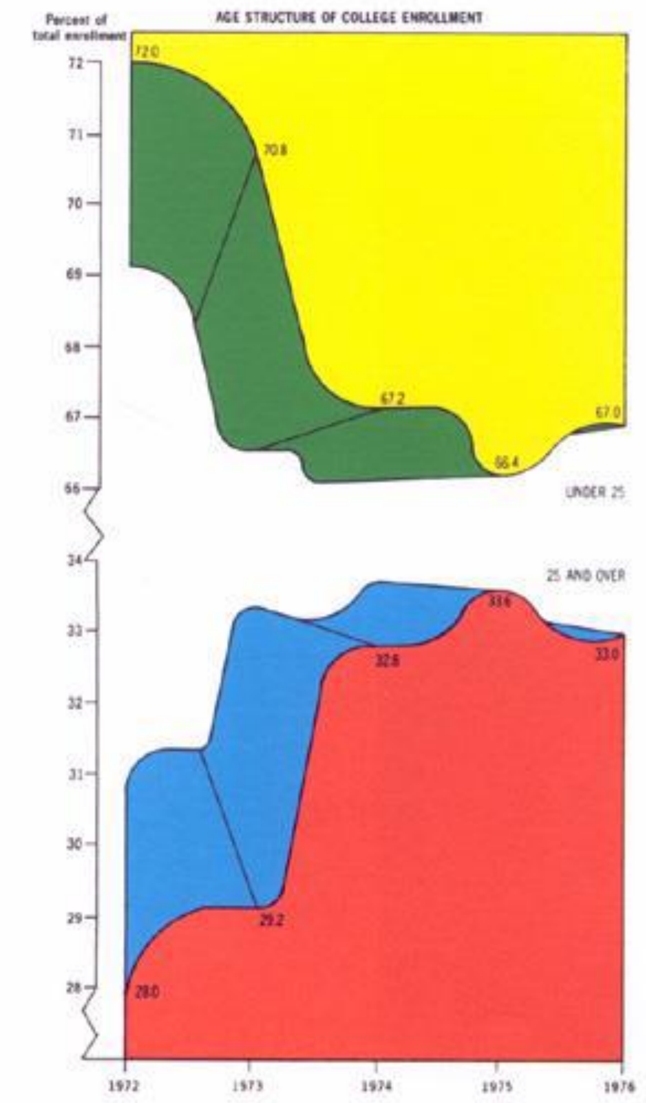


Figure 2.32: The vertical line segments denote the latitudinal extent of sunspots as observed versus time, which is the horizontal axis. Two space dimensions are collapsed into one by ignoring the longitudinal position and width of the sunspots. Note that Maunder has increased the "data-ink" ratio by restricting the latitudinal range to $\pm 40^o$; there is only negligible sunspot at higher latitudes, so expanding the vertical axis would have added nothing. From E. W. Maunder, "Notes on the Distribution of Sun-Spots in Heliographic Latitude, 1874-1902," *Royal Astronomical Society Monthly Notices*, *64*, 747-761 (1904).

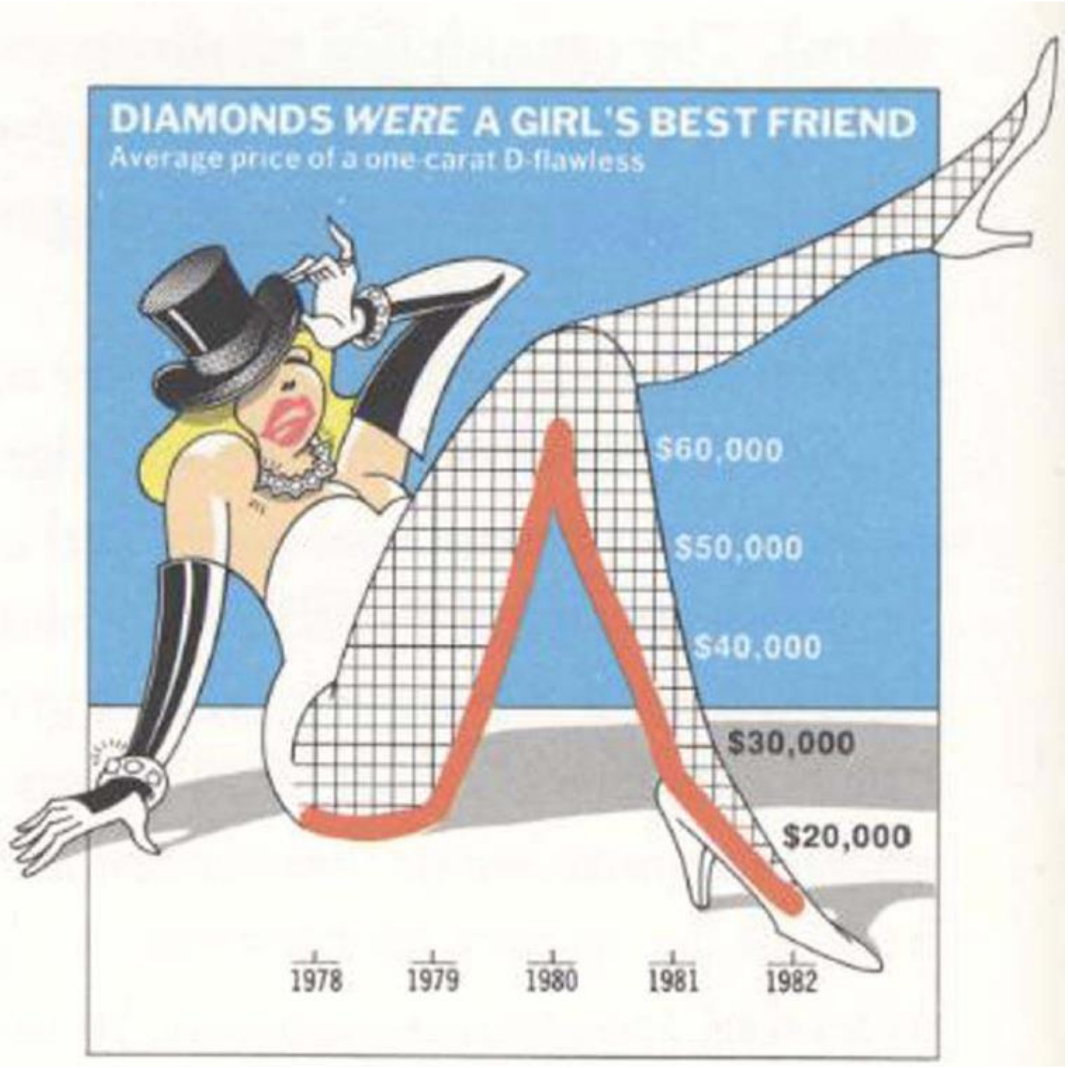



PARIS
6 7 8 9 10 11 MIDI 1 2 3 4 5 6 7 8 9 10 11 MINUIT 1 2 3 4 5 6
Moret
MONTEREAU
Laroche
TONNERRE
Les Laumes
DIJON
Chagny
MACON
LYON Perrache

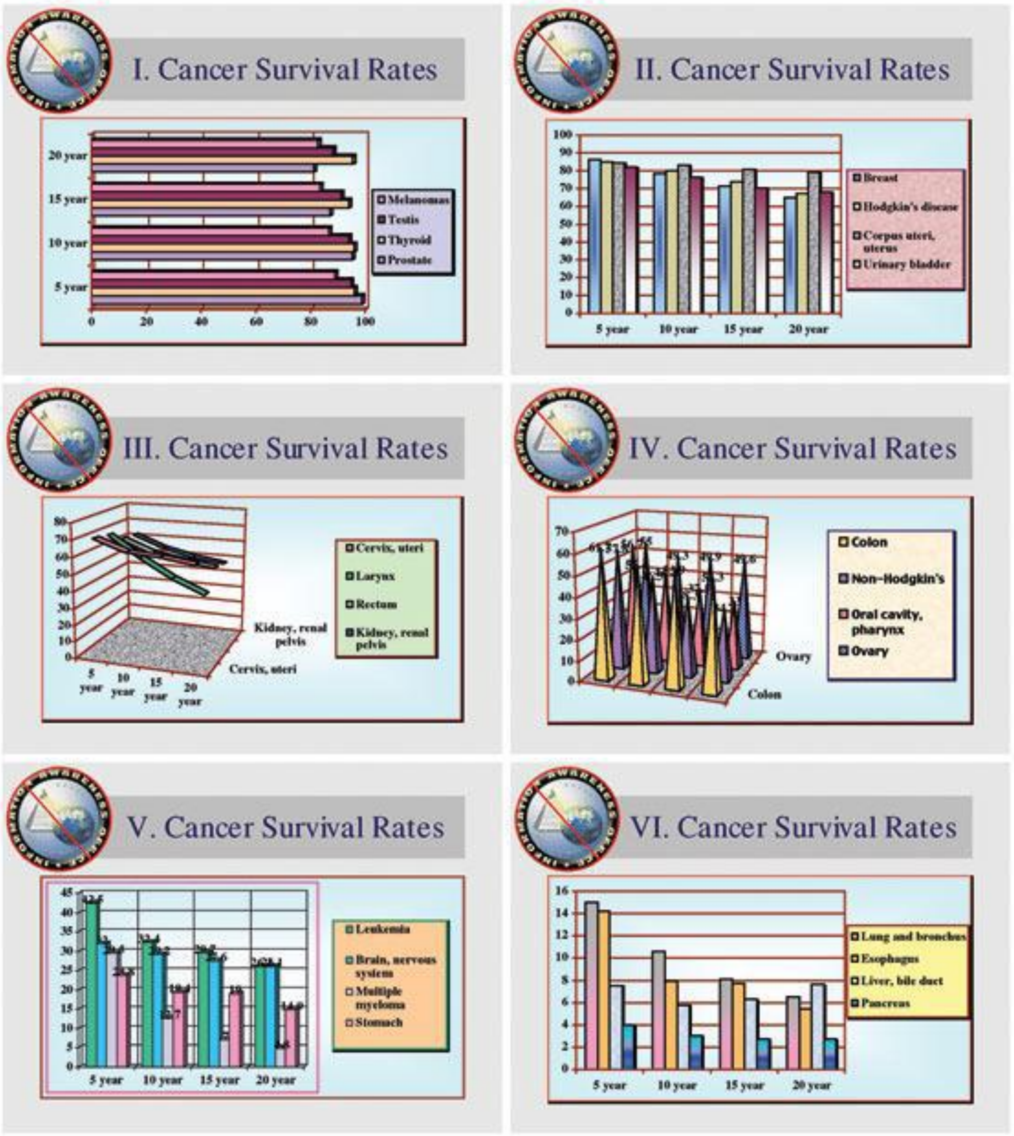
EDWARD TUFTE: CHART JUNK, LIE FACTOR, SMALL MULTIPLES



AGE STRUCTURE OF COLLEGE ENROLLMENT
Percent of total enrollment
72
71
70
69
68
67
66
72.0
70.8
67.2
66.4
67.0
UNDER 25
34
33
32
31
30
29
28
25 AND OVER
33.6
32.6
33.0
29.2
28.0
1972
1973
1974
1975
1976

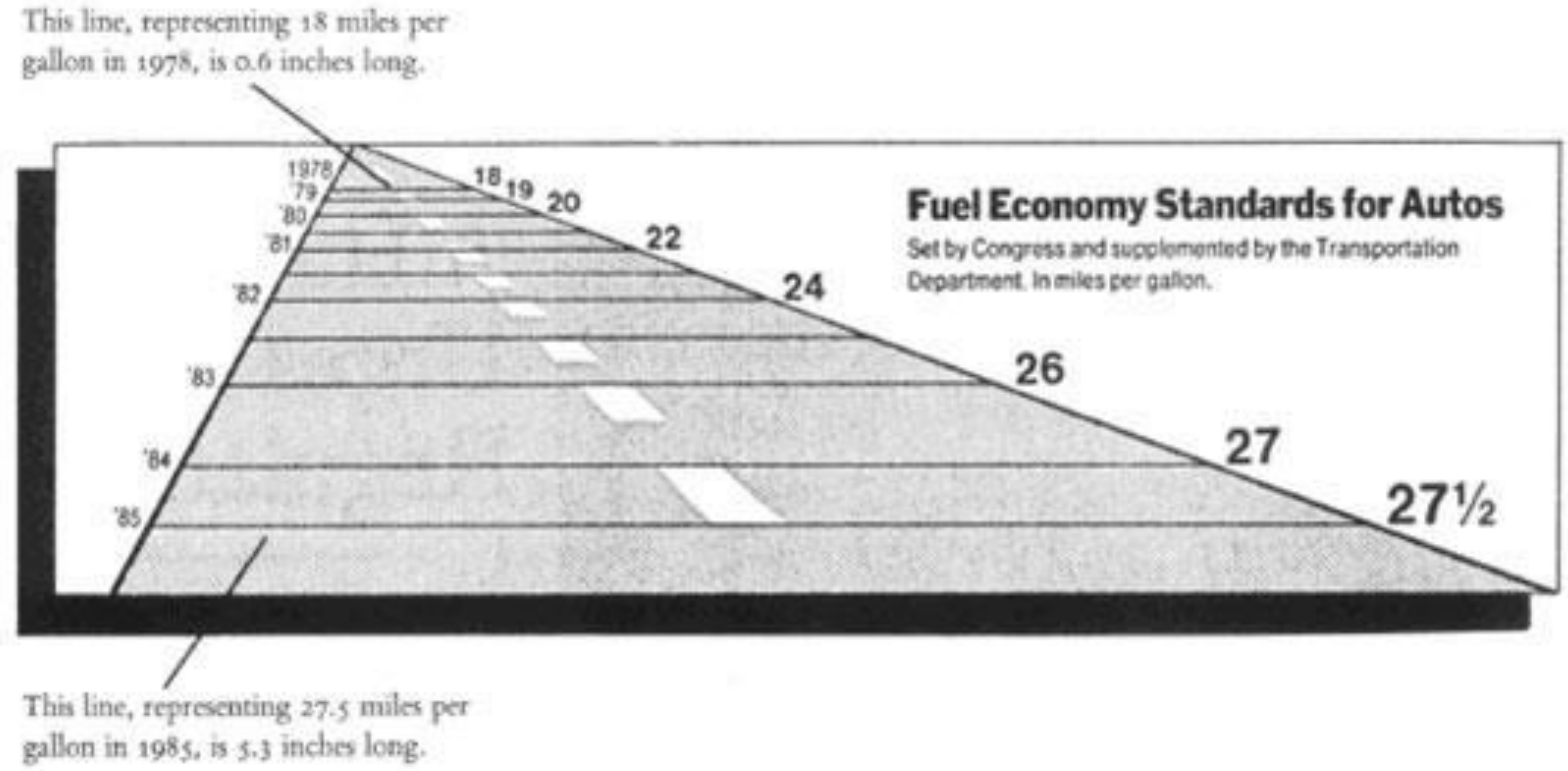


DIAMONDS WERE A GIRL'S BEST FRIEND
Average price of a one-carat D-flawless
$60,000
$50,000
$40,000
$30,000
$20,000
1978
1979
1980
1981
1982



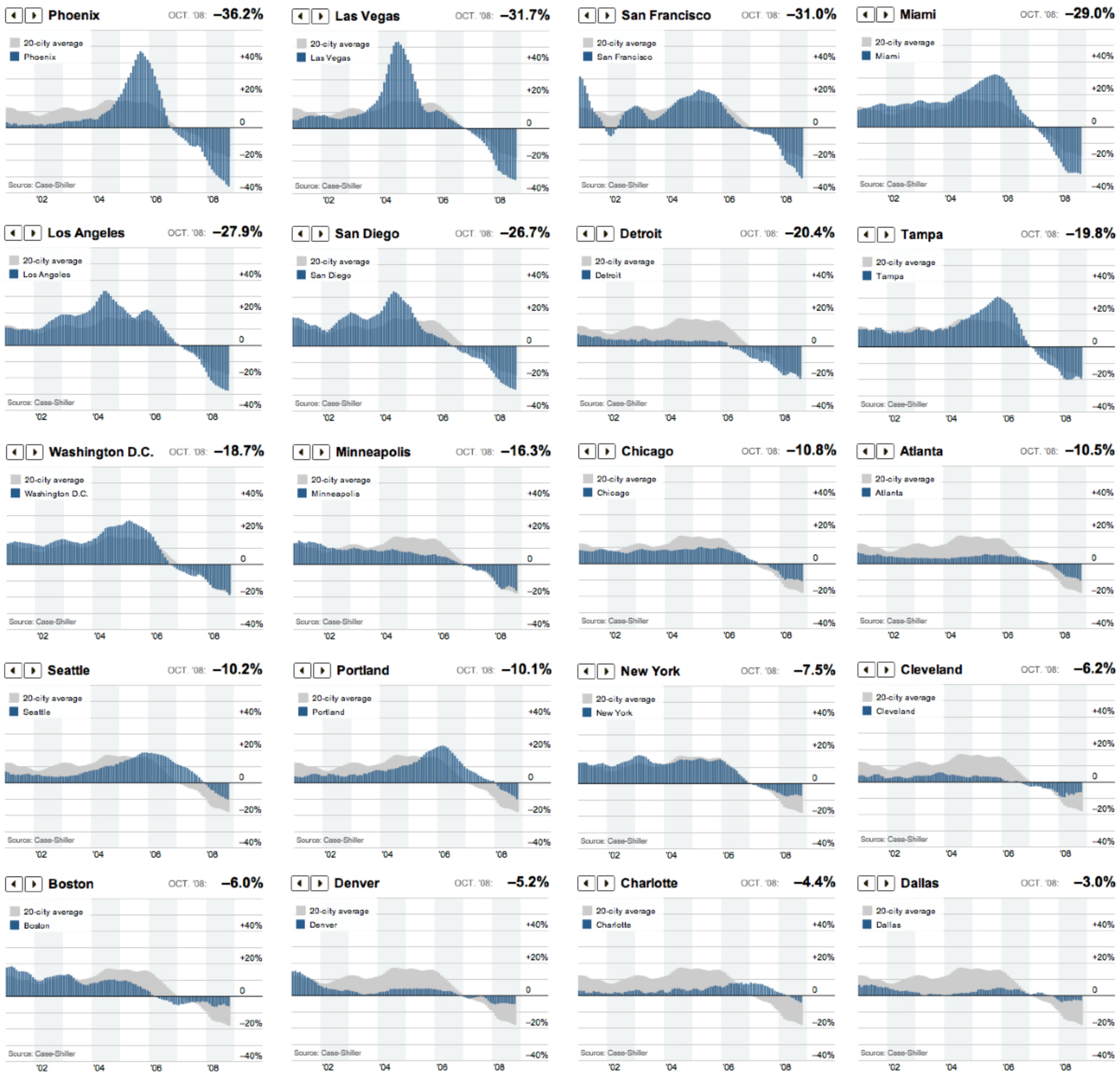
Estimates of % survival rates

	5 year	10 year	15 year	20 year
Prostate	99	95	87	81
Thyroid	96	96	94	95
Testis	95	94	91	88
Melanomas	89	87	84	83
Breast	86	78	71	65
Hodgkin's disease	85	80	74	67
Corpus uteri, uterus	84	83	81	79
Urinary, bladder	82	76	70	68
Cervix, uteri	71	64	63	60
Larynx	69	57	46	38
Rectum	63	55	52	49
Kidney, renal pelvis	62	54	50	47
Colon	62	55	54	52
Non-Hodgkin's	58	46	38	34
Oral cavity, pharynx	57	44	38	33
Ovary	55	49	50	50
Leukemia	43	32	30	26
Brain, nervous system	32	29	28	26
Multiple myeloma	30	13	7	5
Stomach	24	19	19	15
Lung and bronchus	15	11	8	6
Esophagus	14	8	8	5
Liver, bile duct	8	6	6	8
Pancreas	4	3	3	3


This line, representing 18 miles per gallon in 1978, is 0.6 inches long.
Fuel Economy Standards for Autos
Set by Congress and supplemented by the Transportation Department. In miles per gallon.
1978
'79
'80
'81
'82
'83
'84
'85
18
19
20
22
24
26
27
27½
This line, representing 27.5 miles per gallon in 1985, is 5.3 inches long.

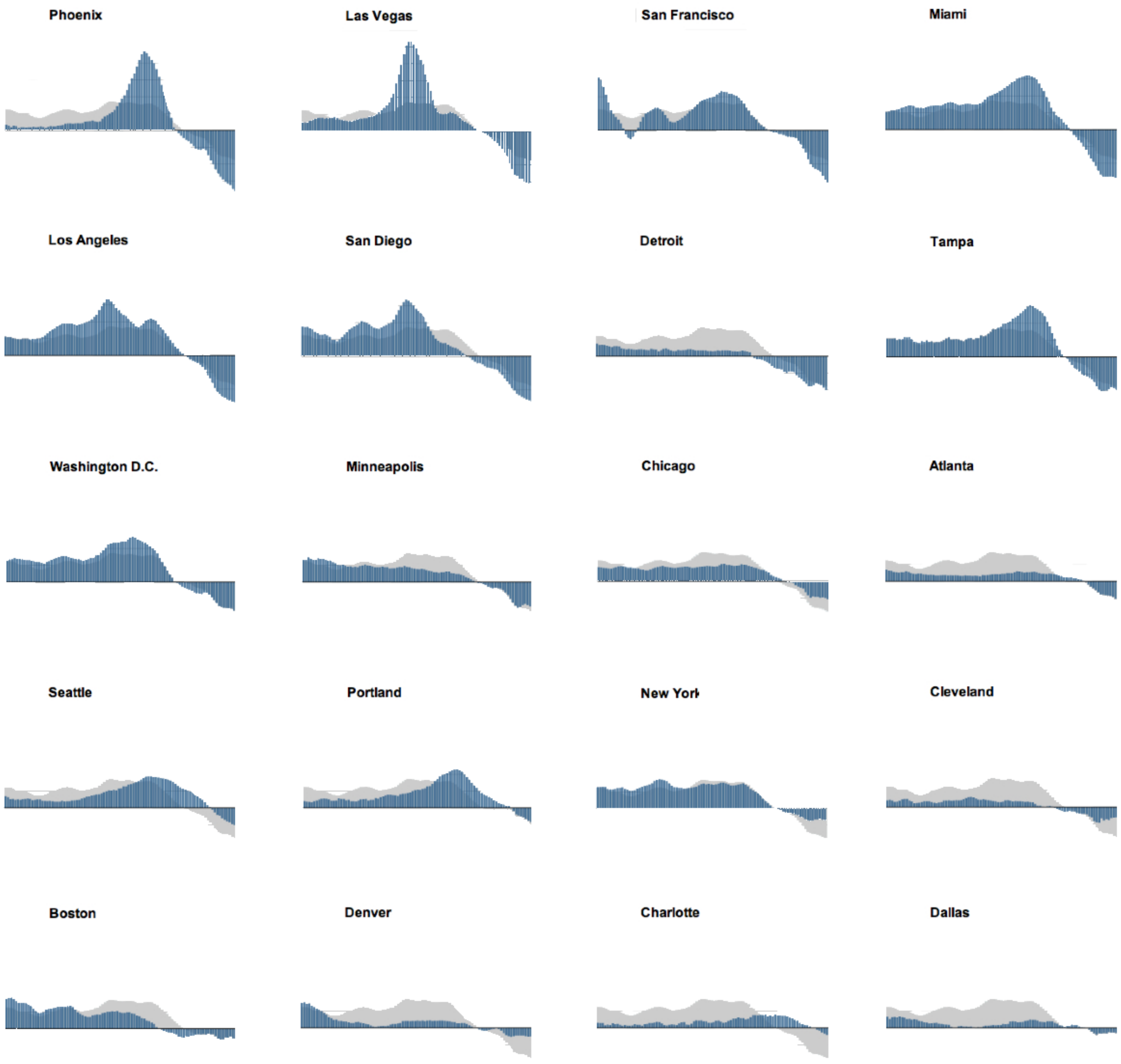
Change in Home Prices (year over year)

From New York Times Economix blog

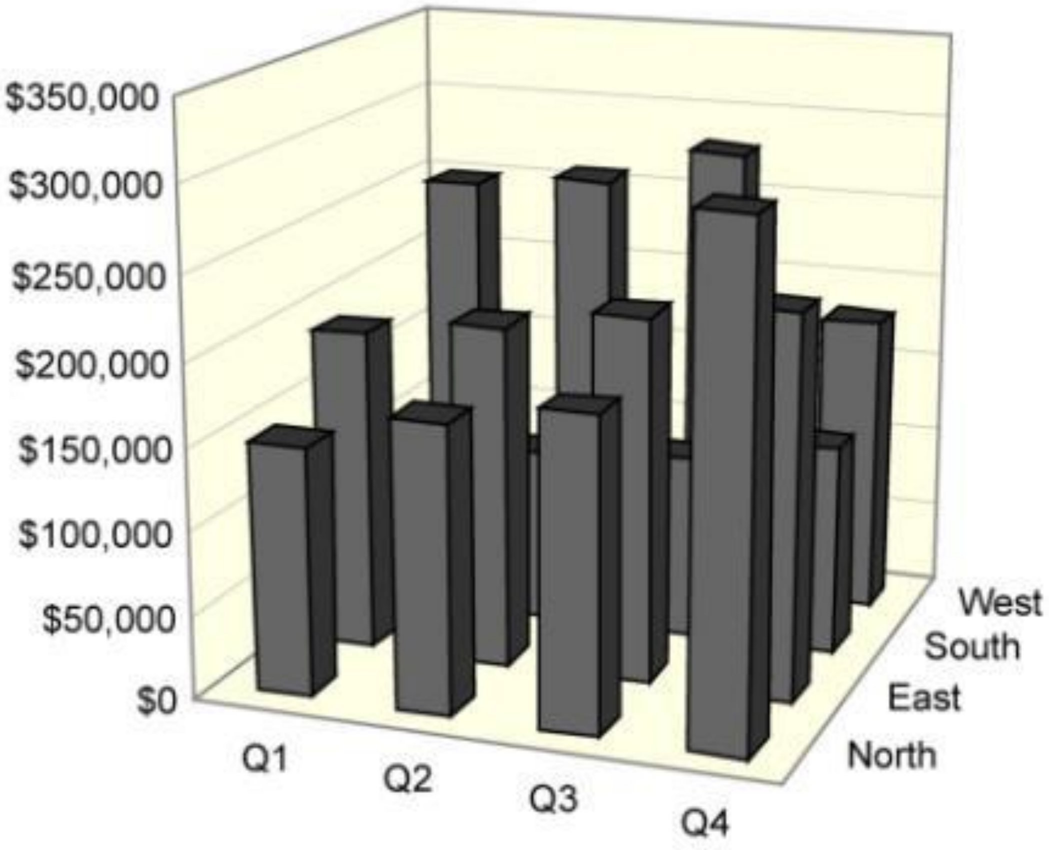


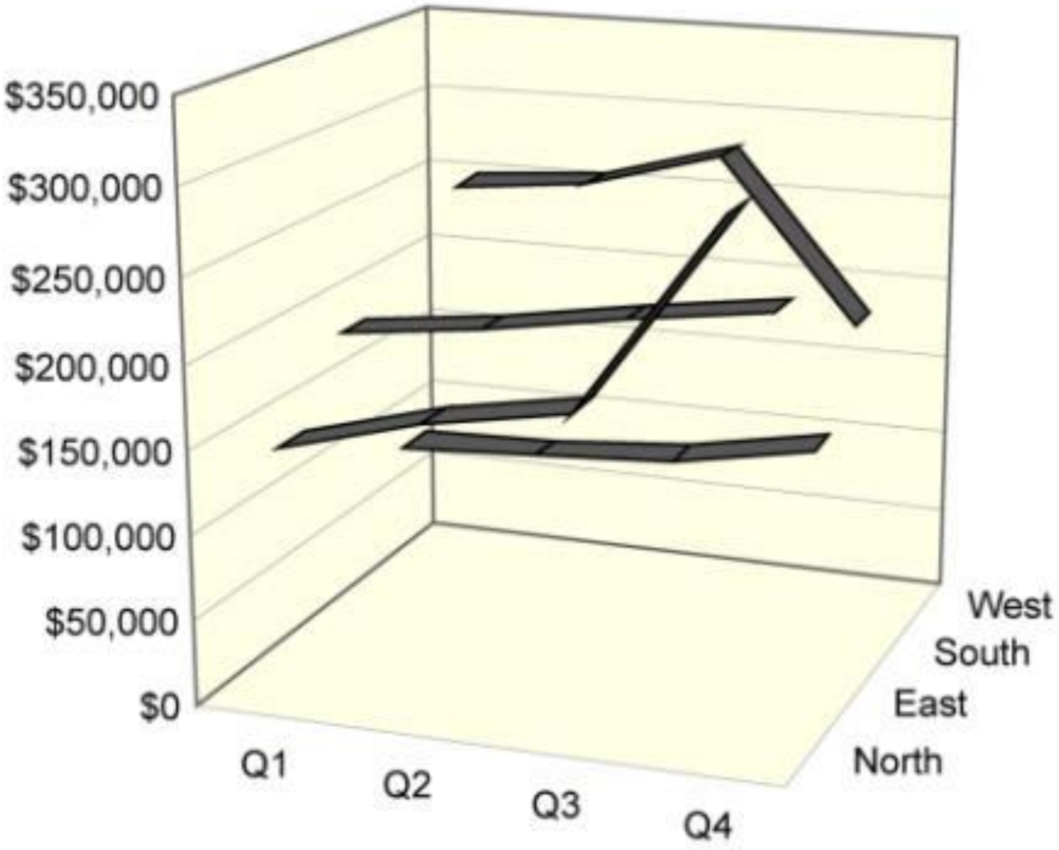
Change in Home Prices (year over year)

