Understanding Interaction Design in Visualization Systems: A Research-Paradigm Perspective

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About Myself

- Current position
  - Associate Professor at IST@Penn State
  - Research area: Human-Computer Interaction (HCI), Visual Analytics
    - Current projects
      - Design methods for gesture-based interaction
      - Visual analytics research paradigm
      - Visual analytics on MOOC data, data-mining algorithms, etc.
  - Teaching interests: Research methods, visual analytics, HCI foundations
- Education
  - Ph.D. in Information Science from University of Michigan
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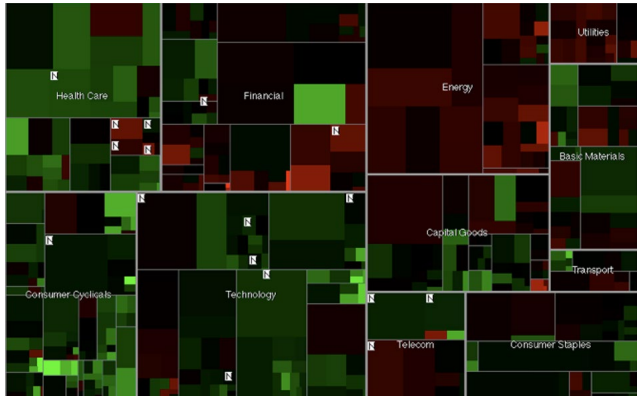
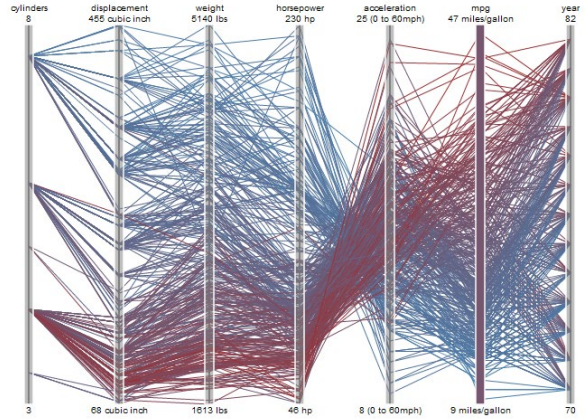
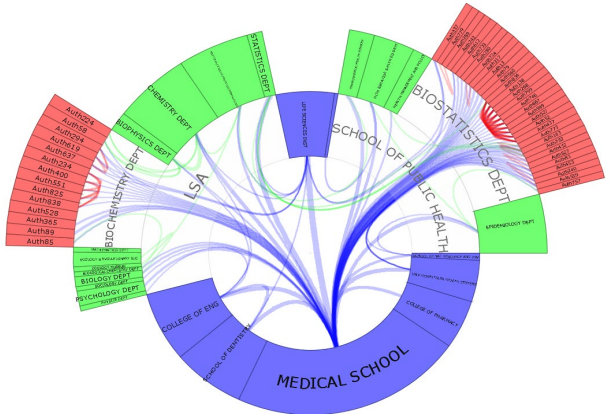
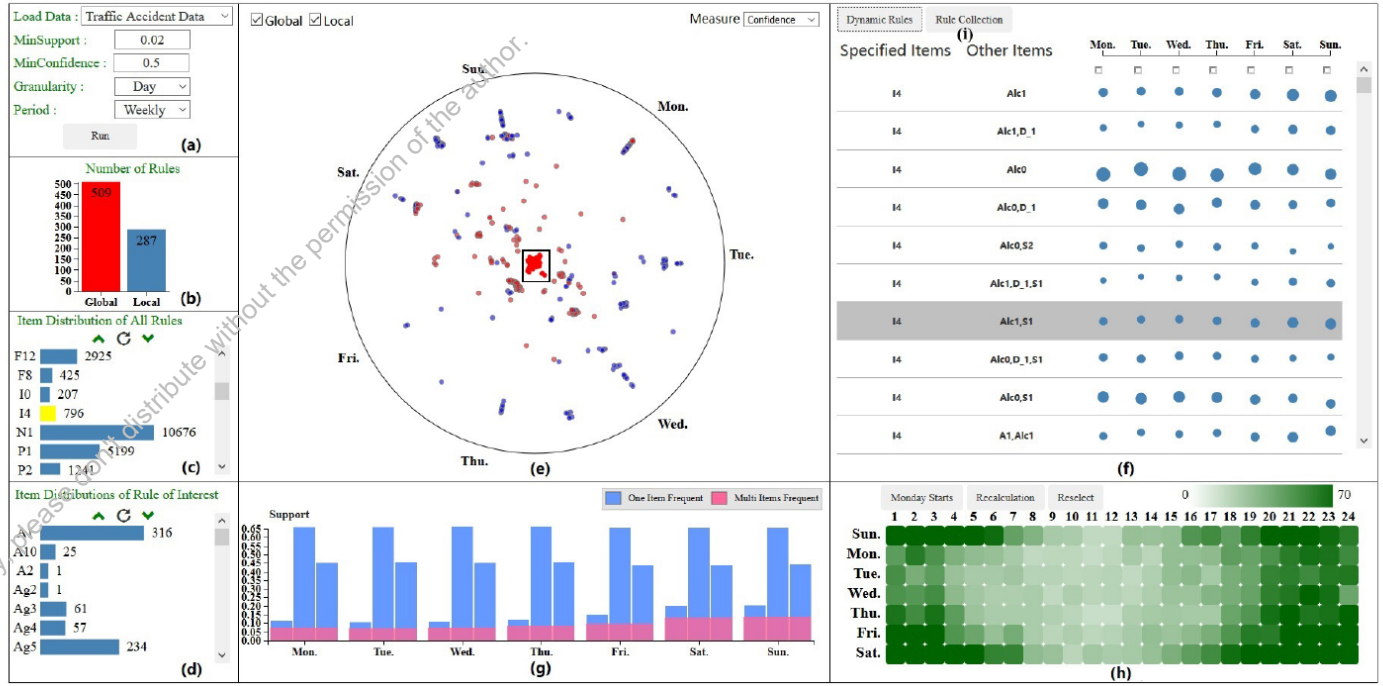
Visualization Systems vs. InfoGraphics



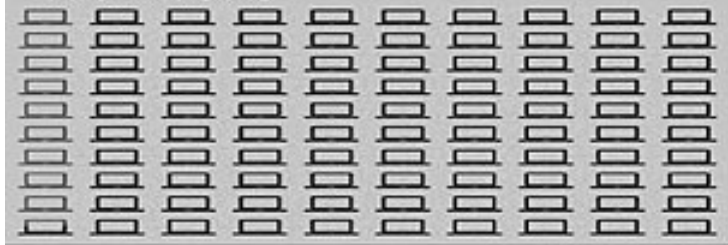






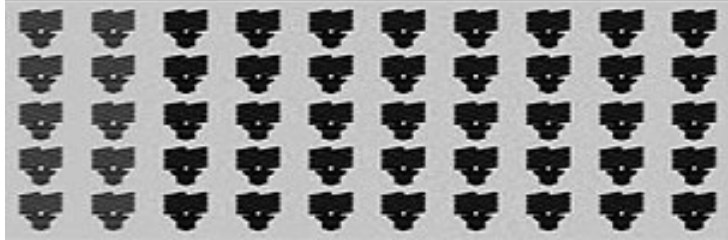
中国生产什么

中国的制造业增长或许放慢了，但仍生产大量东西。以下是中国制造多于别国的 10 样东西。



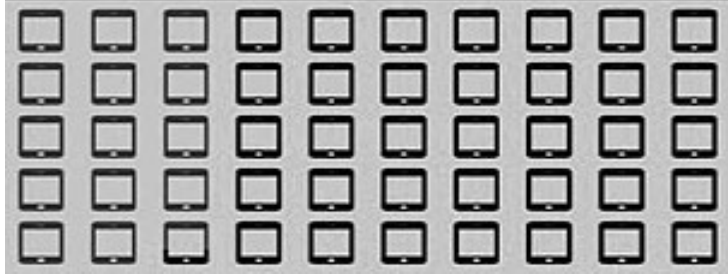
个人电脑 3.204 亿台，占 2011 年全球电脑产量的 90.6%。

空调 1.09 亿台，占 2011 年全球空调总产量的 80%。



节能灯 3.204 亿个，占 2011 年全球总产量的 80%。

太阳能产能 21.8 千兆瓦，占 2011 年全球太阳能产能的 74%。



手机 11 亿部，占 2011 年全球手机产量的 70.6%。

连环话第44期：

一张图看懂中国经济走势

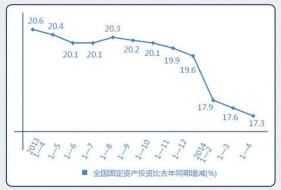
工业

工业增加值

工业增加值占GDP比重过半，是衡量GDP增速的最重要指标，4月规模以上工业增加值比3月回落了0.1个百分点，延续了数月以来的疲弱走势。

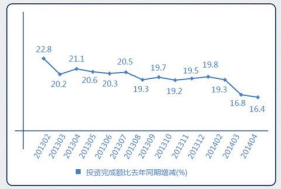
投资

全国固定资产投资



1-4月份，中国固定资产投资较上年同期增长17.3%，较1-3月份17.6%的同比增速放缓。这意味着稳增长政策见效偏慢，水利、铁路、棚户区改造等基建投资进展可能并不顺利。

房地产投资同比增长



房地产投资增速连续三个月下滑，土地购置面积和房屋新开工面积都在下降。很多房企的乐观情绪逐渐消退，对于未来的战略扩张开始持谨慎态度。

消费

社会消费品零售总额

4月社会零售品总额较上年同期增长11.9%，增速较3月的12.2%放缓，消费依然不景气。

全国商品房销售额

What Are Your Interpretations of Interaction Design?

- Interaction design is …

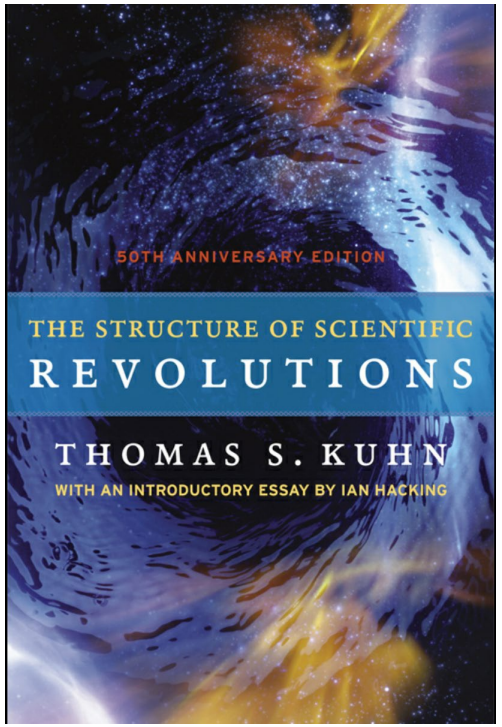
Are These Different Interpretations Related?

How?

A Research-Paradigm Perspective

- Basic idea
  - Using three major research paradigms in HCI as the foundation to (roughly) categorize interaction designs
    - Human-Factors
    - Cognitive revolution
    - Phenomenologically-situated
  - Offering a historic view of HCI and interaction design
  - Linking different design styles with their “appropriate” methods
    - E.g., how to gather design requirements, how to design, and how to evaluate a design
- My goal
  - You will be able to identify what kind of interaction design you are dealing with and what factors you should (not) focus on.
  - You will be able to identify (or use) appropriate methods in support of your design and more importantly know what advantages and disadvantages your methods have.

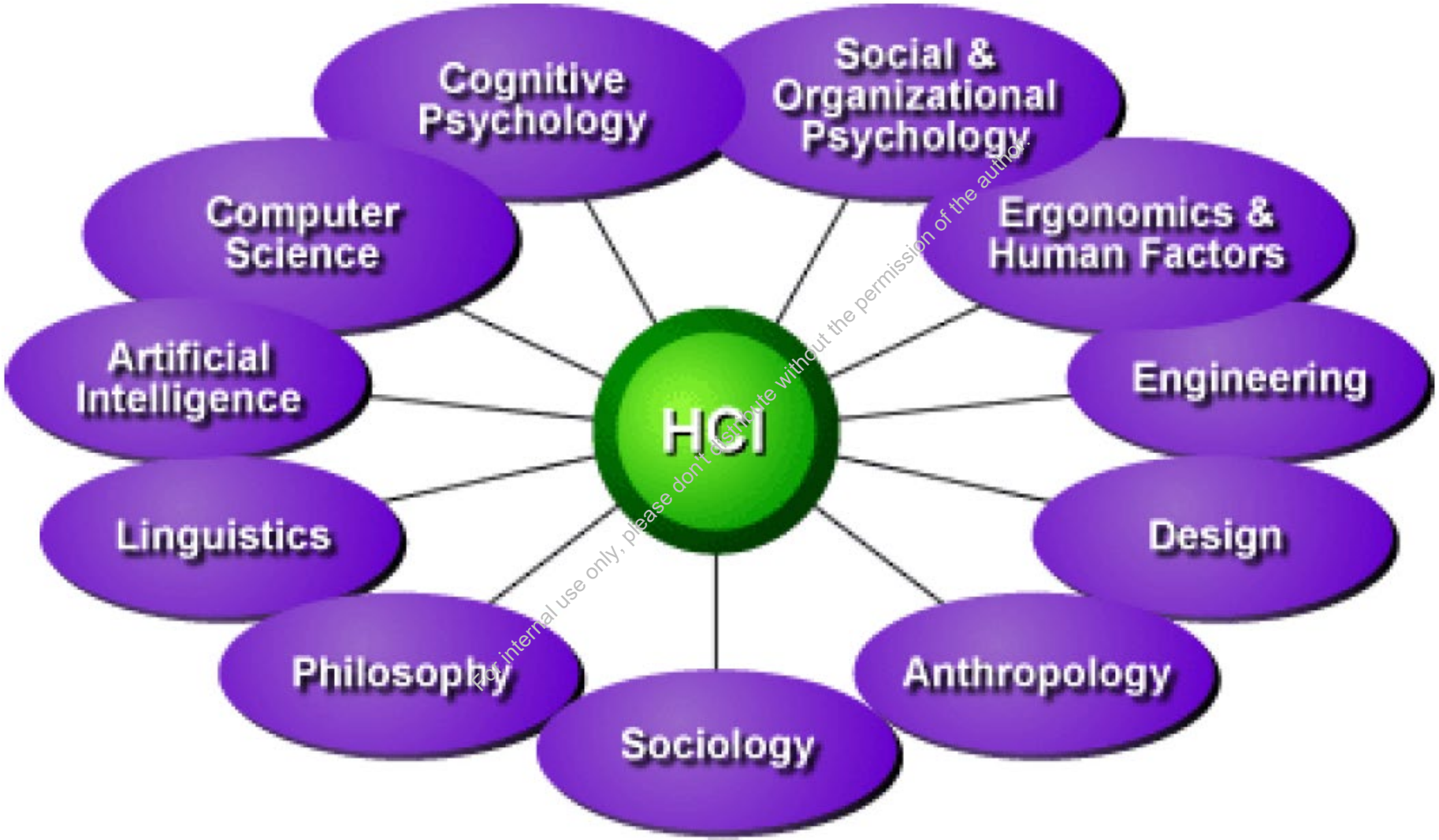
Research Paradigm (范式)

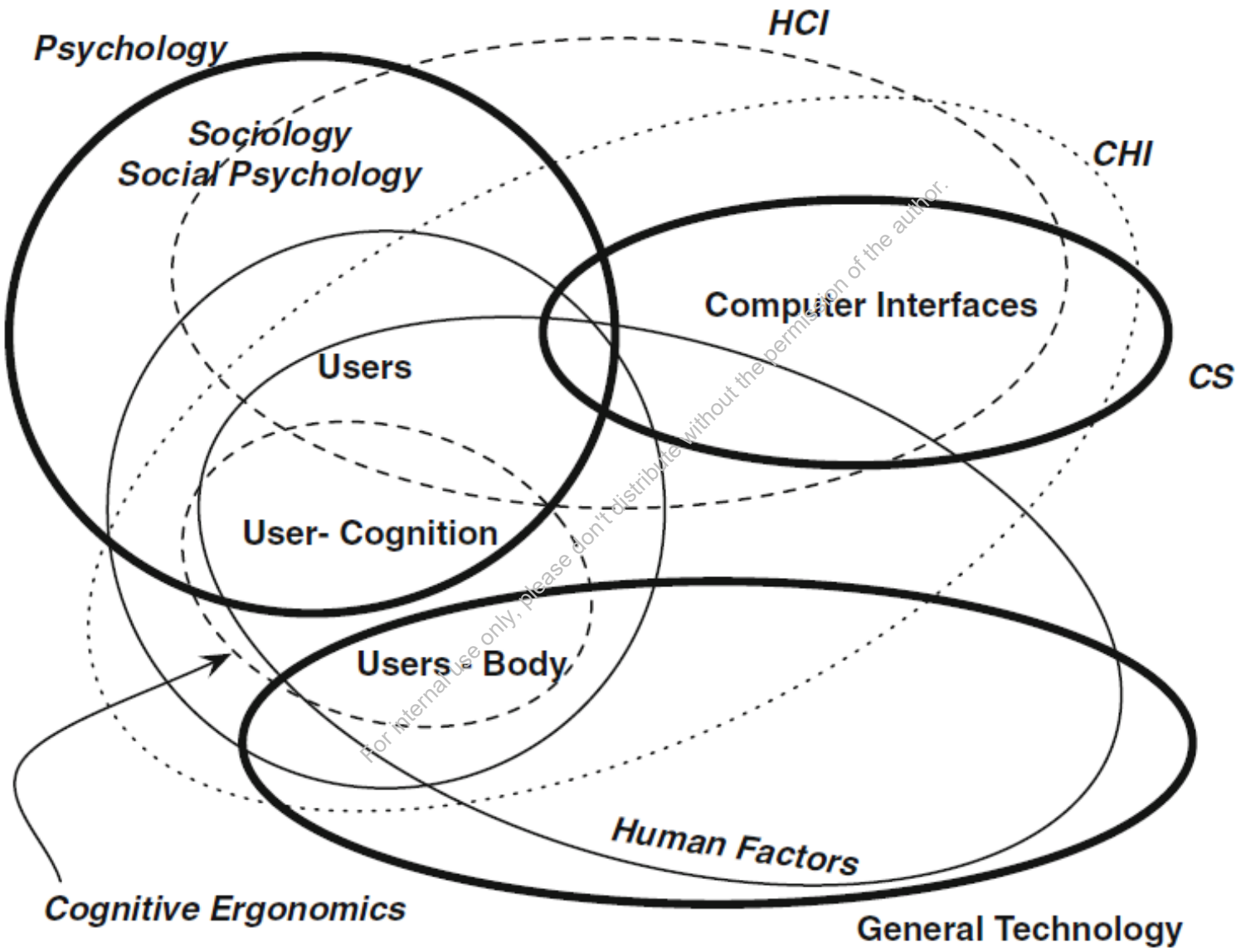


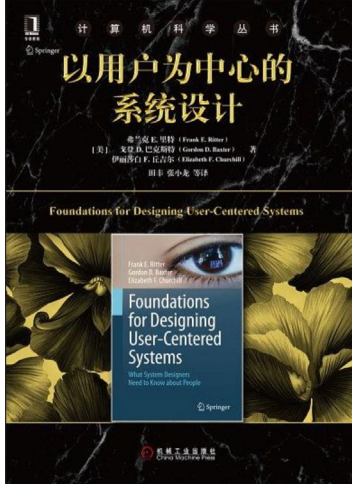
- Paradigm
  - Exemplar
    - “situations where a standard model was to be followed or imitated”
- Research paradigms in a discipline
  - Appeared in Thomas Kuhn’s *The Structure of Scientific Revolution*
    - Commonly accepted methods
    - "examplars of what to do, the kinds of question to ask, successful applications”, and "exemplary observations and experiments“
- Paradigm shift
  - Each discipline has its own stable research paradigm.
  - An old paradigm will be replaced with a new paradigm.
  - Science progresses with the change of paradigm or paradigm shift.