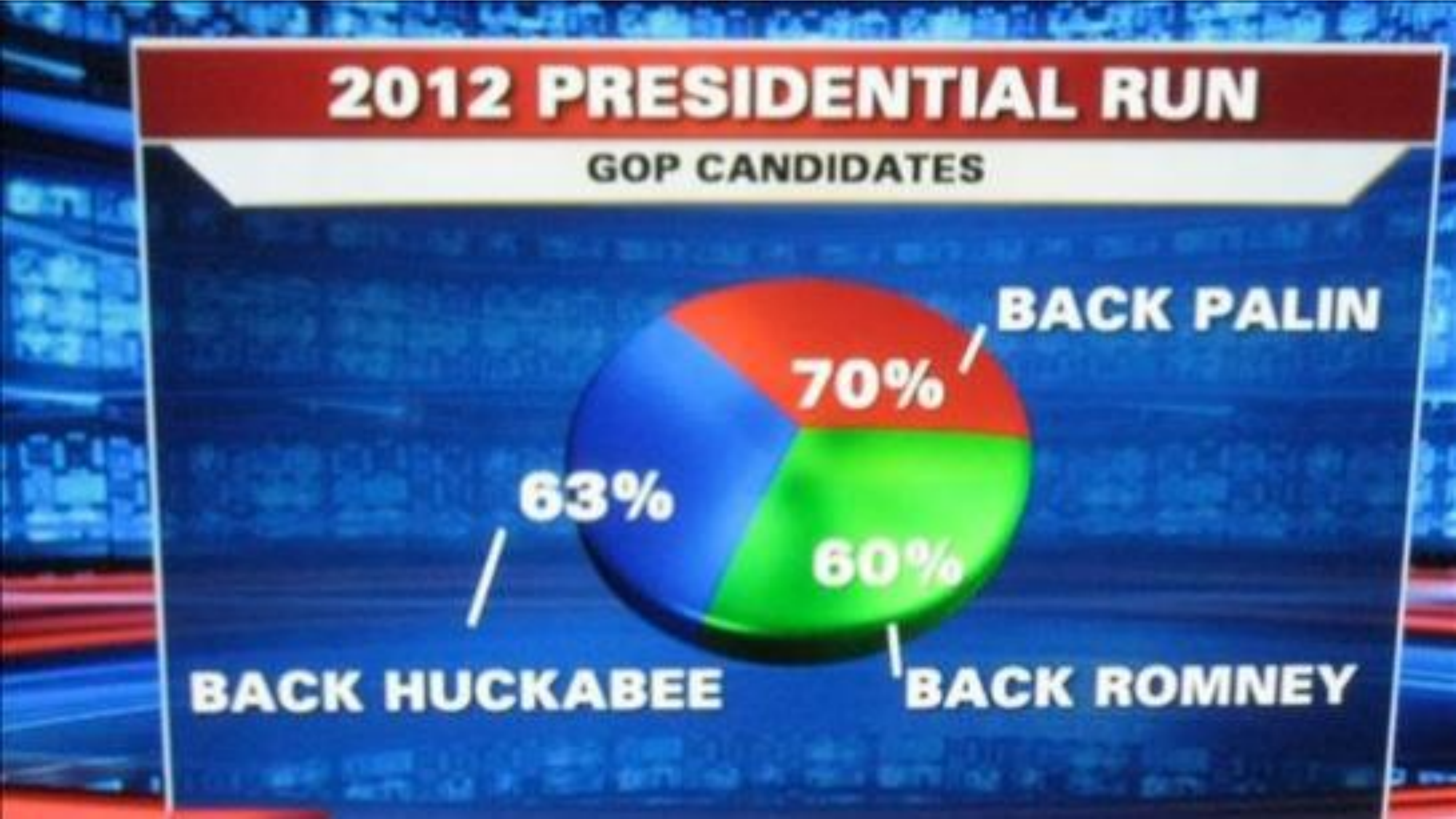
From New York Times Economix blog



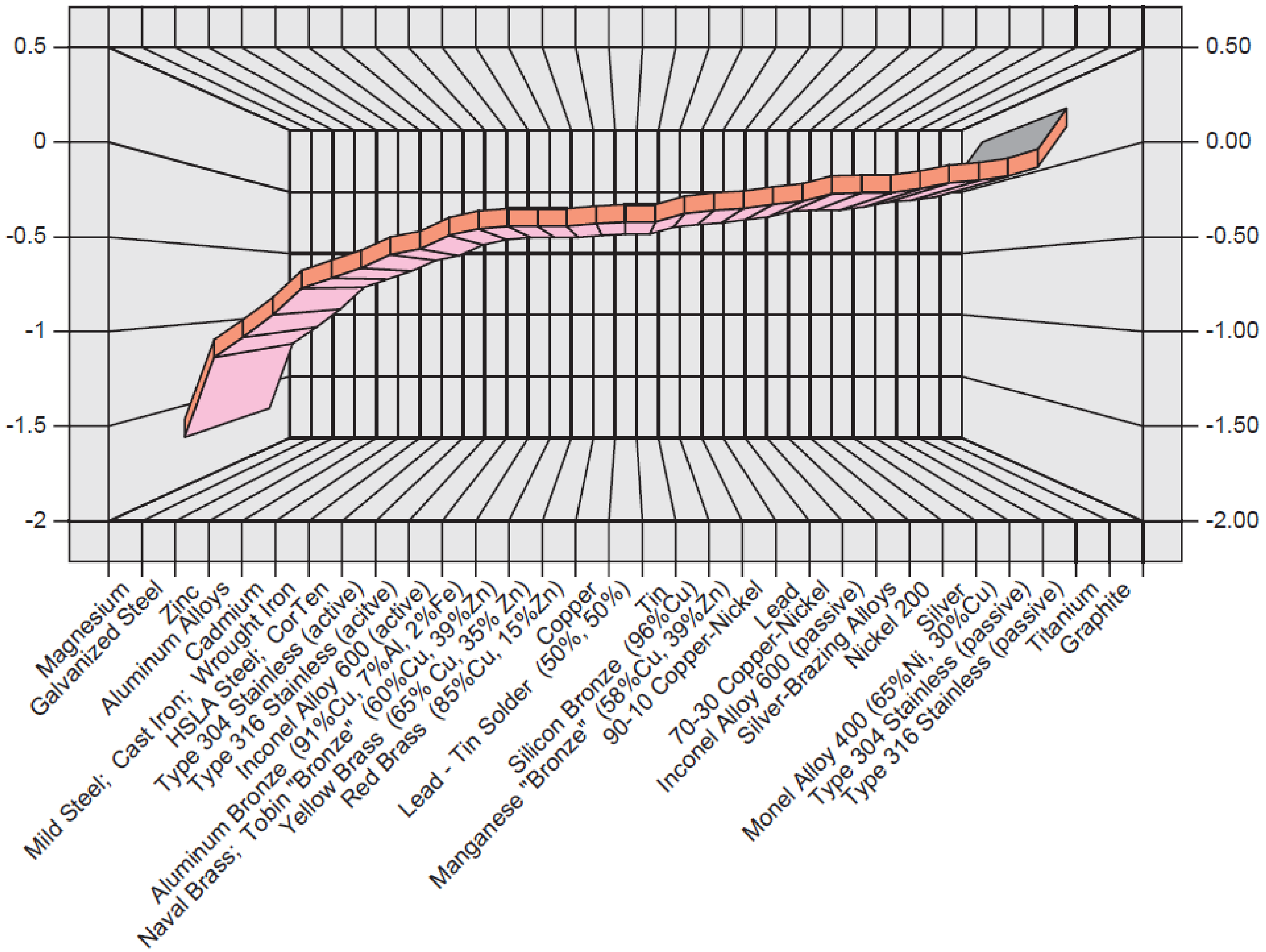
BAD IDEAS: THE THIRD DIMENSION, PIE CHARTS

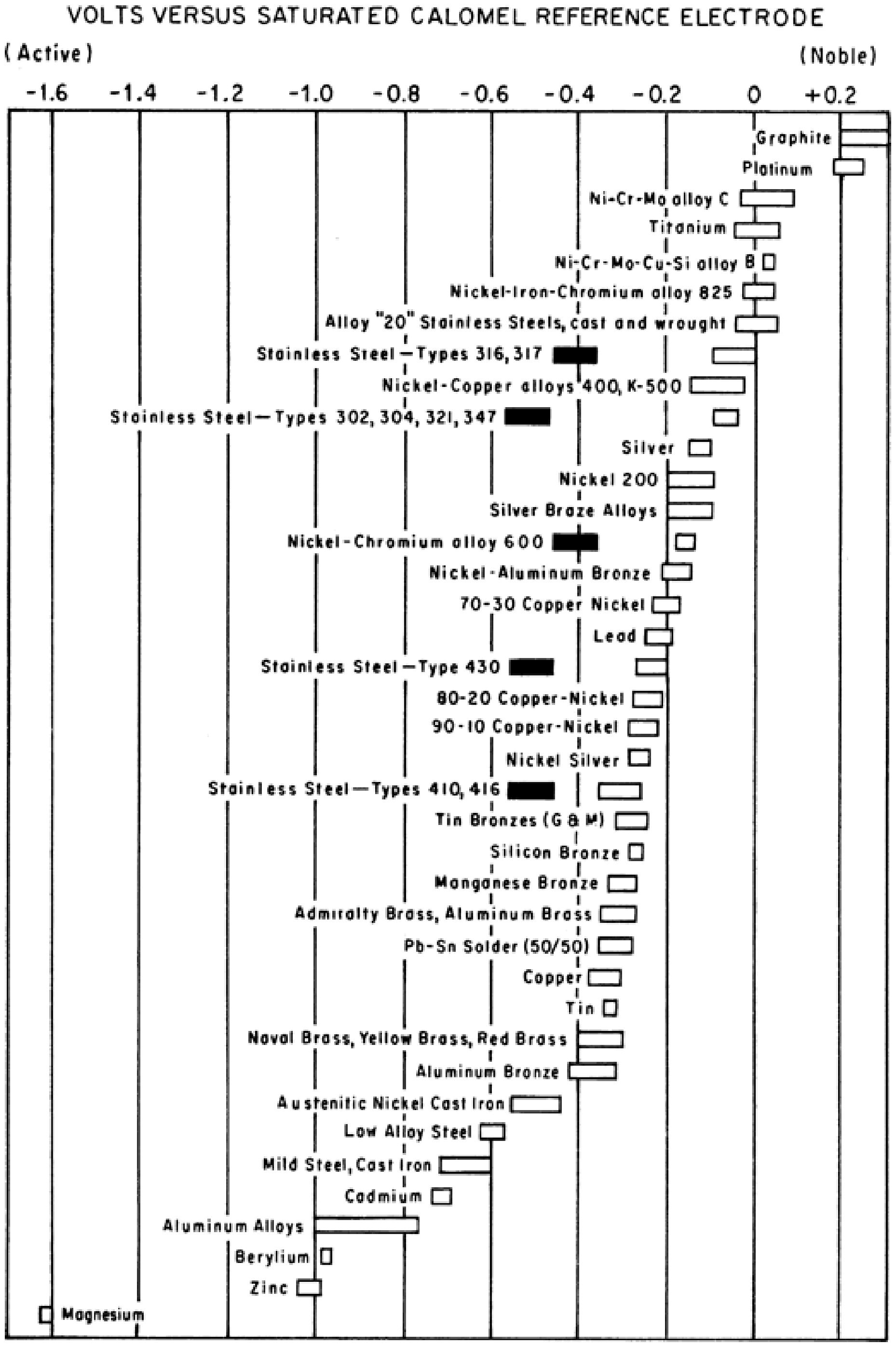

$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
Q1
Q2
Q3
Q4
West
South
East
North

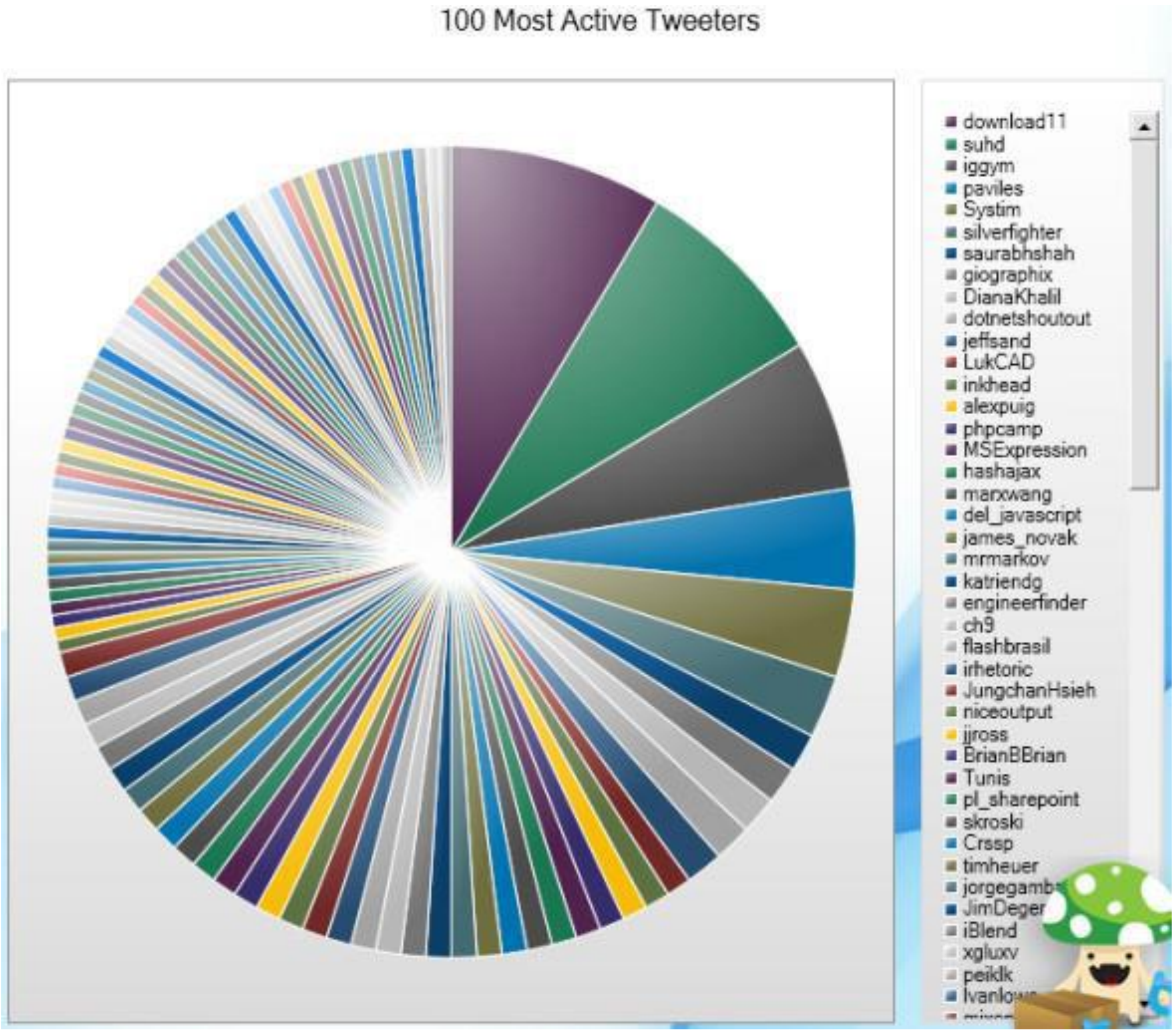

$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
Q1
Q2
Q3
Q4
West
South
East
North


2012 PRESIDENTIAL RUN
GOP CANDIDATES
BACK PALIN
70%
63%
60%
BACK HUCKABEE
BACK ROMNEY

Average Voltage in Seawater




VOLTS VERSUS SATURATED CALOMEL REFERENCE ELECTRODE
(Active)
(Noble)
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0
+0.2
Graphite
Platinum
Ni-Cr-Mo alloy C
Titanium
Ni-Cr-Mo-Cu-Si alloy B
Nickel-Iron-Chromium alloy 825
Alloy "20" Stainless Steels, cast and wrought
Stainless Steel—Types 316, 317
Nickel-Copper alloys 400, K-500
Stainless Steel—Types 302, 304, 321, 347
Silver
Nickel 200
Silver Braze Alloys
Nickel-Chromium alloy 600
Nickel-Aluminum Bronze
70-30 Copper Nickel
Lead
Stainless Steel—Type 430
80-20 Copper-Nickel
90-10 Copper-Nickel
Nickel Silver
Stainless Steel—Types 410, 416
Tin Bronzes (G & M)
Silicon Bronze
Manganese Bronze
Admiralty Brass, Aluminum Brass
Pb-Sn Solder (50/50)
Copper
Tin
Naval Brass, Yellow Brass, Red Brass
Aluminum Bronze
Austenitic Nickel Cast Iron
Low Alloy Steel
Mild Steel, Cast Iron
Cadmium
Aluminum Alloys
Berylium
Zinc
Magnesium



100 Most Active Tweeters
download11
suhd
iggym
paviles
Systim
silverfighter
saurabhshah
giographix
DianaKhalil
dotnetshoutout
jeffsand
LukCAD
inkhead
alexpuig
phpcamp
MSExpression
hashajax
marxwang
del_javascript
james_novak
mrmarkov
katriendg
engineerfinder
ch9
flashbrasil
irhetoric
JungchanHsieh
niceoutput
jjross
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Tunis
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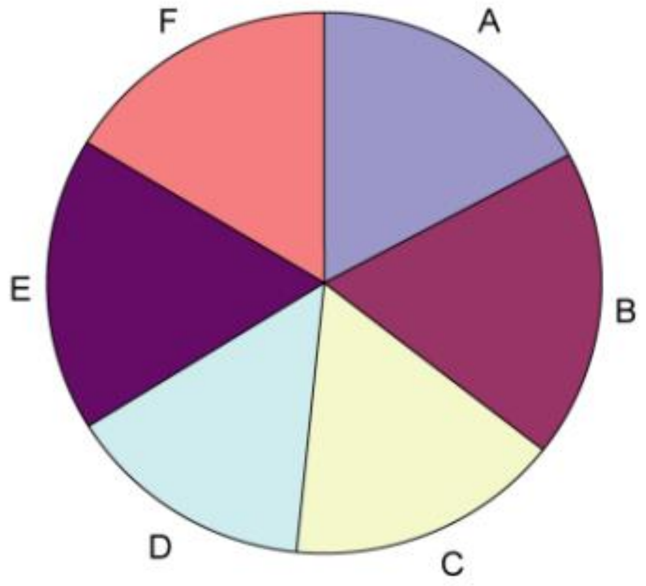
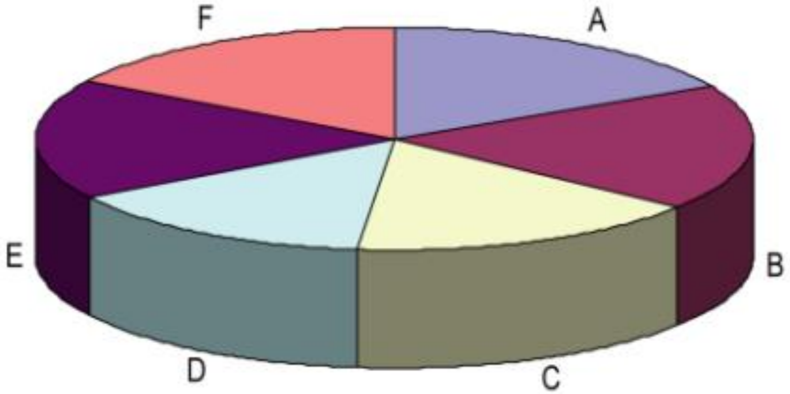
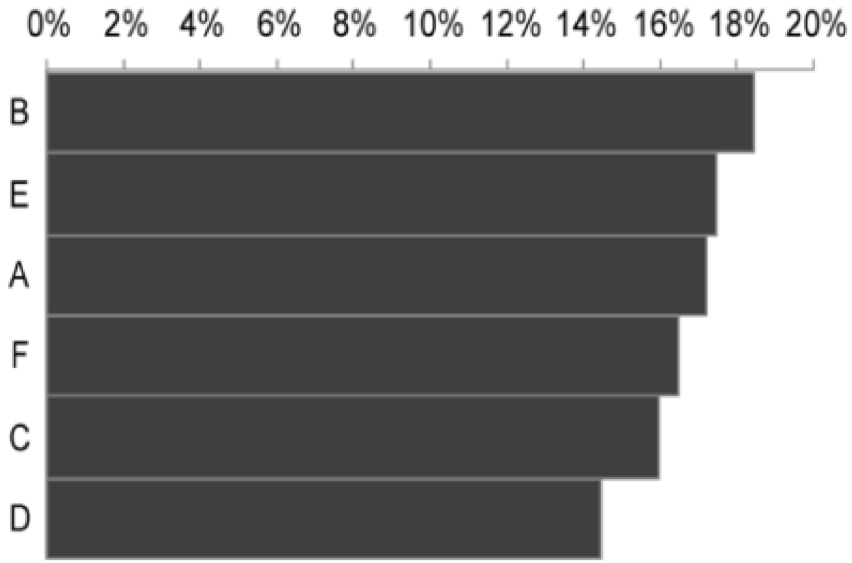
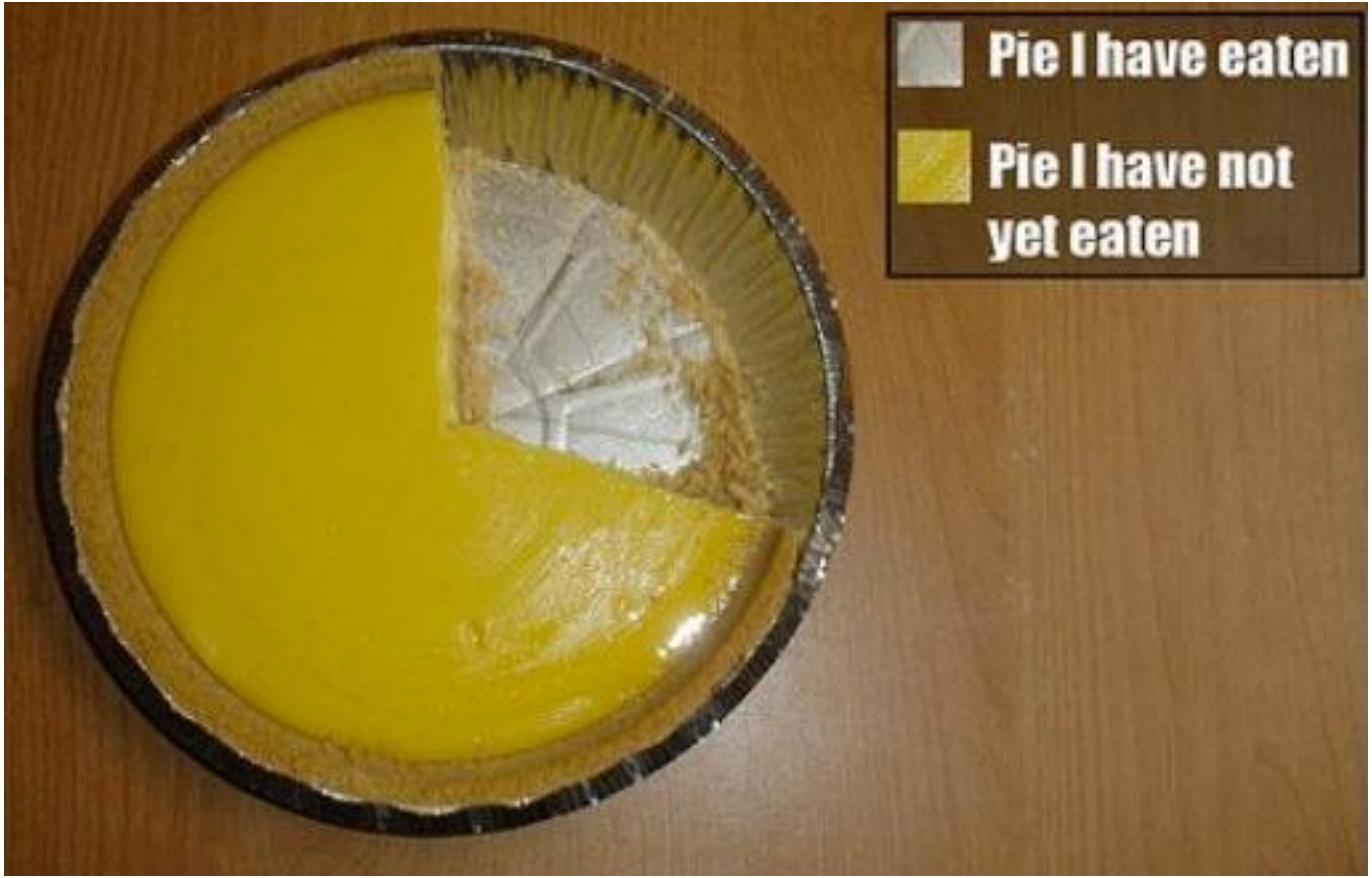
iBlend
xgluxv
peiklk

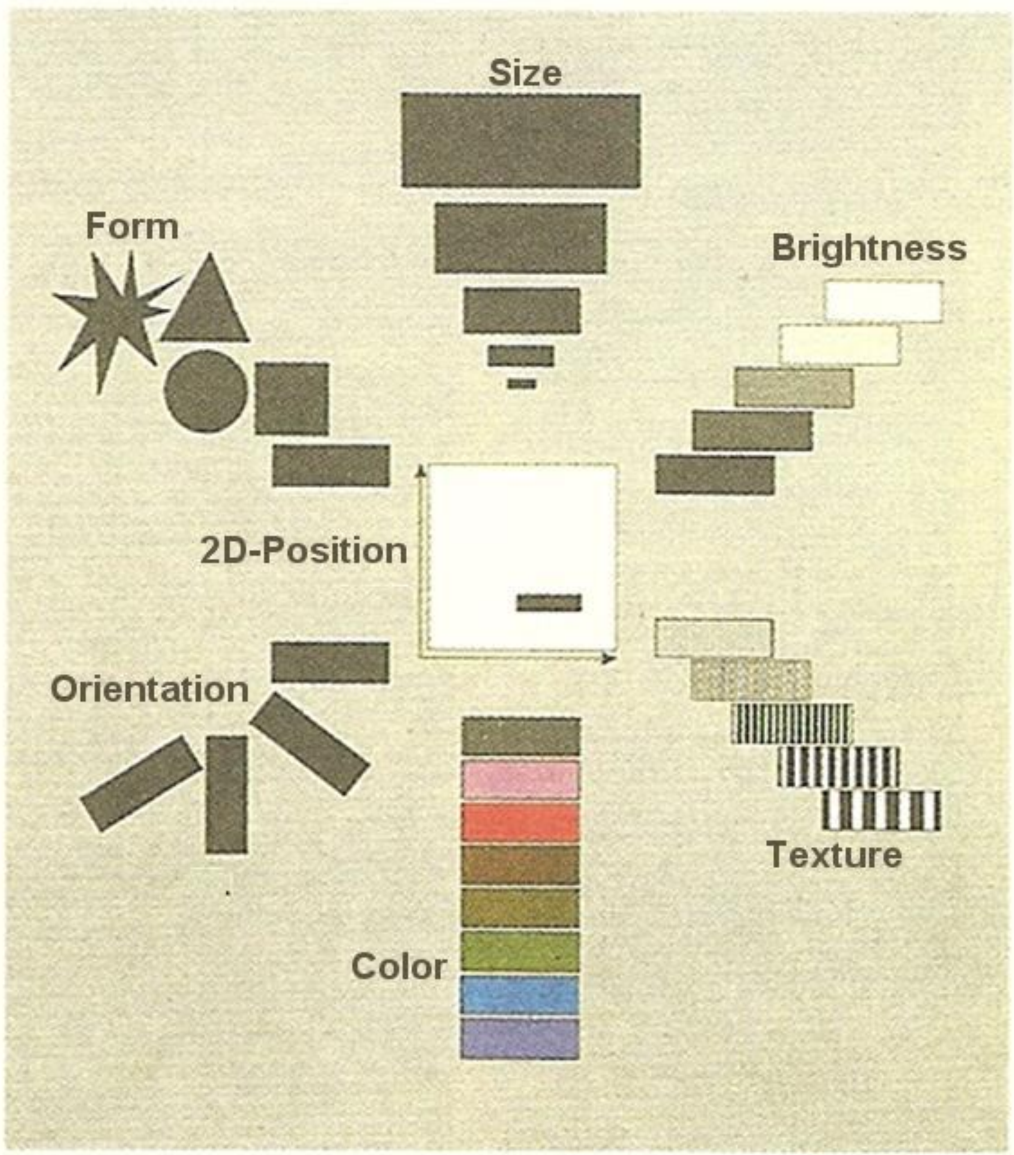

F
A
E
B
D
C


F
A
E
B
D
C

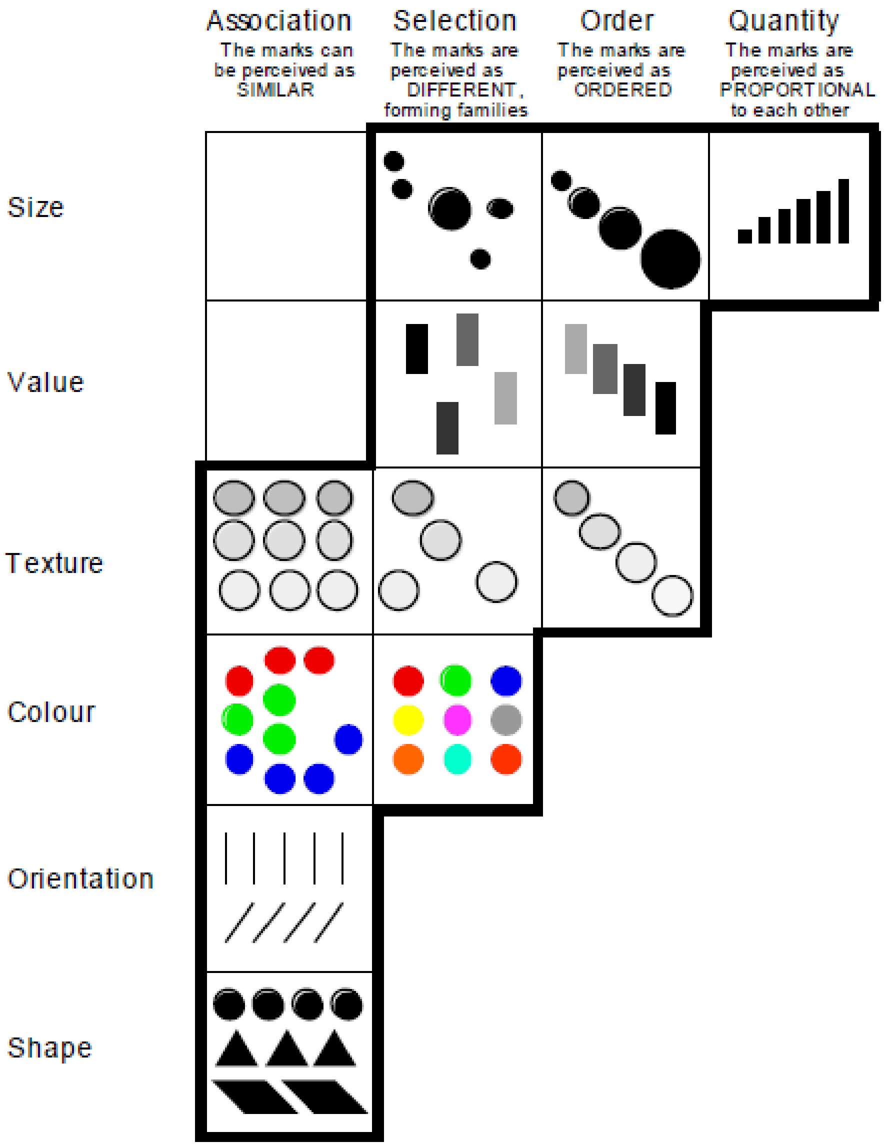

0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20%
B
E
A
F
C
D


Pie I have eaten
Pie I have not yet eaten

VISUAL CLUES: BERTIN, CLEVELAND, MCGILL

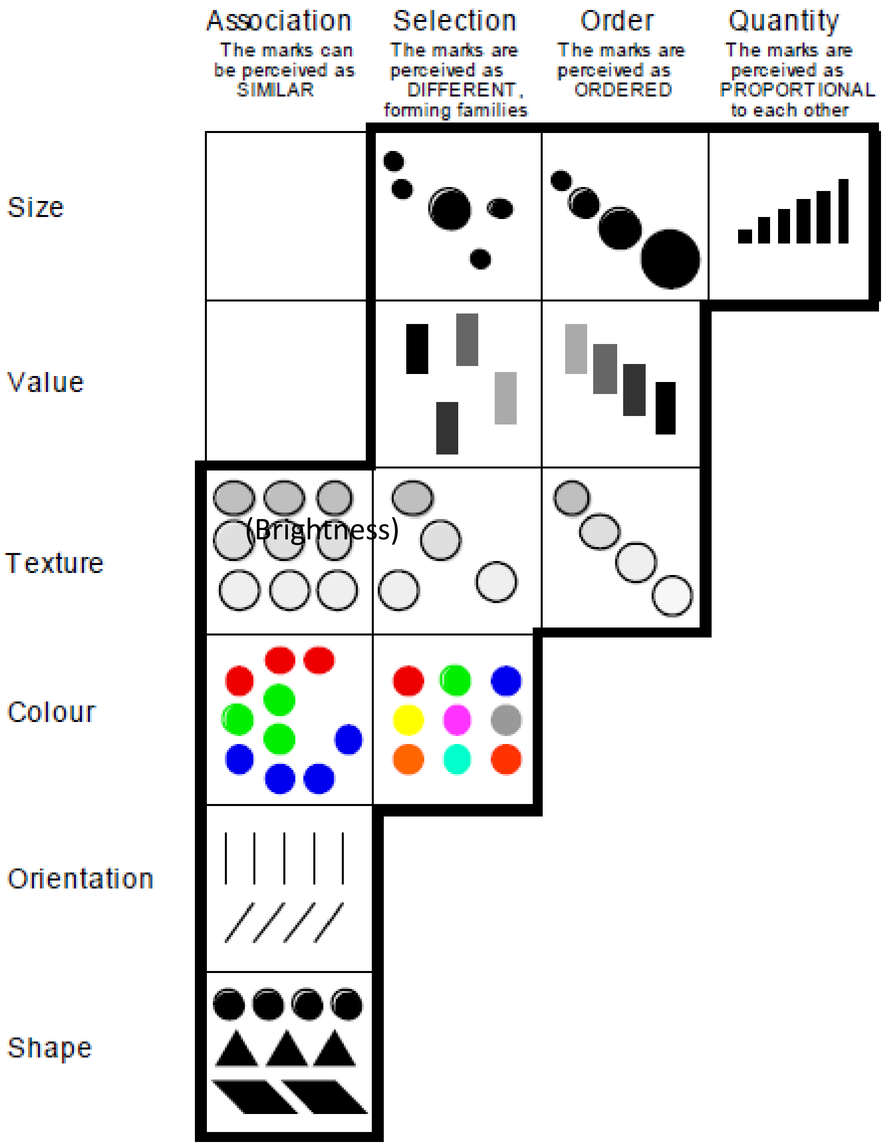


Jacques Bertin

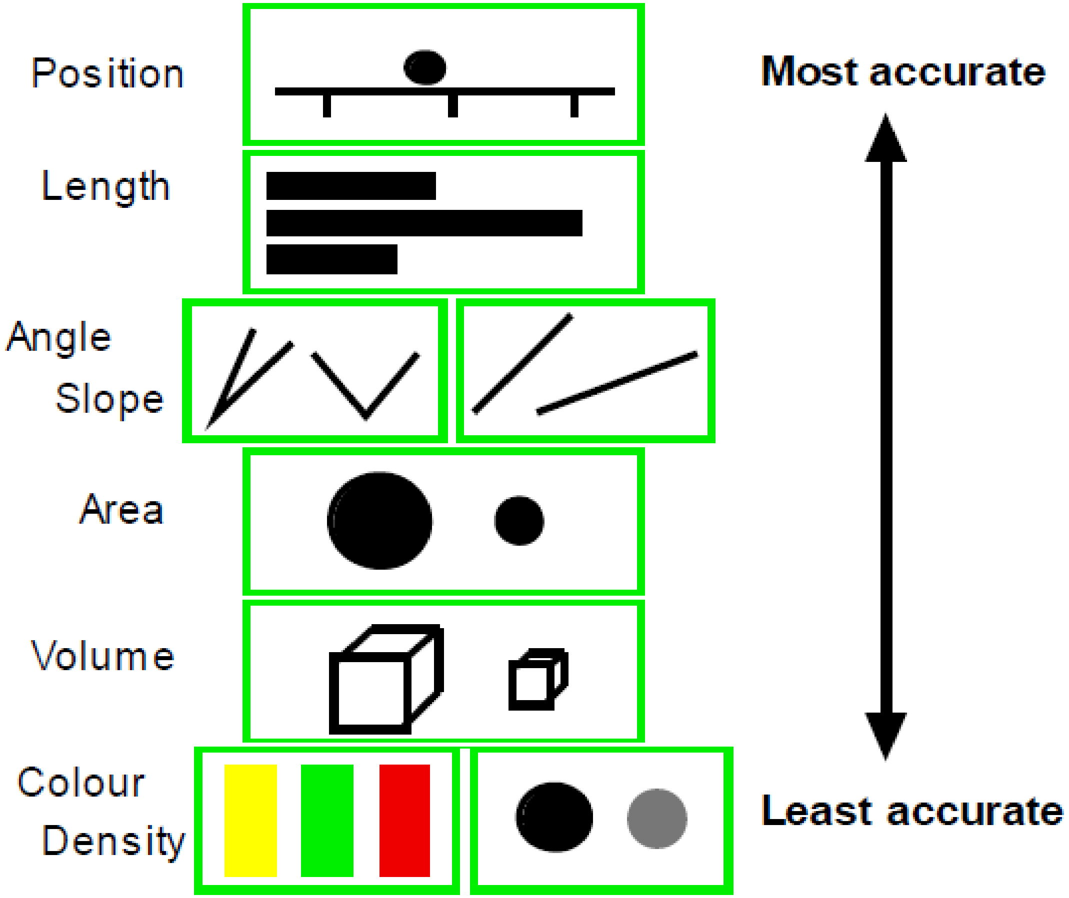


Visual variables	*Measurement scales*			
	Nominal	Ordinal	Interval	Ratio
Dimensions of the plane	2*x	2*x	2*x	2*x
Size		x	x	x
(Grey) value		x	x	
Grain/texture		x	x	
Colour hue	x			
Orientation	x			
Shape	x			

https://ltb.itc.utwente.nl/page/481/concept/78736



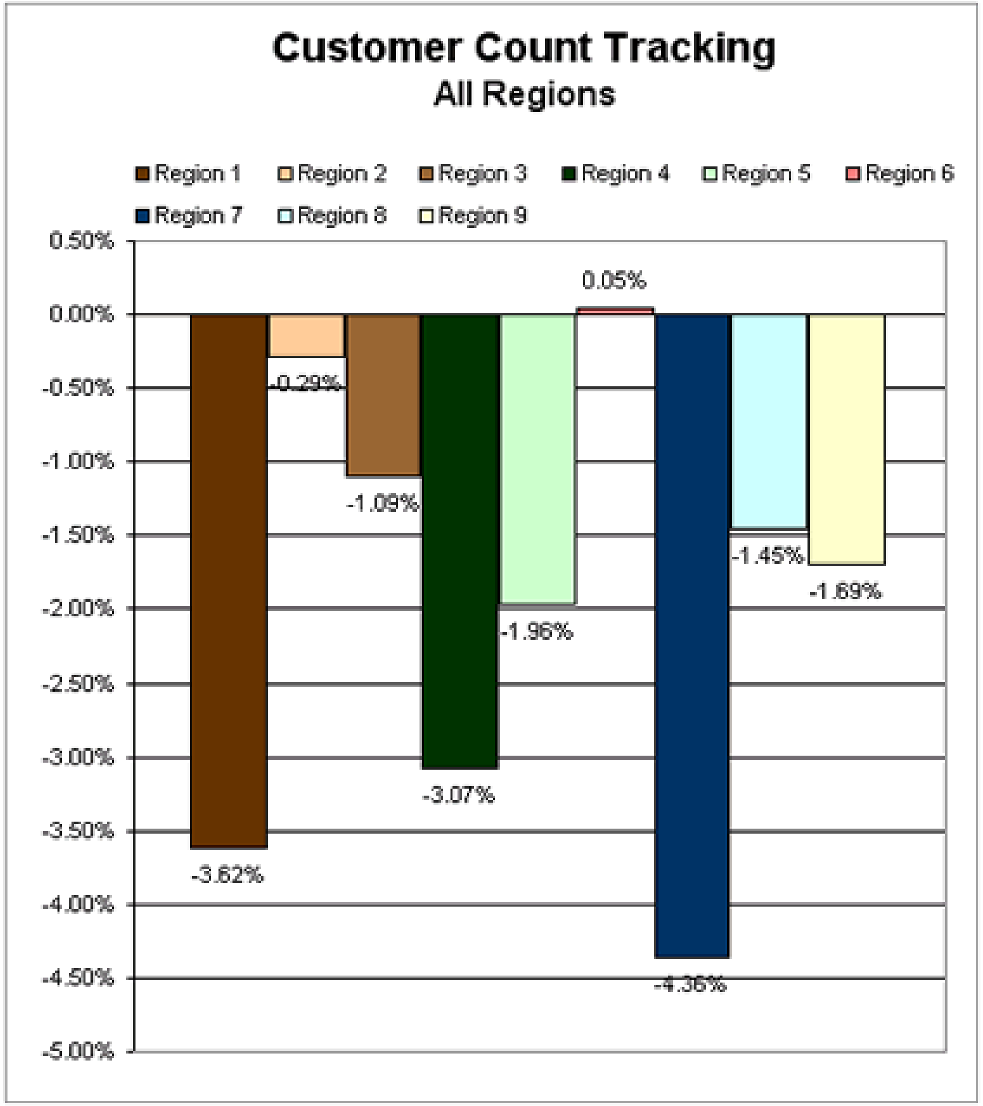
Quantity



The relative difficulty of assessing quantitative value as a function of encoding mechanism, as established by Cleveland and McGill

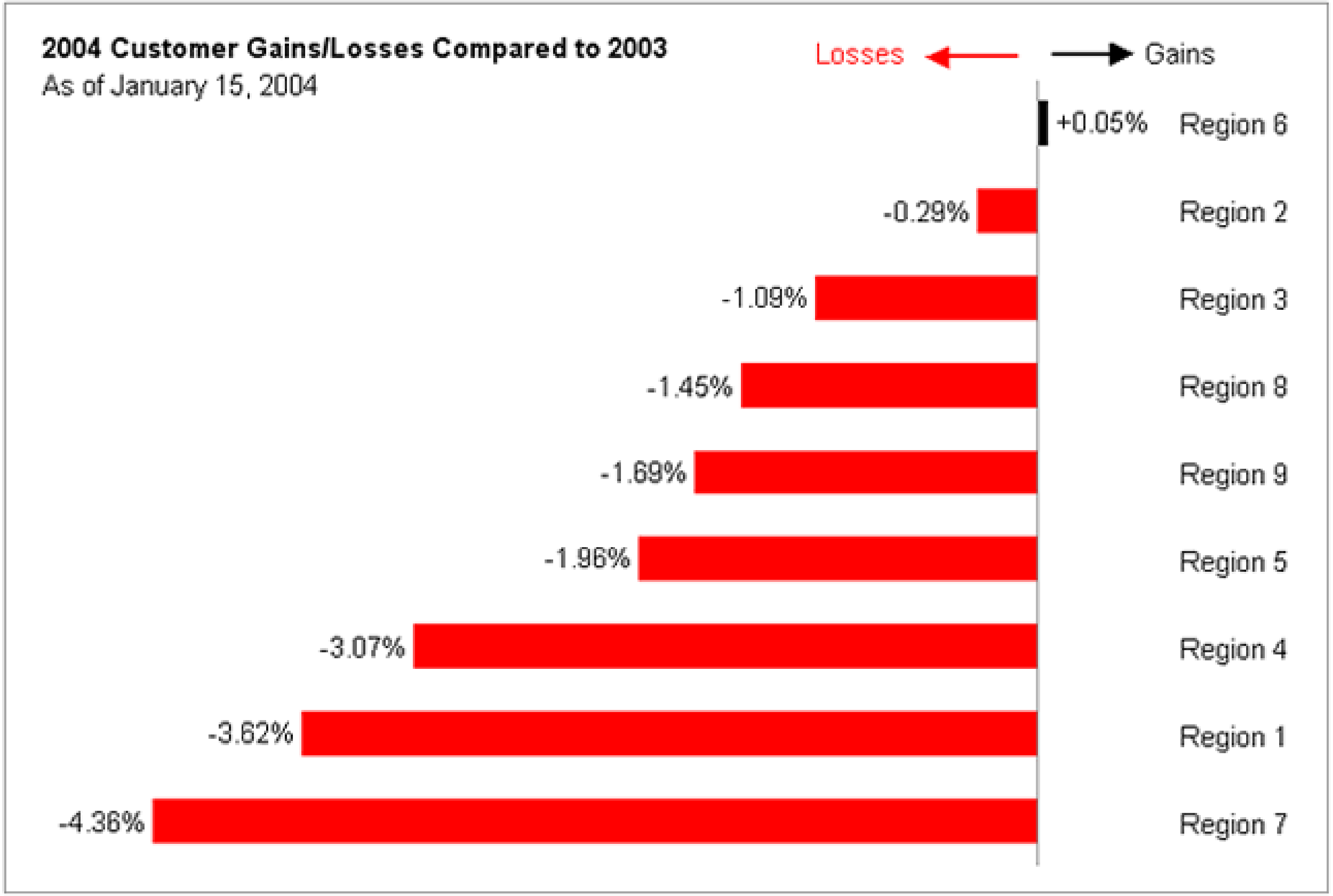
EXAMPLES: BEFORE AND AFTER

BEFORE



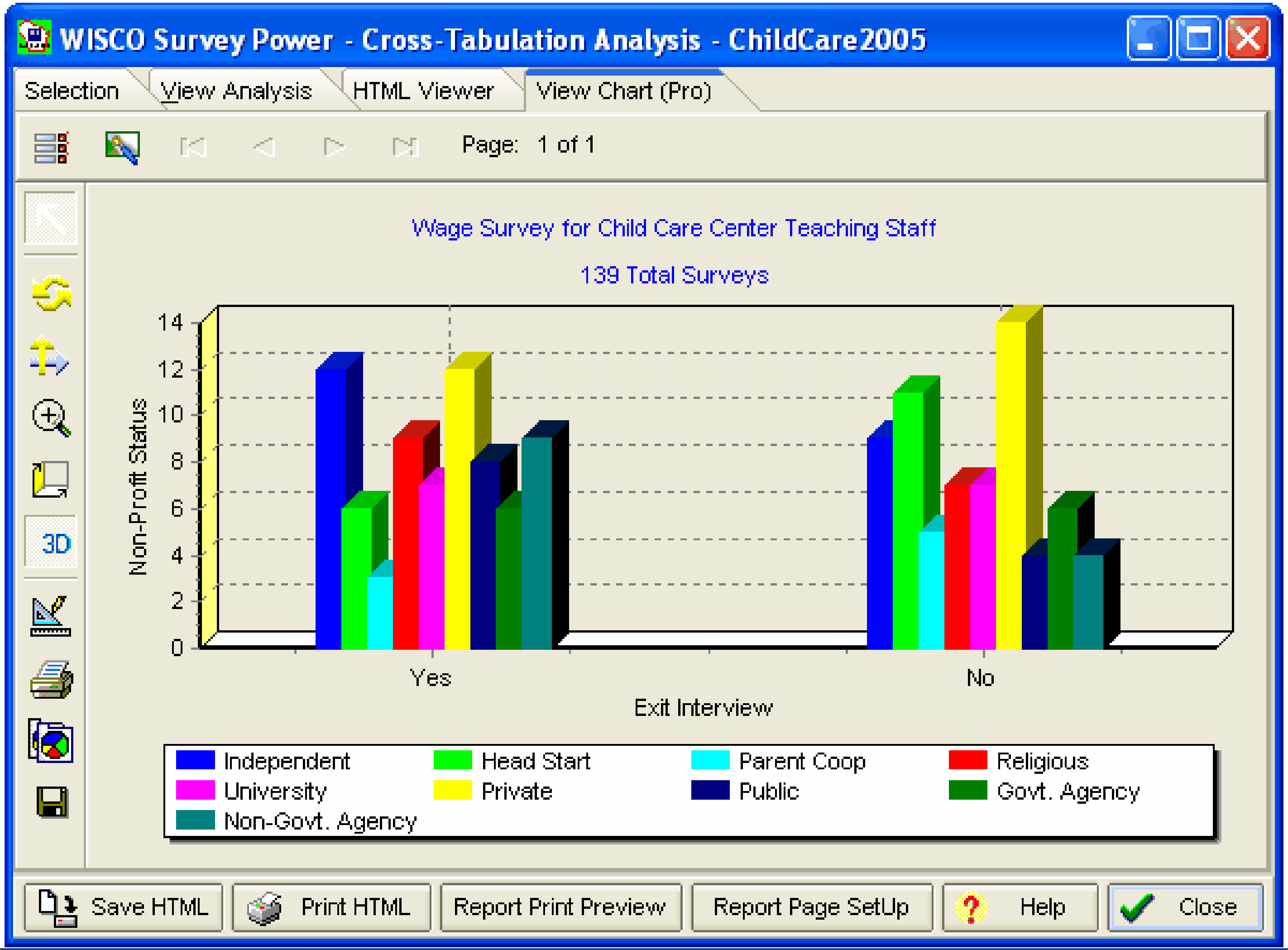
Customer Count Tracking
All Regions
Region 1
Region 2
Region 3
Region 4
Region 5
Region 6
Region 7
Region 8
Region 9
0.50%
0.00%
-0.50%
-1.00%
-1.50%
-2.00%
-2.50%
-3.00%
-3.50%
-4.00%
-4.50%
-5.00%
-3.62%
-0.29%
-1.09%
-3.07%
-1.96%
0.05%
-4.36%
-1.45%
-1.69%

AFTER

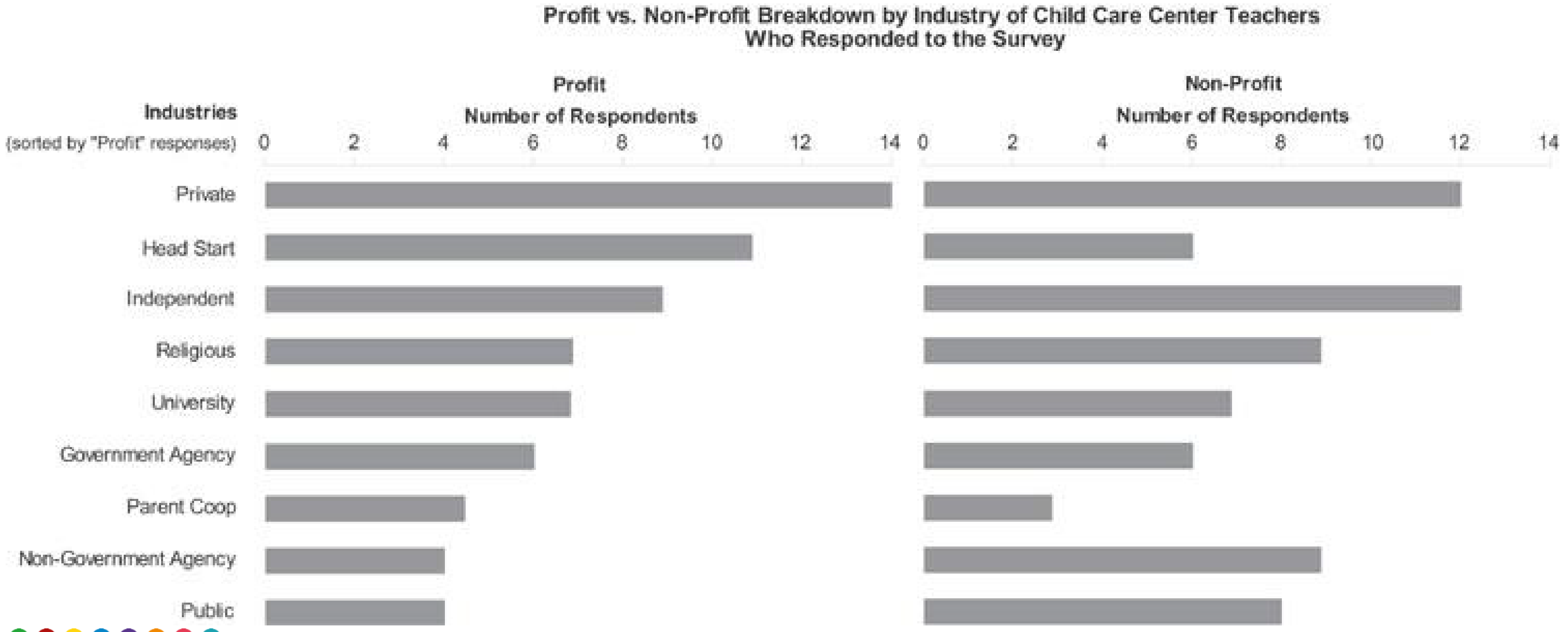


2004 Customer Gains/Losses Compared to 2003
As of January 15, 2004
Losses
Gains
+0.05%
Region 6
-0.29%
Region 2
-1.09%
Region 3
-1.45%
Region 8
-1.69%
Region 9
-1.96%
Region 5
-3.07%
Region 4
-3.62%
Region 1
-4.36%
Region 7

BEFORE

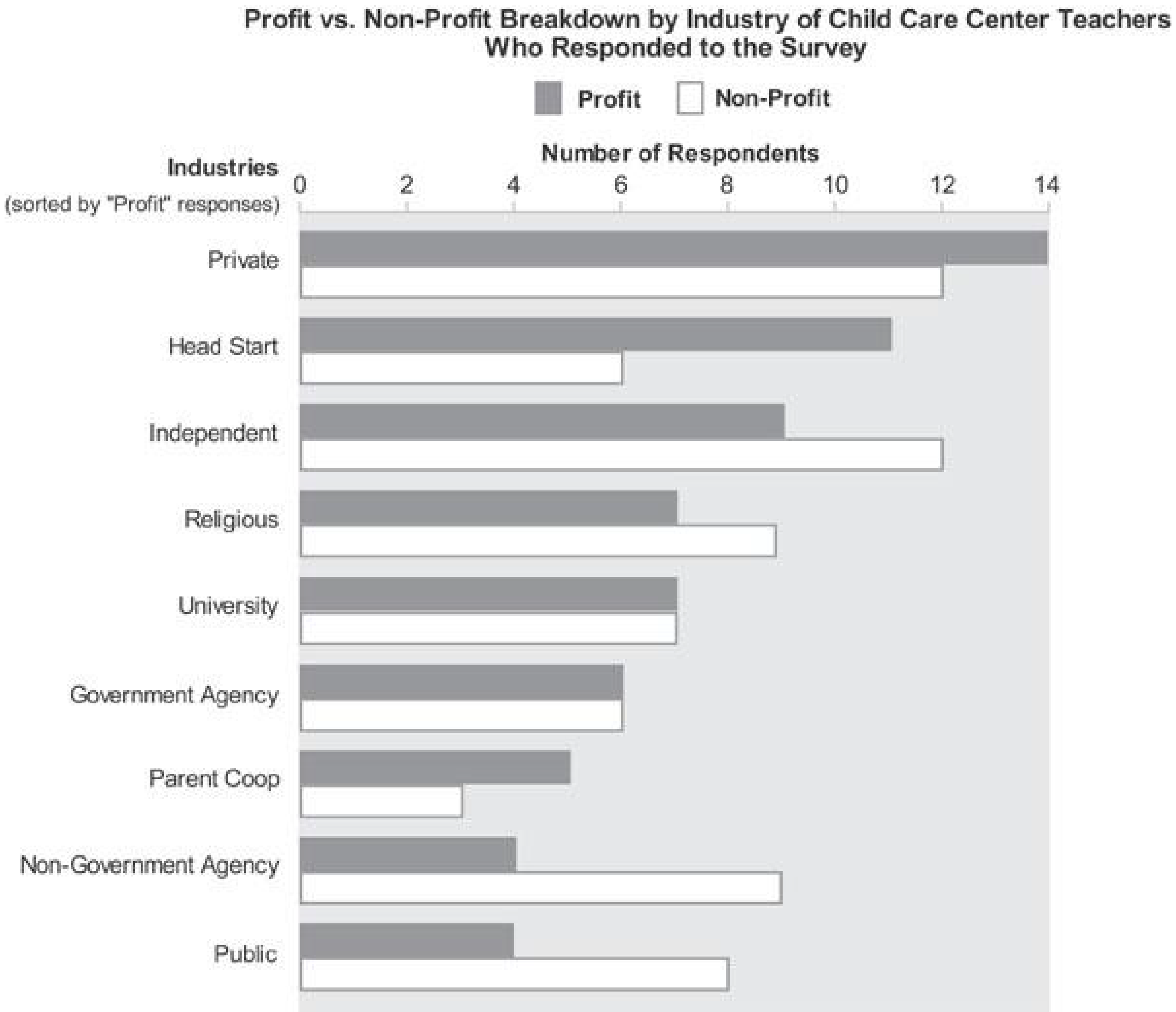

WISCO Survey Power - Cross-Tabulation Analysis - ChildCare2005
Selection
View Analysis
HTML Viewer
View Chart (Pro)
Page: 1 of 1
3D
Wage Survey for Child Care Center Teaching Staff
139 Total Surveys
Non-Profit Status
14
12
10
8
6
4
2
0
Yes
No
Exit Interview
Independent
Head Start
Parent Coop
Religious
University
Private
Public
Govt. Agency
Non-Govt. Agency
Save HTML
Print HTML
Report Print Preview
Report Page SetUp
Help
Close

AFTER



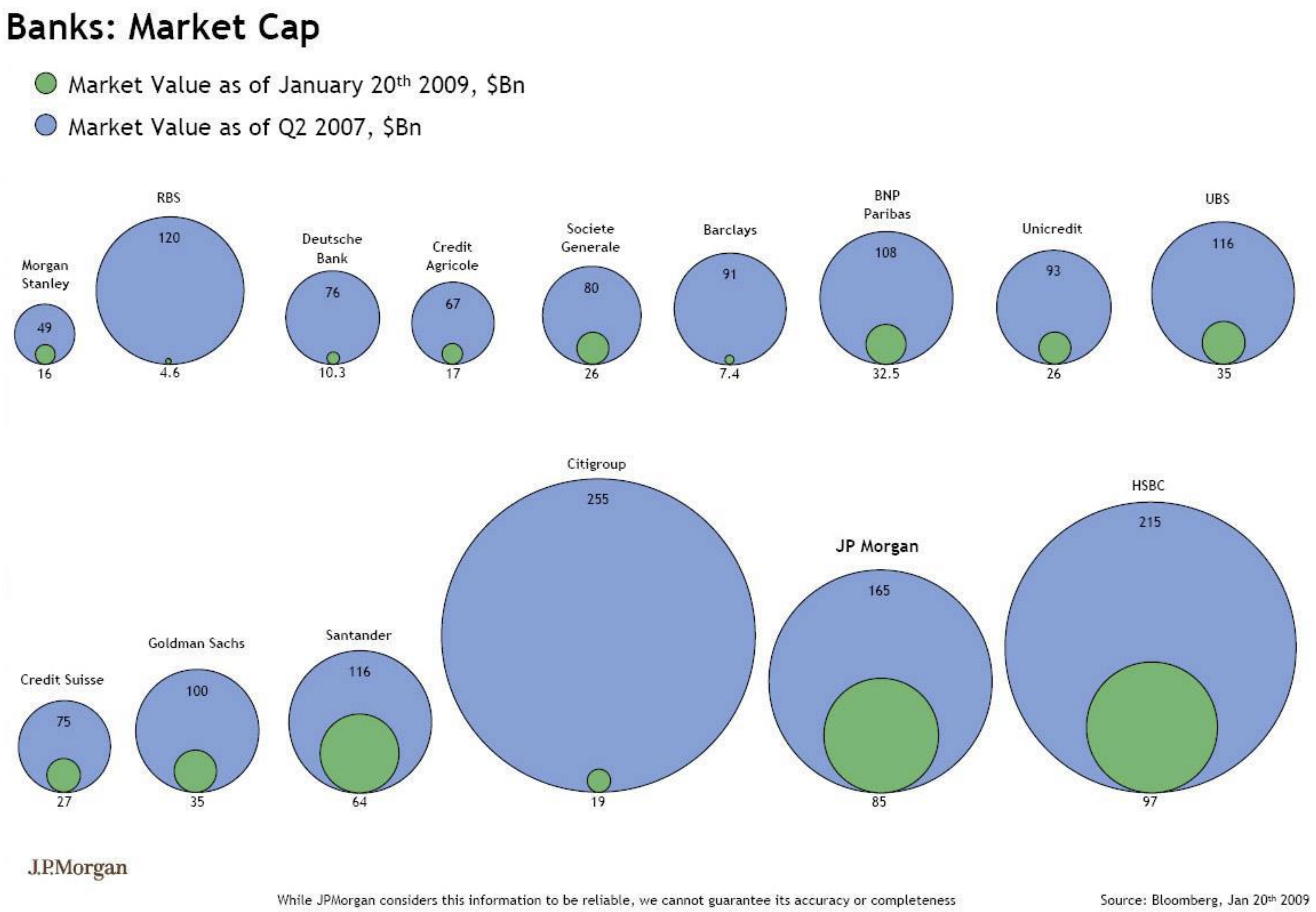
Profit vs. Non-Profit Breakdown by Industry of Child Care Center Teachers
Who Responded to the Survey
Industries
(sorted by "Profit" responses)
Profit
Number of Respondents
Non-Profit
Number of Respondents
0
2
4
6
8
10
12
14
Private
Head Start
Independent
Religious
University
Government Agency
Parent Coop
Non-Government Agency
Public

AFTER

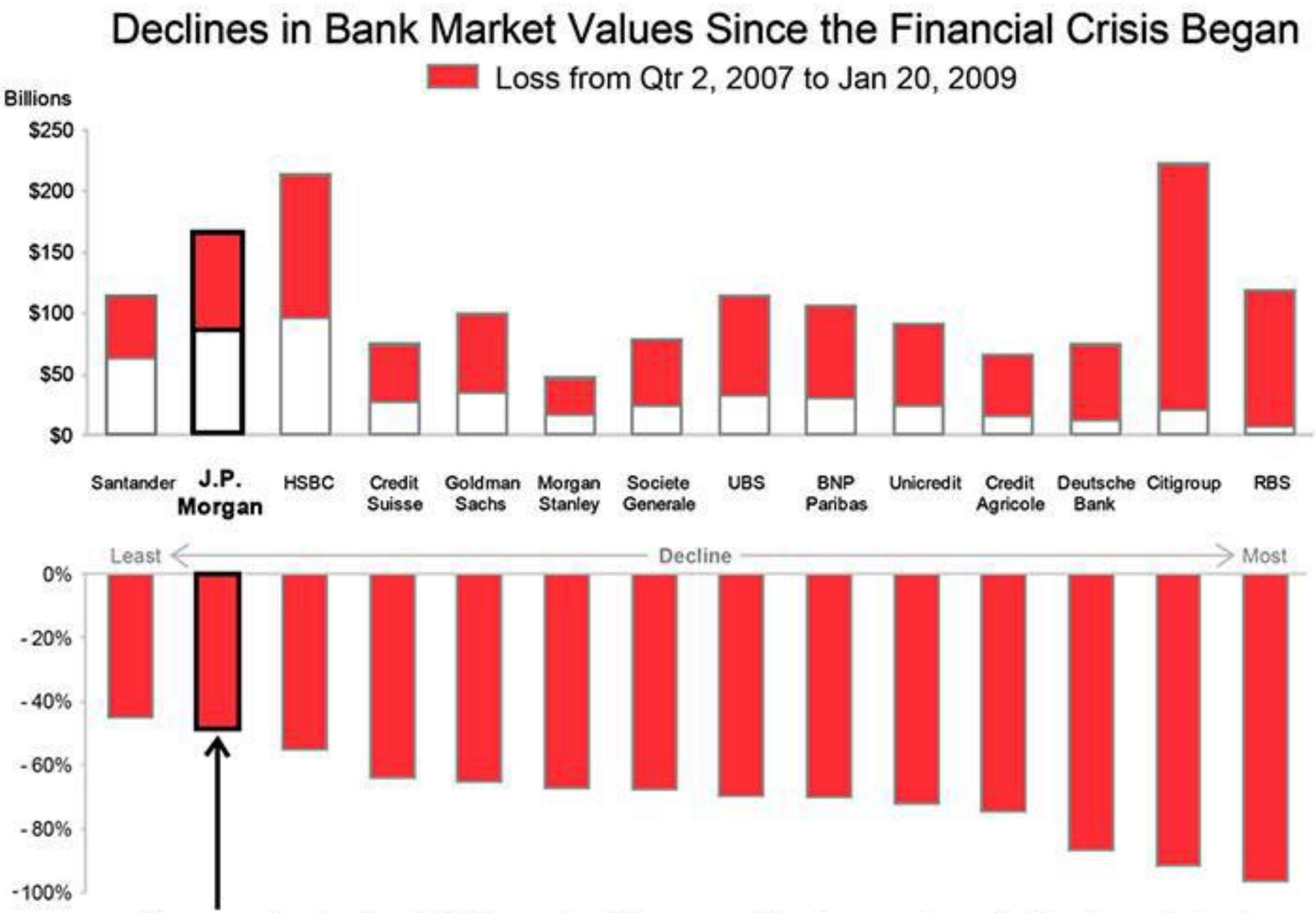


Profit vs. Non-Profit Breakdown by Industry of Child Care Center Teachers Who Responded to the Survey
Profit
Non-Profit
Industries
(sorted by "Profit" responses)
Number of Respondents
0
2
4
6
8
10
12
14
Private
Head Start
Independent
Religious
University
Government Agency
Parent Coop
Non-Government Agency
Public

BEFORE


Banks: Market Cap
Market Value as of January 20th 2009, $Bn
Market Value as of Q2 2007, $Bn
Morgan Stanley
49
16
RBS
120
4.6
Deutsche Bank
76
10.3
Credit Agricole
67
17
Societe Generale
80
26
Barclays
91
7.4
BNP Paribas
108
32.5
Unicredit
93
26
UBS
116
35
Credit Suisse
75
27
Goldman Sachs
100
35
Santander
116
64
Citigroup
255
19
JP Morgan
165
85
HSBC
215
97
J.P.Morgan
While JPMorgan considers this information to be reliable, we cannot guarantee its accuracy or completeness
Source: Bloomberg, Jan 20th 2009

AFTER



Among major banks, J.P. Morgan had the second least percentage decline in market value.