Human-Computer Interaction

- An academic filed focusing on understanding how human users interact with computers and then designing interactive systems to support human activities
  - Multi-disciplinary, cross-disciplinary, inter-disciplinary
    - Computer science, human factors, cognitive psychology, sociology, etc.







Three Research Paradigms in HCI

1. Human Factor
2. Cognitive Revolution
3. Phenomenologically-Situated

The Three Paradigms of HCI

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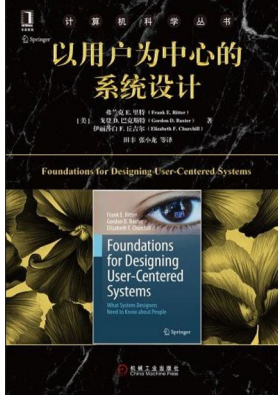
ABSTRACT

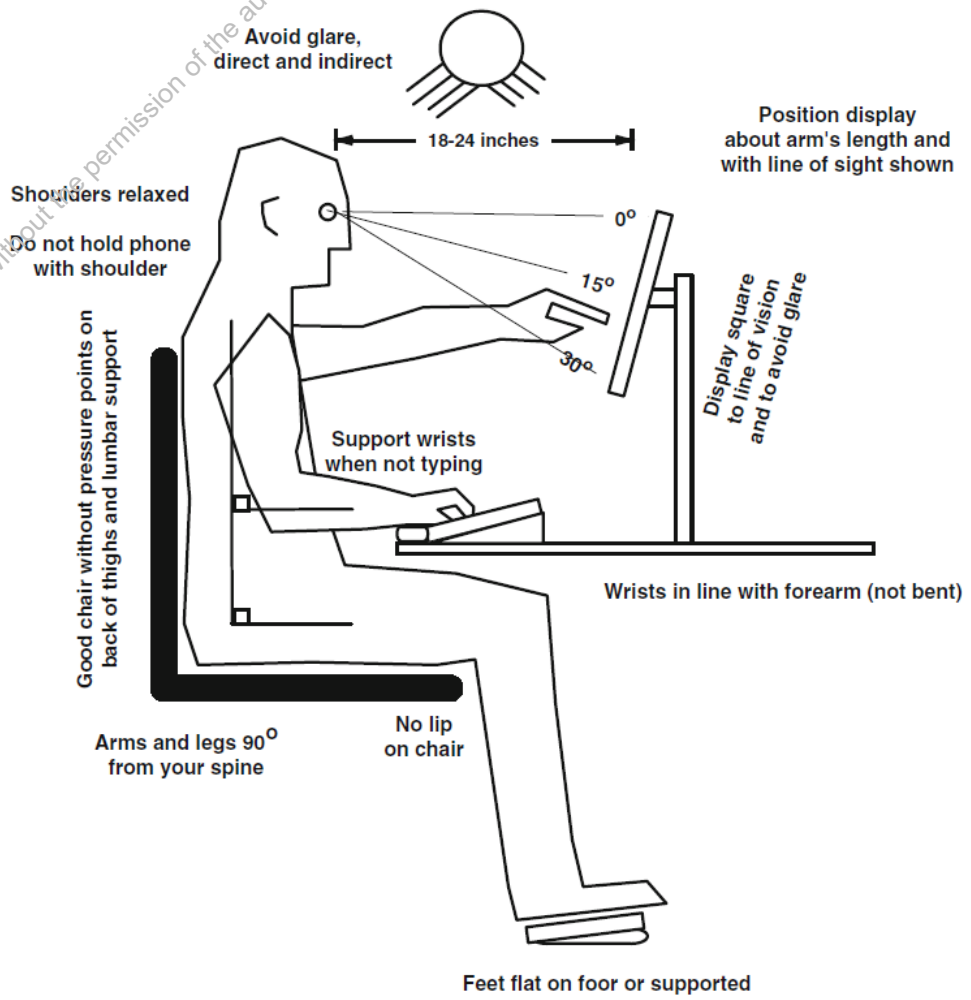
There are three *paradigms* of HCI: Human-Factors, Classical Cognitivism/Information Processing Based and the Third/Phenomenologically-Situated Paradigm. Each of these paradigms represents a world-view and encompasses a set of practices and expectations for the value and contribution of research. Each contributes to HCI, but in different ways. The first two are not particularly controversial in terms of their contributions to larger enterprises of HCI. Human-Factors focuses on optimizing man-machine fit. Classical Cognitivism/Information Processing emphasizes (ideally predictive) models and theories and the relationship between what is in the computer and in the human mind. The third paradigm, with its base in Phenomenology, is less reified, but no less real. It focuses on the experiential quality of interaction, primarily the situated nature of meaning and meaning creation. All three paradigms drive design, but in different ways. All three have their own forms of knowledge creation and criteria for what constitutes knowledge. Identifying these approaches as paradigms allows us to value work more clearly.

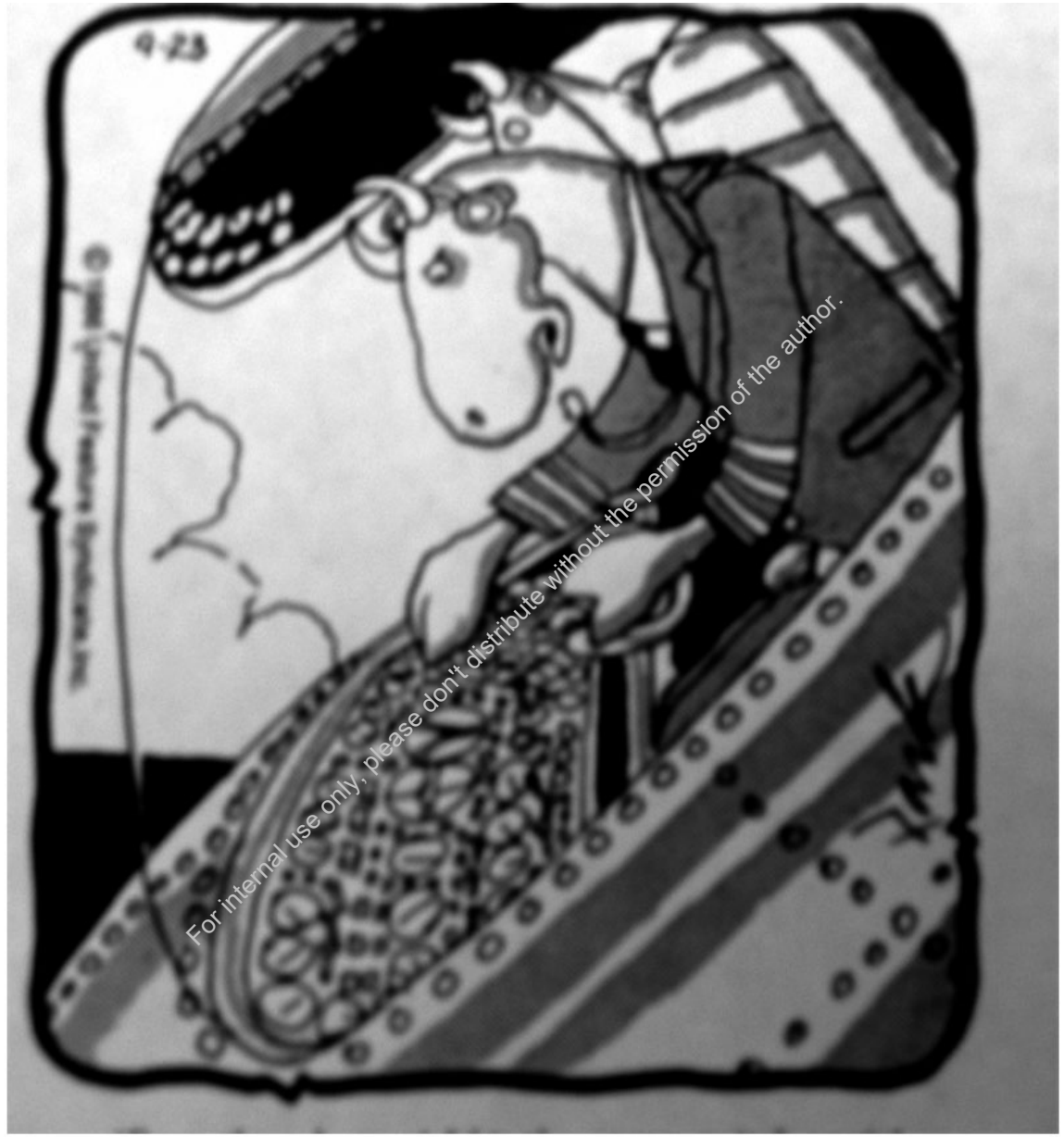
Human Factor



Human Factor

- Basic views
  - Human users are an important factor, if not more important than others, in an interactive system.
    - Other factors: machines, environment, etc.
  - Design is to fit man into a system.
  - Design constraints are largely from the physical constraints of human body and other factors that can directly affect the performances of human physical movements.
- Research practices
  - Developing models that predict human behaviors (usually physical movements)
  - Designing systems to simplify interactive movement.

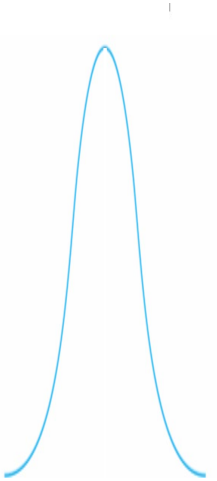




Darn these hooves! I hit the wrong switch again!
Who designs these instrument panels, raccoons?

Design Methods

- Requirement consideration
  - Parameters of human body
    - From census data (assumption: operators are normal people)
    - Dimensions of machines (usually following early generations of designs)
    - Situations of environments where interactions happen (often relatively stable, such as indoor)
  - Tasks: in general prescribed
    - Operators cannot and are not allowed to deviate from the prescribed task trajectory
      - Machine-centered
    - Task analysis
- Design: Engineering-oriented
  - Optimization of existing systems (majority)
    - The space between keys in a keyboard, resistance force of keys, etc.
  - Design of new interaction systems (rarity)
    - Mouse, light pen, tracking ball, etc.
- Evaluation
  - Experiment-oriented
    - Measuring matrix: task efficiency, error rates
    - Subjects: few
      - Homogeneity in performance by targeted operators

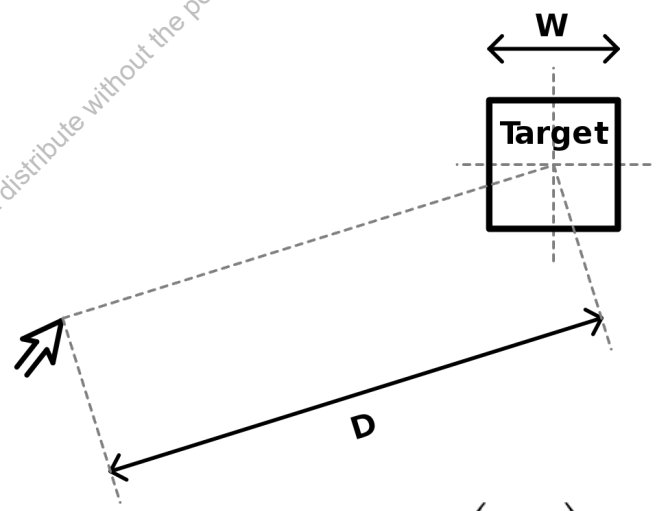


Contributions of This Paradigm

- Recognizing the powers and limitations of human sensory systems.
- Promoting the designs that can leverage such powers and avoid those limitations.
  - Quite successful in the era before information revolution.
    - Concept of ergonomics
    - Some basic parameters used in design
      - E.g., key-stroke level model (time to press a key, to move a mouse, etc.)
    - Justifications of good designs
      - E.g., why mouse is better than tracking ball
- Providing models and tools to understand and analyze interaction activities
  - Improving user interfaces to support expert users
    - Professional typists, customer support representatives, computer scientists, etc.
  - Predicting the efficiency of new UI design

Some Examples under the First Paradigm

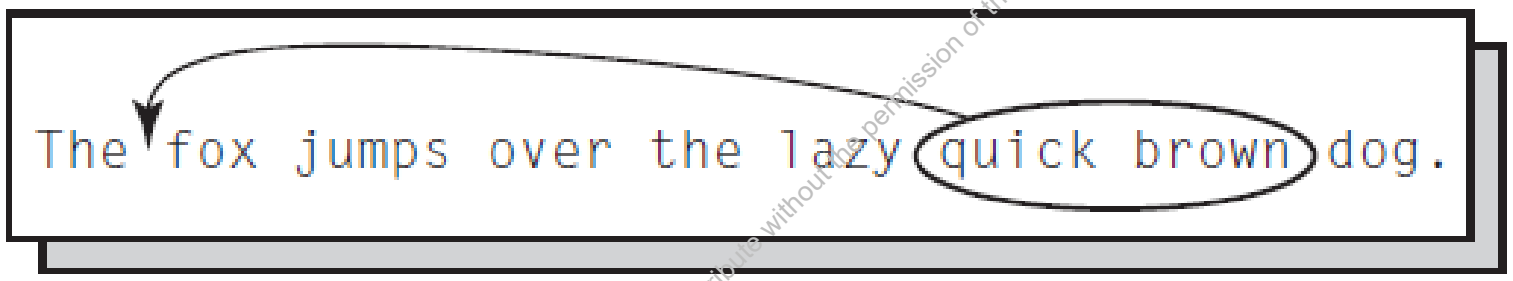
- Fitts's law
  - Mouse vs trackball



$$\mathrm{T} = a + b \cdot \log_2\left(\frac{2D}{W}\right)$$

GOMS Model

- GOMS
  - Goals, operators, methods, selection rules
- A model to represent and analyze an interaction process by an expert users with a keyboard and a point device, usually a mouse.
- Basic idea
  - The process can be decomposed into a series of key strokes, mouse controls, and movements between keyboard and mouse.
  - Each individual activity has a time constant.
  - The efficiency of the process can be calculated by adding the time constants of all relevant activities.



Example of a text-editing task.

Top-level goal	Edit manuscript, or more specifically, move "quick brown" to before "fox"
Subgoal	Highlight text
Operators	Move-mouse Click mouse button Type characters (keyboard shortcuts)
Methods	For the editing goal: 1. Delete-word-and-retype (*retype* method) 2. Cut-and-paste-using-keyboard-shortcuts (*shortcuts* method) 3. Cut-and-paste-using-menus (*menus* method) For the highlighting subgoal: 1. Drag-across text (*dragging* method) 2. Double-click first, shift-click last (*all-clicking* method)
Selection rules	For the editing goal: If text to be moved is one or two characters long, use *retype* method Else, if remember shortcuts, use *shortcuts* method Else, use *menus* method. For the highlighting subgoal: If text to be moved is not whole words, use *dragging* method Else, use *all-clicking* method

Selection of a rule	1.35
Move cursor to “quick”	1.10
Double-click mouse button	0.40
Move cursor to “brown”	1.10
Shift-click mouse button	0.40
Move cursor to Edit menu	1.10
Click mouse button	0.20
Move cursor to “Cut”	1.10
Click mouse button	0.20

Selection of a rule	1.35
Move cursor before “fox”	1.10
Click mouse button	0.20

Selection of a rule	1.35
Move cursor to Edit menu	1.10
Click mouse button	0.20
Move cursor to “Copy"	1.10
Click mouse button	0.20

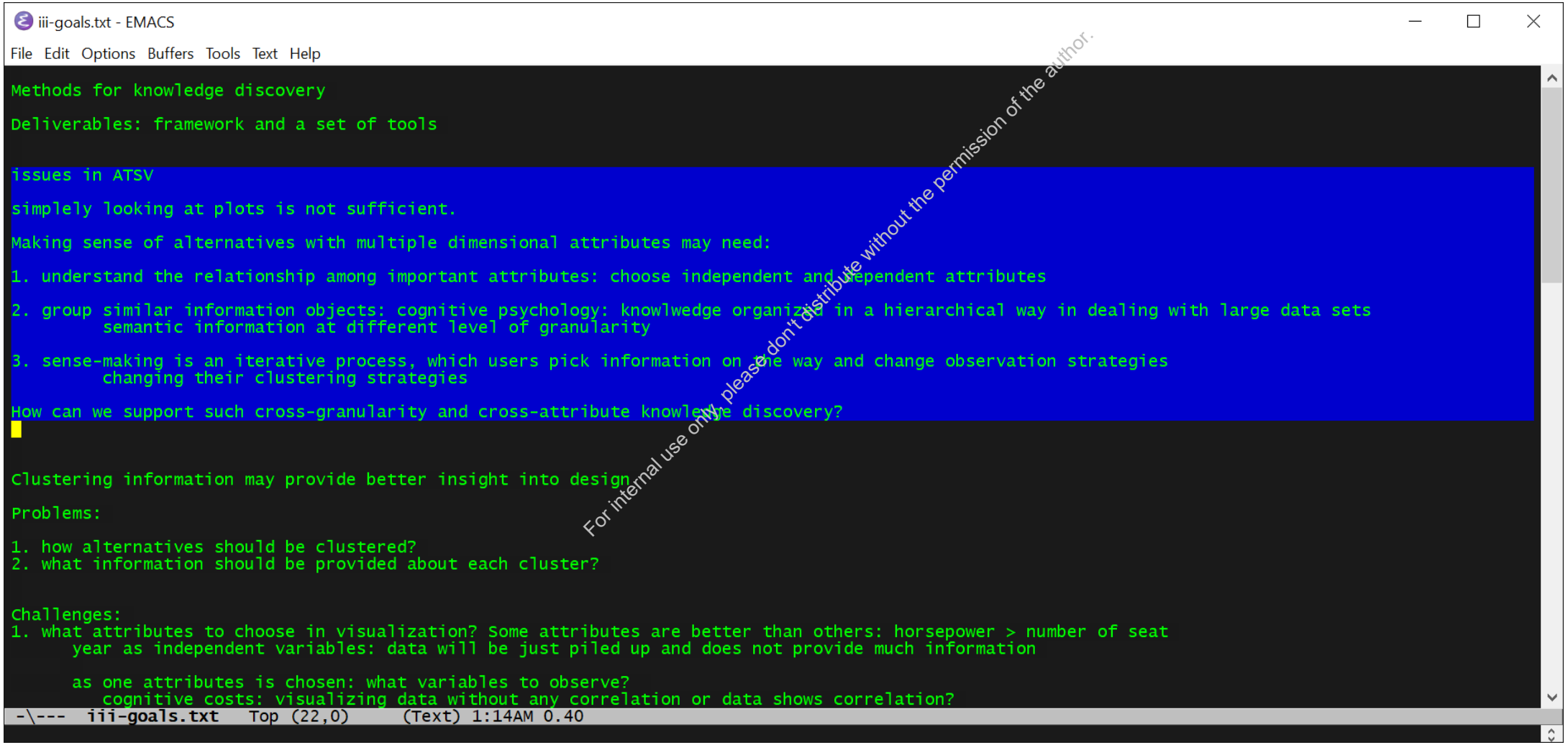
GOMS Models Were Very Successful!

- Predicting user behaviors (largely about task efficiency) in tools/systems to support expert users on routine tasks
  - Text editors, Spreadsheets, CAD systems, operating systems, etc.
- Comparing different designs
  - NYNEX new workstation in 1988.
    - Better technologies: new keyboard, new UI, new display, etc.
    - Slower: critical work paths were longer.
    - Cost $2 million more per year.