EXERCISE: INFORMATION VISUALISATION

1. Is there a north-south economic divide in Italy?
2. Has the social gap in Germany been widening since the 2000s?
3. How bad is the opiod crisis in the USA? Show the progression since 2000.
4. Does educational success in Germany depend on social background?
5. Is road traffic in Germany getting safer over the last decades? Compare with at least one other country.
6. How widespread were and are different programming languages?

EXCERCISE: INFORMATION VISUALISATION

Based on your research about the topic selected:

1. Create a nice chart to visualize your data

2. Use your knowledge about cognitive aspects and design guidelines you have learned about so far

Human Factors and Human-Machine Interaction

Information Dashboards

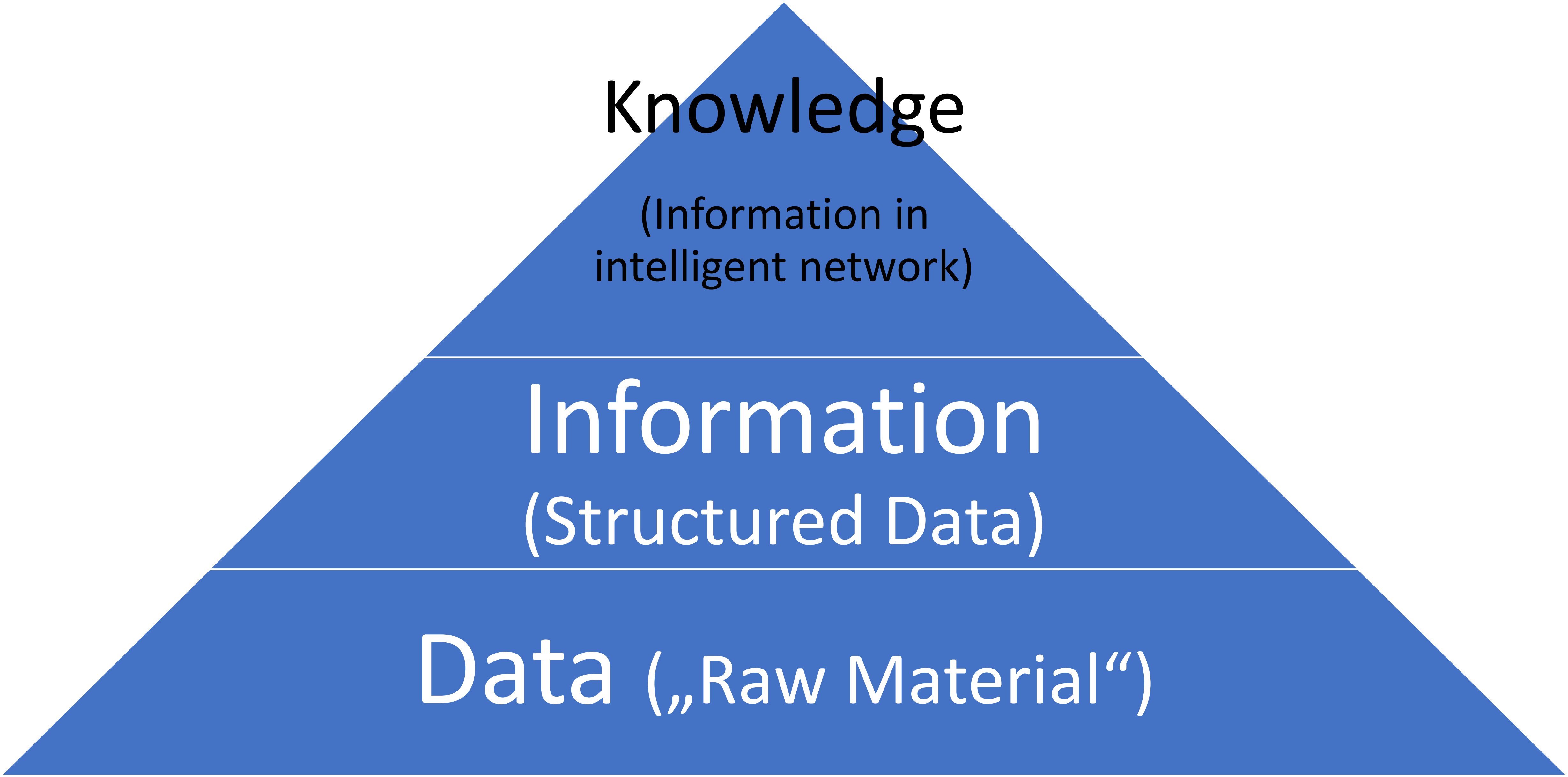
FACULTY

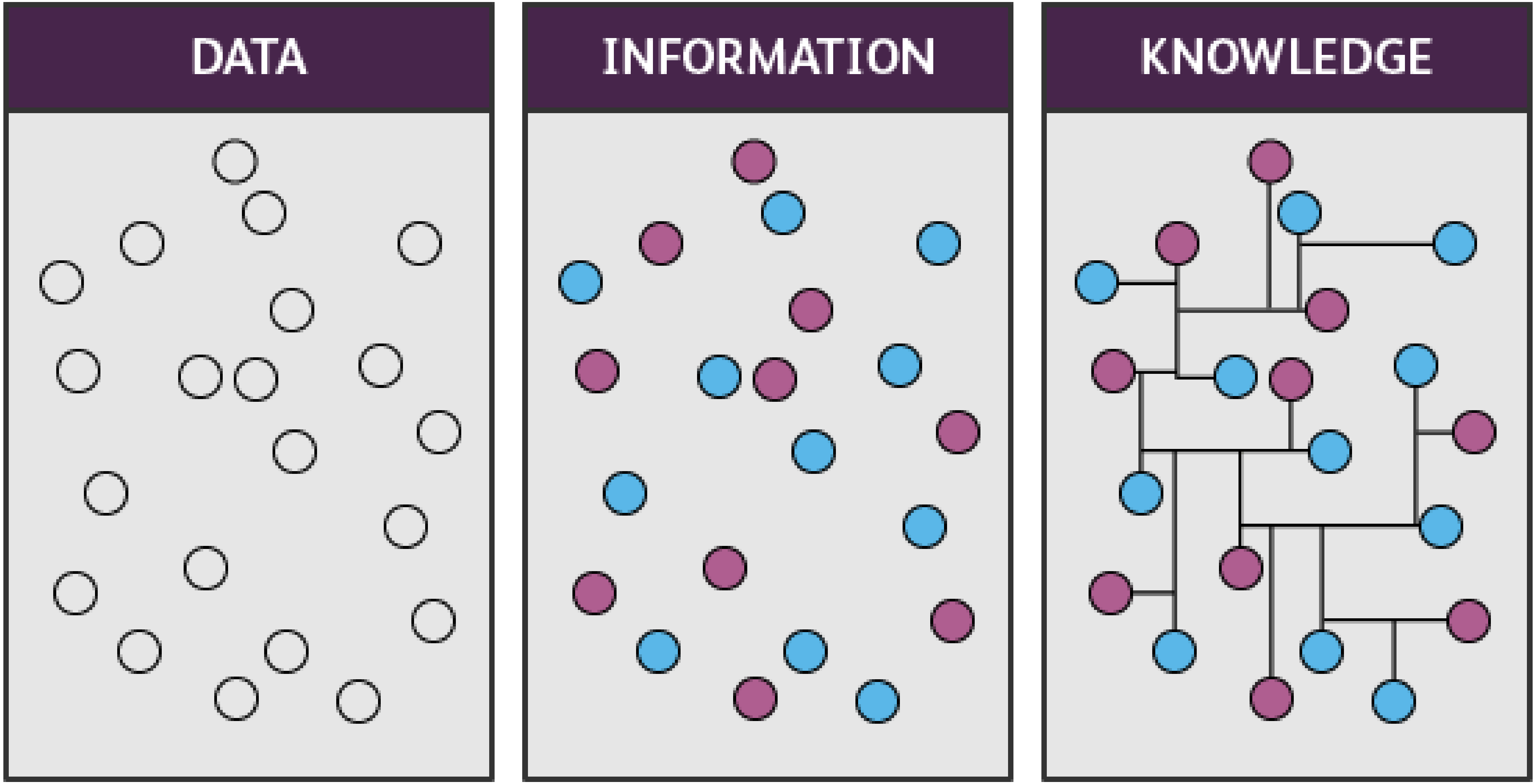
OF COMPUTER SCIENCE

DEGGENDORF INSTITUTE OF TECHNOLOGY

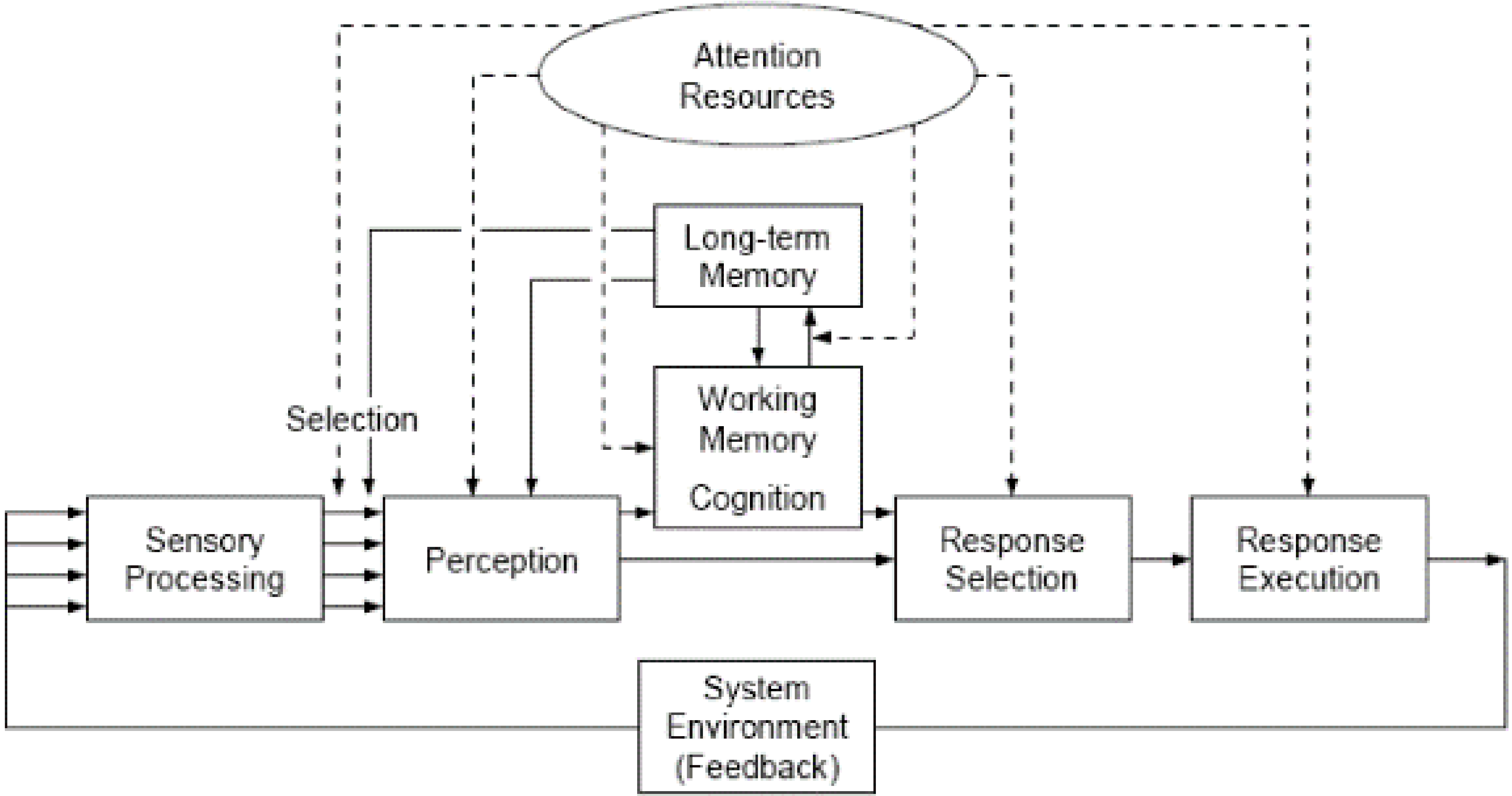

John Doe
Dashboard
lorem ipsum dolor sit amet, consectetur adipiscing elit
Deals Analytics
Impressions
1,563
May 23 - June 01 (2017)
Goal
30,564
May 23 - June 01 (2017)
Impact
42.6%
May 23 - June 01 (2017)
Published Project
532 +1.69%
Completed Task
4,569 -0.5%
Successfull Task
89% +0.99%
Ongoing Project
365 +0.35%
Sales In July
$2665.00
Direct Sale
$1768
Referal
$897
What's New
Your Manager Posted.
You have 3 pending Task.
New Order Received.
Latest Activity
Devlopment & Update
Showcases
New Products
Name
Product Code
Customer
Sofa
#PHD001
abc@gmail.com
Computer
#PHD002
cdc@gmail.com
Total Transactions
Errors Rate
Servers Location
Server Utilization (%)
Active Processes
Server Log
Network Latency (sec)
Deployment Progress
Throughput (bits/sec)
FUSION SMART
Energy Dashboard
October 2018
COST PREDICTED
Total
$214
CHANGE IN COST
5.42%
INCREASE IN COST
USAGE ESTIMATE
ACTIVE APPLIANCES
ENERGY INTENSITY
47
kWh/Sqft
CARBON FOOTPRINT
Social Media - Overview
Klipfolio
Social Media Followers
26,472
45,322
6,524
Facebook Engaged Users and Page Impressions
Engaged Users
19,878
Page Impressions
8,391,834
Twitter Favorites of Last 10 Tweets
26
Twitter Retweets of Last 10 Tweets
418
YouTube Subscribers (Last 30 Days)
Facebook Page Likes
Total Page Likes
8,132
New Page Likes
432
Instagram Overview
192
289
109
LinkedIn Key Metrics (Last 30 Days)
Production rate: Machine
Units YTD
339,194.00
Target 360,000.00
Operators Available
Lost Units: Causes
389
Units lost: Machine
Productivity by: Machine
Overall Productivity: YTD
Lead Conversion Ratio
15:1
Unqualified Leads turned into Customers
Converted Leads - last 30 Days
Leads 1,459
Opportunities 454
Negotiation 355
Proposal 212
Wins 97
Daniel
Sales Manager 1
3 %
CONVERSION RATE
Anna
Sales Manager 2
11 %
CONVERSION RATE
Max
Sales Manager 3
7 %
CONVERSION RATE
35 %
Lead-to-Opportunity Ratio
22 %
Opportunity-to-Win Ratio

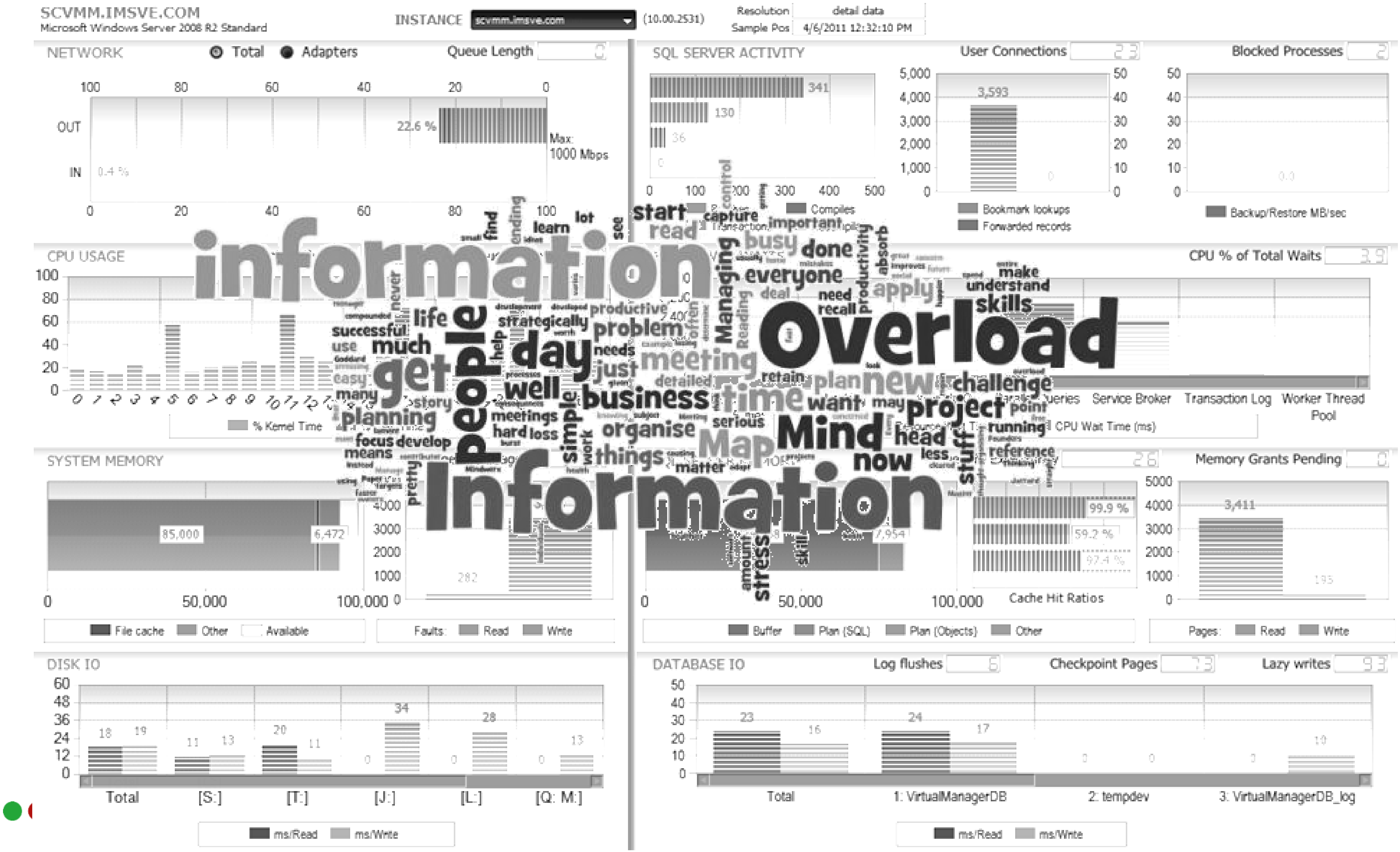
Why should computer science become cognitive?


Knowledge
(Information in intelligent network)
Information
(Structured Data)
Data („Raw Material“)



https://www.evalueserve.com/blog/making-the-leap-from-insights-to-wisdom-a-collaborative-approach/


Attention Resources
Long-term Memory
Working Memory
Cognition
Selection
Sensory Processing
Perception
Response Selection
Response Execution
System Environment (Feedback)


SCVMM.IMSVE.COM
Microsoft Windows Server 2008 R2 Standard
INSTANCE
scvmm.imsve.com
(10.00.2531)
Resolution
detail data
Sample Pos
4/6/2011 12:32:10 PM
NETWORK
Total
Adapters
Queue Length
OUT
IN
22.6 %
0.4 %
Max: 1000 Mbps
SQL SERVER ACTIVITY
User Connections
Blocked Processes
Compiles
Bookmark lookups
Forwarded records
Backup/Restore MB/sec
CPU USAGE
% Kernel Time
CPU % of Total Waits
Service Broker
Transaction Log
Worker Thread Pool
CPU Wait Time (ms)
SYSTEM MEMORY
File cache
Other
Available
Faults:
Read
Write
Memory Grants Pending
Cache Hit Ratios
Buffer
Plan (SQL)
Plan (Objects)
Pages:
DISK IO
Total
[S:]
[T:]
[J:]
[L:]
[Q: M:]
ms/Read
ms/Write
DATABASE IO
Log flushes
Checkpoint Pages
Lazy writes
1: VirtualManagerDB
2: tempdev
3: VirtualManagerDB_log
information
Overload
Information
people
get
day
business
time
Mind
Map
project
meeting
problem
planning
organise
challenge
skills
understand
everyone
done
apply
start
read
capture
important
busy
new
plan
now
head
running
reference
serious
things
stress
simple
well
much
life
successful
strategically
productive
needs
just
retain
want
may
point
make
need
recall
deal
learn
lot
find
focus
develop
meetings
hard
loss
means
matter
stuff
less
many
story
use
easy
skill
amount
Managing

HERBERT A. SIMON

„The design of systems must encompass far more than hardware and software; it must consider with equal care the information processing capabilities of the human members of organizations who form the other half of the system." (1968)

HERBERT A. SIMON

„In the post-industrial society, the central problem is (…) how to organize information to make decisions.“

Simon, H.A. (1973). Administrative Behavior. A Study of Decision Making Processes in Administrative Organization, New York, London.


Big Data
Meldung
Ticketplanung
Einsatz
Ticketübersicht
Meine Aufgaben
Plantafel
Multiprojektplan-Erstellung
Projektbewertung
Projekt-Rechnungslauf
Ressourcenplan-Erstellung
Archiv
Berichte
Einrichten
Mein Menü
Management & Controlling
Einkauf
Lager & Logistik
Verkauf & Marketing
Service & Werkstatt
Projektmanagement
Personalwesen
Projektmanagement : Projektergebnisse
Projektnummer
Projekt
Umsatz
Kosten
Projektmanagement : Budgetstunden-Überwachung
Verbleibend
Budget
Ist
5. Hot Lead
4. Interesse
3. On Hold
2. In Kontakt
1. Neuer Lead
2012
2013
Monatsumsatz:
Aktuelle OPOS-Bestände:
Forderungen:
3.806.345,07 €
Verbindlichkeiten:
2.882.179,43 €
Lagerwert:
Anzahl Re / Gt:
Volumen netto:
23.720,00 €
Rohertrag:
12.341,00 €
Bestell-Bestand:
Fakturierung:

STATUS QUO

- More and **more data**
- Bottleneck: human information **processing**
- Increasing **challenges for the design** of information-dense displays
- Design must know, take into account and exploit **principles** and **mechanisms** of perception and information processing.
- Daniel Kahneman: „Whatever else it produces, an organization is a factory that manufactures judgments and decisions" (p. 418)

STATUS QUO

- History & Kewords:
    - Executive Information Systems
    - Decision Support Systems
    - Data Warehousing
    - OLAP
    - Business Intelligence, Business Analytics
    - Key Performance Indicators
- Flashy Dashboards

DASHBOARD DEFINITION

A dashboard is a ***visual*** *display of the* ***most important information*** *needed to achieve one or more* ***objectives****; consolidated and arranged on a* ***single screen*** *so the information can be monitored at a glance.* (Few, 2013; p. 26)

GENERAL REMARKS

- Dashboards ≠ display for **data analysis**/exploration, **scorecard**, report to look up **facts**
- Use **skeuomorphism** purposefully - rather avoid/don't overuse metaphors
- Dashboards are **customized** solutions; *not one-size-fits-all*
- Dashboards support formation and maintenance of **situational awareness**
  - Perception
  - Understanding
  - Anticipation

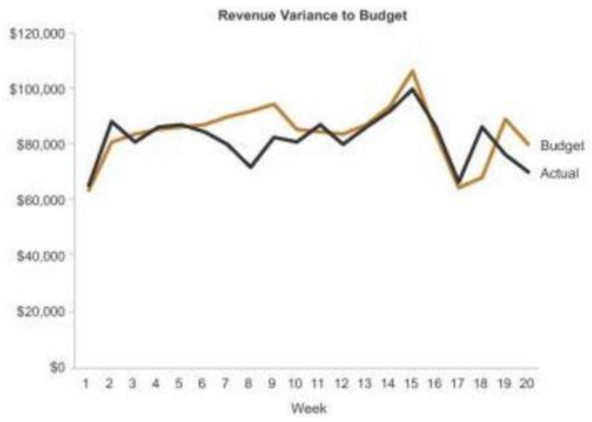
EXERCISE: SKETCH A DIT STUDENT DASHBOARD

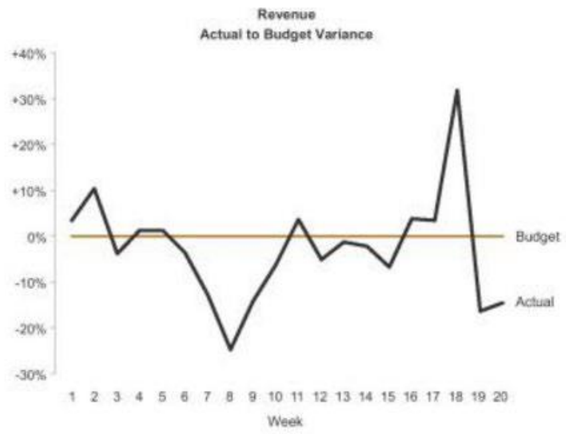
Part 1: Requirements Engineering

1. What information should be displayed on a dashboard? **Write user stories** (a user story is an informal, general explanation of a software feature written from the end user's perspective).
2. Create an **initial sketch** of your dashboard having the following questions in mind:
   - Which questions/information have the highest priority? How can these priorities be weighted visually?
   - Is attention appropriately directed (SEEV model)? Which contrasts can be used appropriately?
   - How can you use which gestalt laws appropriately?
   - Are there certain states, events, particularities to which attention must be drawn as soon as they occur?

COMMON MISTAKES

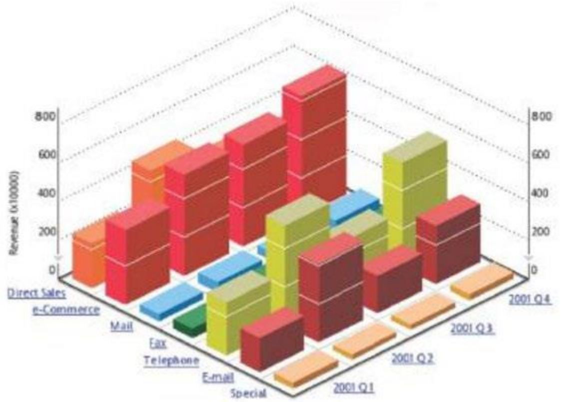
- Exceeding the boundaries of a **single screen**
  - Scrolling/fragmented screens: Information Access Costs
  - No overview, no relationships
- Supplying inadequate **context** for the data
  - Comparison biases (baseline, min/max, mean, SD, …)
  - Measures
  - Evaluations
- Displaying excessive **detail** or precision
  - Suitable rounding (3,301,654.93 EUR vs. 3.3 million EUR)
  - Avoid clutters
- Expressing **measures** indirectly (choosing a deficient measure)
  - Task orientation
  - Absolute values or relative developments?
  - Deviation from reference measure?



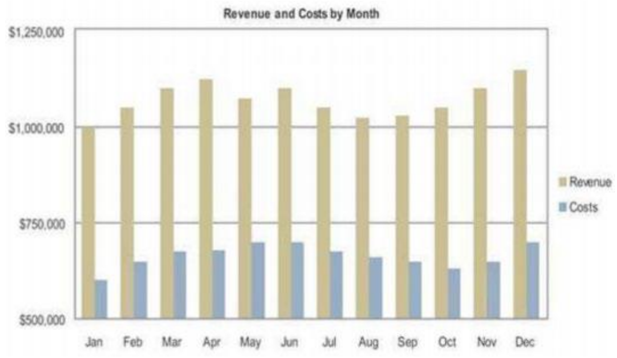


COMMON MISTAKES

- Choosing inappropriate **display media**
  - Diagram instead of table or vice versa
  - Circle diagrams
  - Areas, volumes for exact quantities

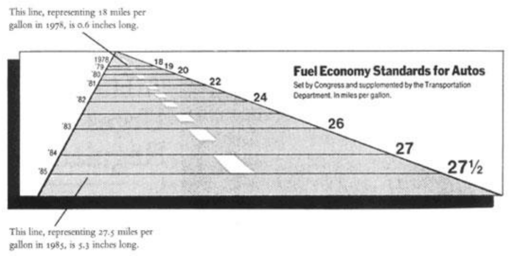


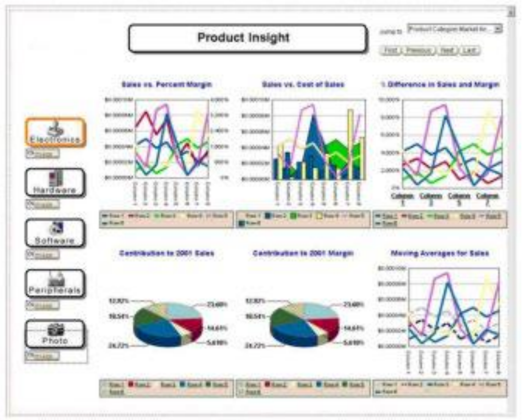
- Using poorly designed **display media**
  - Unnecessary legends with colour areas that are too small
  - Structures in the data are not used (e.g., sorting by size)
  - Contrasts are too strong
  - Chart junk, 3-D, ...
- Introducing meaningless **variety**
  - Visual differences should reflect differences in content
  - No different diagrams for similar sizes just for the sake of variety



COMMON MISTAKES

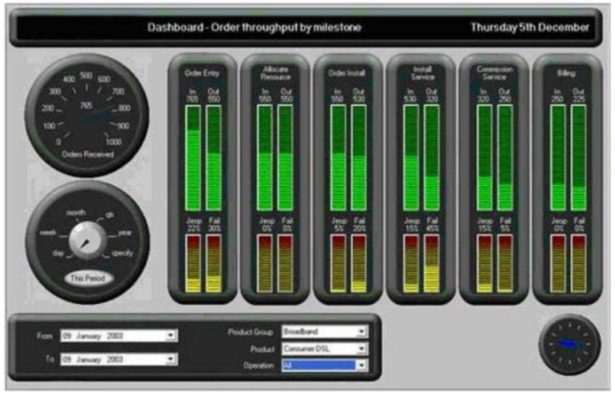
- Encoding **quantitative data** inaccurately
  - Visual Lies→ Lie Factor = depicted effect size/actual effect size
- **Arranging** the data poorly
  - Ignoring the direction of reading
  - Wasting prominent placements
- **Highlighting** important data ineffectively or not at all
  - Drawing attention to wrong content
  - Too much contrast; if everything is prominently designed, nothing stands out.

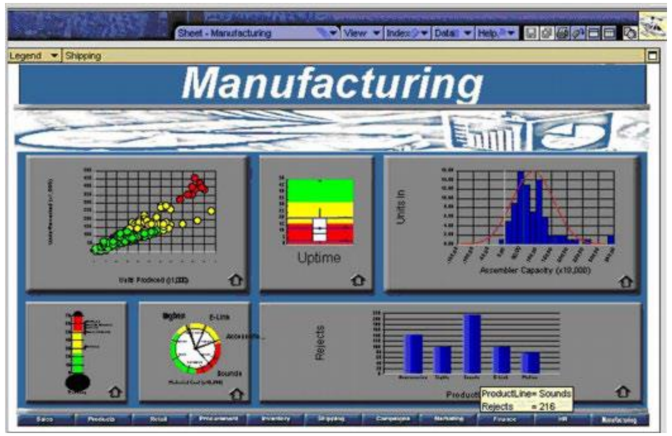




COMMON MISTAKES

- **Cluttering** the display with visual effects
  - Decoration
  - Metaphors, skeuomorphism
- **Misusing** or overusing **color**
  - Economical use
  - Generation of references: (un)intentional
  - Use for attention control
- Designing an **unattractive** visual display
  - Aesthetics are not created through decoration
  - Reduced colour saturation
  - White space important
  - C.R.A.P.



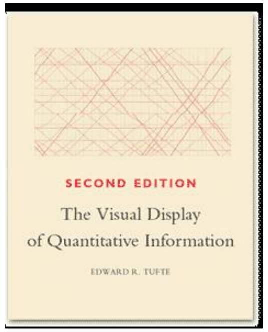


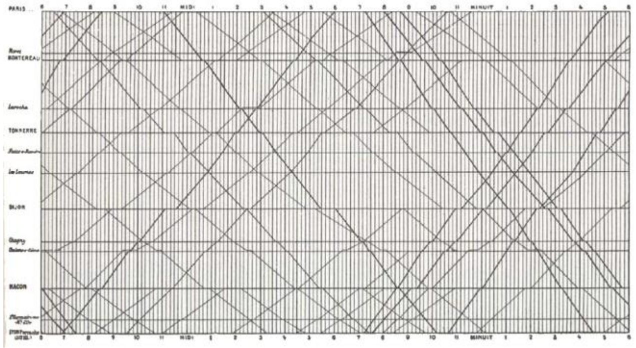
REQUIREMENTS ANALYSIS

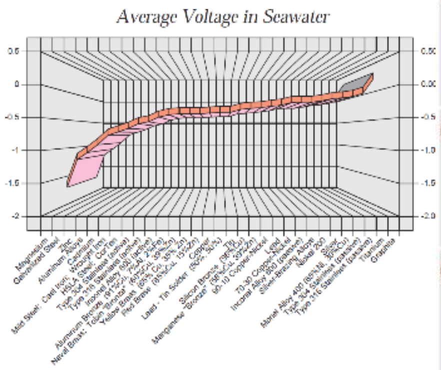
- Focus on the **goals** not the means/methods
- Identify **mental models** of users:
  - Structures, processes, dependencies
  - Mapping via simple sketches
- Identify **requirements** through questions
  - How often is information/dashboard used?
  - Who is/are the user(s) (expert, novice, layperson)?
  - What objectives does the dashboard need to support?
  - What questions should the dashboard answer?
  - What information in what level of detail; what data types?
  - Which information is important for the goals and how?
  - Which logical groupings exist?
  - What comparisons, benchmarks, assessments are useful and necessary?
  - ...

DATA-INK RATIO

- Data-ink (or data-**pixel**) = "*the ink changing as the data change*" (Tufte, 1983; p. 93)
- Representation of quantitative information should consist mainly of data (data-ink) and as little non-data as possible.
- **Design principle**: *Maximize the data-inkratio, within reason. Every bit of ink on a graphic requires a reason. And nearly always that reason should be that the ink presents new information*. (p. 96)
- **In short**: reduction of unnecessary (non-data) pixels, reduction of unnecessary variability (cf. right o. linear colour gradients), improvement of data pixels.







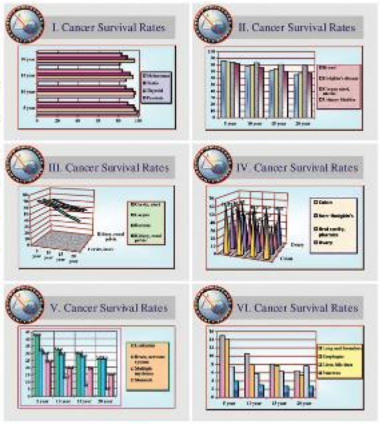
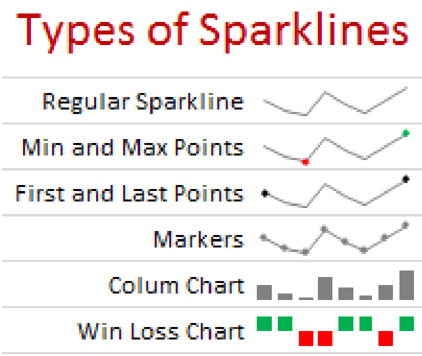
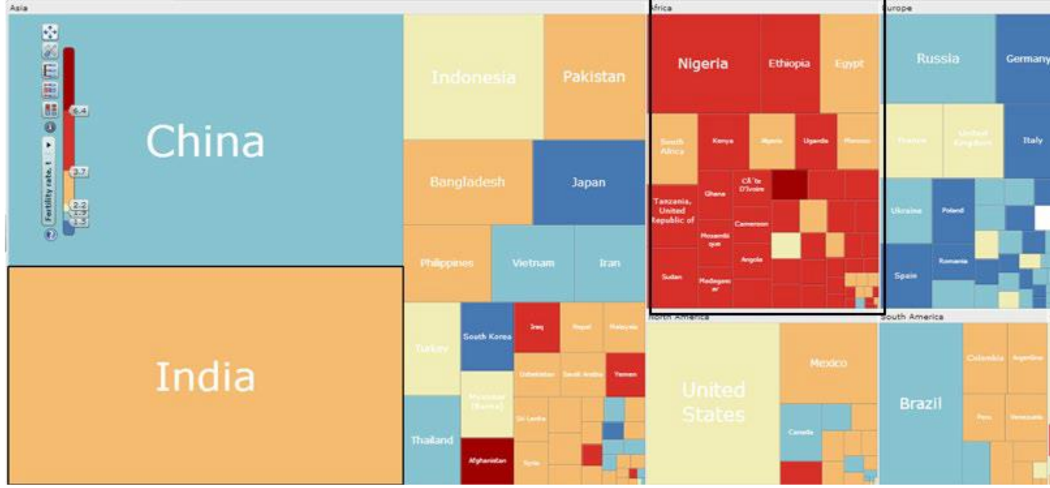


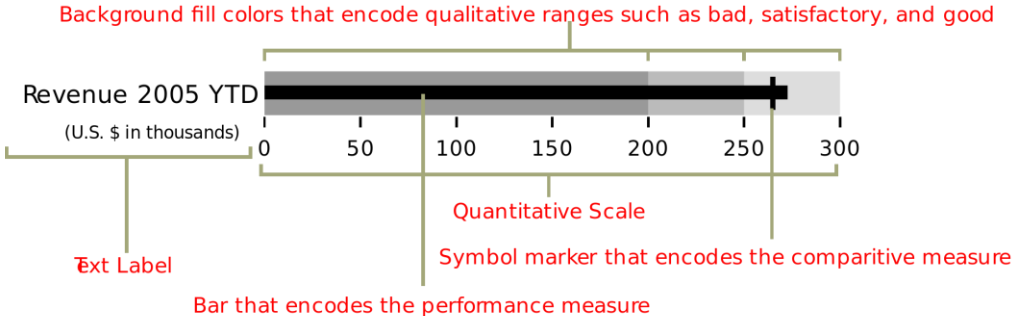
DIAGRAM TYPES

- Diagram types:
  - Bar charts
  - Scatter plots
  - Line charts
  - Sparklines
  - Box Plot
  - Spatial maps
  - Heatmaps
  - Treemaps
  - Bullet graphic

- Recommended reading:
  - Evergreen, S. D. H. (2019). Effective Data Visualization. London: Sage.
  - Kirk, A. (2019). Data Visualization. London: Sage.







BEST PRACTICES

- **Organize** information to support its meaning and use.
    - Reading flow
    - Grouping
    - Gestalt laws
    - Enable or prevent comparisons

- Maintain **consistency** to enable quick and accurate interpretation
    - Top-down processing: use prior knowledge/experience and expectations
    - Differences generate attention

- Put **supplementary information** within reach
    - Outsource details
    - → interaction

- Expose **lower-level** conditions
    - For issues below the granularity level
    - Yes/No prompt is often sufficient, with the possibility for interaction
    - Exercise restraint!

BEST PRACTICES

- Make the experience **aesthetically** pleasing
    - Subtle color saturation
    - Few, deliberate contrasts
    - High resolution, readability
    - C.R.A.P.

- Prevent excessive **alerts**
    - Crying wolf

- Keep viewers **in the loop**
    - Maintain situational awareness
    - Don't rely solely on red/green traffic lights when comprehension is important

- Accomodate **real-time monitoring**
    - Update frequency; consider stopping if necessary
    - Consider audio alerts
    - Timestamp alerts

EXERCISE: SKETCH A DASHBOARD

Step 1: Select one of the following applications:

Corporate Performance Monitoring:

An information dashboard can be used to monitor the performance of a company in real-time. Various metrics such as revenue, expenses, profit margins, inventory levels, customer satisfaction, etc., can be visualized. This allows executives to quickly respond to trends, identify bottlenecks, and make strategic decisions.

Healthcare Analysis:

In healthcare, dashboards can be employed to track various aspects of patient care. This could include analyzing hospital occupancy, patient flows, treatment outcomes, medication availability, and more. Physicians and hospital administrators could use this information to make efficiency improvements and enhance the quality of care.

Traffic Monitoring and Management:

In urban areas, dashboards can be used to monitor and manage traffic. By integrating data from traffic cameras, sensors, and GPS systems, traffic flows can be analyzed, congestion can be detected, and alternative routes can be suggested. This enables traffic authorities to quickly respond to events, improve traffic efficiency, and enhance traffic safety.

EXERCISE: SKETCH A DASHBOARD

Step 2: Sketching your dashboard

Use sketching software or pen and paper to sketch your dashboard.

Think about the following questions:

- What level of detail should be offered? In case of doubt, it is better to offer too much detail than too little. Edward Tufte clearly recommends this: To clarify show detail!
- Do you consider the common mistakes in dashboard design mentioned by Stephen Few?

Human Factors and Human-Machine Interaction

Usability Engineering –Introduction

FACULTY

OF COMPUTER SCIENCE

OVERVIEW

- What is usability?
    - Definition
    - Framework
    - Process

- What is User Experience (UX)?


Pull
AUTOMATIC DOOR
AUTOMATIC DOOR
Pull


STOP RUN
PHONE
FIRE SERVICE
CALL
CANCEL
OFF HOLD ON
FIRE SERVICE
Insert key and
remove quickly
20
21
22
16
17
18
12
13
14
8
9
10
11
4
5
6
7
C
2

USABILITY: DEFINITION

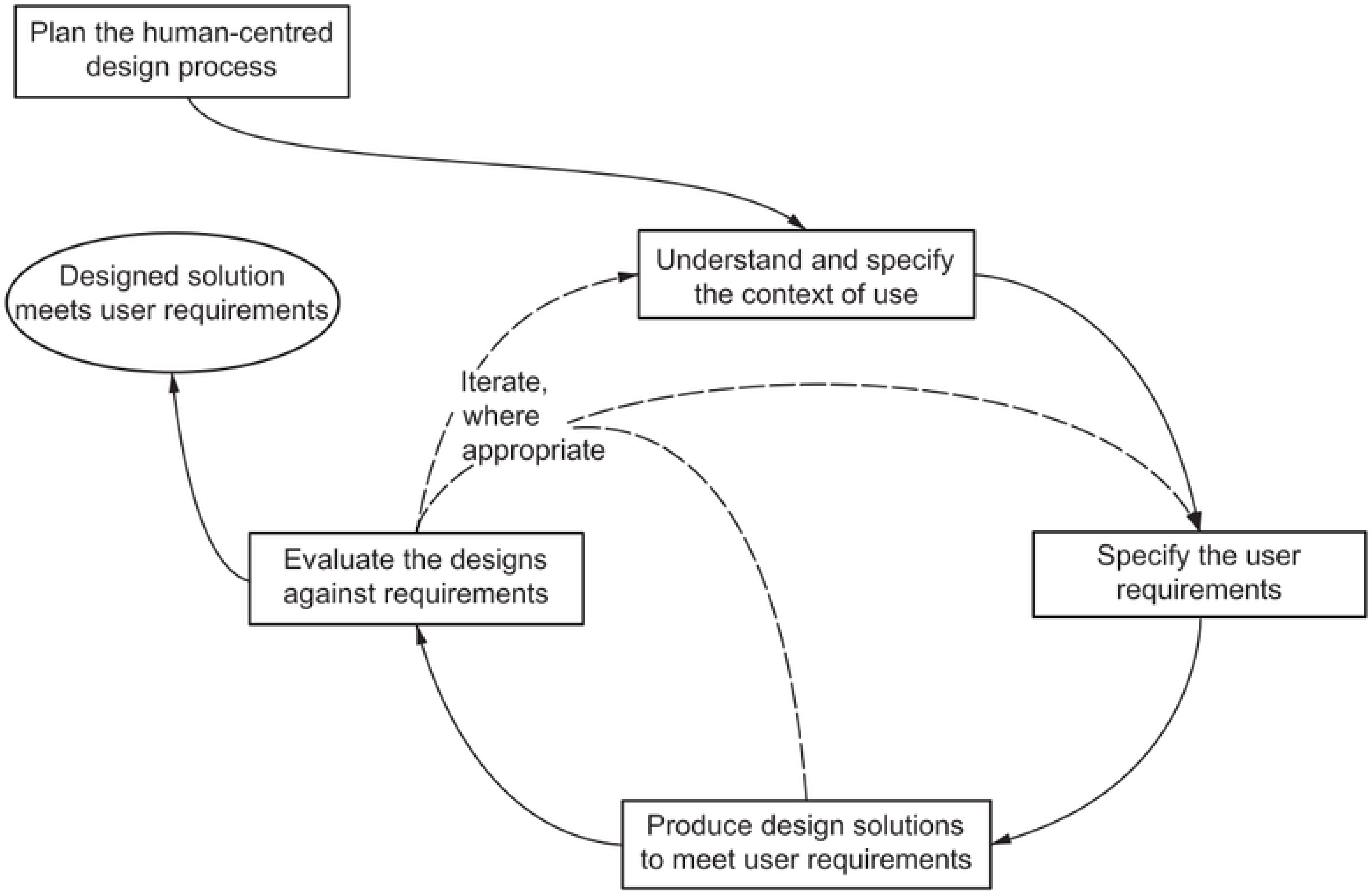
“The extent to which a **product** can be used by specified **users** to achieve specified **goals** with **effectiveness**, **efficiency** and **satisfaction** in a specified **context of use**.” (Usability – ISO 9241-11)

effectiveness: the accuracy and completeness with which specified users can achieve specified goals in particular environments

efficiency: the resources expended in relation to the accuracy and completeness of goals achieved

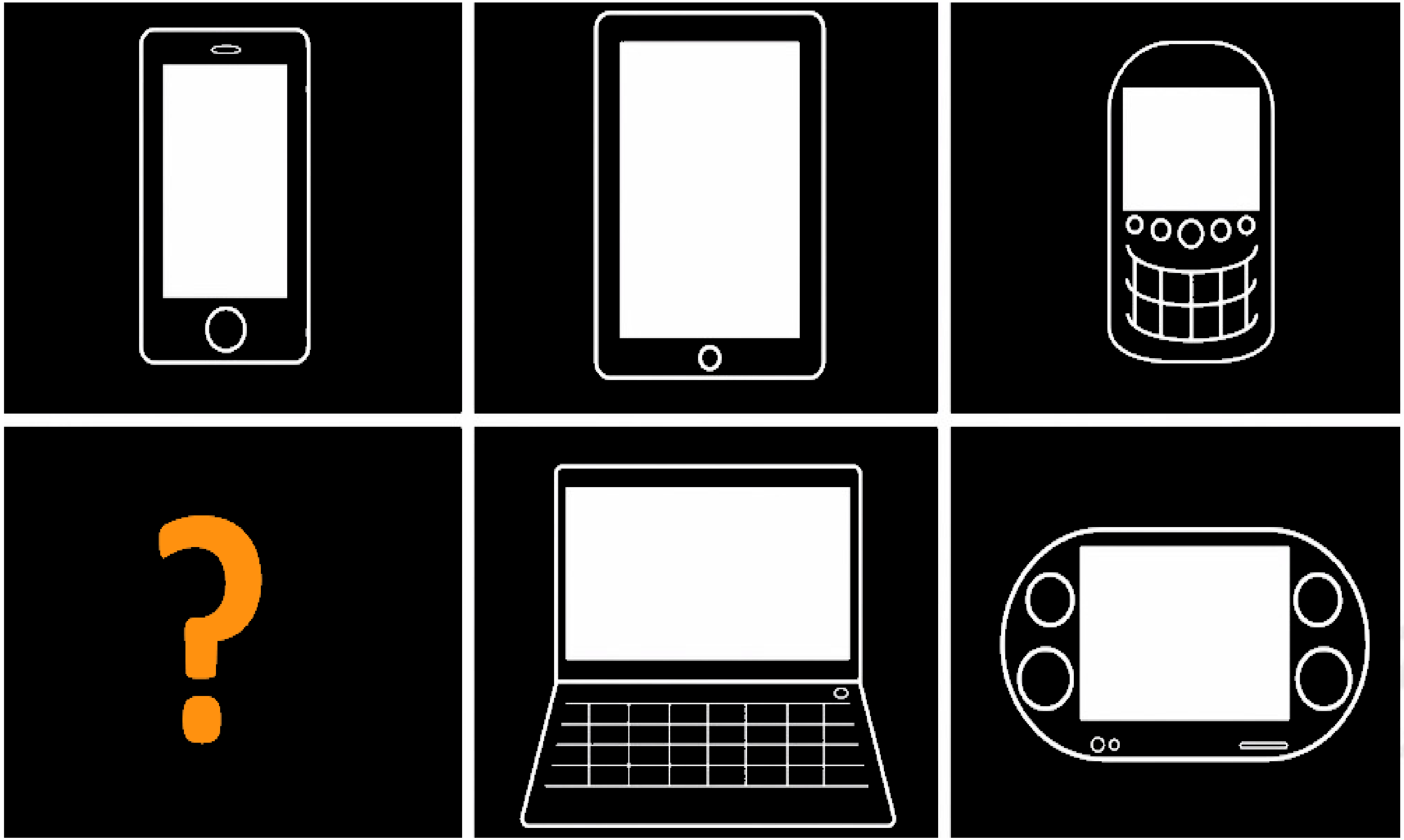
satisfaction: the comfort and acceptability of the work system to its users and other people affected by its use

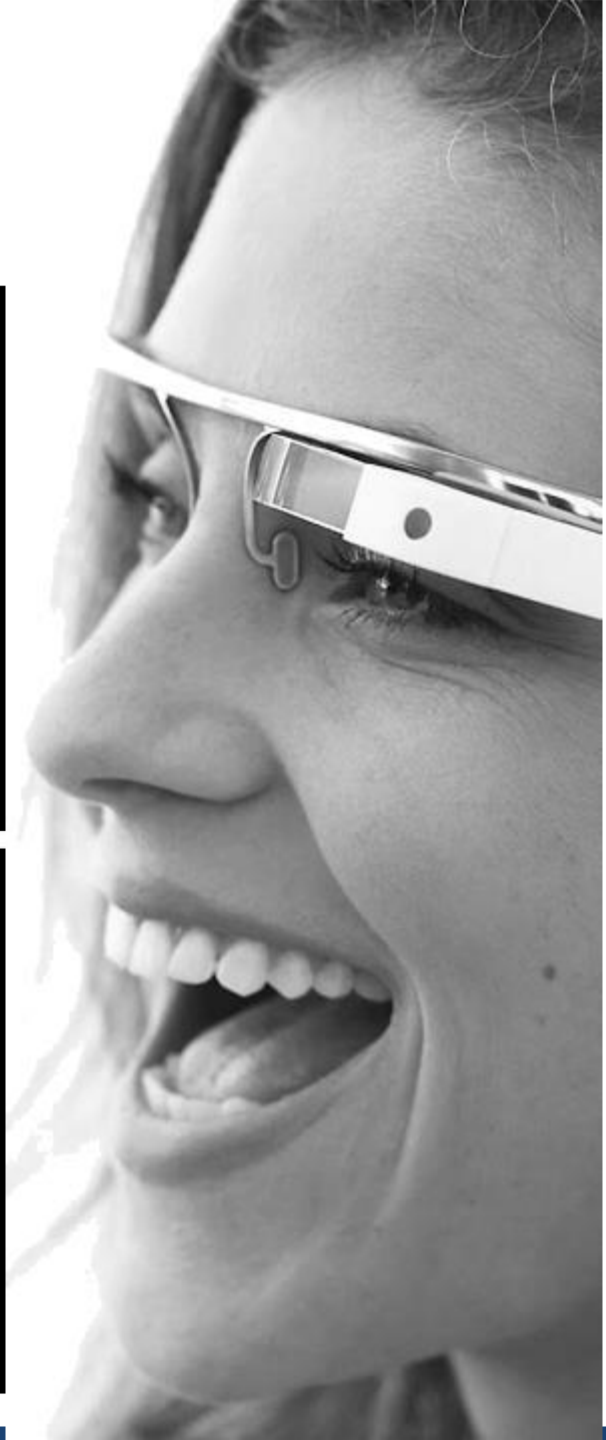
USABILITY: PROCESS

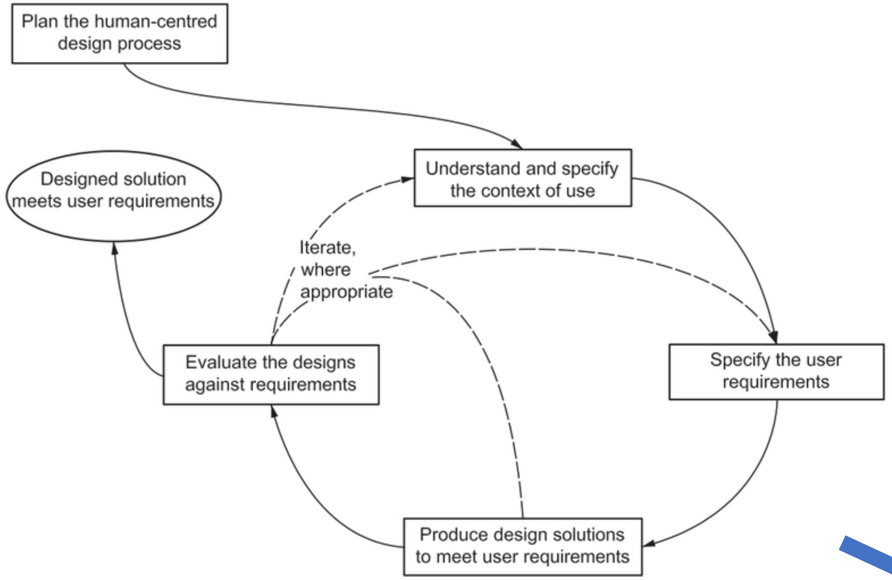


-210 (2010)

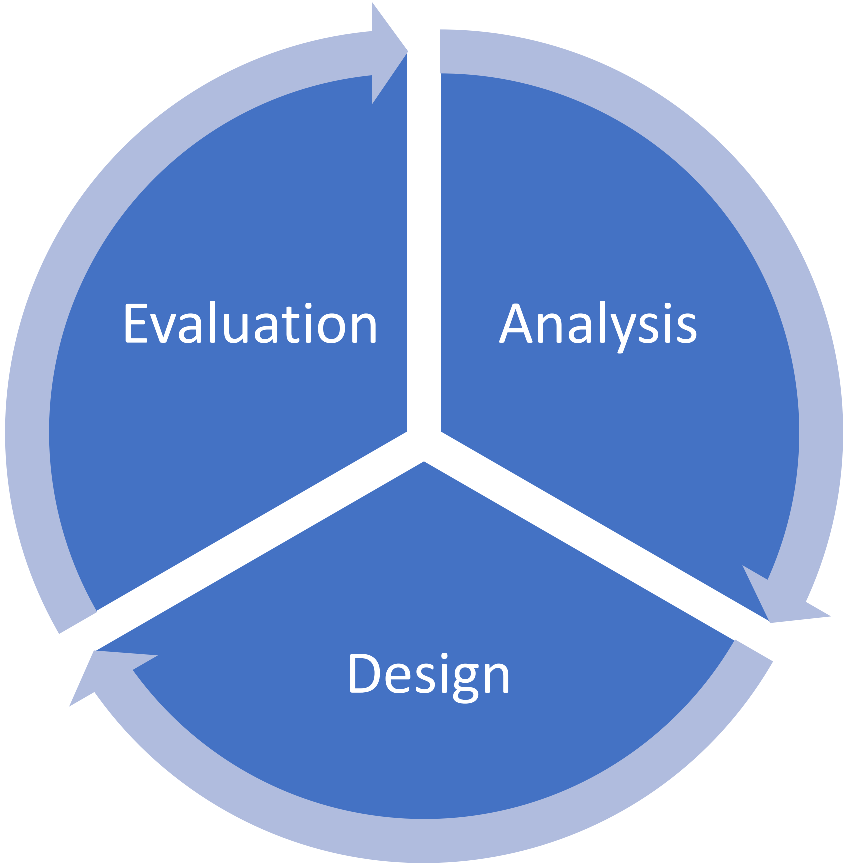
MOBILE SYSTEMS







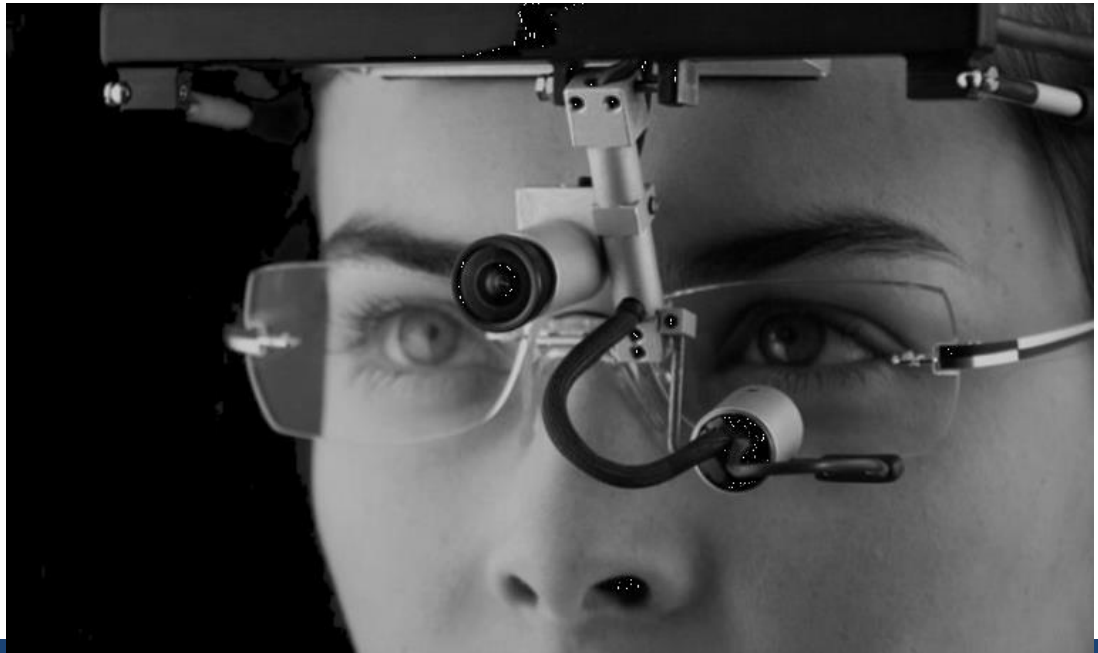
Plan the human-centred design process
Understand and specify the context of use
Designed solution meets user requirements
Iterate, where appropriate
Evaluate the designs against requirements
Specify the user requirements
Produce design solutions to meet user requirements



Evaluation
Analysis
Design

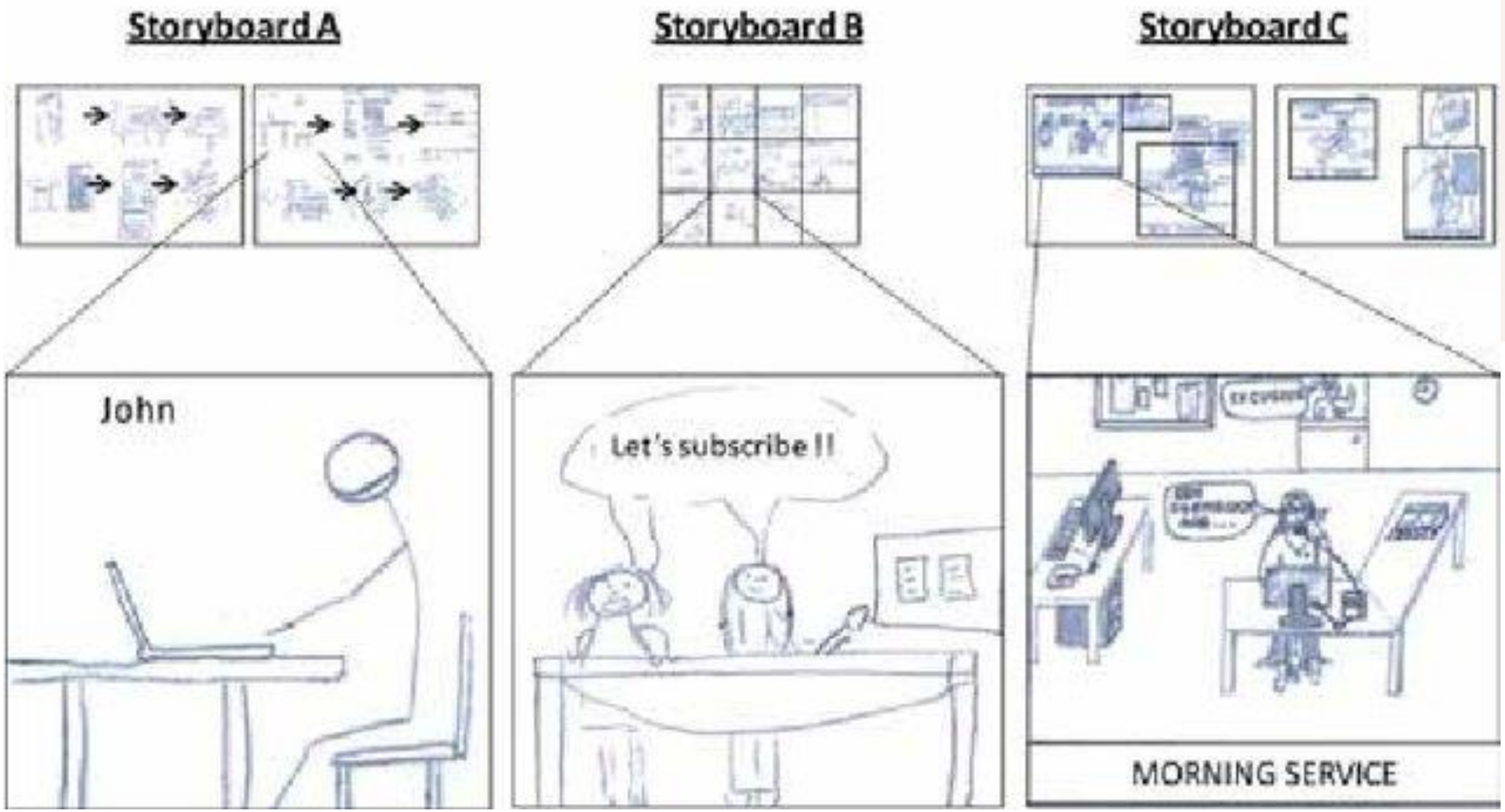
METHODS: ANALYSIS

- Personas & Scenarios
- Interviews, Focus Groups
- Field Studies, Ethnographic Studies
- Eye Tracking
- Lab Experiments
- User Modelling



METHODS: DESIGN

- Wireframes
- Storyboards
- Agile Methods
- Rapid Prototyping
- …



METHODS: EVALUATION

- **Discount Usability**: Usability Inspection (Heuristic Evaluation, Cognitive Walkthrough)
- Questionnaires
- DIY Usability Tests
- Context-oriented methods
- (Classic) User tests
- User Modelling

USABILITY++ = USER EXPERIENCE (UX)

USER EXPERIENCE

„A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service."