Challenges of This Paradigm

- Rigid and passive views on the roles of human operators
  - Factor vs. actor
  - E.g., heavy burden on learning a UI.

Emacs Command Key Combinations



GNU Emacs Reference Card

(for version 26)

Starting Emacs

To enter GNU Emacs 26, just type its name: `emacs`

Leaving Emacs

suspend Emacs (or iconify it under X)	`C-z`
exit Emacs permanently	`C-x C-c`

Files

read a file into Emacs	`C-x C-f`
save a file back to disk	`C-x C-s`
save **all** files	`C-x s`
insert contents of another file into this buffer	`C-x i`
replace this file with the file you really want	`C-x C-v`
write buffer to a specified file	`C-x C-w`
toggle read-only status of buffer	`C-x C-q`

Getting Help

The help system is simple. Type `C-h` (or `F1`) and follow the directions. If you are a first-time user, type `C-h t` for a **tutorial**.

remove help window	`C-x 1`
scroll help window	`C-M-v`
apropos: show commands matching a string	`C-h a`
describe the function a key runs	`C-h k`
describe a function	`C-h f`
get mode-specific information	`C-h m`

Error Recovery

abort partially typed or executing command	`C-g`
recover files lost by a system crash	`M-x recover-session`
undo an unwanted change	`C-x u`, `C-_` or `C-/`
restore a buffer to its original contents	`M-x revert-buffer`
redraw garbaged screen	`C-l`

Incremental Search

search forward	`C-s`
search backward	`C-r`
regular expression search	`C-M-s`
reverse regular expression search	`C-M-r`
select previous search string	`M-p`
select next later search string	`M-n`
exit incremental search	`RET`
undo effect of last character	`DEL`
abort current search	`C-g`

Use `C-s` or `C-r` again to repeat the search in either direction. If Emacs is still searching, `C-g` cancels only the part not matched.

Motion

entity to move over	**backward**	**forward**
character	`C-b`	`C-f`
word	`M-b`	`M-f`
line	`C-p`	`C-n`
go to line beginning (or end)	`C-a`	`C-e`
sentence	`M-a`	`M-e`
paragraph	`M-{`	`M-}`
page	`C-x [`	`C-x ]`
sexp	`C-M-b`	`C-M-f`
function	`C-M-a`	`C-M-e`
go to buffer beginning (or end)	`M-<`	`M->`

scroll to next screen	`C-v`
scroll to previous screen	`M-v`
scroll left	`C-x <`
scroll right	`C-x >`
scroll current line to center, top, bottom	`C-l`
goto line	`M-g g`
goto char	`M-g c`
back to indentation	`M-m`

Killing and Deleting

entity to kill	**backward**	**forward**
character (delete, not kill)	`DEL`	`C-d`
word	`M-DEL`	`M-d`
line (to end of)	`M-0 C-k`	`C-k`
sentence	`C-x DEL`	`M-k`
sexp	`M-- C-M-k`	`C-M-k`

kill **region**	`C-w`
copy region to kill ring	`M-w`
kill through next occurrence of *char*	`M-z` *char*
yank back last thing killed	`C-y`
replace last yank with previous kill	`M-y`

Marking

set mark here	`C-@` or `C-SPC`
exchange point and mark	`C-x C-x`
set mark *arg* **words** away	`M-@`
mark **paragraph**	`M-h`
mark **page**	`C-x C-p`
mark **sexp**	`C-M-@`
mark **function**	`C-M-h`
mark entire **buffer**	`C-x h`

Query Replace

interactively replace a text string	`M-%`
using regular expressions	`M-x query-replace-regexp`

Valid responses in query-replace mode are

replace this one, go on to next	`SPC` or `y`
replace this one, don't move	`,`
skip to next without replacing	`DEL` or `n`
replace all remaining matches	`!`
back up to the previous match	`^`
exit query-replace	`RET`
enter recursive edit (`C-M-c` to exit)	`C-r`

Multiple Windows

When two commands are shown, the second is a similar command for a frame instead of a window.

delete all other windows	`C-x 1`	`C-x 5 1`
split window, above and below	`C-x 2`	`C-x 5 2`
delete this window	`C-x 0`	`C-x 5 0`
split window, side by side	`C-x 3`	
scroll other window	`C-M-v`	
switch cursor to another window	`C-x o`	`C-x 5 o`
select buffer in other window	`C-x 4 b`	`C-x 5 b`
display buffer in other window	`C-x 4 C-o`	`C-x 5 C-o`
find file in other window	`C-x 4 f`	`C-x 5 f`
find file read-only in other window	`C-x 4 r`	`C-x 5 r`
run Dired in other window	`C-x 4 d`	`C-x 5 d`
find tag in other window	`C-x 4 .`	`C-x 5 .`
grow window taller	`C-x ^`	
shrink window narrower	`C-x {`	
grow window wider	`C-x }`	

Formatting

indent current **line** (mode-dependent)	`TAB`
indent **region** (mode-dependent)	`C-M-\`
indent **sexp** (mode-dependent)	`C-M-q`
indent region rigidly *arg* columns	`C-x TAB`
indent for comment	`M-;`
insert newline after point	`C-o`
move rest of line vertically down	`C-M-o`
delete blank lines around point	`C-x C-o`
join line with previous (with arg, next)	`M-^`
delete all white space around point	`M-\`
put exactly one space at point	`M-SPC`
fill paragraph	`M-q`
set fill column to *arg*	`C-x f`
set prefix each line starts with	`C-x .`
set face	`M-o`

Case Change

uppercase word	`M-u`
lowercase word	`M-l`
capitalize word	`M-c`
uppercase region	`C-x C-u`
lowercase region	`C-x C-l`

The Minibuffer

The following keys are defined in the minibuffer.

complete as much as possible	`TAB`
complete up to one word	`SPC`
complete and execute	`RET`
show possible completions	`?`
fetch previous minibuffer input	`M-p`
fetch later minibuffer input or default	`M-n`
regexp search backward through history	`M-r`
regexp search forward through history	`M-s`
abort command	`C-g`

Type `C-x ESC ESC` to edit and repeat the last command that used the minibuffer. Type `F10` to activate menu bar items on text terminals.

Challenges of This Paradigm

- Rigid and passive views on the roles of human operators
  - Factor vs. actor
  - E.g., heavy burden on learning a UI.
- Failed to fully release the powers of human intelligence
  - Operators merely follow pre-defined task trajectories on specially-purposed systems.
    - Repeated and mechanical movements
- Inadequate when applied to design for general purpose systems, such as personal computer.
- Lack of solid theories to guide design
  - Engineering practices (hacking)
- Ignorance on large contextual factors (e.g., group, social, societal factors)

An Example of Research Paper

A COMPARISON OF INPUT DEVICES IN ELEMENTAL POINTING AND DRAGGING TASKS

I. Scott MacKenzie[†], *Abigail Sellen*[§], *and William Buxton*[§]

https://www.yorku.ca/mack/CHI91.html

Is This Paradigm Relevant to Designing Visualization Systems?

HUMAN-COMPUTER INTERACTION, 1986, Volume 2, pp. 227-249

Softening Up Hard Science: Reply to Newell and Card

John M. Carroll and **Robert L. Campbell**
IBM Thomas J. Watson Research Center

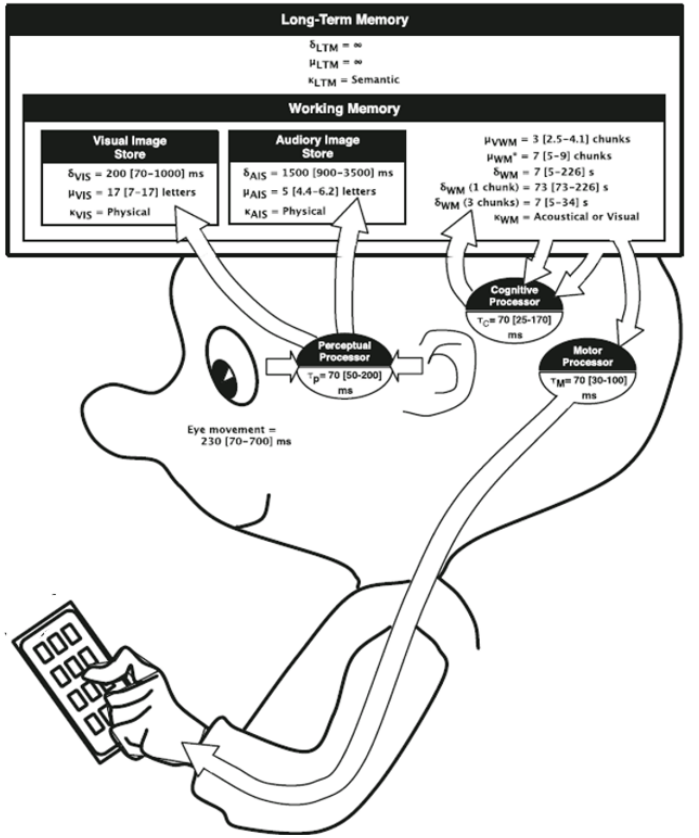
ABSTRACT

A source of intellectual overhead periodically encountered by scientists is the call to be "hard," to ensure good science by imposing severe methodological strictures. Newell and Card (1985) undertook to impose such strictures on the psychology of human-computer interaction. Although their discussion contributes to theoretical debate in human-computer interaction by setting a reference point, their specific argument fails. Their program is unmotivated, is severely limited, and suffers from these limitations in principle. A top priority for the psychology of human-computer interaction should be the articulation of an alternative explanatory program, one that takes as its starting point the need to understand the real problems involved in providing better computer tools for people to use.

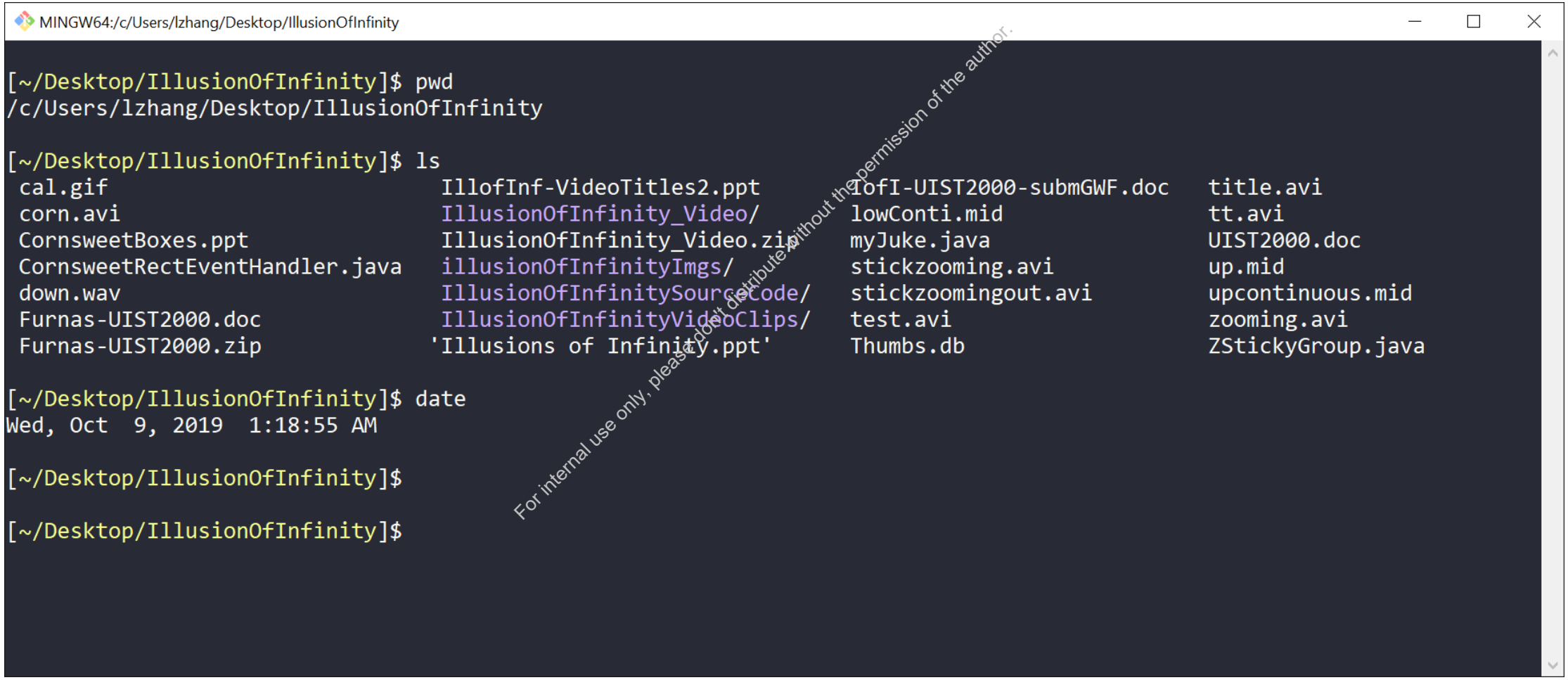
Cognitive Revolution

Cognitive Revolution

- Cause: main frames ➔ personal computers
  - General purpose systems
  - Heterogeneous users



This Is What A User Interface Used to Be …



This Is What A Text Editor Looked Like …

iii-goals.txt - EMACS

File Edit Options Buffers Tools Text Help

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Methods for knowledge discovery

Deliverables: framework and a set of tools


issues in ATSV

simplely looking at plots is not sufficient.

Making sense of alternatives with multiple dimensional attributes may need:

1. understand the relationship among important attributes: choose independent and dependent attributes

2. group similar information objects: cognitive psychology: knowlwedge organized in a hierarchical way in dealing with large data sets
        semantic information at different level of granularity

3. sense-making is an iterative process, which users pick information on the way and change observation strategies
        changing their clustering strategies

How can we support such cross-granularity and cross-attribute knowledge discovery?


Clustering information may provide better insight into design

Problems:

1. how alternatives should be clustered?
2. what information should be provided about each cluster?


Challenges:
1. what attributes to choose in visualization? Some attributes are better than others: horsepower > number of seat
     year as independent variables: data will be just piled up and does not provide much information

     as one attributes is chosen: what variables to observe?
        cognitive costs: visualizing data without any correlation or data shows correlation?
-\---  iii-goals.txt    Top (22,0)      (Text) 1:14AM 0.40
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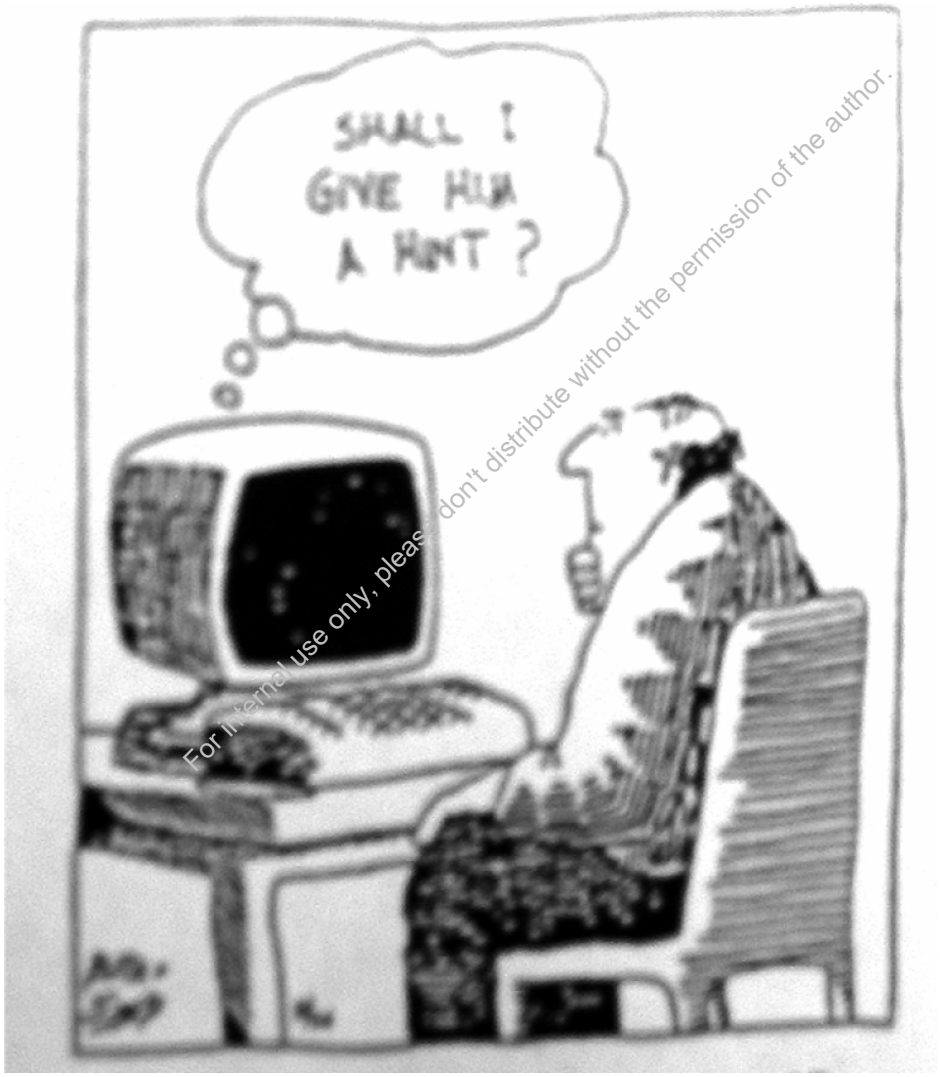
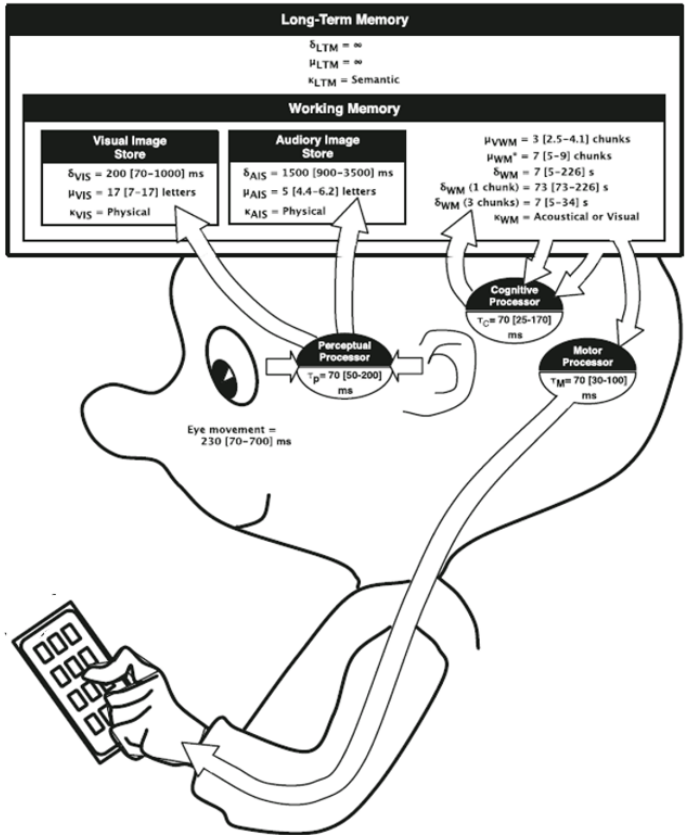
Troubles for Ordinary Users



Do We Have Similar Problems in Visualization/Visual Analytics Systems?