(User Experience – ISO 9241-210)

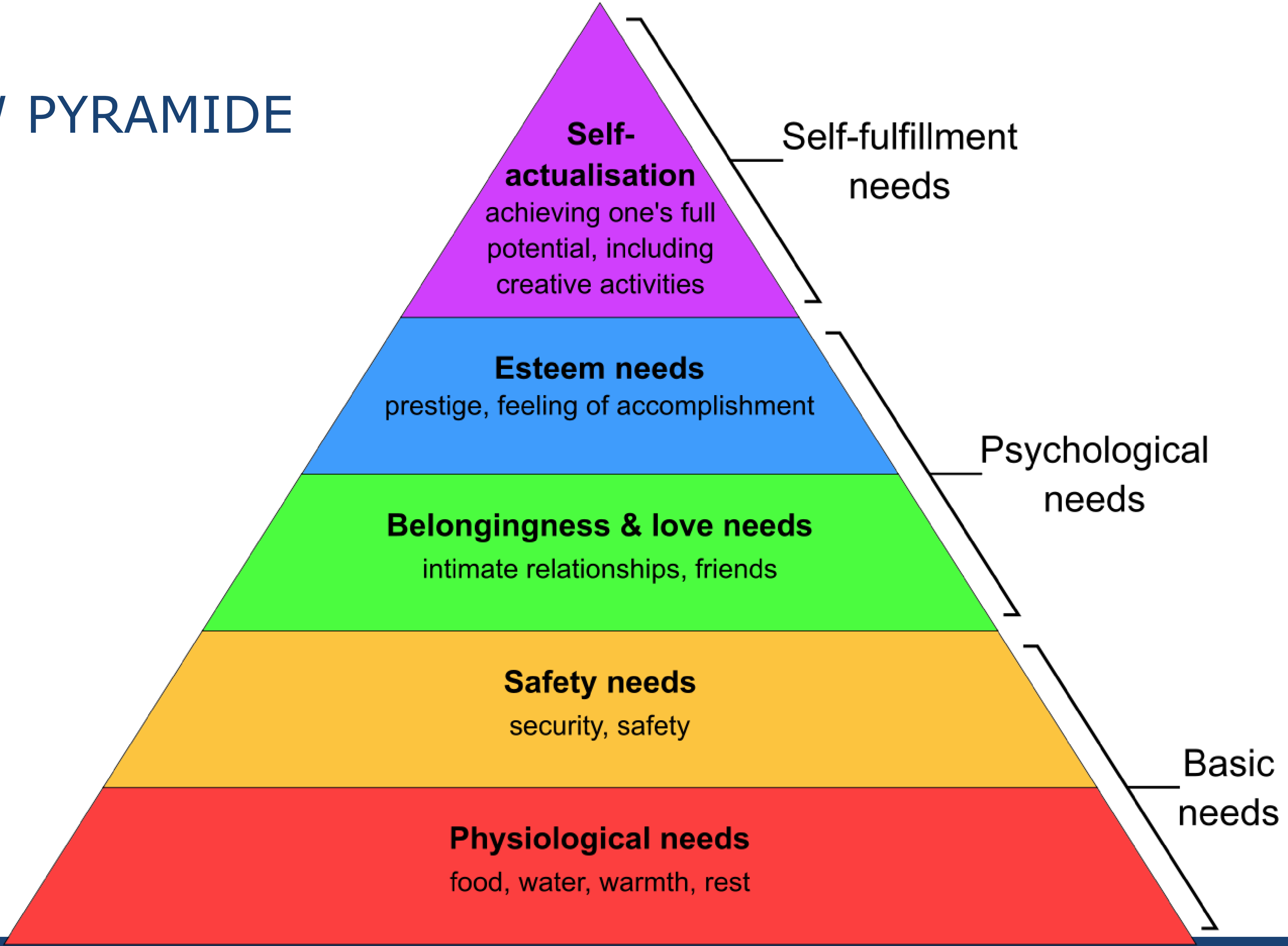
User Experience encompasses all **emotions**, perceptions, preferences, physiological and psychological responses, behaviors, and performances that arise **before, during, and after** the use.

METHODS: USER EXPERIENCE

- Holistic, temporal dynamics: Stories
- Subjective:
  - Emotions: PANAS
  - Needs: Questionnaires
  - Hedonic AND pragmatic Quality: AttrakDiff
- Objective performance measures:
  - Reaction times
  - Error rates

➡ **Not suitable for UX**

MASLOW PYRAMIDE



NEEDS AND USER EXPERIENCE

- Fulfillment of needs → positive emotions
- Experiences characterized by a **profile of needs**
- Positive experiences often characterized by a **single need**
- Needs as a **categorization system** for experiences
- Needs are not instrumentally serving a **goal or purpose**
- **Design** is instrumental in satisfying needs
- Design starting point (container): **Stories**

USABILITY VS. UX

Anticipated Use → **Actual Use** → **Digested Use**

Conceptualization of product usage without actually using it

Effective and efficient task completion

No impairments

Usability

Processing of the experienced usage

Identification with the product or creating distance from the product

User Experience

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Human Factors and Human-Machine Interaction

Usability Engineering –Analysis and Design

FACULTY
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OVERVIEW

- Analysis
  - Observation
  - Contextual analysis
  - Personas
  - Scenarios
- Design
  - Methods
  - Principles of dialogue design

USABILITY: DEFINITION

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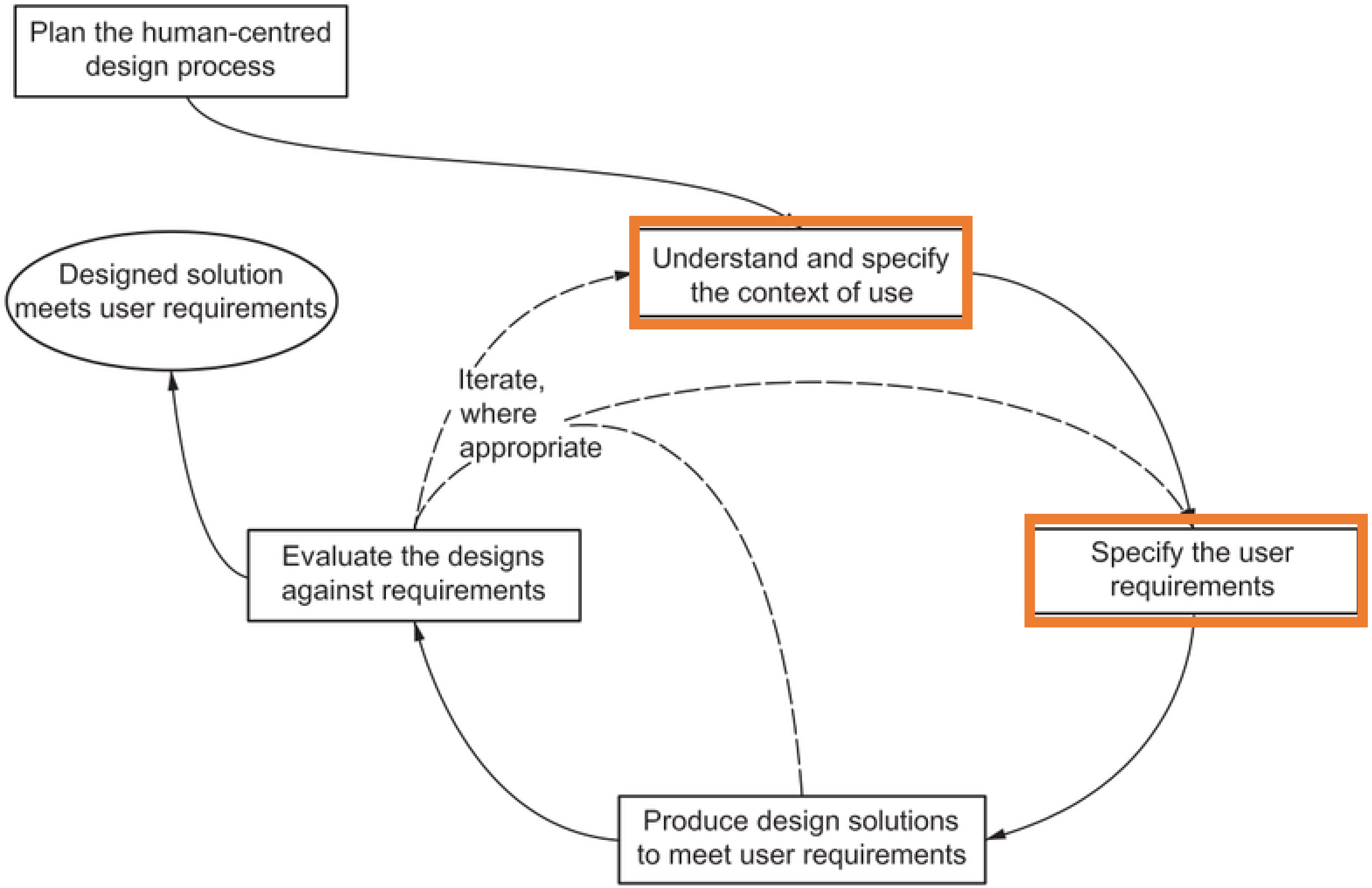
USABILITY: PROCESS



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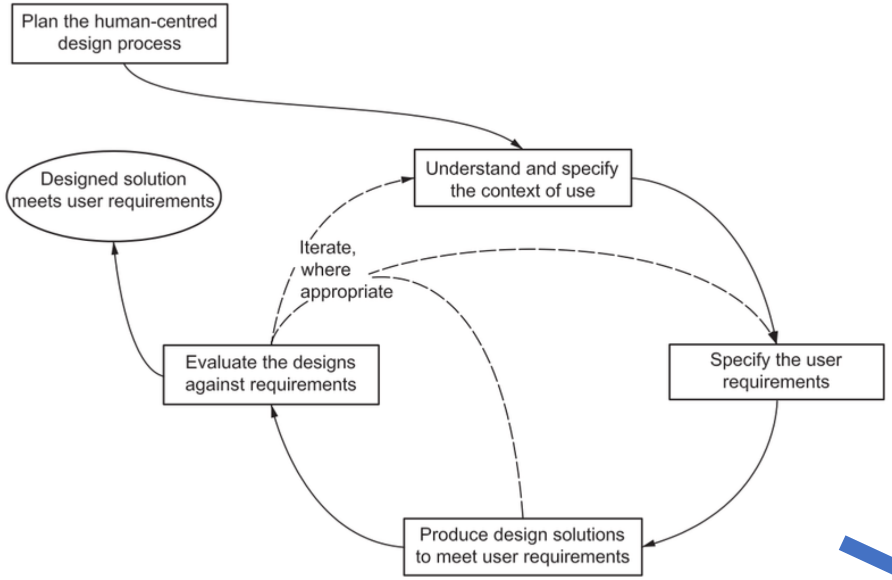
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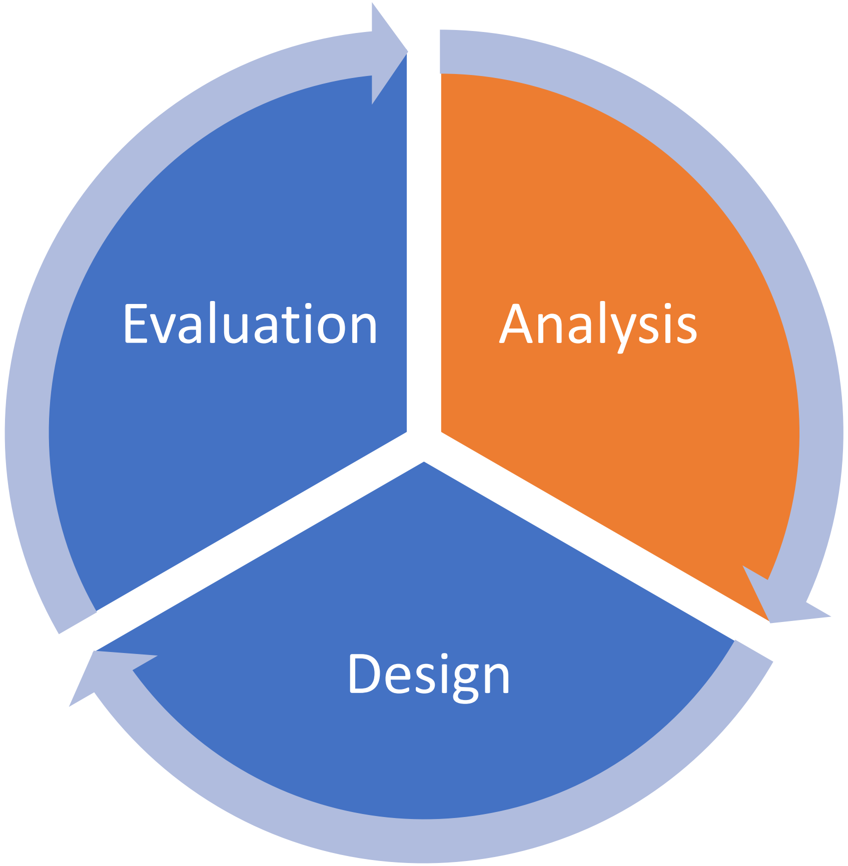

Evaluation
Analysis
Design

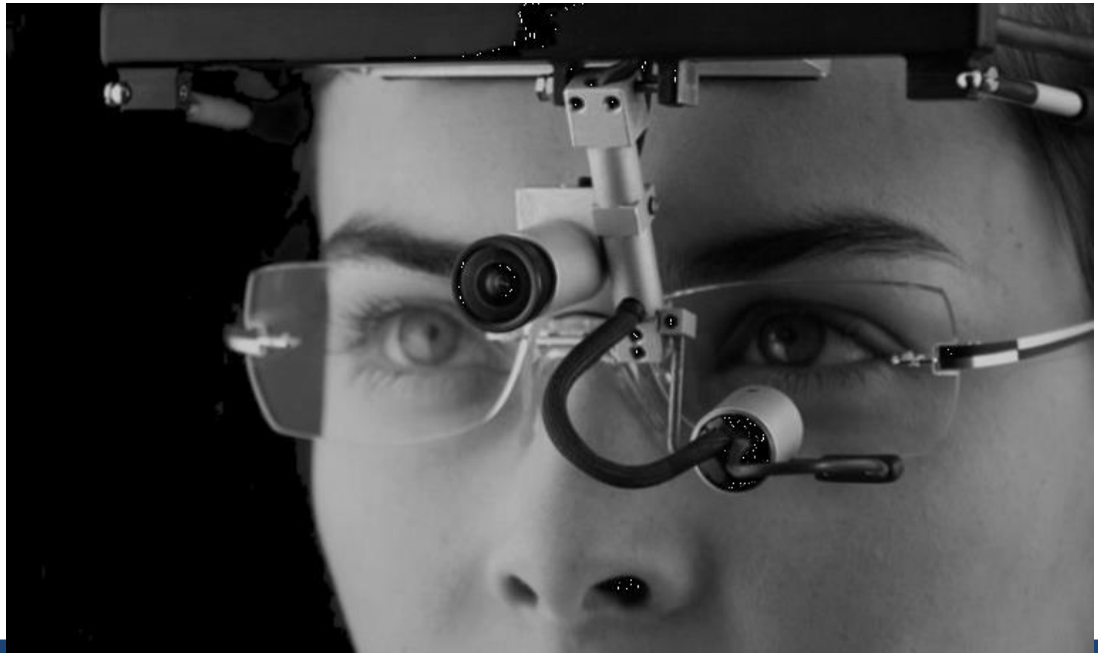
METHODS: ANALYSIS

Types of data **collection**:

- Survey: Interviews, focus groups
- Observation: Field studies, ethnography
- (e.g., Hierarchical) task analysis, contextual inquiry
- Laboratory experiments
- Critical incidents method
- Literature studies
- User research, market research

Types of **representation**:

- Personas & scenarios
- Quantitative user models (e.g., GOMS)



OBSERVATION

"when perception is determined by a deliberate, selective search attitude and is directed towards the **possibility of evaluating the observed** in terms of an overarching intention"

Graumann, C.F. (1966). Grundzuge der Verhaltensbeobachtung. In E. Meyer (Hrsg.), Fernsehen in der Lehrerbildung (S. 86–107). München: Manz

SYSTEMATIC OBSERVATION VS. EVERYDAY OBSERVATION

- **What** is being observed?
- **Who** is observing?
- What is **irrelevant** for the observation?
- In what way can the observed behavior be **interpreted**?
- **When** and **where** does the observation take place?
- **How** is the observed behavior documented or recorded?

Bortz, J & Döring, N. (2006). Forschungsmethoden und Evaluation für Human-und Sozialwissenschaftler. Heidelberg: Springer.

OBSERVATION: SYSTEMATIZATION

"The **degree of systematization** of an observation depends on the research objective (finding hypotheses, testing hypotheses, or description) or the precision of prior knowledge about the subject under investigation. The more precisely one knows the object of observation in principle, the more systematic the observation should be designed."

OBSERVATION: TYPES

- Participatory – non-participatory
- Open - covert
- Apparative (instrumental)
- Automatic
- Multiple observers: Inter-rater agreement
- Self-observation

OBSERVATION: ADVANTAGES/DISADVANTAGES

🙂Compared to self-reports: not rationalized or **filtered**

🙂Compared to laboratory: no influence of the (possibly artificial) **experimental situation**

🙂Interpretable **facial expressions and gestures**

🙂Exploring the terrain: **gathering information**, generating hypotheses

🙁Compared to surveys: higher **effort**, reduced repeatability

CONTEXTUAL INQUIRY

- **Observation interview**: observation + questioning or follow-up questions
- Based on the master/apprentice model
- **User: Master** - Observer: Apprentice
- Literature recommendation (Chapter 3; accessible at http://wtf.tw/ref/holtzblatt.pdf): Holtzlatt, K. (2015). Contextual Design - Evolved. San Francisco: Morgan & Claypool.

Beyer, H. & Holtzblatt, K. (1998). Contextual Design: Defining Customer-Centered Systems. San Francisco, CA: Morgan Kaufmann Publishers.

CONTEXTUAL INQUIRY: PRINCIPLES

- **Context**: Collecting data at the location of the events; observing real and concrete occurrences.
- **Partnership**: The goal is to achieve a shared understanding of the work.
- **Interpretation**: Individual observations gain significance; to be verified by the user; deriving requirements.
- **Focus**: Pre-determining and directing interaction towards relevant aspects; considering nonverbal aspects.

CONTEXTUAL INQUIRY: GUIDING QUESTIONS

- Who primarily uses the system?
- What goals does the user have?
- What tasks does the user have?
- What aspects of the environment (interruptions, noise, etc.) need to be considered?
- What is the initial situation at the start of the task?
- What is the situation like at the end of the task?
- What individual steps does the user take?
- Are additional tools or aids used?
- How long does it take to complete the task?
- ...

CONTEXTUAL INQUIRY: PROCEDURE

- **Preparation**
    - Define goals
    - Select companies/locations
    - Select and recruit participants
    - Create a schedule
    - Choose and refine methods
    - Prepare materials
    - Coordinate approach with all stakeholders
    - Determine and prepare documentation procedures
    - Determine data analysis approach
- **Execution**
    - Arrive at the company, greet participants
    - Coordinate approach with all involved parties
    - Prepare all necessary items (e.g., recording equipment)
    - Observe and ask questions, remain neutral
    - Take notes throughout the visit
    - Conduct interviews if necessary
    - Express gratitude, say goodbye, possibly provide a gift
- **Post-processing & Evaluation**
    - Analyze and interpret data; discuss with team and users
    - Summarize key findings and document them
    - Communicate results to responsible parties and possibly all involved parties

CONTEXTUAL INQUIRY: PROS AND CONS

🙂 Can uncover tacit knowledge

🙂 Detailed information

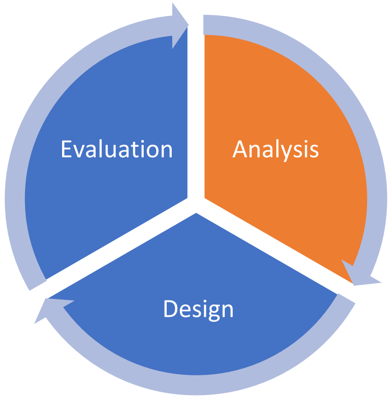
🙂 Reliable information: Less assumptions compared to questionnaires or tests

🙂 Flexibility

🙁 Difficult for statistical analysis

🙁 Requires time and personnel

EXERCISE: USABILITY ENGINEERING - ANALYSIS



Choose **one** of these options and gather requirements.

- Option 1: Design the user interface of an **alarm clock** (which can also be an app).
- Option 2: Design the user interface of an **answering machine** (which can also be an app).
- Option 3: Design the user interface of an app that allows you to track and assess the **fuel consumption of your car.**
- Option 4: **Any other app** with similar complexity

Human Factors and Human-Machine Interaction

Usability Engineering –Analysis and Design

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PERSONAS

A persona is a **specific user**

- Originally: Personas are based on **typical behavioral patterns**
- Personas are based on **empirically collected data** as much as possible
- Personas represent **user groups** and their **typical characteristics** (goals, roles, abilities, attitudes, environment)
- Personas have **goals**: "*if it has no goal, it is not a persona*" (Cooper)

Alan Cooper: Personas are “*fictitious, specific, concrete representations of target users*“

Jared Spool: “*Personas are model users that the team creates to help understand the goals, motivations, and behaviors of the people who will use the interface.*”

PERSONAS

- Personas are **not** user roles or user profiles or market segments.
- Personas can represent **relevant non-users**.
- A persona can represent a **desired target audience** that is not currently addressed by the existing product.

PERSONAS: GOALS

- "**Goals**" have multiple facets or **dimensions**.
- **Main goal**: The user should not feel stupid (Hassenzahl: need for competence).
- Hassenzahl's needs:
  - Competence
  - Autonomy
  - Relatedness
  - Stimulation
  - Security
  - Popularity

PERSONAS: ADVANTAGES

- **Specify** abstract information.
- Facilitate **shared understanding** of users.
- Create **empathy** with users.
- Facilitate **communication** among all **stakeholders** involved: developers, marketing, design.
- Serve as a template for **selecting users** for testing.

PERSONAS: ADVANTAGES

- Using personas avoids...
  - the **elastic user**
  - **self-referential** design
  - edge cases (=rare special cases)

- It **prevents** design *by* engineers/computer scientists *for* engineers/computer scientists.

PERSONAS: TYPES

- **Primary** Persona: Each interface addresses a primary persona.
- **Secondary** Persona: Minor additions to the primary persona.
- **Anti-Persona**: Should not be addressed.
- **Buyer** Persona.

PERSONAS: CREATION

- **Length**: One to two pages.
- Information about the **person**: Name, age, ...
- Definitely include a **photo**; possibly a **collage** of multiple photos in different situations.
- Use **fiction** only where necessary; keep it minimal.
- Do **not include solutions** in the description.

PERSONAS: STRUCTURAL ELEMENTS

- **Name, age, gender**
- Strong character traits
- **Image**
- Relevant quotes
- **Goals**
- Occupation, role, responsibilities, tasks
- Professional education, knowledge, and skills
- Behavioral patterns and approaches
- Needs, values, fears, desires, preferences
- General (computer/product) knowledge
- Knowledge about related products, previous systems, competing products

PERSONAS: EXAMPLES

Bridget DAY

AGE 26
OCCUPATION Marketing Director
STATUS Single
LOCATION New York, NY

TIER Enthusiast
ARCHETYPE The Marketer

Ambitious | Admired | Focused

"I would like to find and learn skills that would help me grow my business footsprint online."

MOTIVATIONS

- Incentive
- Fear
- Acheivement
- Growth
- Power
- Social

GOALS

- To grow a strong industry reputation
- To build her own Blog
- To expand and learn new skills

FRUSTRATIONS

- Slow download times
- Data crashes
- Poor communication

BIO

Bridget's business has been slowing lately and she could really use a set of skills that would help her undertsand evolution of her work.

ACTION

Read How To articles
Looking for expert analysis

PERSONALITY

Extrovert — Introvert
Sensing — Intuition
Thinking — Feeling
Judging — Perceiving

TECHNOLOGY

IT and Internet
Software
Mobile Apps
Social Networks

JLeclainche.wordpress.com

SCENARIOS

- Bring **personas** to life
- Based on the principle of **storytelling**
- In the context of personas, a scenario is a description of an **activity** in which the **persona** achieves one of their **goals** by using the **system** being developed.
- Scenarios are based on user **needs** and describe the **emotional state** of users during the **interaction**.

Alan Cooper: *“A scenario is a concise description of a persona using a software-based product to achieve a goal.”*

SCENARIOS: 3 TYPES

- At different stages in the **development process**
- **Context** scenarios:
    - Broad and shallow: A-Day-in-a-Life
    - High-level
    - Ideal interaction flow (WHAT before HOW)
    - Possible before the first design of an interface
    - How goals are addressed/achieved
    - "High-level interactions in a particular setting, used to envision the potential use of a product, focusing on a persona's needs, goals, and motivation."
- **Key-Path** scenarios
    - Details of the interaction
    - Introduction of the design vocabulary
- **Validation** scenarios
    - Different situations
    - What if...

CONTEXT SCENARIOS: ELEMENTS

Address the following questions:

- In what setting(s) will the product be used?
- Will it be used for extended amounts of time?
- Is the persona frequently interrupted?
- Are there multiple users on a single workstation or device?
- With what other products will it be used?
- What primary activities does the persona need to perform to meet her goals?
- What is the expected end result of using the product?
- How much complexity is permissible, based on persona skill and frequency of use?

Cf. Cooper (2014); copied from http://www.hci.otago.ac.nz/info410/Readings/Scenarios.pdf

(CONTEXT) SCENARIOS

- Described from the **user's perspective** (the **persona**) (but not in first-person narration)
- Include **social, emotional** context, **motivations**, etc.
- Document the current or future **usage context** in a narrative form
- **Reused** in the design process
- Can be **broad** or detailed; not exhaustive in terms of details

SCENARIOS: ELEMENTS

- Application **situation** with a **focused theme**
- **Persona** at the center of attention
- One or more **actors** with **goals**
- **Tools** and objects required
- **Sequence** of actions and events: problem state → obstacles → result
- Varying levels of **abstraction** and detail
- **Length**: no more than 1 page A4

SCENARIOS: STRENGTHS

- Proximity to the user and their **needs**
- Facilitated **communication** and communicability in the project
- Reduced **complexity** through concretization
- **Verifiability** and **flexible** adaptability: data-driven
- **Memorability**: scenario is stored as a whole; episodic memory

SCENARIOS: EXAMPLES

- Peter wants to drive to his friends' soccer game in the neighboring town. Since his tank is almost empty, he needs to stop at a gas station on the way.
- In the car, he first takes out his phone and checks where the cheapest gas station is located, then places his phone in the center console.
- Afterwards, he drives to the gas station and fills up his tank but not completely due to the high prices.
- Peter has to drive about 7 km on a country road to reach the next town. He knows the route like the back of his hand. His smartphone warns him with a beep and an additional display of a construction sign one kilometer before a construction site in a blind curve.
- Peter reduces his speed and approaches the spot cautiously.
- Upon arriving at the game, he takes his phone with him and checks his driving data (estimated fuel consumption, appropriate driving behavior) on his way to the edge of the playing field.
- Additionally, he marks the construction site on the highway to notify other drivers, so that his friends will also be informed about the construction site.