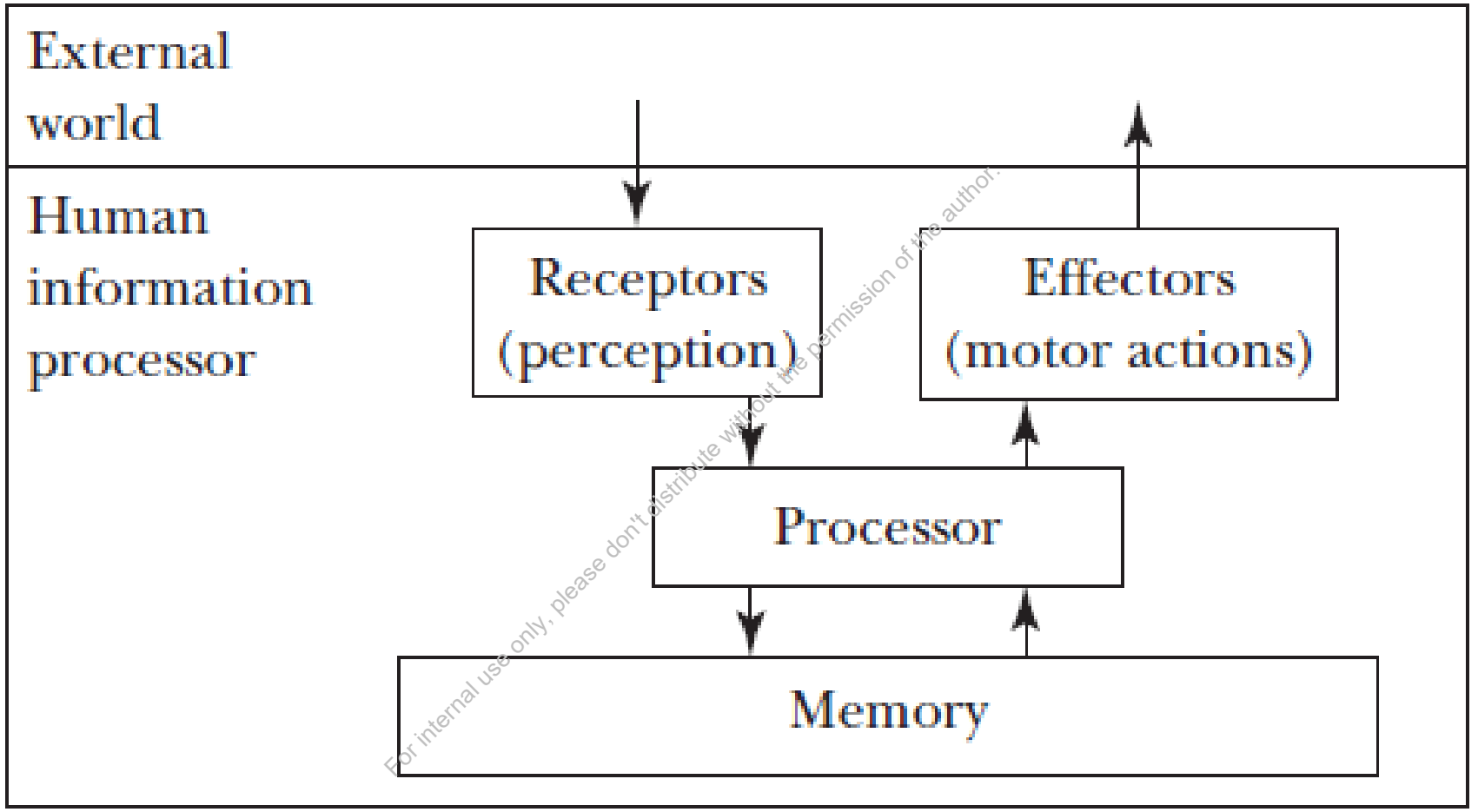
Cognitive Revolution



- Cause: main frames ➔ personal computers
  - General purpose systems
  - Heterogeneous users
- Emphasizing the important roles of human cognition in interacting with computers
  - Human sensory systems
    - Visual perception: the sensory system we know best
      - Dominant information input channel
    - Auditory perception: not as much as what we know about visual perception
      - Supportive roles in input
  - Human memory systems
    - Different kinds of memory: sensory storage, short-term storage, and long-term storage
    - Mechanisms to remember and recall the information stored in our brain

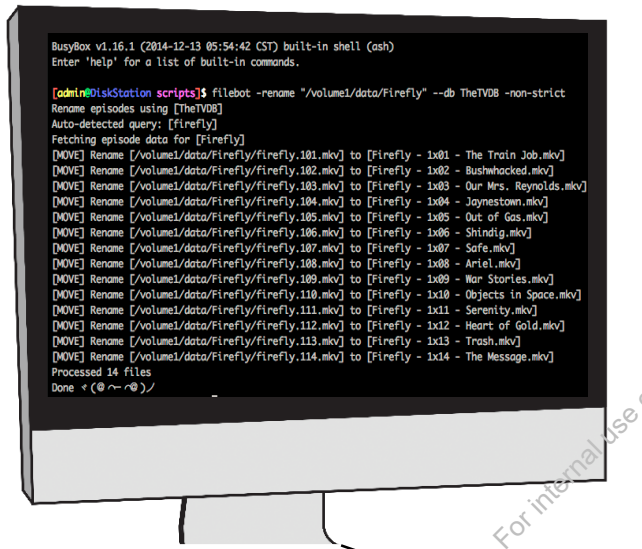
Design Methods

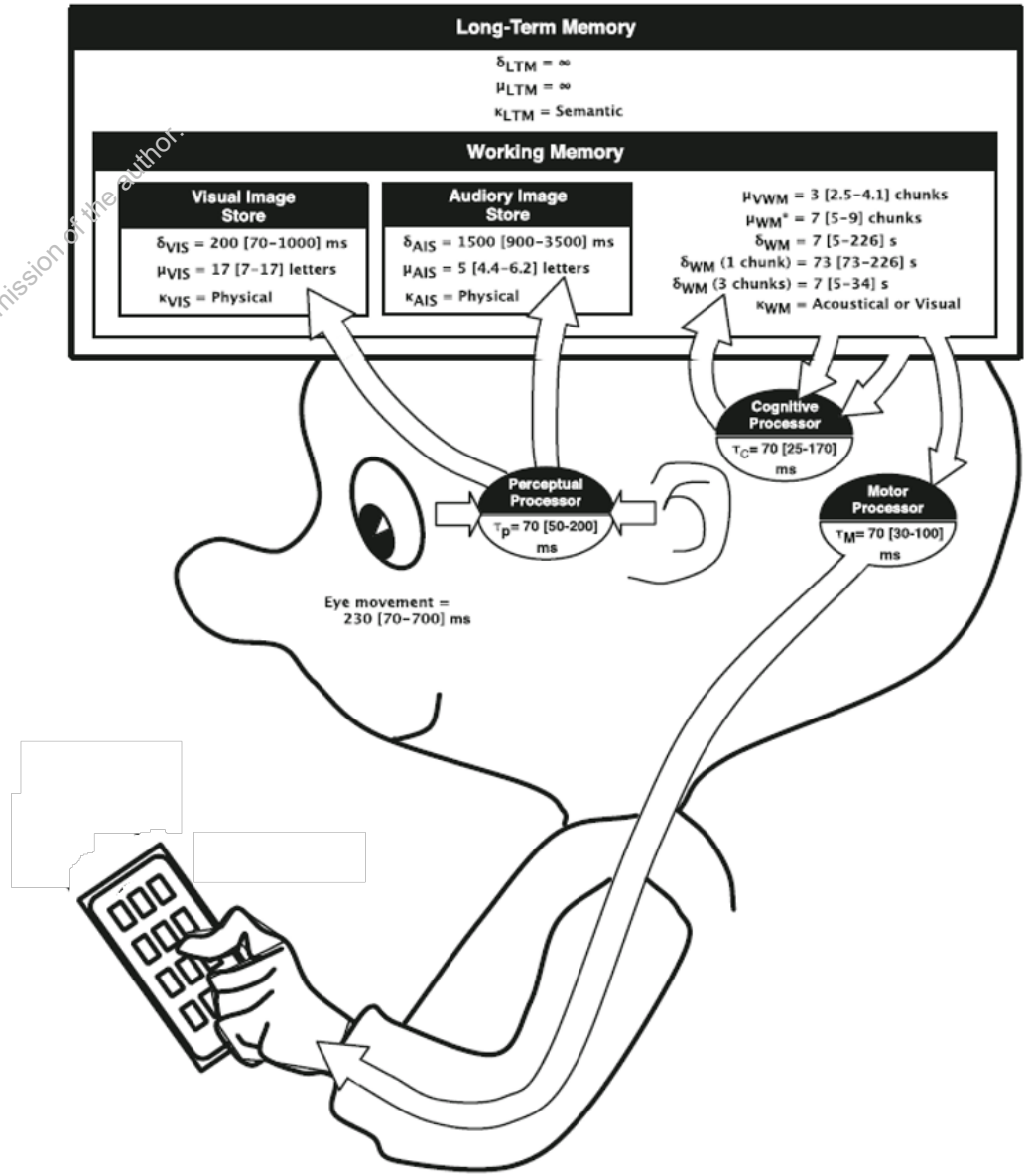
- Requirement consideration
  - Significantly focusing on cognitive perspectives of users
  - Task: recognition of the diversity of user activities in carrying out the same task



A generic human information-processing system.

Model Human Processor (MHP)





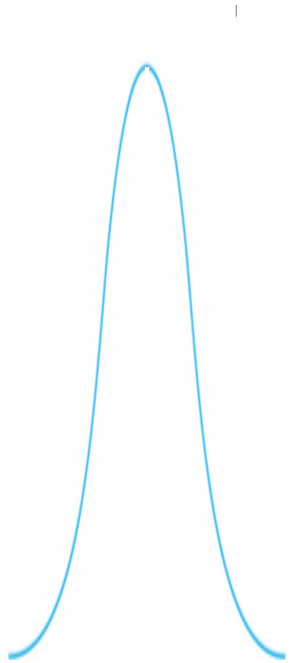
Design Methods

- Requirement consideration
  - Significantly focusing on cognitive perspectives of users
  - Task: recognition of the diversity of user activities in carrying out the same task
- Design
  - Visual design of a UI based on visual perception principles
    - Icons, color choices, etc.
  - Organization of UI components based on user mental models
    - Organization of UI components (e.g., menu, task bar, etc.)
  - Innovation of UIs in general
  - Improvement of UI components
- Evaluation (if available)
  - Experiment-based
    - Measure matrix: usability (task completion time, error rates, user satisfaction, etc.)
  - Sample size: varying
    - Design concerning low-level cognition: small sample size (again homogeneity in user performance)
    - Design concerning cognition related individual experiences: large sample size

Example: Automaticity

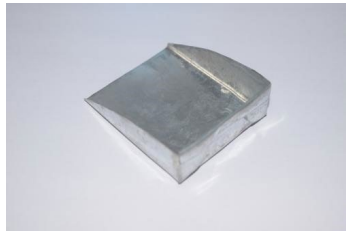
Red Green Blue Yellow
Black Pink Brown Purple

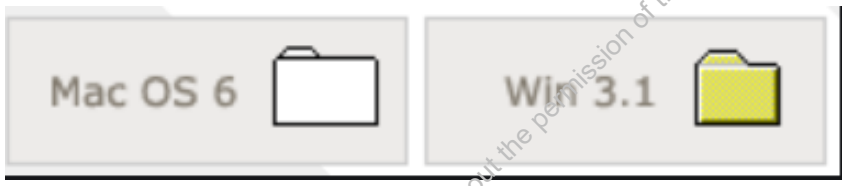
- Automatic processing
  - Occurs without intention (Stroop Effect)
  - No conscious awareness of the process used
  - Does not consume much cognitive resource
- Measuring average time and error rate
  - Performance: most people are similar.
  - Small sample is good enough.

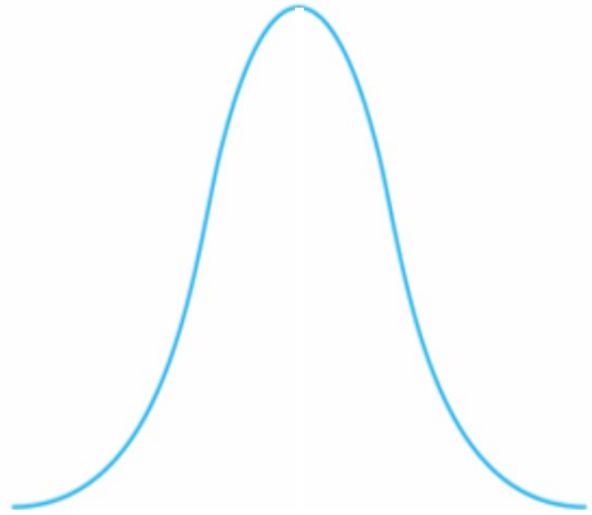


Example: Icon Design

- Understanding the meaning of an icon depends individual experiences







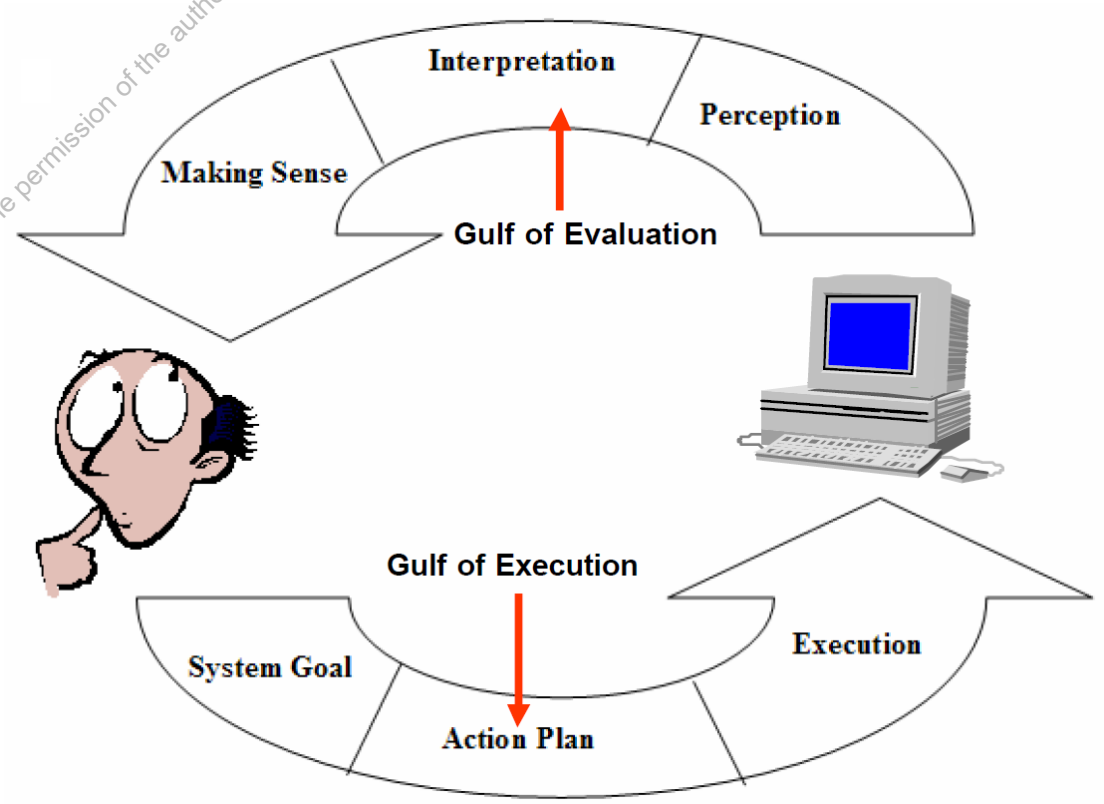
- User preferences may vary significantly.
  - Need large samples

Contribution of This Paradigm

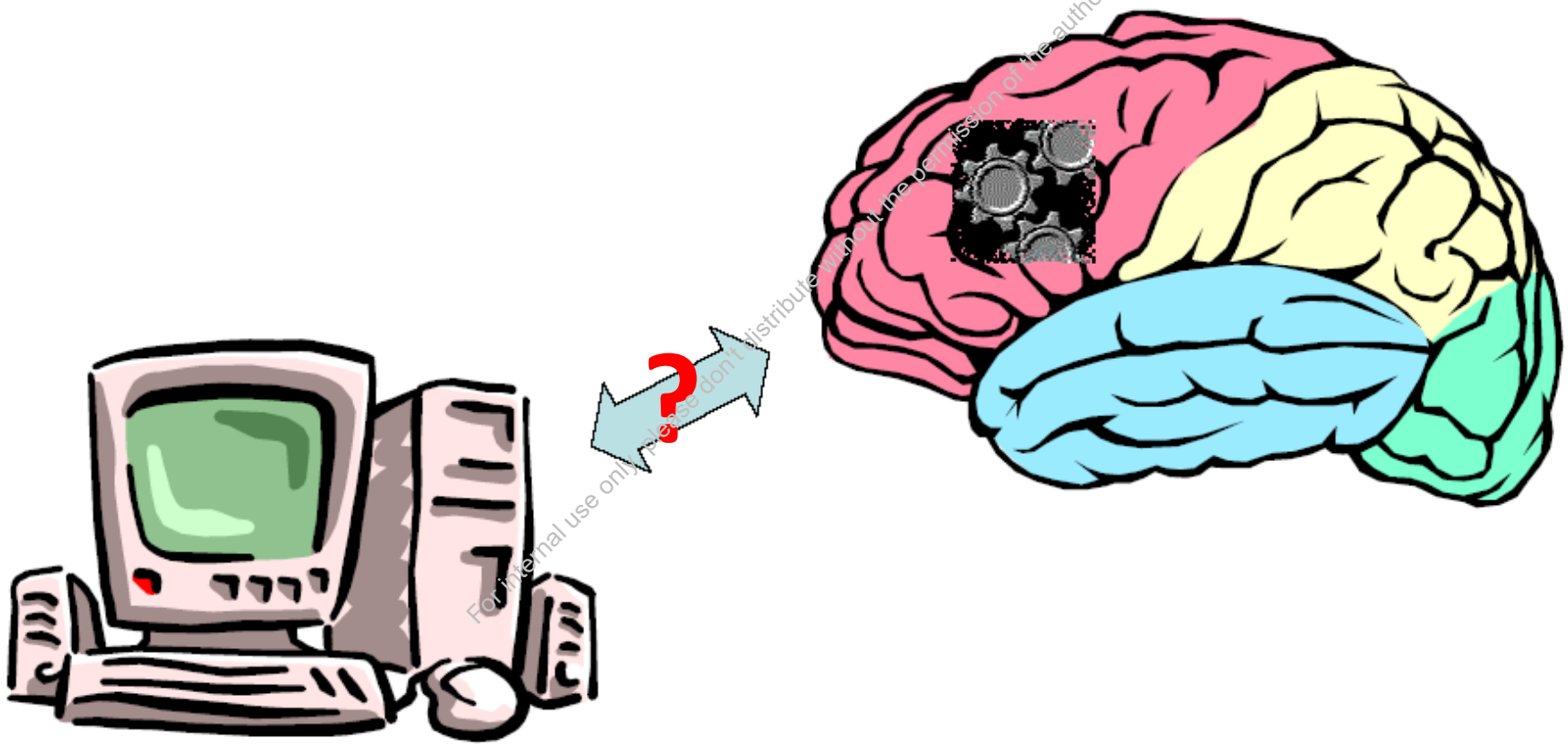
- Revealing the importance of human cognition to interaction design
  - Match between human cognition and system model
- Offering a new way to look at relationship between human users and information systems
  - Interaction as information communication between users and systems
- Promoting the development of new theories/models to support complex interaction
  - Systems as a part of human cognition (distributed cognition)
- Offering a series of theories and models to guide interaction designs
  - Drawn from cognition psychology on color, brightness, info organization, etc.
  - Developed for UI design specifically
    - Mental model (e.g., desktop UI)
    - Distributed cognition (e.g., UI for group)

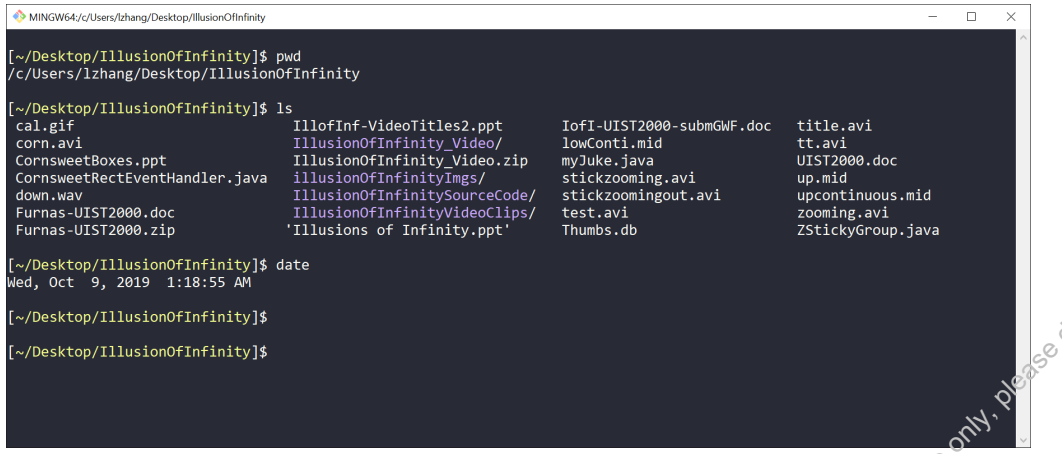
Success of This Design Paradigm

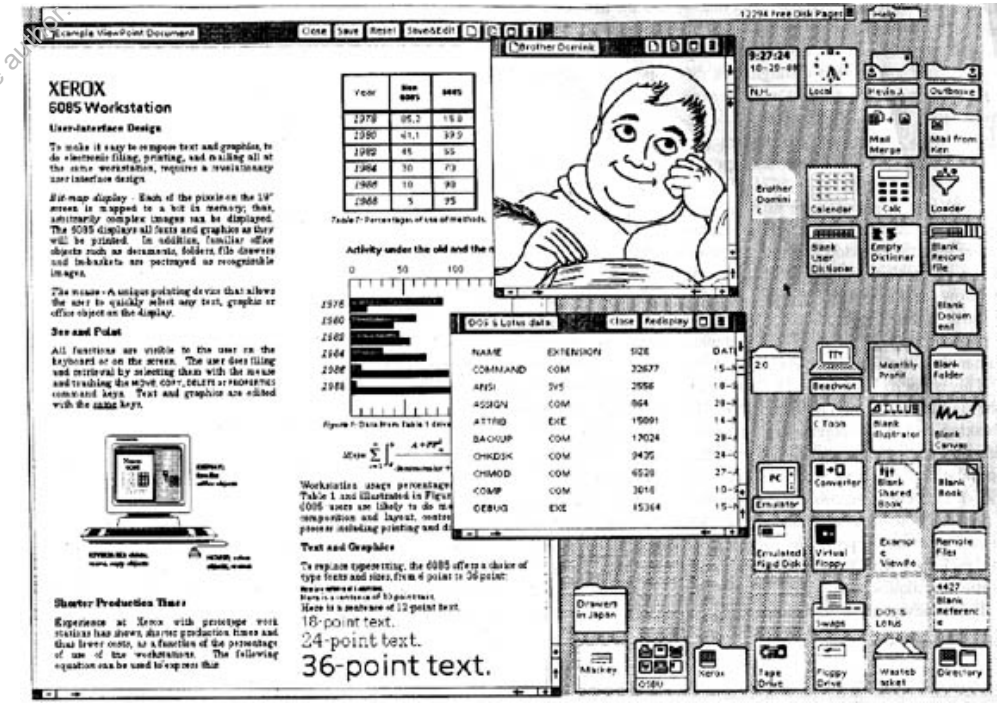
- Graphical User Interface (GUI)
  - Recall vs. recognition
  - Visually guided interactions
  - GUI makes computer easy to use
- Various information visualization designs for different data types
  - Long list, table, tree, networks, etc.



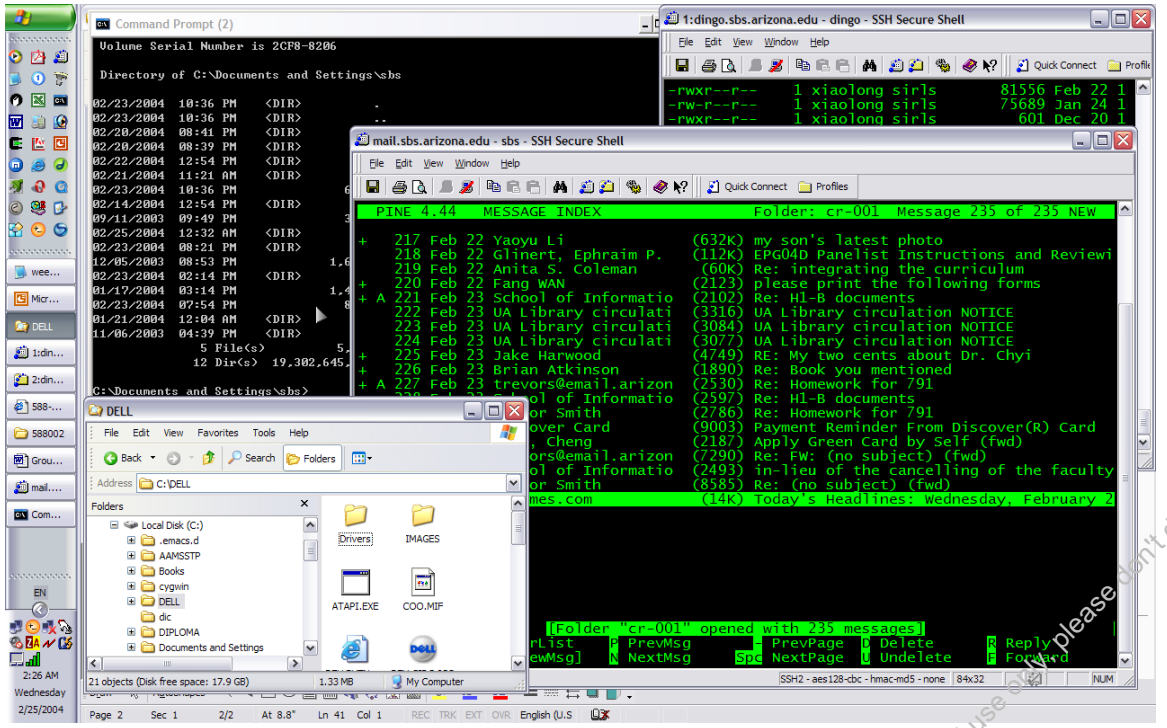
Mental Model (Metaphor)

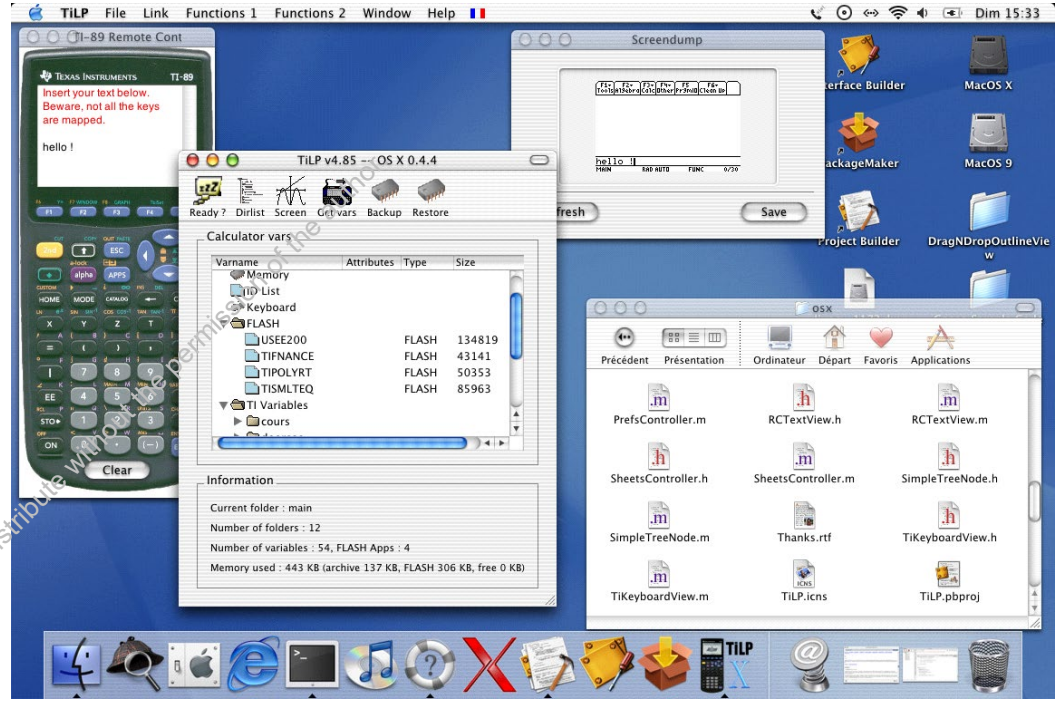




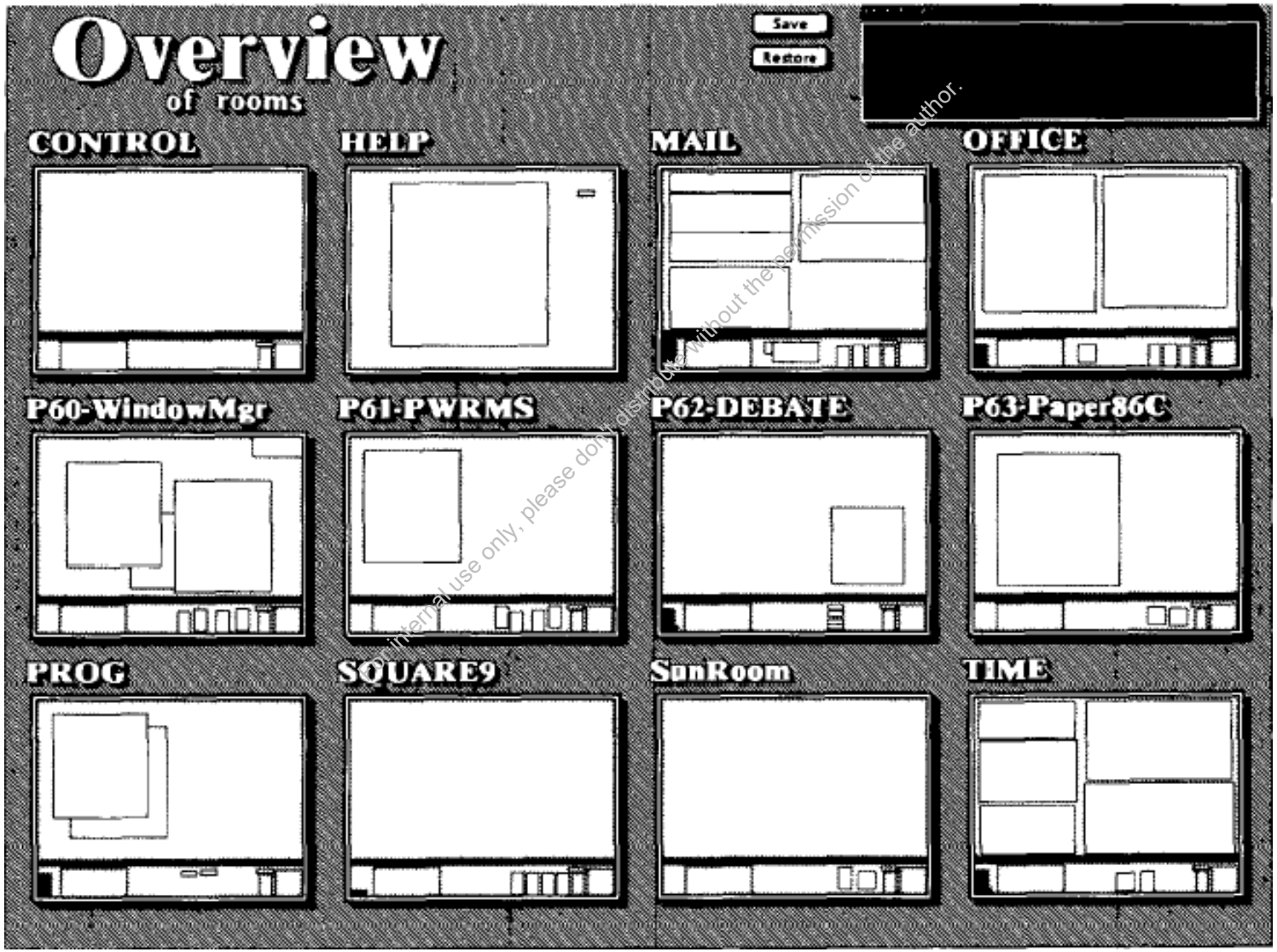


Desktop





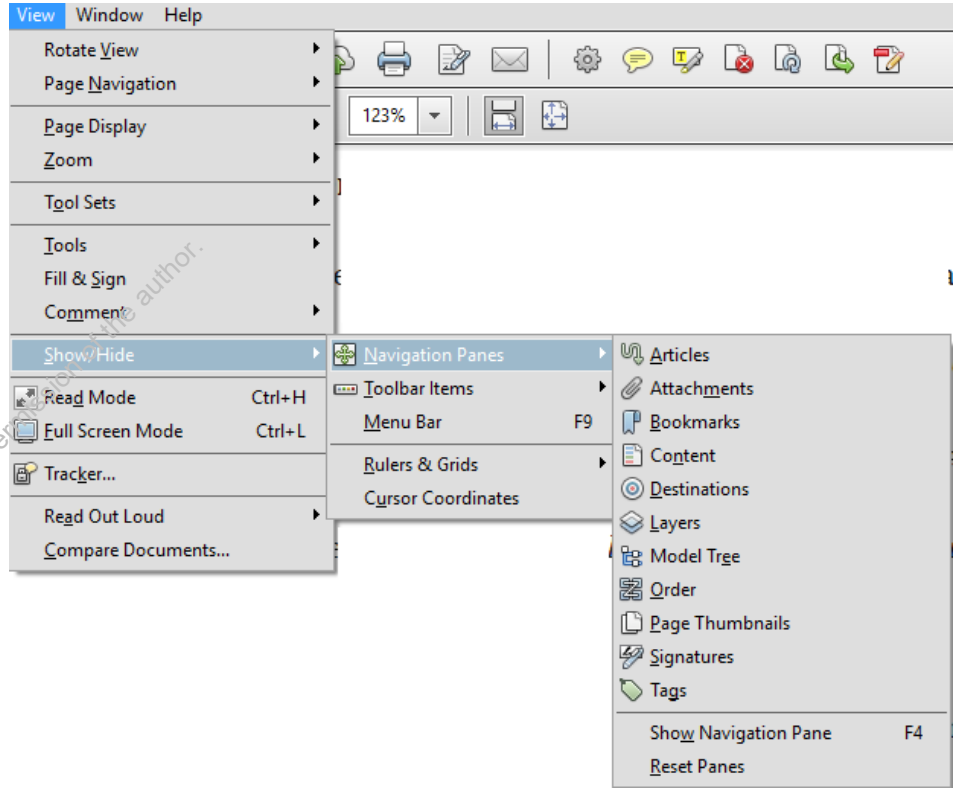
Room



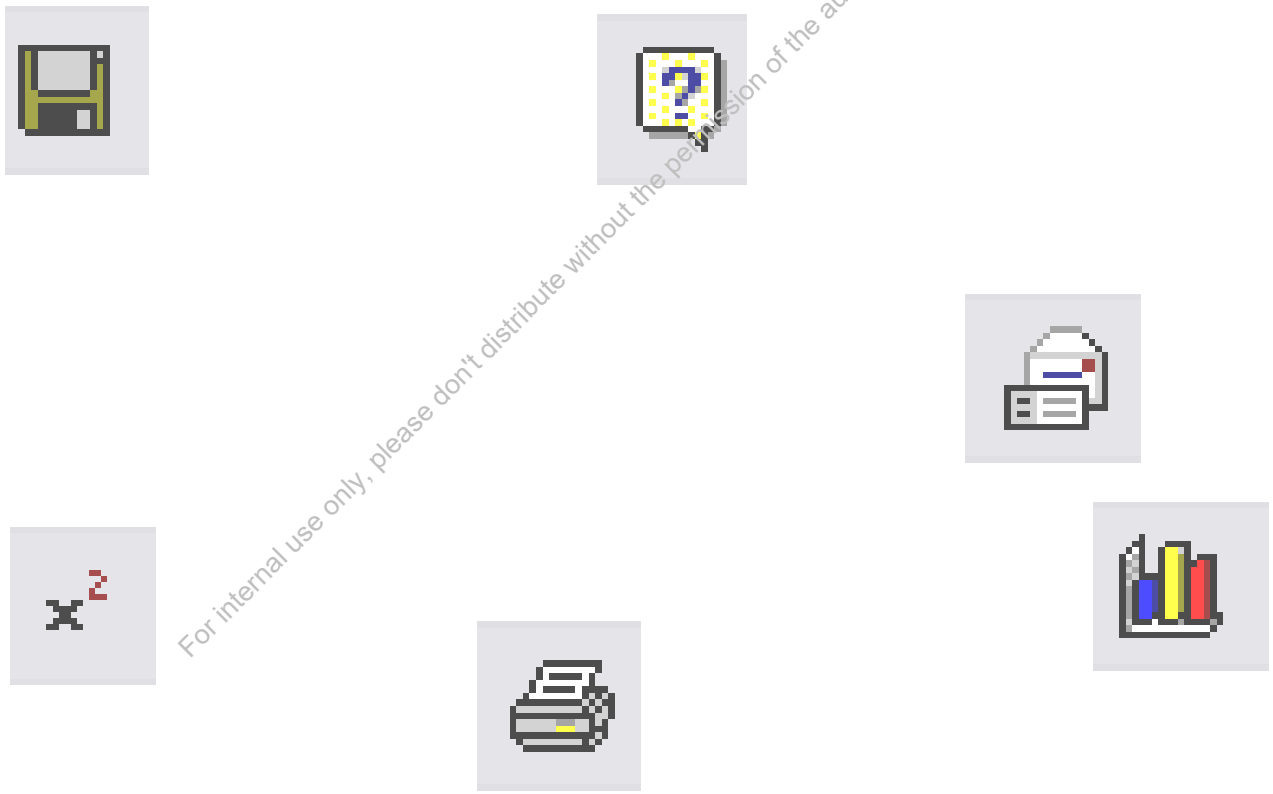
Book

UI Organization

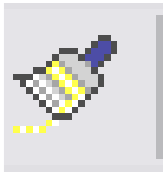
- Menu (List)