OVERVIEW

- Analysis
  - Observation
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- Design
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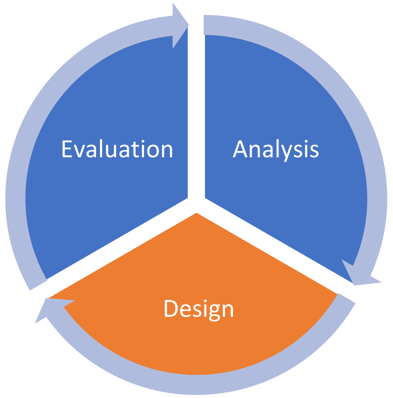
OVERVIEW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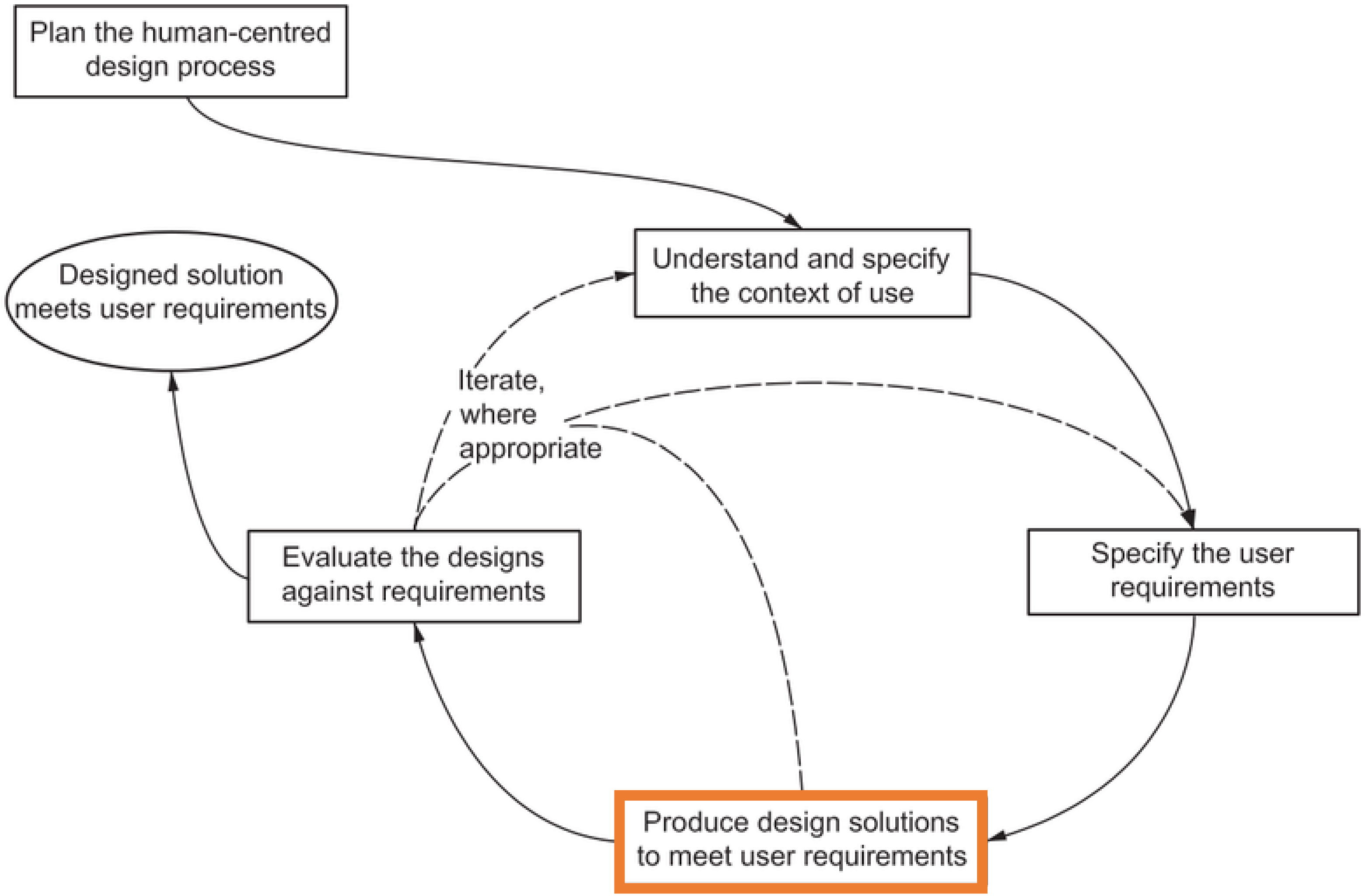
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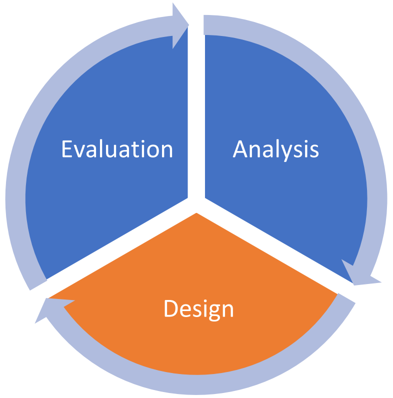
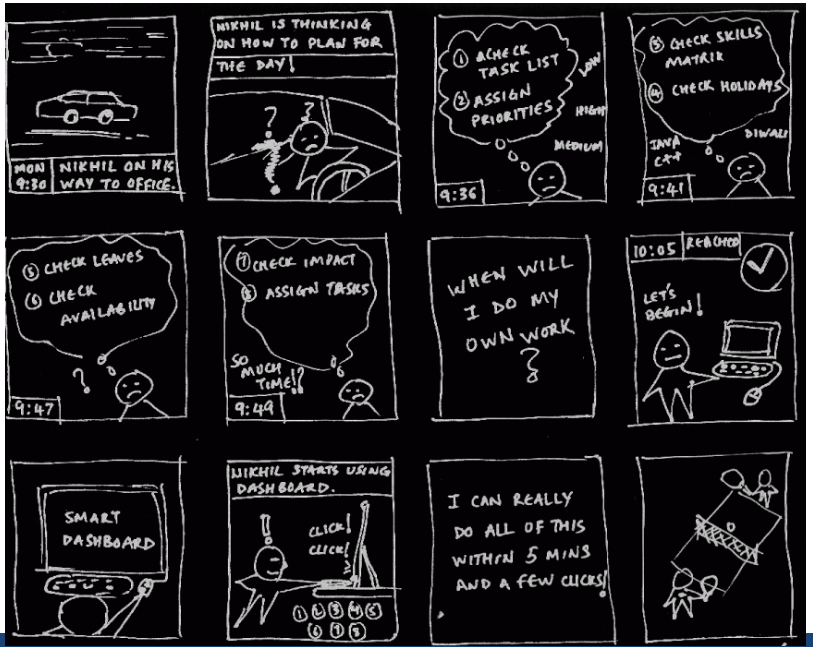
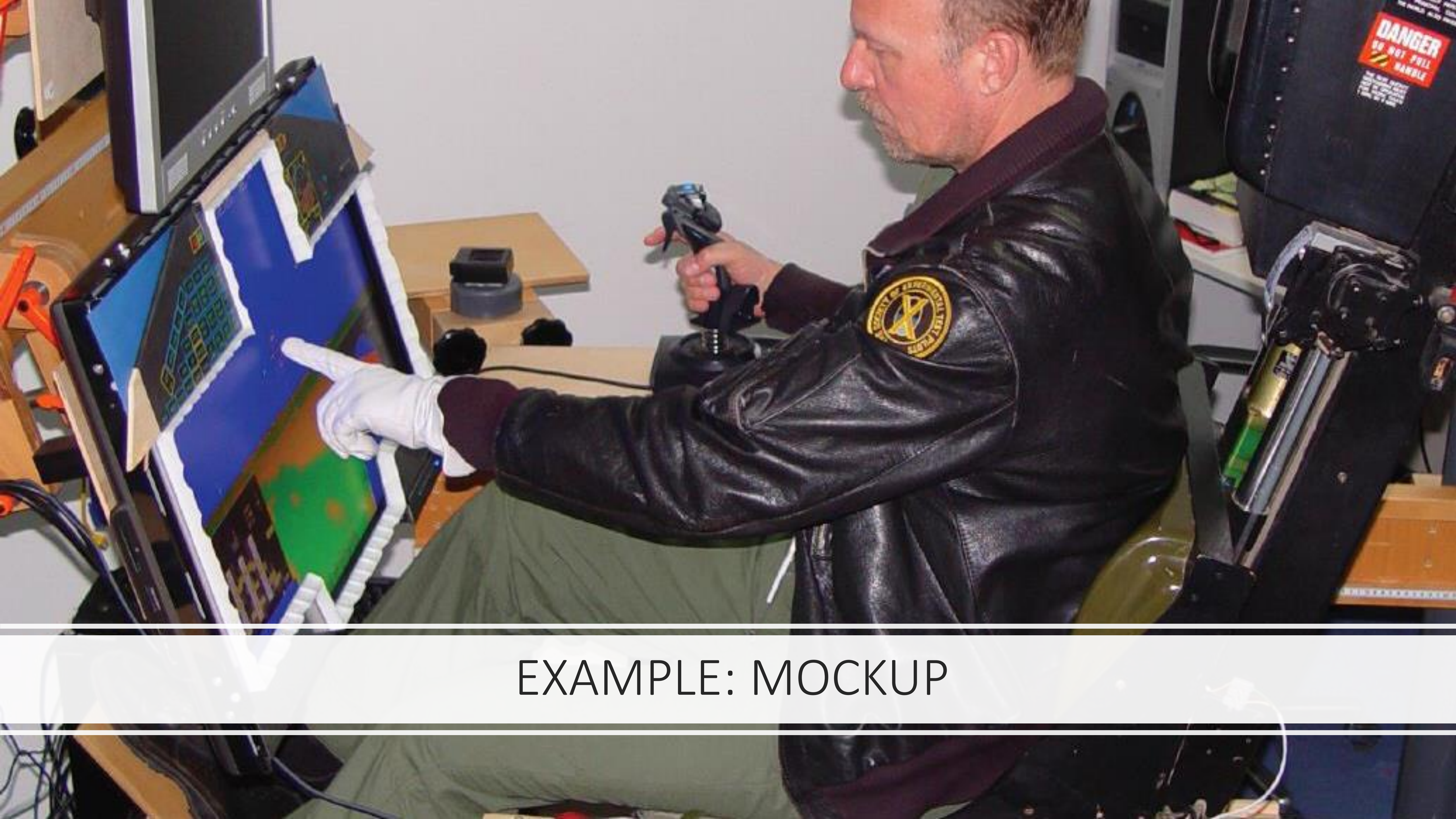


DESIGN METHODS

- **Drawings/Sketches**
- **Wireframes** (schematic representation, often of a single page template)
- **Storyboards** (sequential, visually illustrative representation; similar to comics)
- **Mockups** (often physical models or representations)
- **Prototypes**
  - Static
  - Animated/interactive
  - High fidelity
  - Vertical vs. horizontal





EXAMPLE: MOCKUP

DIALOGUE PRINCIPLES

1. Suitability for the user‵s tasks
2. Self-descriptiveness
3. Conformity with user expectations
4. Learnability
5. Controllability
6. Use error robustness
7. User engagement

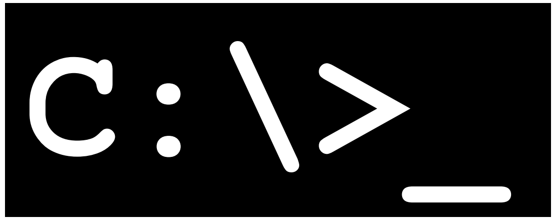
ISO 9241 Part 110 (2020)

SUITABILITY FOR THE USER‘S TASKS

An interactive system is suitable for the user’s tasks when it supports the users in the completion of their tasks, i.e. when the operating functions and the user-system interactions are based on the task characteristics (rather than the technology chosen to perform the task).

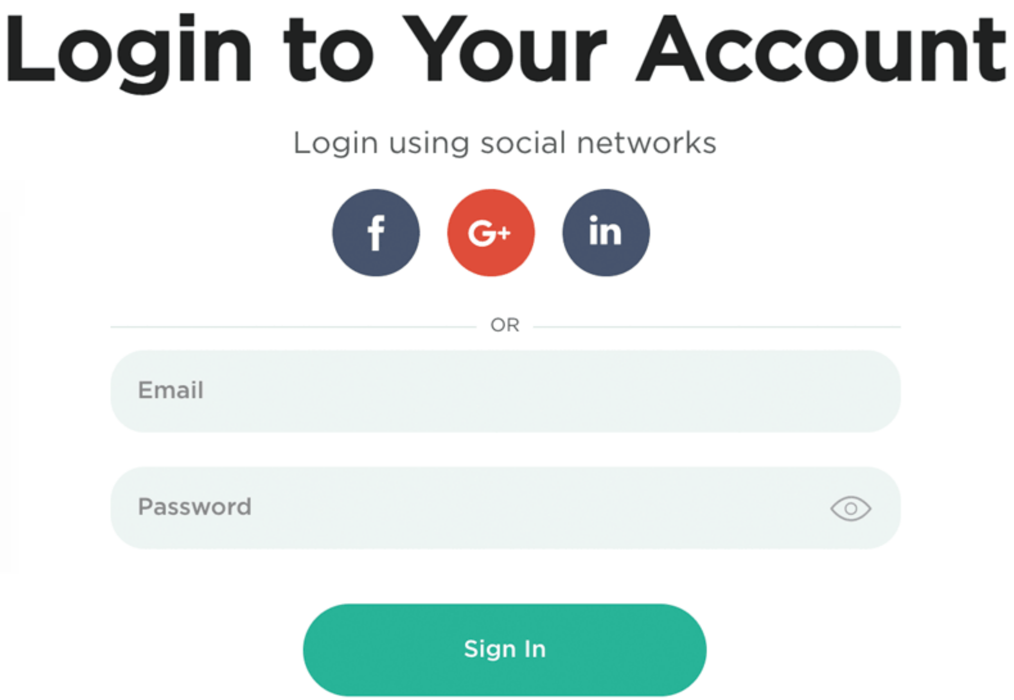
SELF-DESCRIPTIVENESS

The interactive system presents appropriate information, where needed by the user, to make its capabilities and use immediately obvious to the user without unnecessary user-system interactions.



CONFORMITY WITH USER EXPECTATIONS

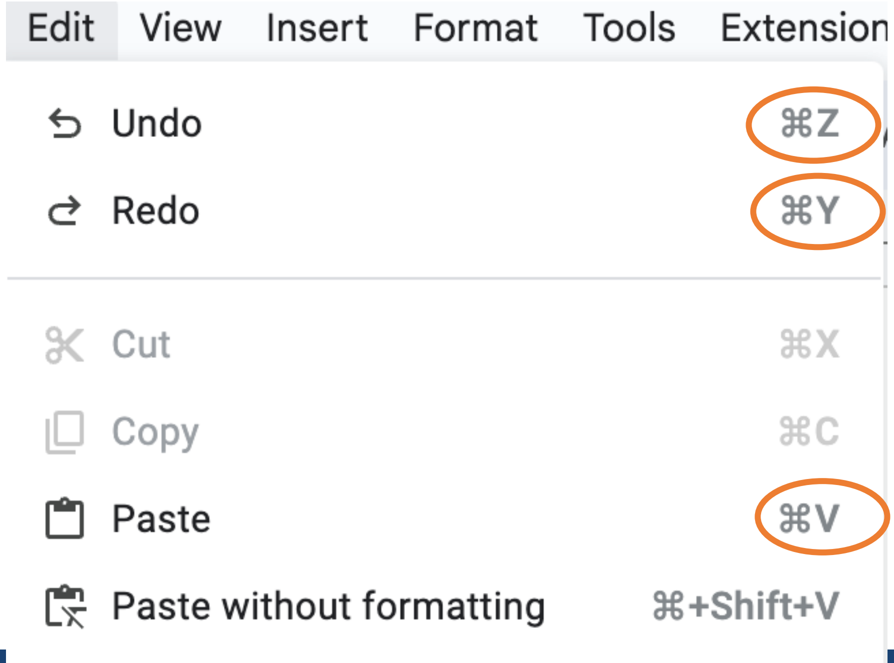
The interactive system's behavior is predictable based on the context of use and commonly accepted conventions in this context.



LEARNABILITY

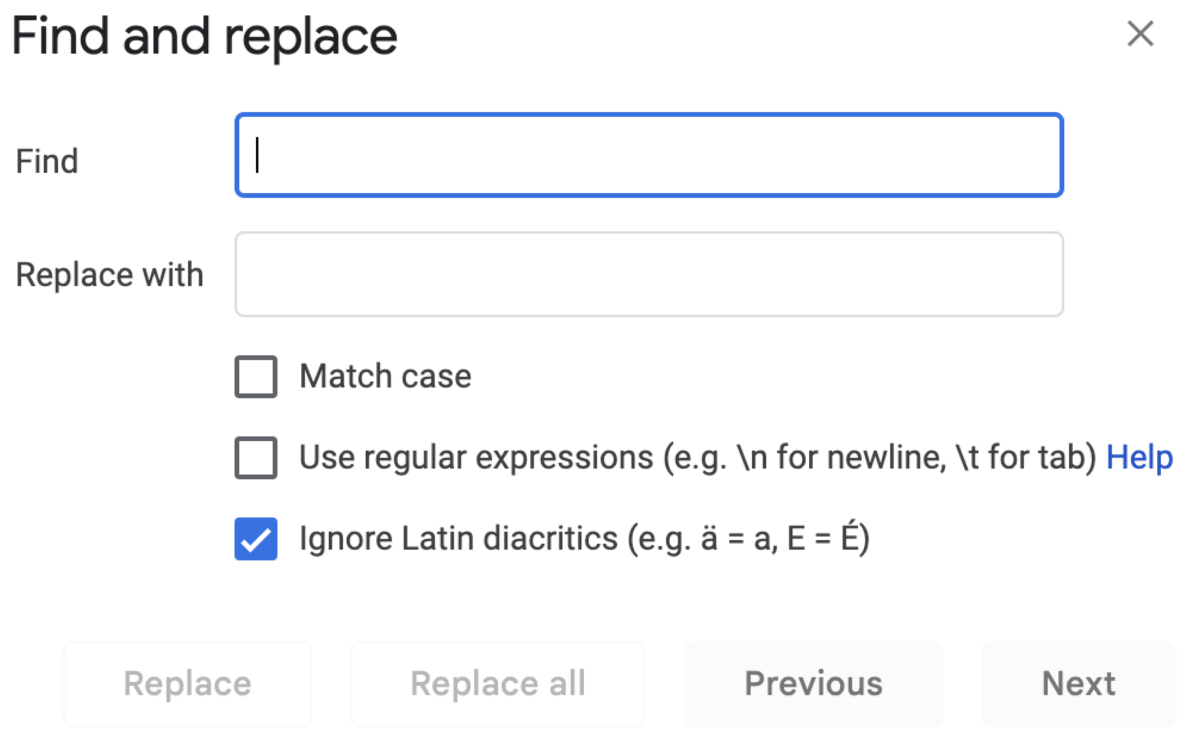
The interactive system supports discovery of its capabilities and how to use them, allows exploration of the interactive system, minimizes the need for learning and provides support when learning is needed.

Learnability involves guidance related to discovery of information and controls that users are looking for; exploration of information and controls that users have discovered; and retention of information about the system



CONTROLLABILTY

The interactive system allows the user to maintain control of the user interface and the interactions, including the speed and sequence and individualization of the user-system interaction.



USE ERROR ROBUSTNESS

The interactive system assists the user in avoiding errors and in case of identifiable errors treats them tolerantly and assists the user when recovering from errors. Use error robustness involves guidance related to use error avoidance; use error tolerance; use error recovery.

https://rstudio.github.io/shinyvalidate/reference/figures/demo.gif

USER ENGAGEMENT

The interactive system presents functions and information in an inviting and motivating manner supporting continued interaction with the system.

EXERCISE: USABILITY ENGINEERING – ANALYSIS & DESIGN

Following the exercise from last week:

1. Create Personas and Scenarios

2. Design an initial prototype. Choose a suitable method.

Human Factors and Human-Machine Interaction

Usability Engineering – Evaluation: Inspection

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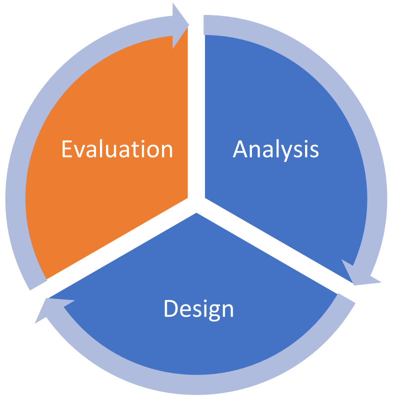
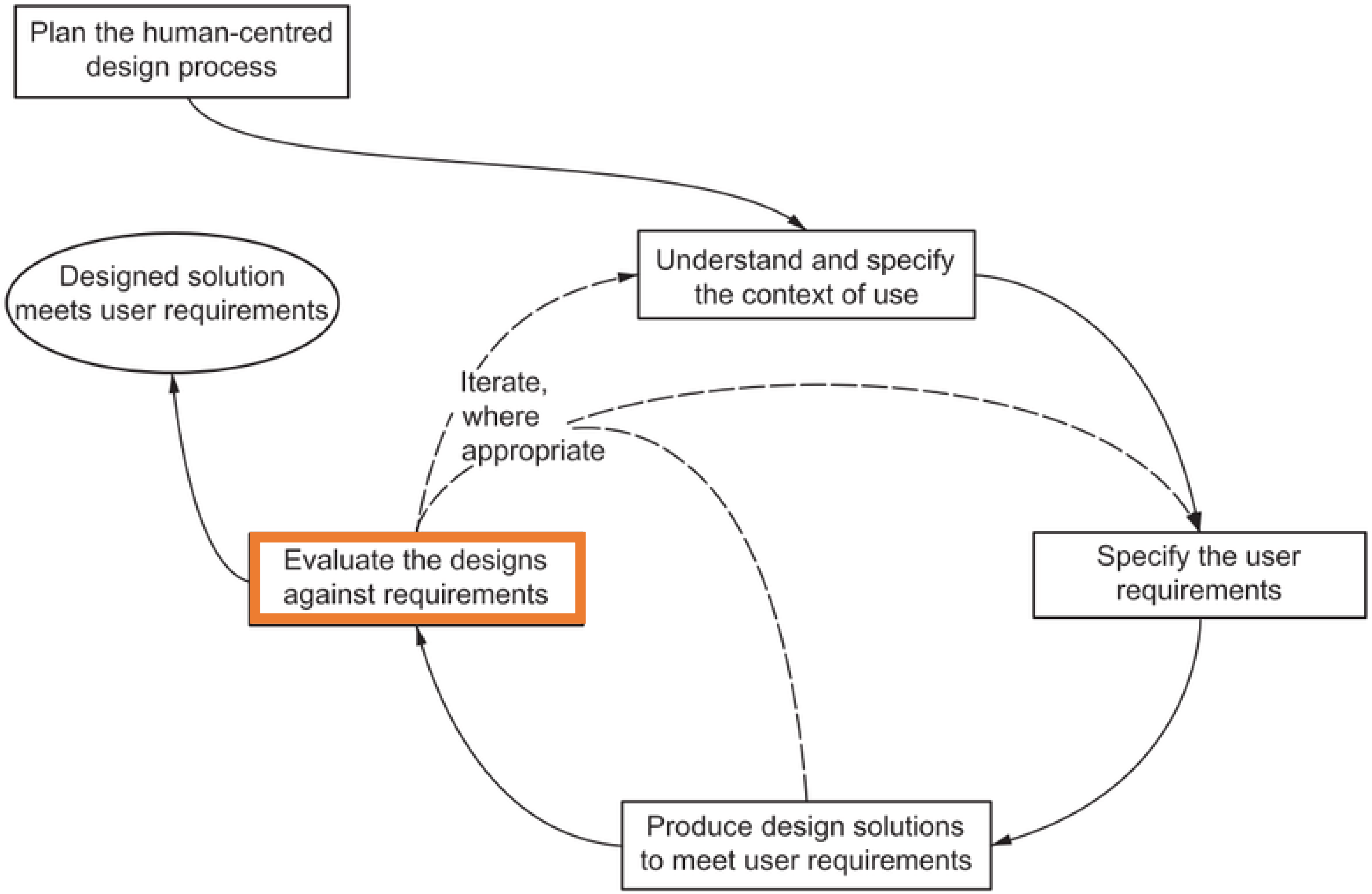
OF COMPUTER SCIENCE

USABILITY: PROCESS





USABILITY EVALUATION

- Reference point: User requirements
- Examination and evaluation of the system by users and/or experts
- System assessment: absolute judgment vs. system optimization: identification of strengths and weaknesses
- Types of evaluation:
  - Summative vs. formative
  - Comparative: Product A vs. B
  - Evaluative: Product A - Attribute x
  - Analytical: Product A - Problems
  - Empirical vs. analytical

UE: ANALYTICAL VS. EMPIRICAL

- Analytical:
  - **Model-based**: e.g., GOMS
  - Usability **Inspection** (UI): e.g., Heuristic Evaluation, Cognitive Walkthrough
- Empirical:
  - **Questionnaires**: e.g., SUS, PSSUQ, AttrakDiff
  - Usability **Tests**

MODEL-BASED: KLM

- Video about GOMS & KLM on YouTube: https://www.youtube.com/watch?v=Ocz1hV34flk
- KLM = Keystroke-level model
- GOMS variant
- Required times on average in experimental conditions:
  - K (Keystroke): Pressing a key: $\mathbf{t_k = 0.28s}$
  - P (Pointing): Pointing to a screen position: $\mathbf{t_P = 1.1s}$
  - H (Homing): Switching between keyboard and mouse: $\mathbf{t_H = 0.4s}$
  - M (Mental preparation): Mentally preparing for a subsequent operation: $\mathbf{t_M = 1.35s}$
  - R(t) (response time)

EXAMPLE KLM

Which of the methods M1 or M2 is faster?

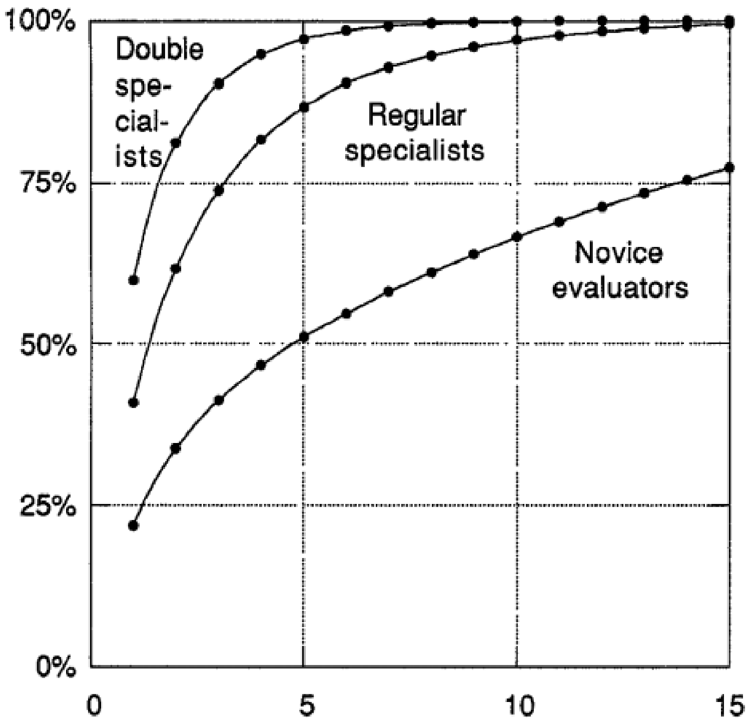
M1: *Switch to the mouse, move the mouse cursor to the file, click on the file, drag it to the trash can, and release it, switch to the keyboard.*

M2: *Switch to the mouse, select the file, switch to the keyboard, press the Delete key.*

$t_{M1} = t_H + t_P + t_K + t_P + t_H = 0.4 + 1.1 + 0.28 + 1.1 + 0.4 = 3.28s$

$t_{M2} = t_H + t_P + t_H + t_K = 0.4 + 1.1 + 0.4 + 0.28 = 2.18s$

UI: NUMBER OF EVALUATORS



- Nielsen and Molich (1990)
  - 1 usability specialist discovers 38% of usability problems
  - 10 lay evaluators: approximately 2/3
  - 5 double experts: > 95%
- $G = N (1 - (1 - p)^i)$
  - G: discovered usability problems
  - N: total number of usability problems
  - p: proportion of problems that an evaluator finds
  - i: number of evaluators
- Recommended number: about 3 to 10 evaluators

METHODS: EVALUATION

- **Discount Usability Inspection**: Heuristic Evaluation, Cognitive Walkthrough
- Questionnaires
- (DIY) Usability Tests
- Big Data: Automated Evaluation
- Context-oriented methods

- Classic Usability Tests
- User Modeling

USABILITY INSPECTION

Usability inspection is the generic name for a set of **methods** that are all **based on having evaluators inspect a user interface**. Typically, usability inspection is aimed at finding usability problems in the design, though some methods also address issues like the severity of the usability problems and the overall usability of an entire system. Many inspection methods lend themselves to the inspection of user interface specifications that have not necessarily been implemented yet, meaning that inspection can be performed early in the usability engineering lifecycle. (Nielsen, 1994)

https://www.nngroup.com/articles/summary-of-usability-inspection-methods/

HEURISTIC EVALUATION

- **Evaluators** review usability-relevant aspects of a product
- **Goal**: Identification of **problems**; not necessarily generating solution proposals
- **Problem**: Characteristics of a product that could affect the efficiency or effectiveness of interaction or user satisfaction (cf. definition)
- Located in the realm of **Discount Usability Engineering**
- Usability **experts** find more problems than laypeople
- **Double experts**: Usability experts with domain knowledge achieve the highest rate

HE: PROCESS

- Description of the **target audience**.
- Creation of one or more **usage scenarios** (e.g., tasks; see Key-Path scenarios).
- Embedding in a **context scenario with persona**.
- Selection and determination of the **heuristics**.
- Each expert conducts the **evaluation** individually and documents usability issues.
- Classification and **prioritization** of usability problems (e.g., "catastrophic," "major problem," "minor problem," and "cosmetic problem").
- Compilation of a problem list/**report** (organized by heuristics/problem categories or functional groups or information processing model, etc.).

HE PROCESS: SEVERITY RATINGS

Problem evaluation along three dimensions:

- **Problem Frequency**: Does the problem occur in many or few interaction situations?
- **Problem Impact**: To what extent does it affect task performance?
- **Persistence**: Is the problem easily avoidable once it is known?

Nielsen (1994) suggests the following **scale**:

0. I don't agree that this is a usability problem at all.

1. Only a **cosmetic issue** - doesn't need to be addressed unless additional time is available.

2. **Minor usability problem** - fixing it has low priority.

3. **Major usability problem** - should be fixed with high priority.

4. **Usability catastrophe** - must be fixed before product launch.

HE: CLASSIC HEURISTICS

1. Visibility of system status

The system should always inform the user about what is happening, providing appropriate **feedback** within a reasonable time frame.

2. Match between system and the real world

The system should speak **the user's language**, using words, phrases, and concepts that are familiar to the user, rather than system-oriented terms. Follow real-world conventions so that information appears in a natural and logical order.

3. User control and freedom

Users often choose software functions accidentally. They need a clearly marked "**emergency exit**" to be able to leave an unintended state without having to go through an extensive dialogue. Support **undo** and **redo** actions.

HE: CLASSIC HEURISTICS

4. Consistency and standards

Users should not have to think about whether different terms, situations, or actions mean the same thing. Follow platform conventions.

5. Error prevention

Better than good error messages is a careful design that prevents problems from occurring in the first place.

6. Recognition rather than recall

Make objects, actions, and options visible. The user should not be forced to memorize information from one part of the dialogue to another. Instructions for system usage should be visible or easily retrievable whenever appropriate.

7. Flexibility and efficiency of use

Shortcuts that are not visible to the novice user can speed up interaction for experienced users, making the system suitable for both beginners and experts. Allow users to customize frequent actions to their needs.

HE: CLASSIC HEURISTICS

8. Aesthetic and minimalist design

Dialogues should not contain information that is irrelevant or rarely needed. Every extra piece of information in a dialogue competes with relevant information and reduces its relative visibility.

9. Support for error recognition, understanding, and recovery

Error messages should be presented in **plain language** (no codes). They should accurately describe the problem and provide constructive suggestions for resolving it.

10. Help and documentation

While it is preferable for the system to be usable without documentation, it may be necessary to provide help and information. Any such information should be easy to search, focus on the user's tasks, and provide concrete steps for execution. The documentation should not be overly extensive.

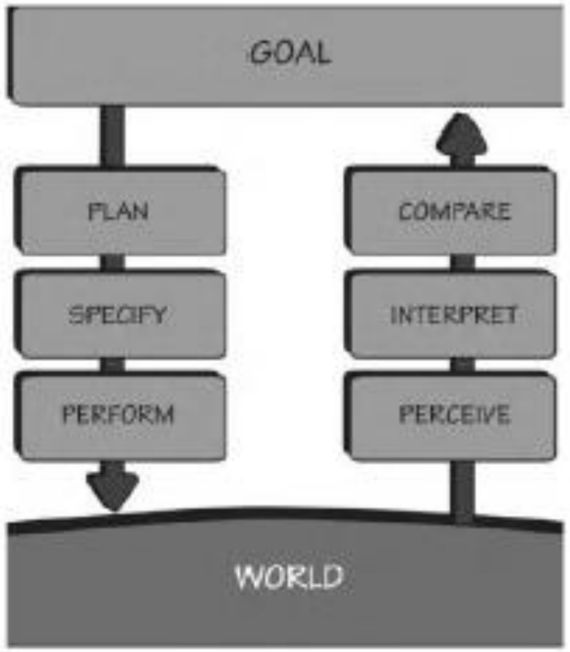
HE: ALTERNATIVE HEURISTICS

- Deriving heuristics from Don Norman's concepts - design of everyday things: Affordances, Signifiers, Constraints, Mappings, Feedback
  → **Design principles**

- **Seven Stages of Action**

- Deriving heuristics from the stages of visual perception, particularly the Gestalt principles.

- Deriving heuristics from the model of selective attention SEEV (Selective Encoding, Effortful Engagement of Attention, Voluntary Disengagement) by Wickens.