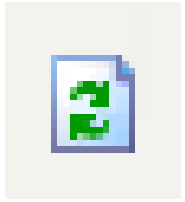


Icon Design: The Good

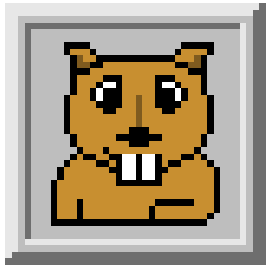


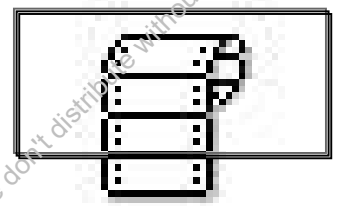
The Bad

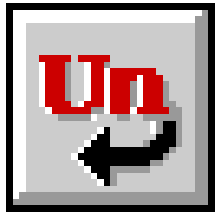




The Ugly

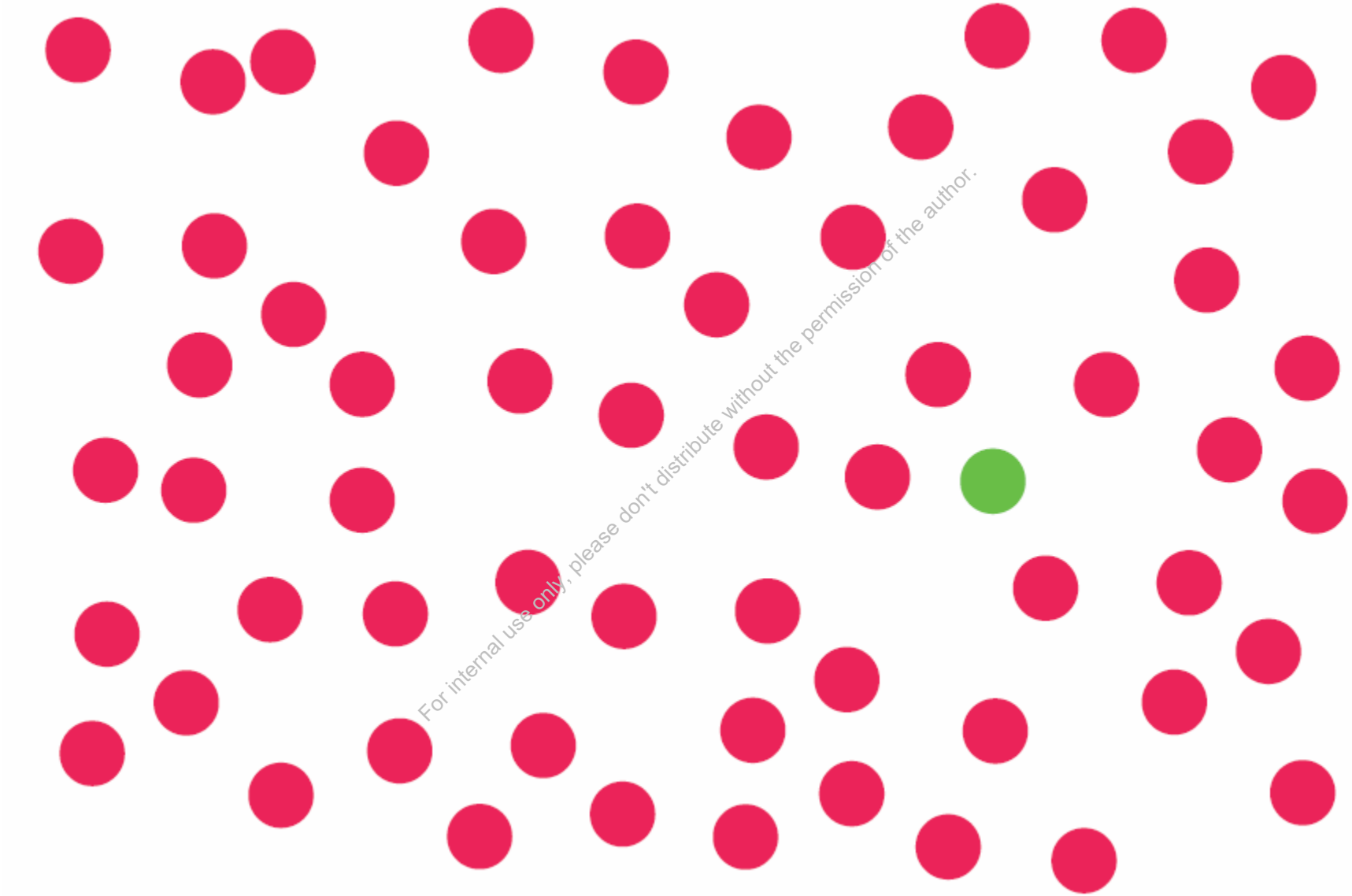


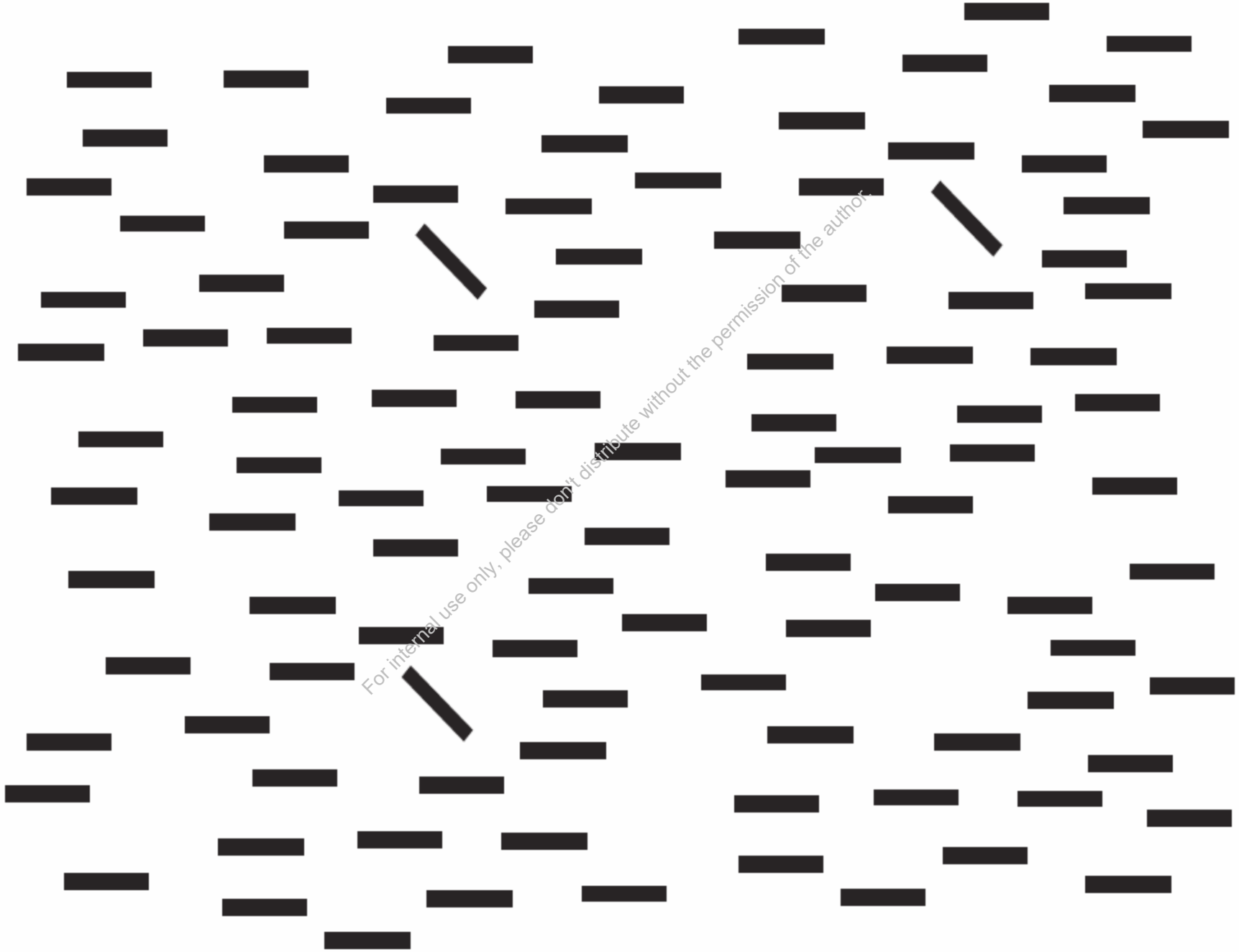


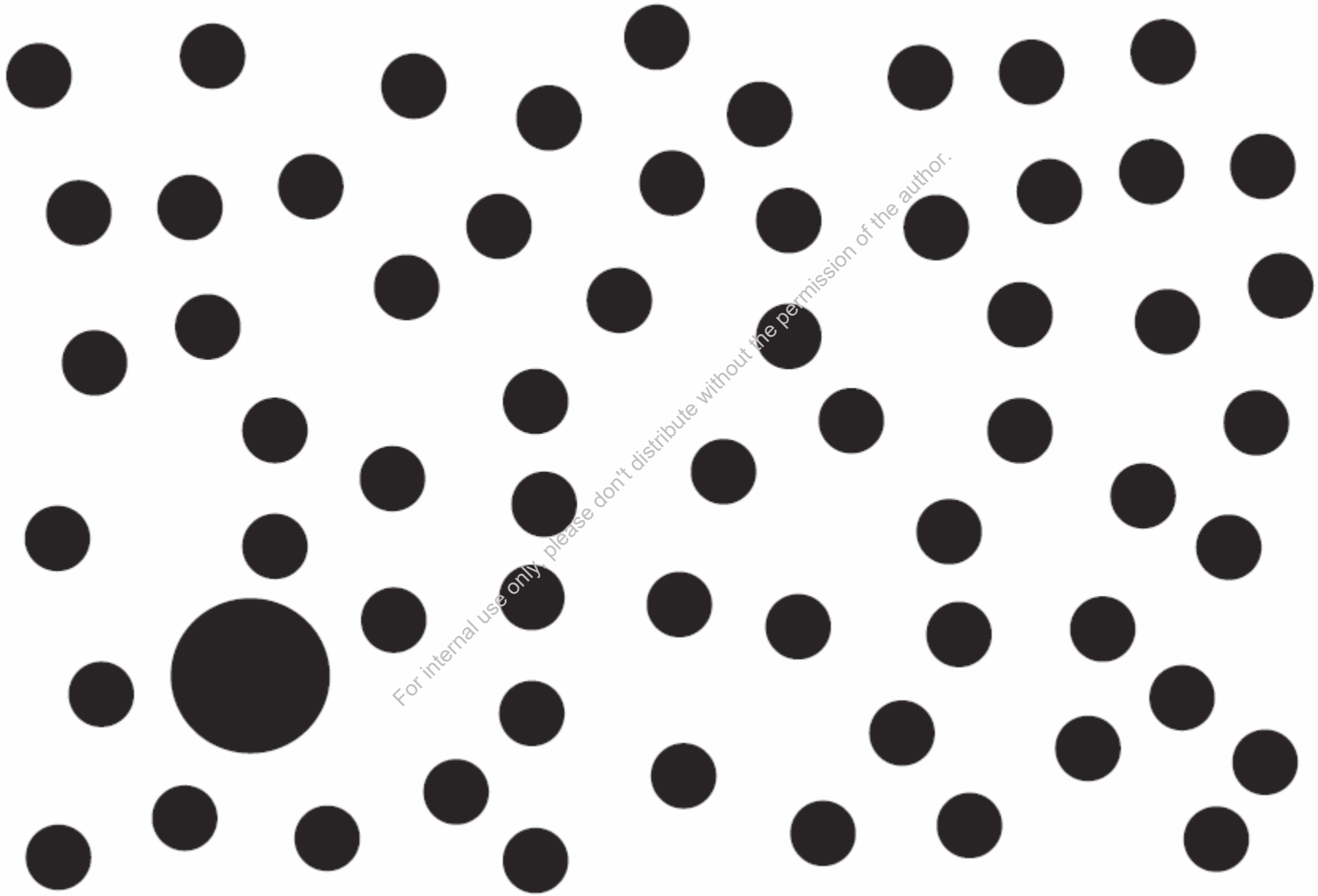


What Lessons Can We Draw from This Paradigm to Help the Design of Visualization Systems?

How to Draw Users’ Attention?





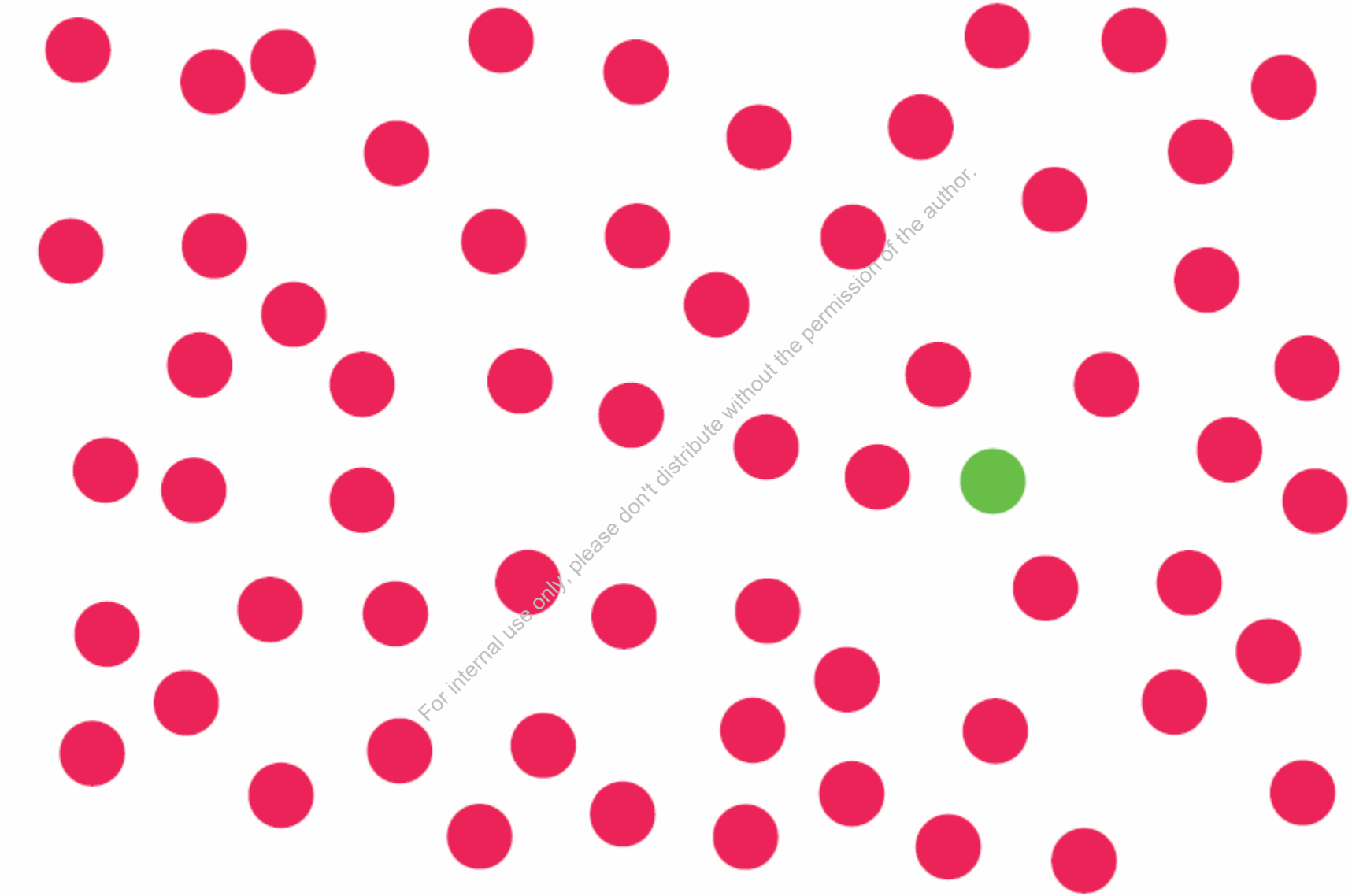


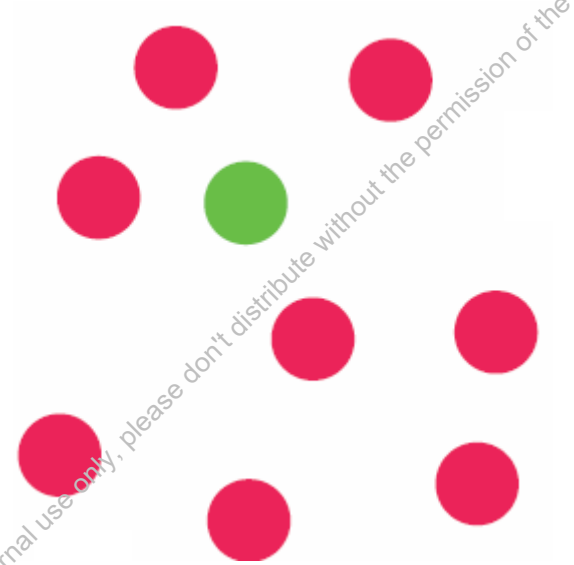
What Stands Out?

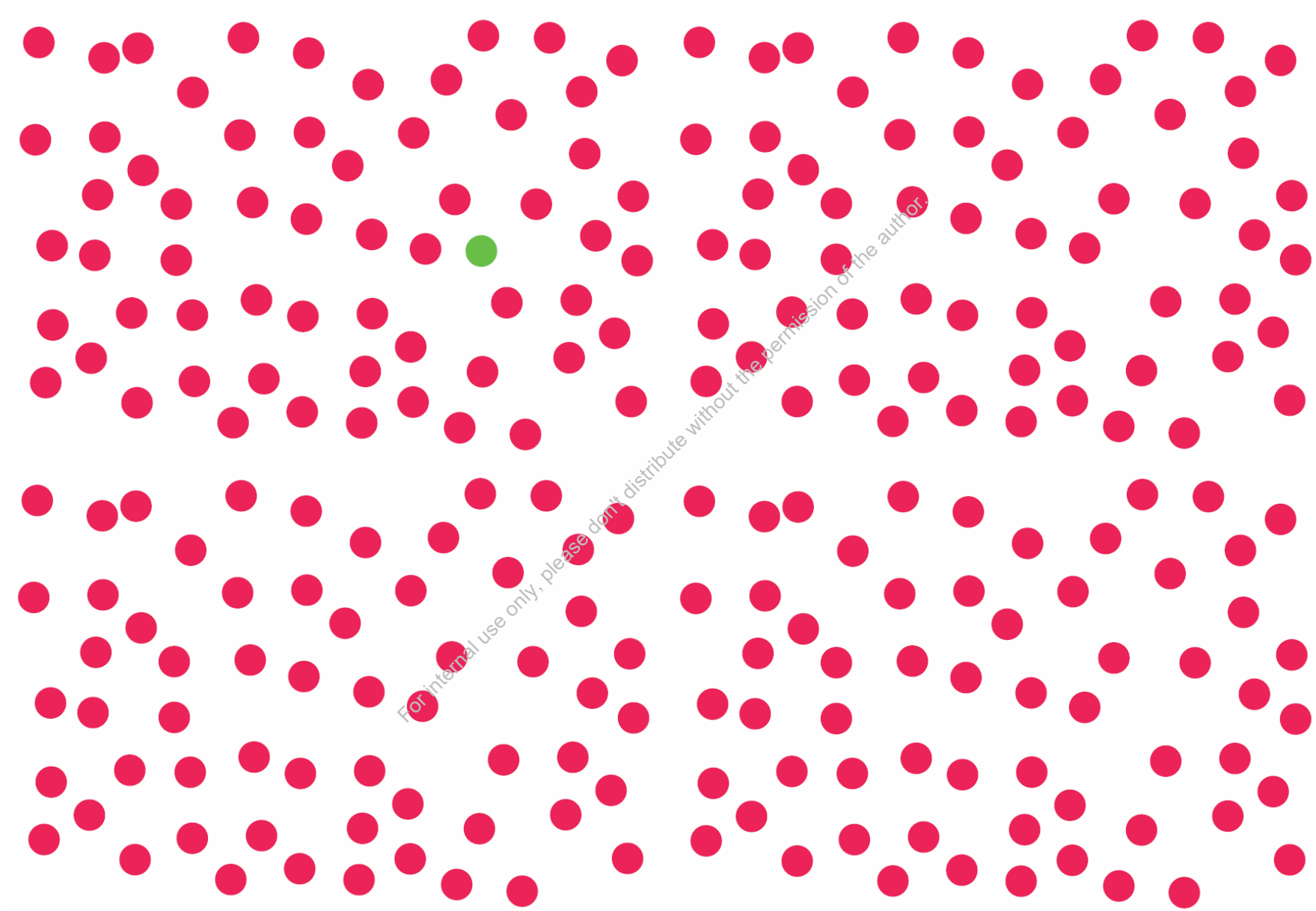
What Objects Stand Out?