HE: ADVANTAGES

- No **user** required
- **Cost-effective**
- Relatively easy to **learn** - low implementation barriers
- Minimal **planning** and preparation effort
- Can be used early in the **development process**
- Well suited for **agile** methods and processes

HE: DISADVANTAGES

- **Poorly scalable** for complex interfaces
- **No solution proposals**

- Identification of relatively **minor problems** (controversial)
- Identifies **fewer problems** than usability tests (controversial)
- **False alarms** (controversial)

HE ON YOUTUBE

https://www.youtube.com/watch?v=J09MeSfOTJE

COGNITIVE WALKTHROUGH

- **Expert** method
- (User) target group: rather **inexperienced** users
- Starting point: **correct action sequences** (key-path scenarios)
- Provides **reasons** for problems
- Takes into account the **user's mental processes**
- Problem areas:
  - Mismatch between developer's and user's **concepts** (cf. Don Norman, DoET: Consistency of conceptual models)
  - Naming of **controls/elements**
  - **Feedback**

CW: PROCESS

The execution of the Cognitive Walkthrough can be divided into the following **steps**:

1. Definition of the **input**
2. **Examination** of the action sequences for each task
3. **Logging** critical information
4. **Revision** of the interface

CW-1: INPUT

- Description of **user characteristics**
- Selection of sample tasks (**scenarios**)
- Detailed **action sequences**
- Description or implementation of the **interface**

CW-2: ACTION SEQUENCES

Guiding Questions

- Will the user recognize that the correct action is available? ("*Perception*")
- Will the user attempt to achieve the desired effect? ("*Mental model*")
- Will the user establish a connection between the correct action and the desired effect? ("*Understanding*")
- If the correct action has been performed, will the user recognize the progress? ("*Feedback*")

CW-3: DOCUMENTATION

- **Information** and knowledge **required** for specific actions
- Potentially **error-prone actions**
- **Reasons** for potential errors
- No **design alternatives**

CW-4: REVISION

- The user does not attempt to achieve **the desired effect**:
  - Eliminate the action by having the system perform it automatically or combining it with another action.
  - Direct the user to the correct action to be performed.
  - Modify the interface to make it clearer why the action should be performed.
- The user does not **recognize** that the correct action is available:
  - Assign the action to a more obvious control element.
- The user fails to establish a **connection** between the correct action and the desired effect:
  - Modify the design/labeling of the control elements.
- The user does not receive **feedback** on their action:
  - Provide feedback on what is happening and the result of the action.

CW, HE VS. USABILITY TESTS

Usability inspection

- Not a substitute for usability **tests**
- Applicable even for **simplest prototypes**
- Fewer **problems** compared to usability tests
- Less **effort** required

Heuristic Evaluation and Cognitive Walkthrough

- Different **perspective**: CW focuses on **user** characteristics, HE focuses on **interface** characteristics
- HE has a broader approach; CW focuses on key tasks → Combination

CW ON YOUTUBE

https://www.youtube.com/watch?v=QcBPSmDW-Dc

EXERCISE: USABILITY INSPECTION

Search for an app on your smartphone that you want to evaluate.

Try out Heuristic Evaluation and/or Cognitive Walkthrough.

DEGGENDORF INSTITUTE OF TECHNOLOGY

Human Factors and Human-Machine Interaction

Usability Engineering – Evaluation: Usability Tests

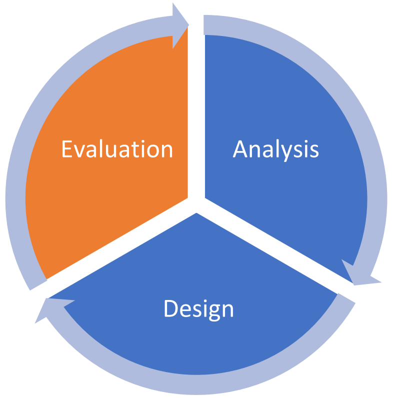
FACULTY

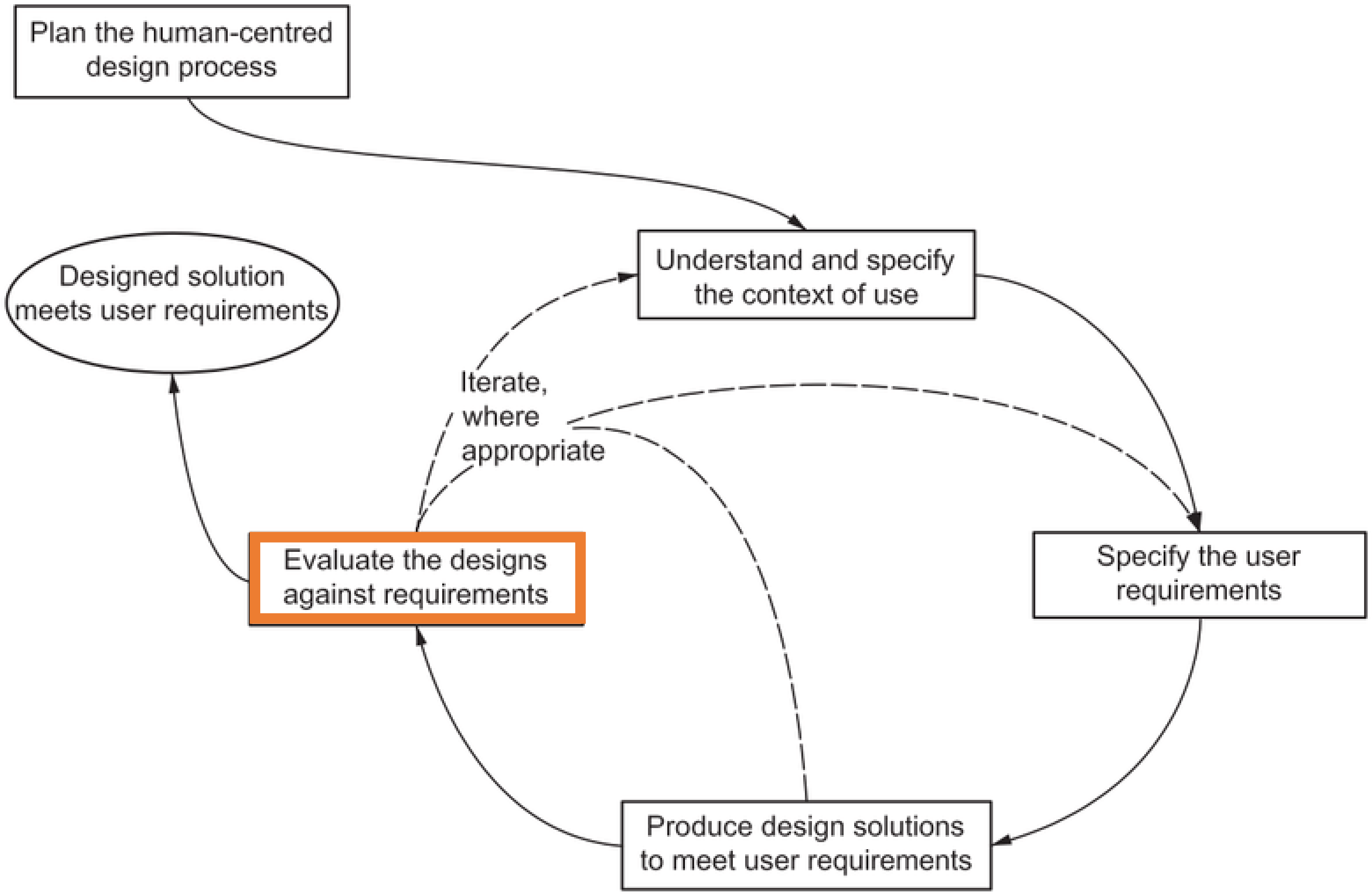
OF COMPUTER SCIENCE

OVERVIEW

- Motivation
- Demo Test
- Recommendations
- Literature

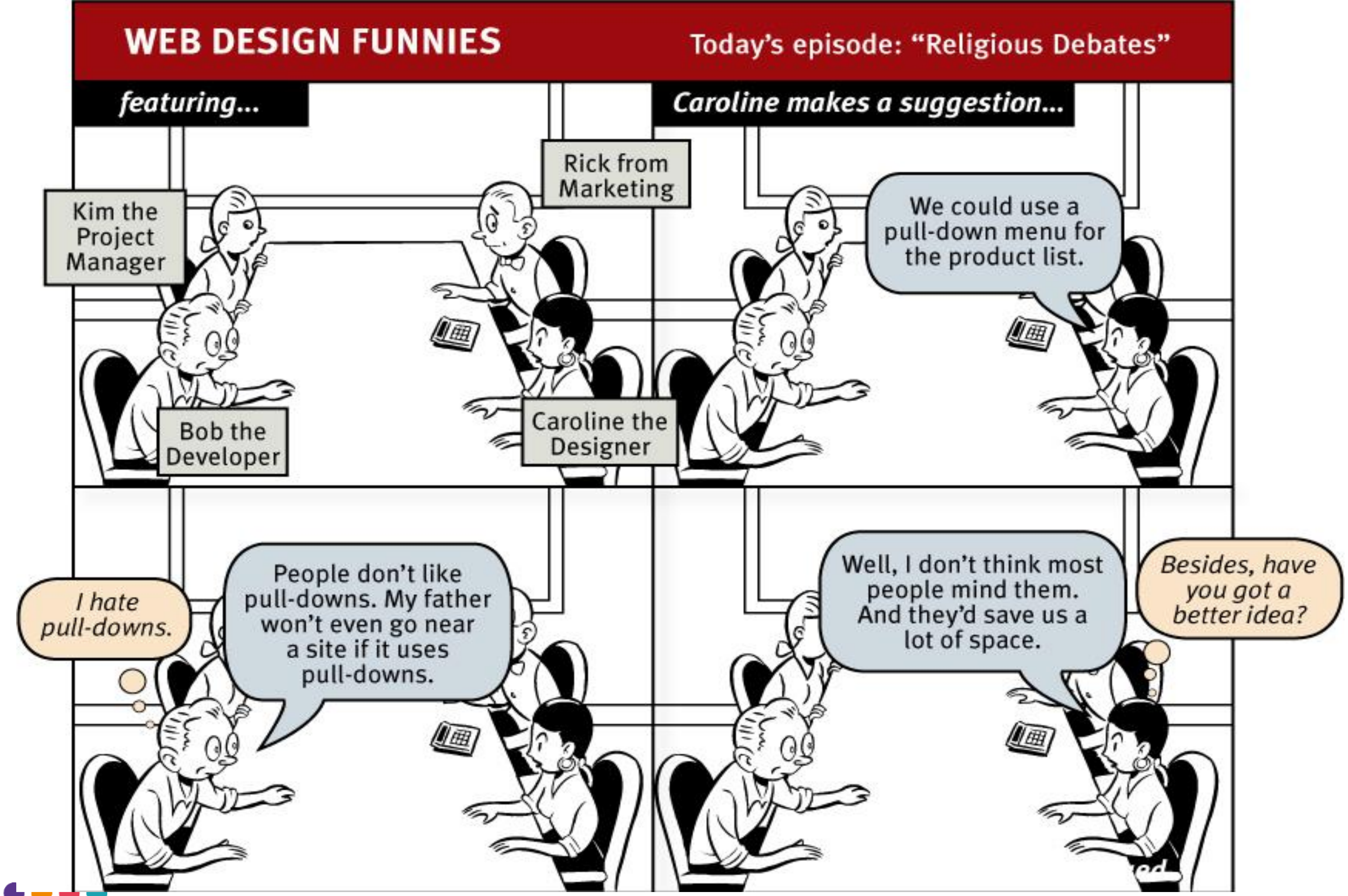
USABILITY: PROCESS





Steve Krug

Why Usability Testing?



https://www.oreilly.com/library/view/dont-make-me/9780133597271/ch08.xhtml

CEO

Developer

Designer

Business development

USABILITY TESTING: INTRO

- Not all people are the same - in fact, most are **different**
- **Focus groups** are not usability tests
- Better to have **one** test than none - Why? Because tests always work!
- Better to have a test at the **beginning** than 50 at the end

DEMO USABILITY TEST

https://www.youtube.com/watch?v=QckIzHC99Xc

USABILITY TESTING

- "Definition": *In a usability test, you observe a single user as they attempt to solve a typical task (either on a website, a prototype, or the designs of a new product) in order to identify and address issues that confuse or frustrate them.*
- <u>Qualitative</u> vs. quantitative
- Most severe problems are easy to find
- Usability tests provide insights into **why** users do certain things

USABILITY TESTING

- *A morning a month, that's all we ask* (Agile: every two weeks)

- *Start earlier than you think makes sense*
  - No need for a functional product
  - Napkin test

- *Recruit loosely and grade on a curve*
  - Representativeness is not crucial
  - Three per session

UT: TASKS → SCENARIOS

- Selecting tasks
  - Important!
  - Represent actual user goals
  - Quantity/length can vary (one to ten; max. 35 minutes)
- Developing (UT) scenarios:
  - Provide tasks with details and context, as necessary
  - From the perspective of a persona, as necessary
  - Use user vocabulary
  - Print: one scenario per A5 page
- Pilot test

UT: PHASES

- Introduction – 4 min
- Questions – 2 min
- "Home Page Tour" – 3 min
- Tasks & Scenarios – 35 min
- Tips:
  - If you don't know what the user is thinking, ask
  - Encourage participants to think aloud (Thinking Aloud)
  - Remain neutral
  - Participants should not be in a worse condition after the test than before

USABILITY TESTING: VARIANTS

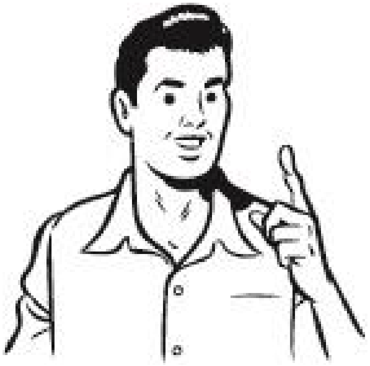
- **Classic**:
    - Usability lab with observation room
    - Many & representative participants
    - Cost: $20,000 - $50,000

- **Discount Usability Testing:**
    - No need for a lab
    - Fewer participants are sufficient
    - Cost: $5,000 - $10,000

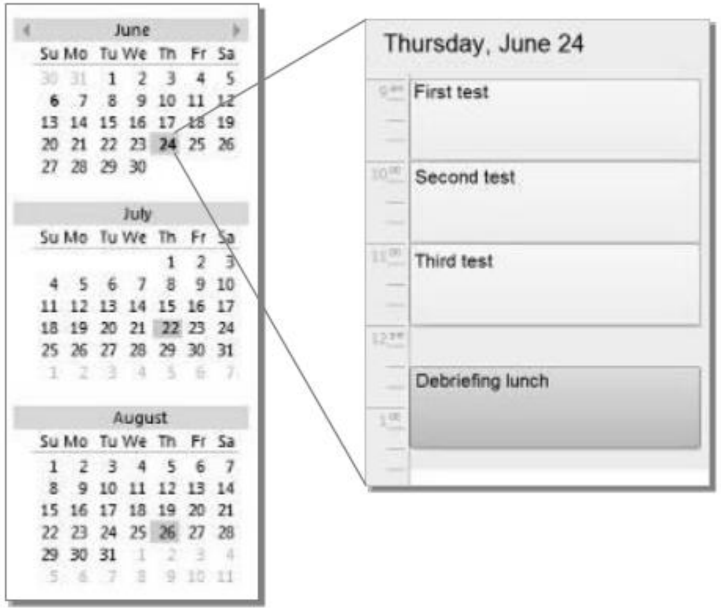
- Alternative: **Do-it-yourself UT**

UT.: CLASSIC VS. DIY

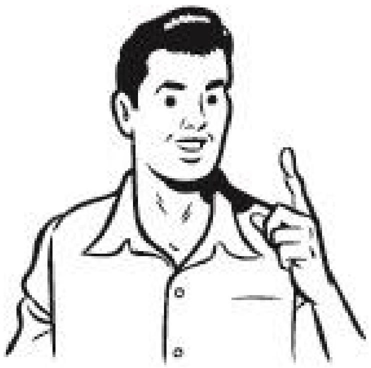
	Classic or Discount	DIY
Time Investment	1-2 days for testing, reporting, presentation, further planning	One morning per month with subsequent debriefing
When	Towards the end of development	Continuously
Iterations	One iteration per project	Once per month
Participants	Approx. eight	Three
Participant Selection	Target group	Relatively arbitrary
Where	Off-site, Usability Lab	On-Site
Observers	Few observers due to duration	Short duration → many observers
Reports	20-50 pages	Short email
Analysis	Experimenter	Development team plus stakeholders
Purpose	Identify as many problems as possible	Identify the most critical problems
Cost	$ 5 – 10.000	$ 100 - 300

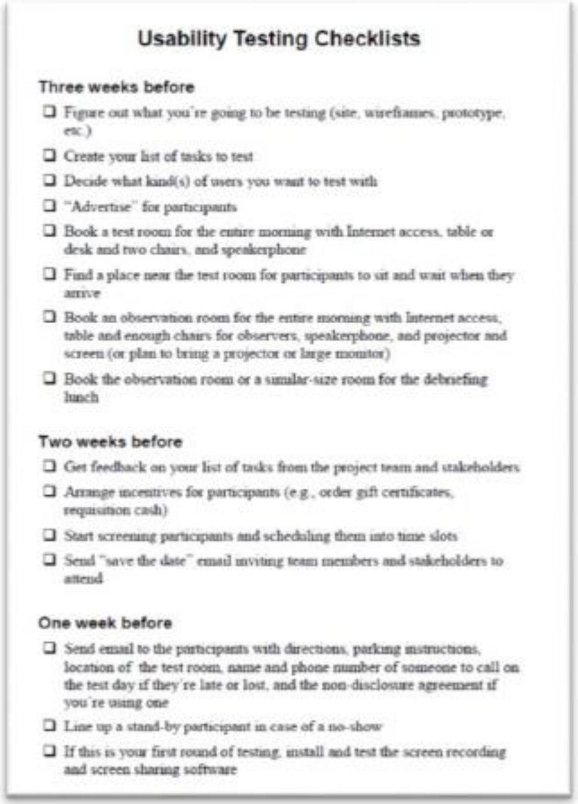


Half a day every month



Start earlier than you think is necessary





Usability Testing Checklists

Three weeks before

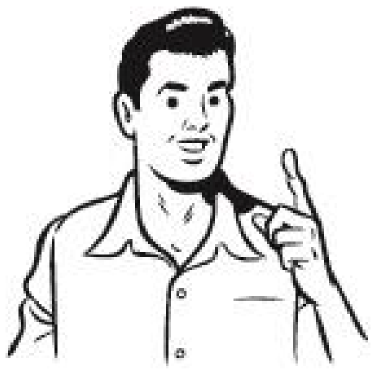
- ❑ Figure out what you're going to be testing (site, wireframes, prototype, etc.)
- ❑ Create your list of tasks to test
- ❑ Decide what kind(s) of users you want to test with
- ❑ "Advertise" for participants
- ❑ Book a test room for the entire morning with Internet access, table or desk and two chairs, and speakerphone
- ❑ Find a place near the test room for participants to sit and wait when they arrive
- ❑ Book an observation room for the entire morning with Internet access, table and enough chairs for observers, speakerphone, and projector and screen (or plan to bring a projector or large monitor)
- ❑ Book the observation room or a similar-size room for the debriefing lunch

Two weeks before

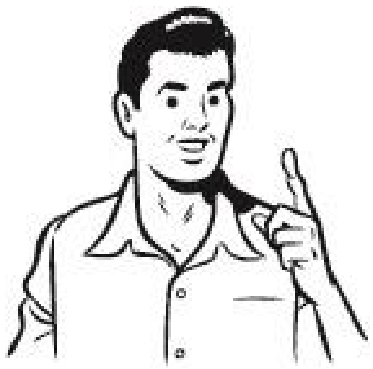
- ❑ Get feedback on your list of tasks from the project team and stakeholders
- ❑ Arrange incentives for participants (e.g., order gift certificates, requisition cash)
- ❑ Start screening participants and scheduling them into time slots
- ❑ Send "save the date" email inviting team members and stakeholders to attend

One week before

- ❑ Send email to the participants with directions, parking instructions, location of the test room, name and phone number of someone to call on the test day if they're late or lost, and the non-disclosure agreement if you're using one
- ❑ Line up a stand-by participant in case of a no-show
- ❑ If this is your first round of testing, install and test the screen recording and screen sharing software



Recruit loosely and grade on a curve.

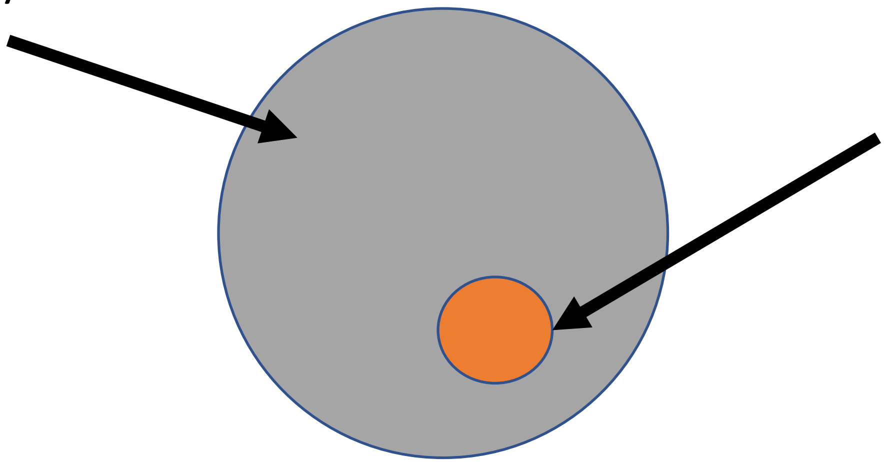


Make it a spectator sport.

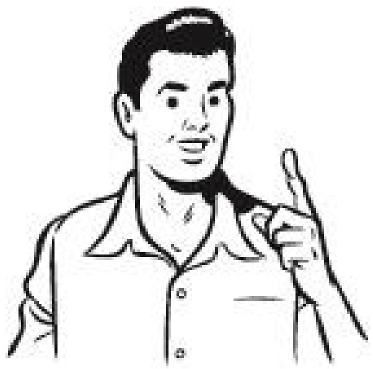
PROBLEM: IT WORKS!

- Usability testing **identifies many problems** in a short amount of time.
- You discover more problems per day than can be **fixed** in a month.

Problems that you identify with few participants.



Problems that you can address with your resources.



Focus on a small number of important problems.

Top Three Usability Problems

After each test session, list the three most serious usability problems you noticed.

Participant #1

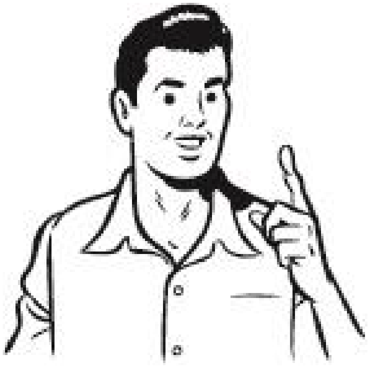
1. ....

2. ....

3. ....

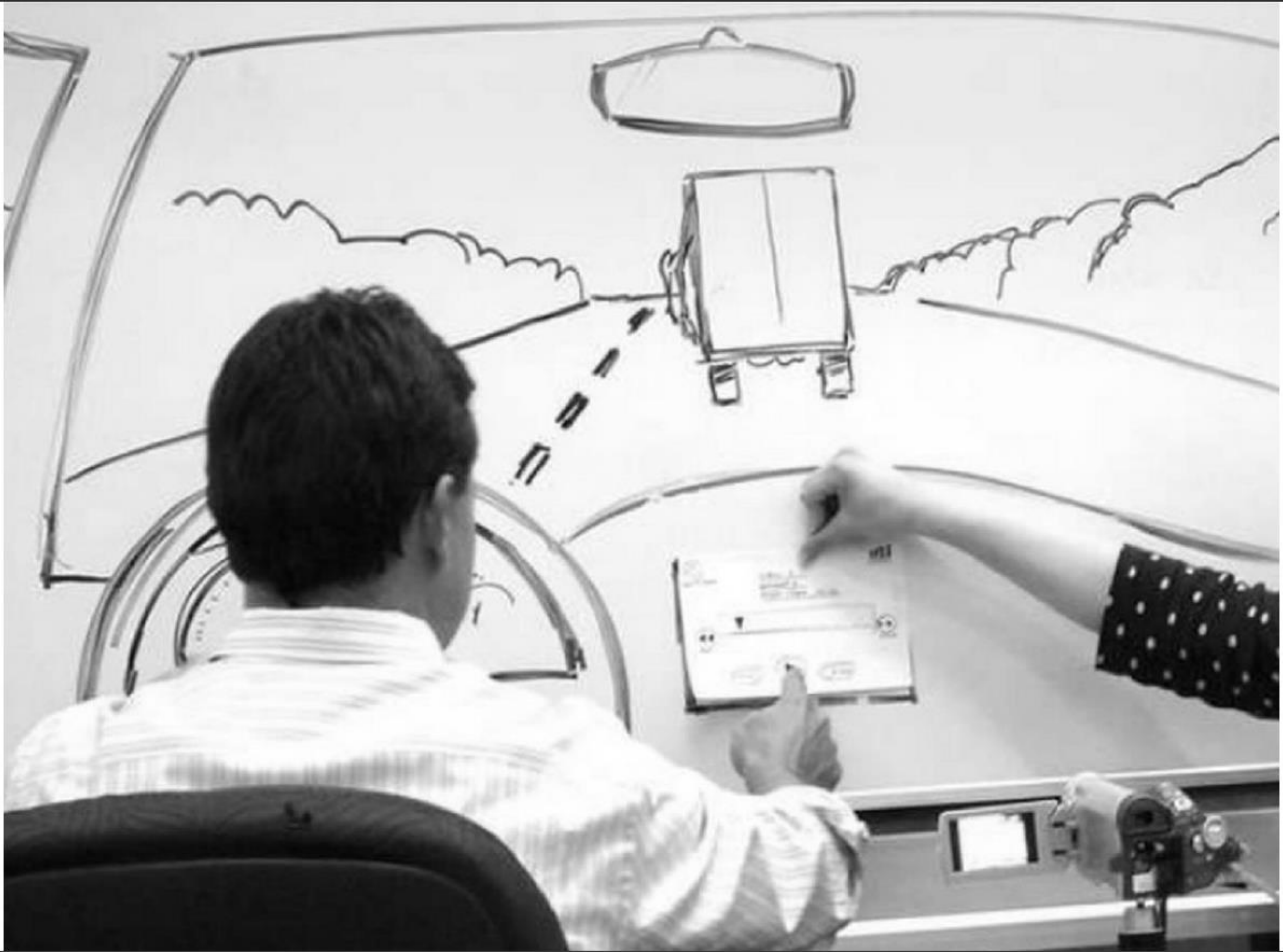
Participant #2

1. ....



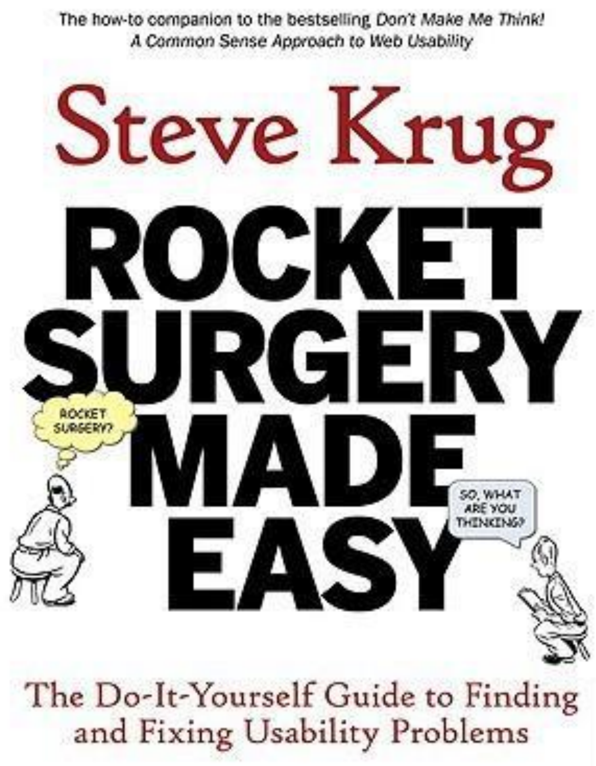
When fixing problems, do no more than necessary.

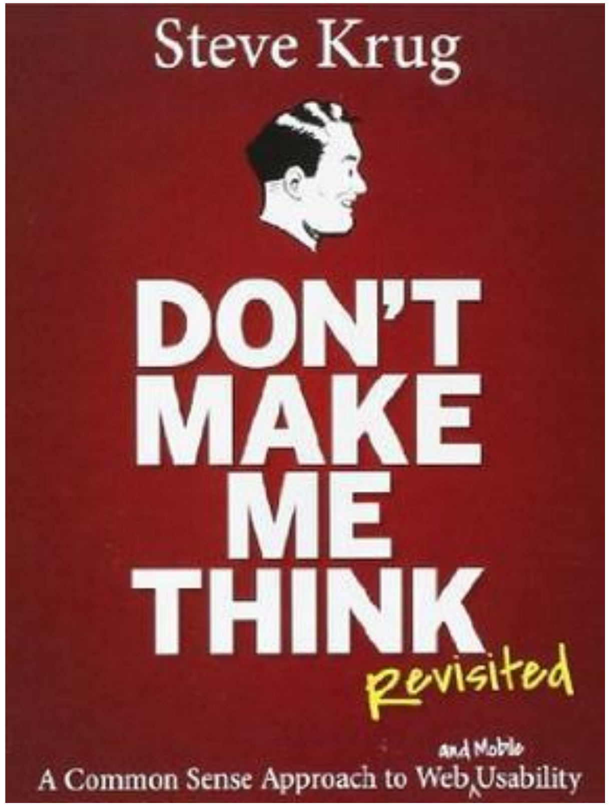
MOBILE USABILITY TESTING



THE TOP FIVE PLAUSIBLE EXCUSES FOR NOT TESTING

„We don‘t have the time“	Simplify testing as much as possible No additional to-dos for all involved Time savings through shortened discussions
„We don‘t have the money.“	Do-it-yourself tests are cost-effective, especially when participants are recruited on their own
„We don‘t have the expertise.“	Every test produces usable results. *It's not rocket surgery*
„We don‘t have a usability lab.“	We don't need it! - Room with desk, chairs, computer plus observation room with monitor
„We wouldn‘t know how to interpret the results.“	The most important lessons are obvious. The most serious problems are hard to overlook.


The how-to companion to the bestselling Don't Make Me Think! A Common Sense Approach to Web Usability
Steve Krug
ROCKET SURGERY MADE EASY
ROCKET SURGERY?
SO, WHAT ARE YOU THINKING?
The Do-It-Yourself Guide to Finding and Fixing Usability Problems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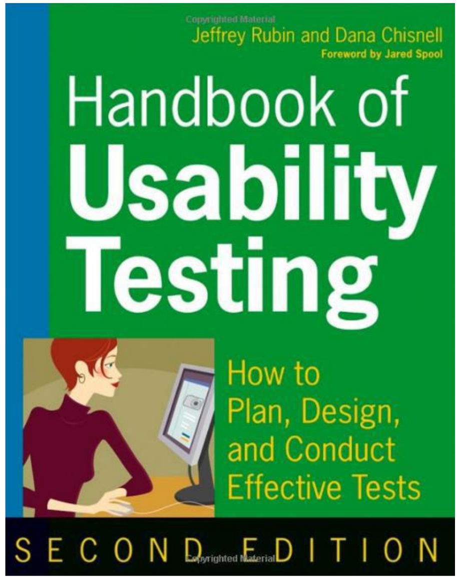
Jeffrey Rubin and Dana Chisnell
Foreword by Jared Spool
Handbook of Usability Testing
How to Plan, Design, and Conduct Effective Tests
SECOND EDITION

EXERCISE: USABILITY ENGINEERING

- Option 1: Design the user interface of an **alarm clock** (which can also be an app).
- Option 2: Design the user interface of an **answering machine** (which can also be an app).
- Option 3: Design the user interface of an app that allows you to track and assess the **fuel consumption of your car.**
- Option 4: **Any other app** with similar complexity

EXERCISE: USABILITY TESTS

1. Create plausible scenarios

2. Create a usability test plan an justify your decisions