Pop Out Effect

- Objects with certain unique features will pop out of the distracters in the background.
  - The number of distracters does not matter.

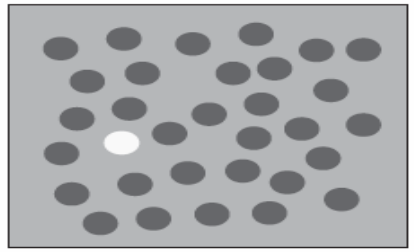


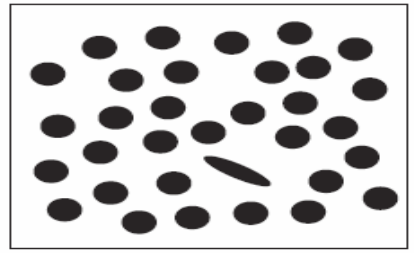


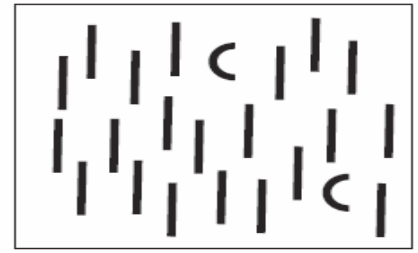


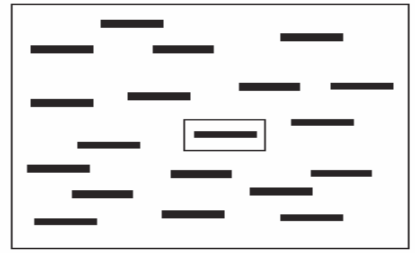
Pop Out Effect

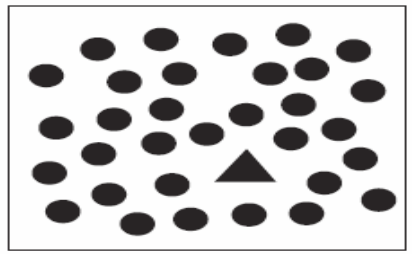
- Objects with certain unique features will pop out of the distracters in the background.
  - The number of distracters does not matter.
- Very quick
  - 0.1 second
- Various visual features can give rise to pop-out effect.
  - Color, shape, orientation, motion, stereoscopic depth, etc.

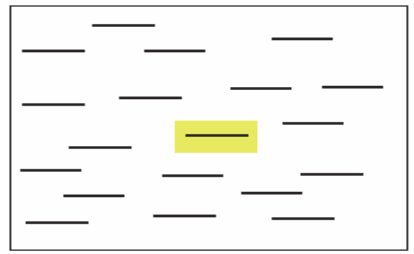

Grey value

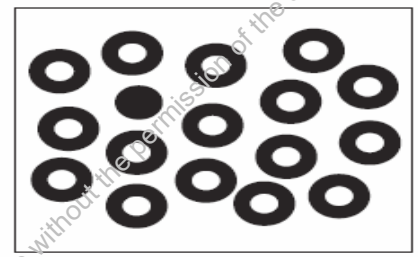

Elongation

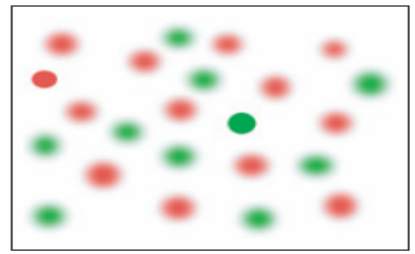

Curvature

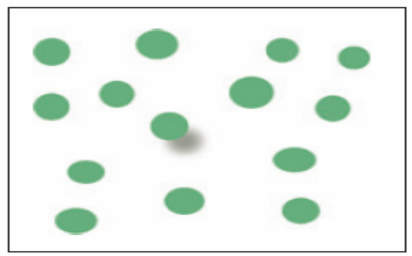

Added surround box

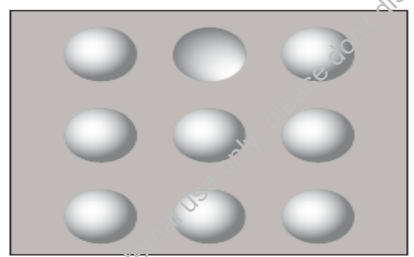

Shape

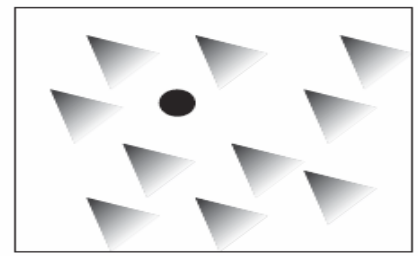

Added surround color

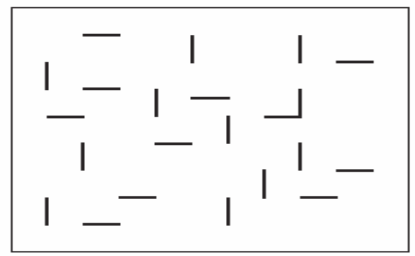

Filled

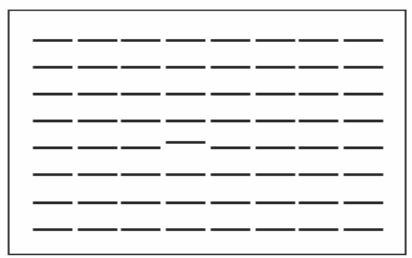

Sharpness

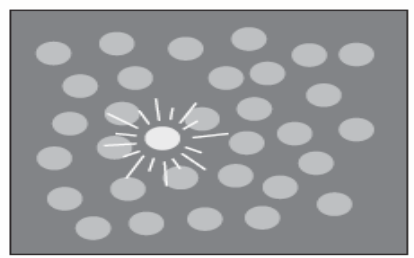

Cast shadow

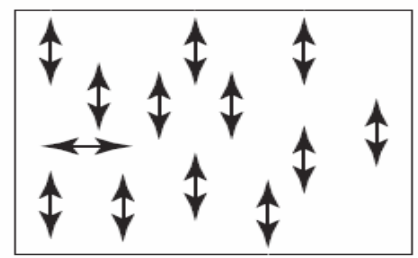

Convex and concave

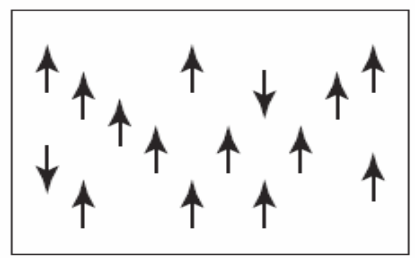

Sharp vertex


Joined lines


Misalignment


Blinking


Direction of motion


Phase of motion

Pop Out Effect

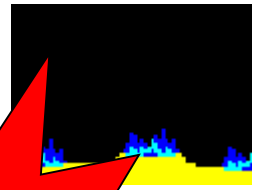
- Objects with certain unique features will pop out of the distracters in the background.
  - The number of distracters does not matter.
- Very quick
  - 0.1 second
- Various visual features can give rise to pop-out effect.
  - Color, shape, orientation, motion, stereoscopic depth, etc.
- Visual distinction between the target and the distracters should be large enough.

Motion

- Very powerful pop-out effect.
  - Results of long-term evolution
- In particular, things that emerge into the view.
  - Design: interruption
    - Quick motion vs. slow motion
- Abuse of motion
  - Online commercials
    - High-frequency, rapid motion
  - TV commercials

BANDWIDTH SPEEDS -

WARNING!



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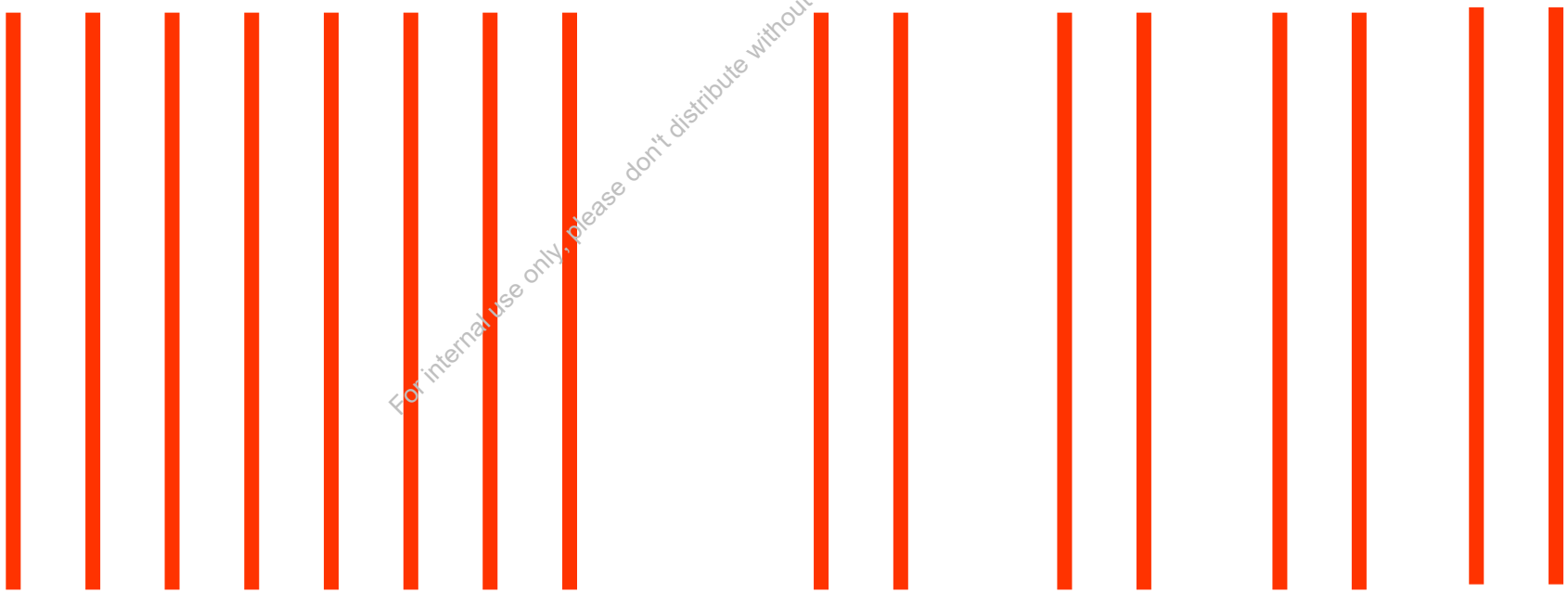
CONGRATULATIONS! YOU'VE WON! Click Here

How We Perceive Spatial Form, Shape, Structure, and Patterns?

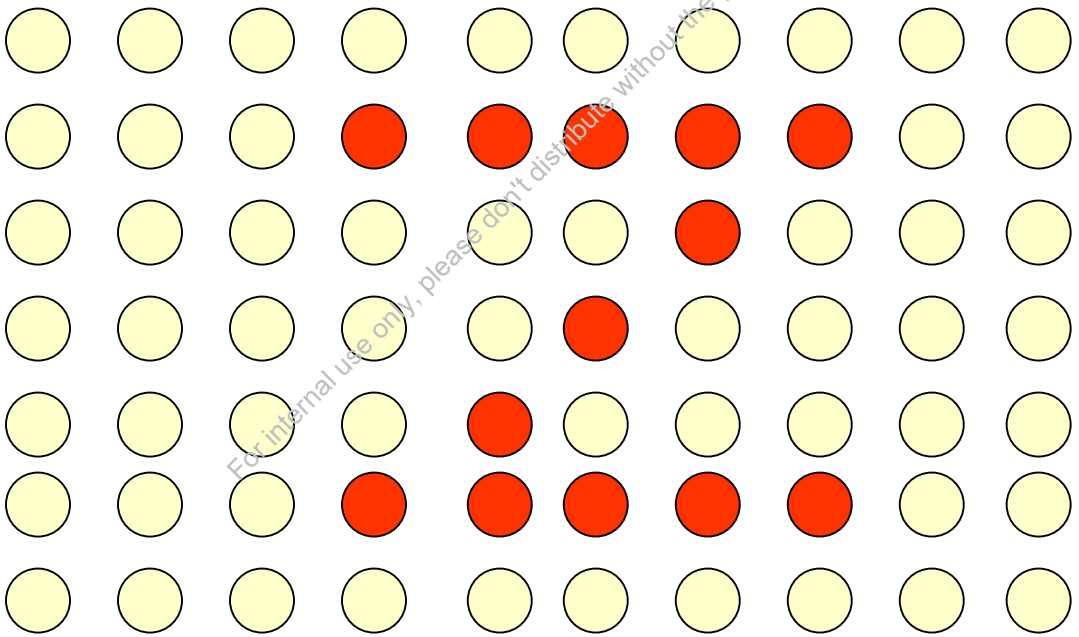
Law of Proximity

- Things that stay close tend to be regarded as a group



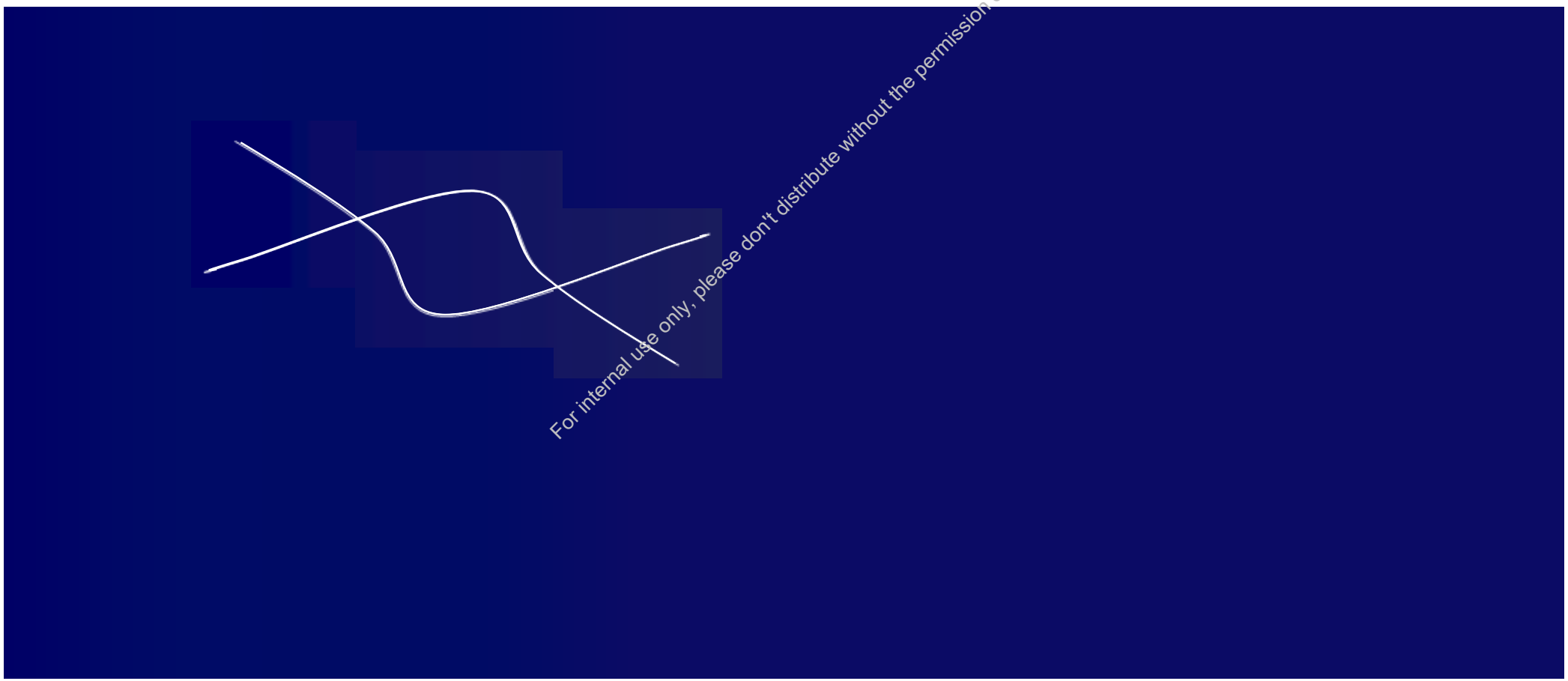
Law of Similarity

- Similar objects tend to be seen as parts of the same pattern



Law of Continuity

- Tendency to perceive unseen parts of a patterns as continuing in a predictable and simple manner



Goal-Oriented Eye Movement

- We must rely on eye movement to see the world better.

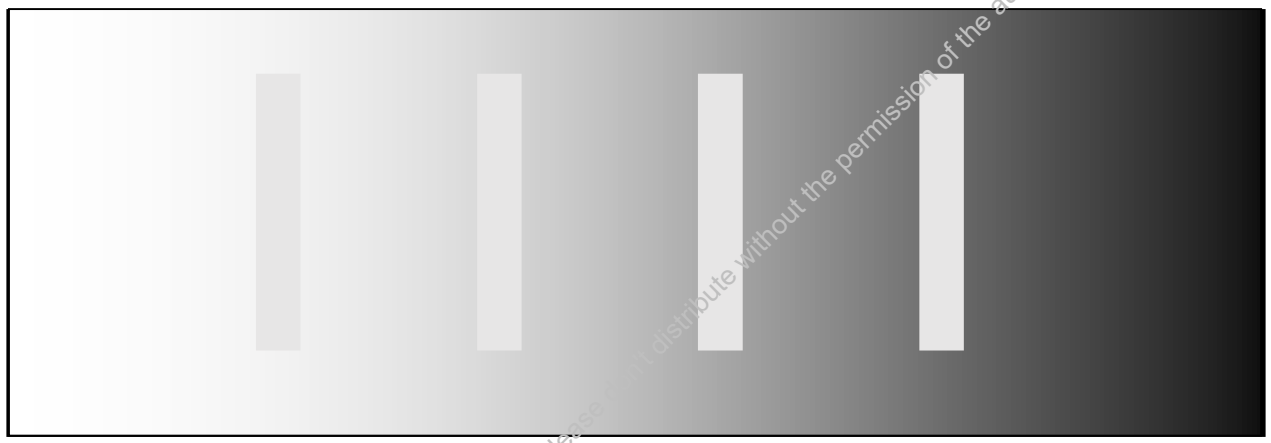
How affluent?

What are their ages?

Accurate Representations

- We often use graphs to compare measures.
- Can we human beings accurately tell the difference between graphs?

Using Brightness to Represent Values

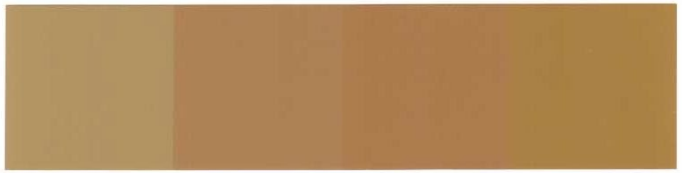


Use Color?

Skirt Color: White-Gold or Black-Blue

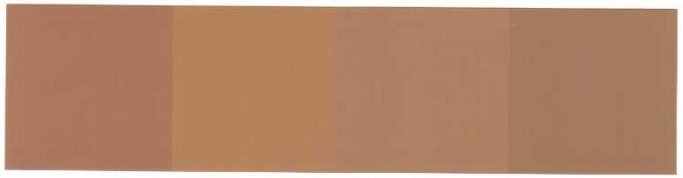
Why?

Our Visual Perception Is More about the Difference between External Information, Rather Than Absolute Values!

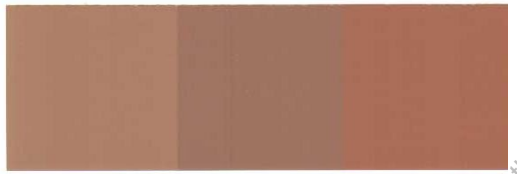


Champagne	Sierra	Yellowstone	Gold
420	605/30	605/30	420
2 lbs.	2 lbs.	3 lbs.	4 lbs.

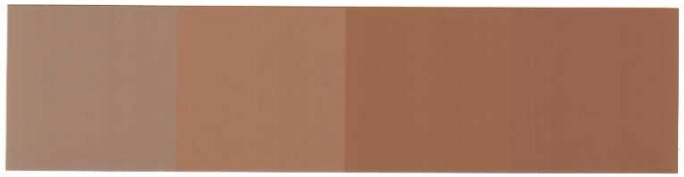
Buckskin	Doeskin	Dark Buff
6524	6530	6524
2 lbs.	3 lbs.	3 lbs.



Pine Needle	Sandstone Buff	Latte	Mocha
3396-X	960/4	6524	6530
1 lb.	1.5 lbs.	1 lb.	1 lb.

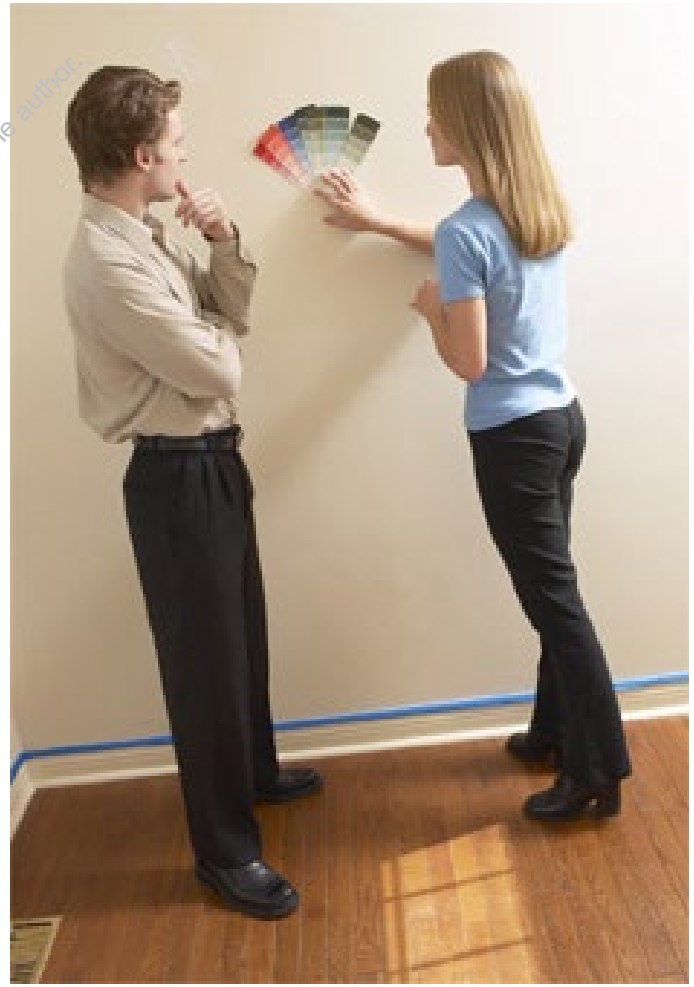


Fawn	Boulder	Cinnamon
1300	6567	1300
.5 lb.	1 lb.	1 lb.

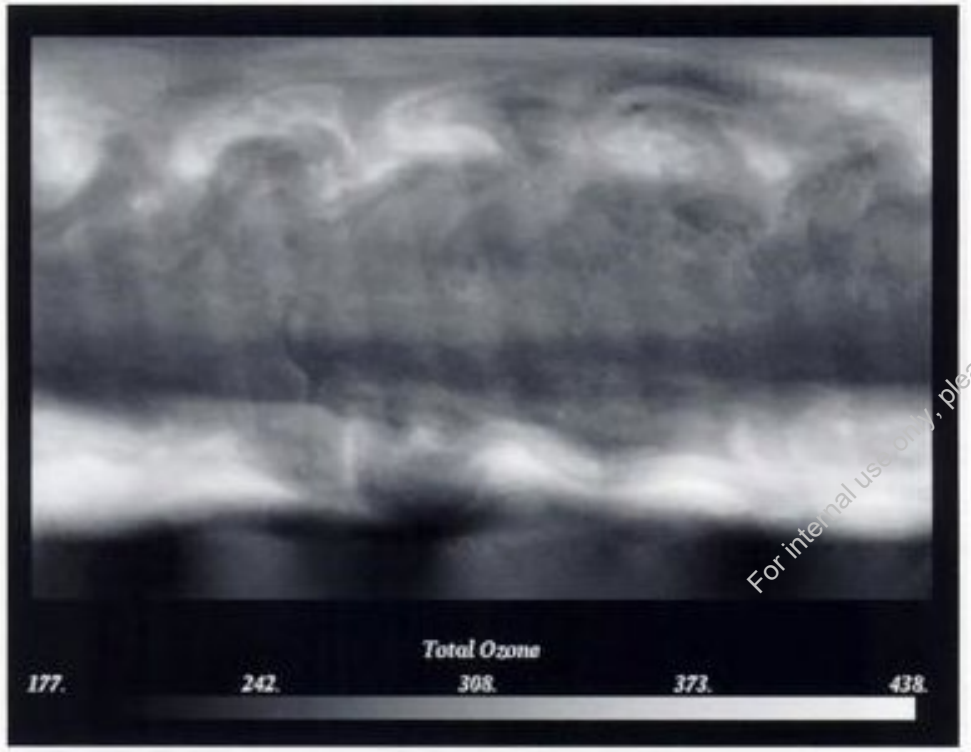


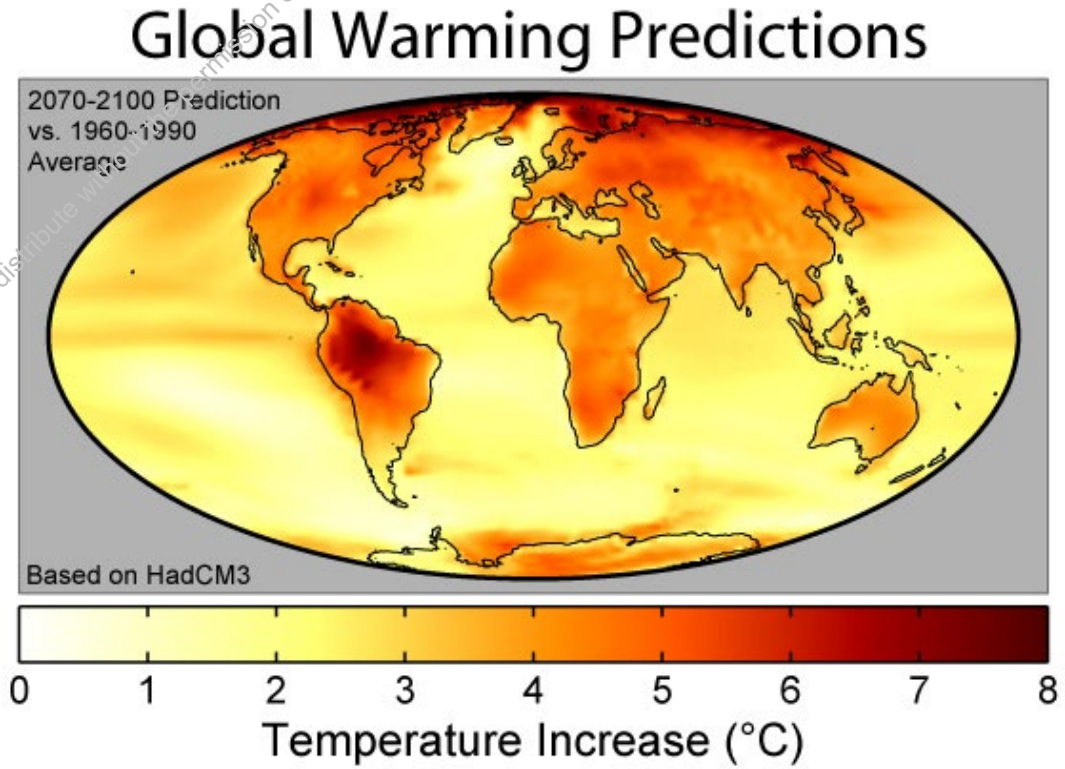
Willow	Maple	Camel	Autumn
6567	6557	6530	6557

Mission	Terra Cotta	Coral Red
130	110	130



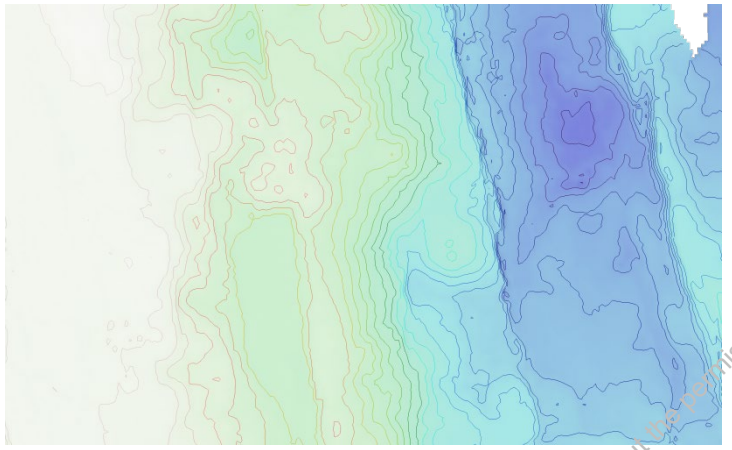
We May Make Errors in Reading This Figure

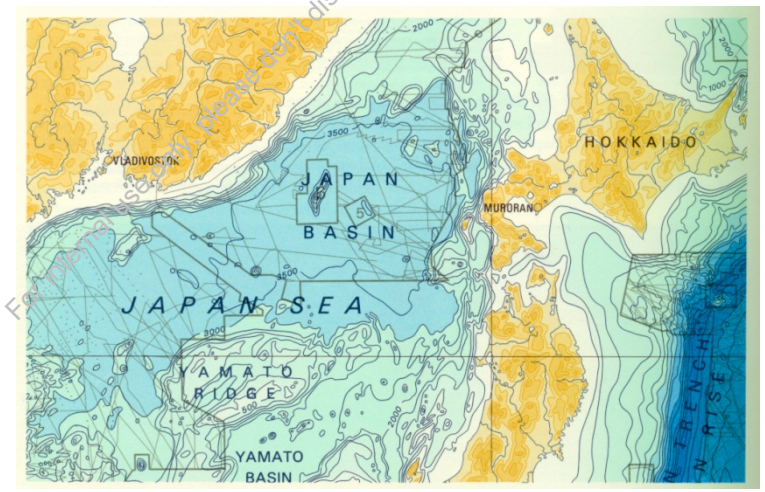


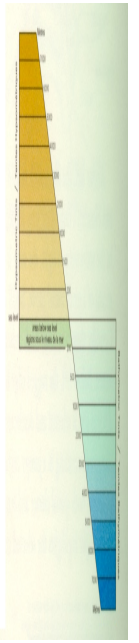


Spectrum Sequence

- The whole spectrum sequence is not perceptually ordered.
  - Part of the spectrum is.
- To use spectrum sequence, you should provide color keys.
  - Ordering colors according to their luminance.

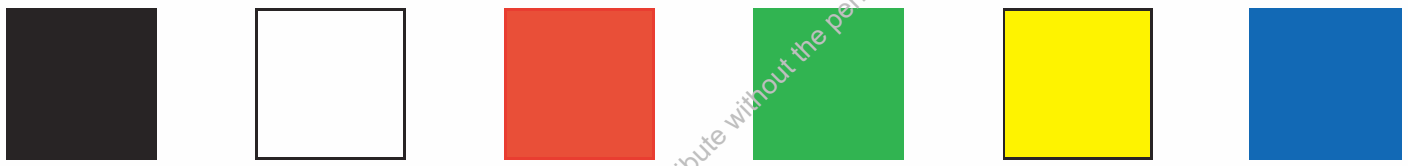




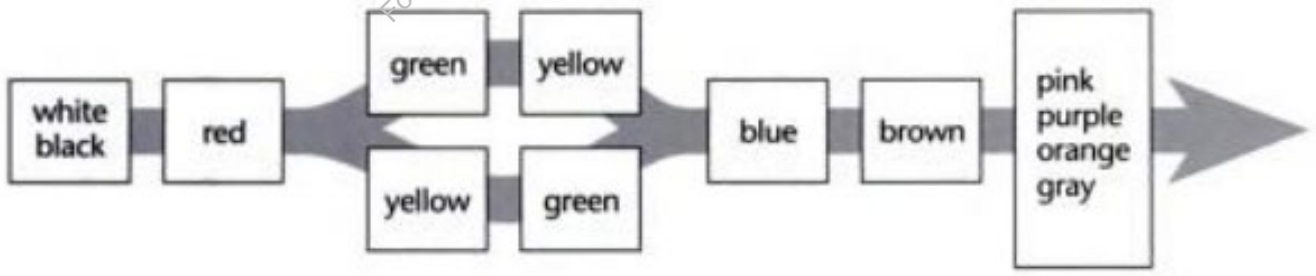


Unique Hues

- Six basic colors

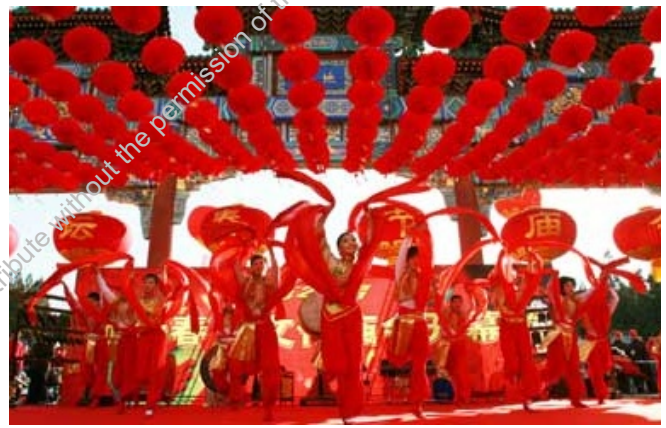


- Cross-Culture Names



Semantics of Color

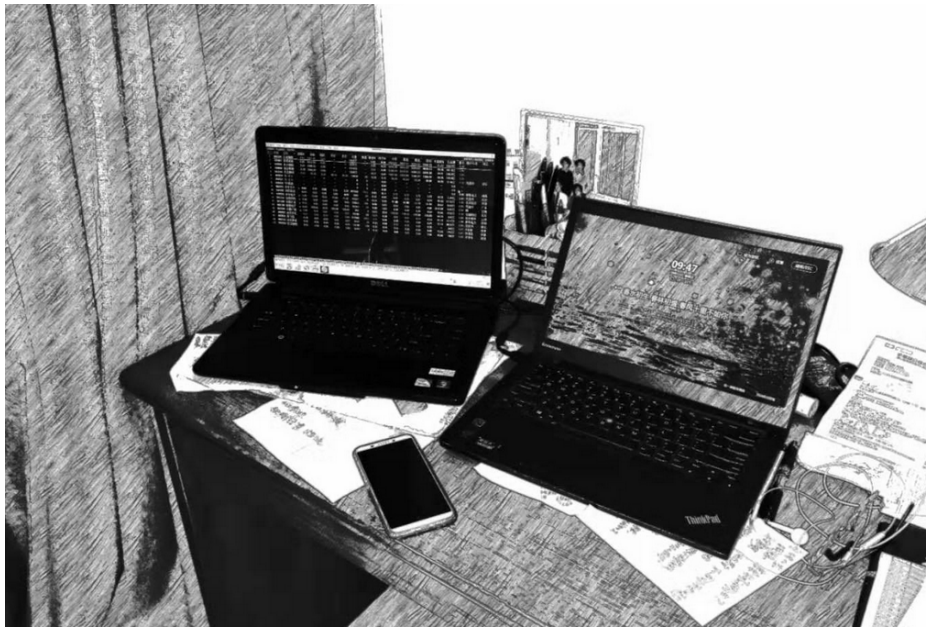
- Could be culture-dependent



Inadequacy of the Second Paradigm

- Success of GUIs has made PCs ubiquitous and deeply integrated into people's work and life.
  - People need computers to do more, supporting all kinds of interactions.

*a **Computer** on every **desk** and in every **home***



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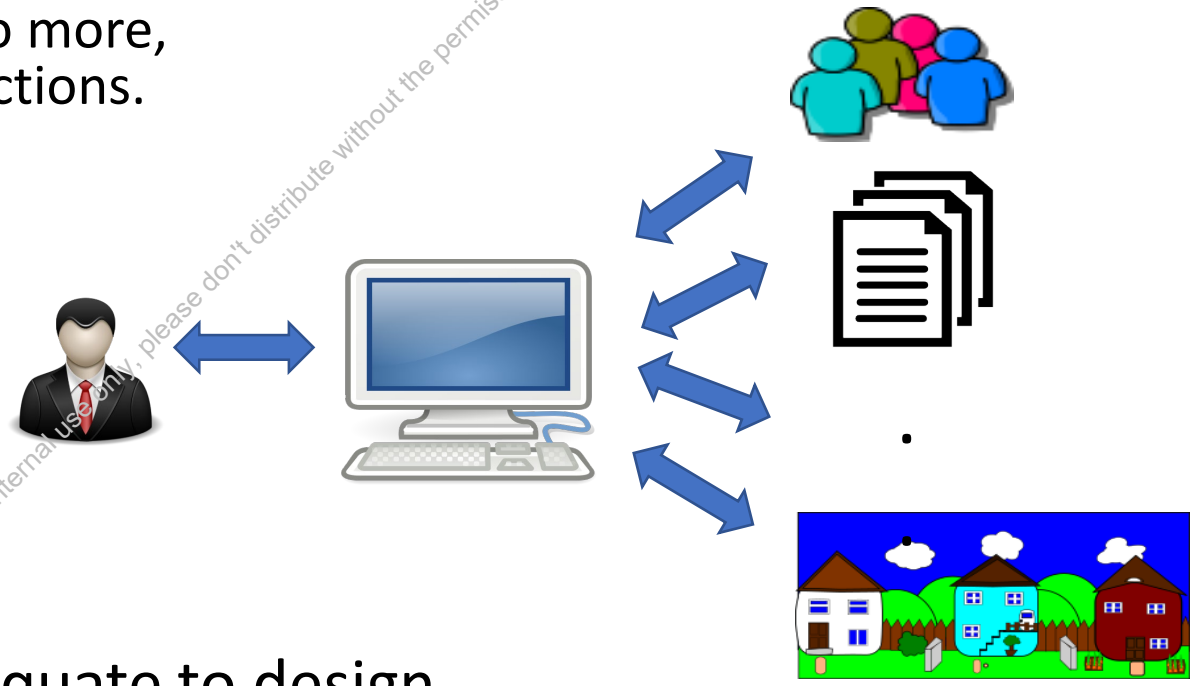


- Individual cognition is inadequate to design.
  - Must consider other contextual factors.

Phenomenologically-Situated

Phenomenologically and Situated

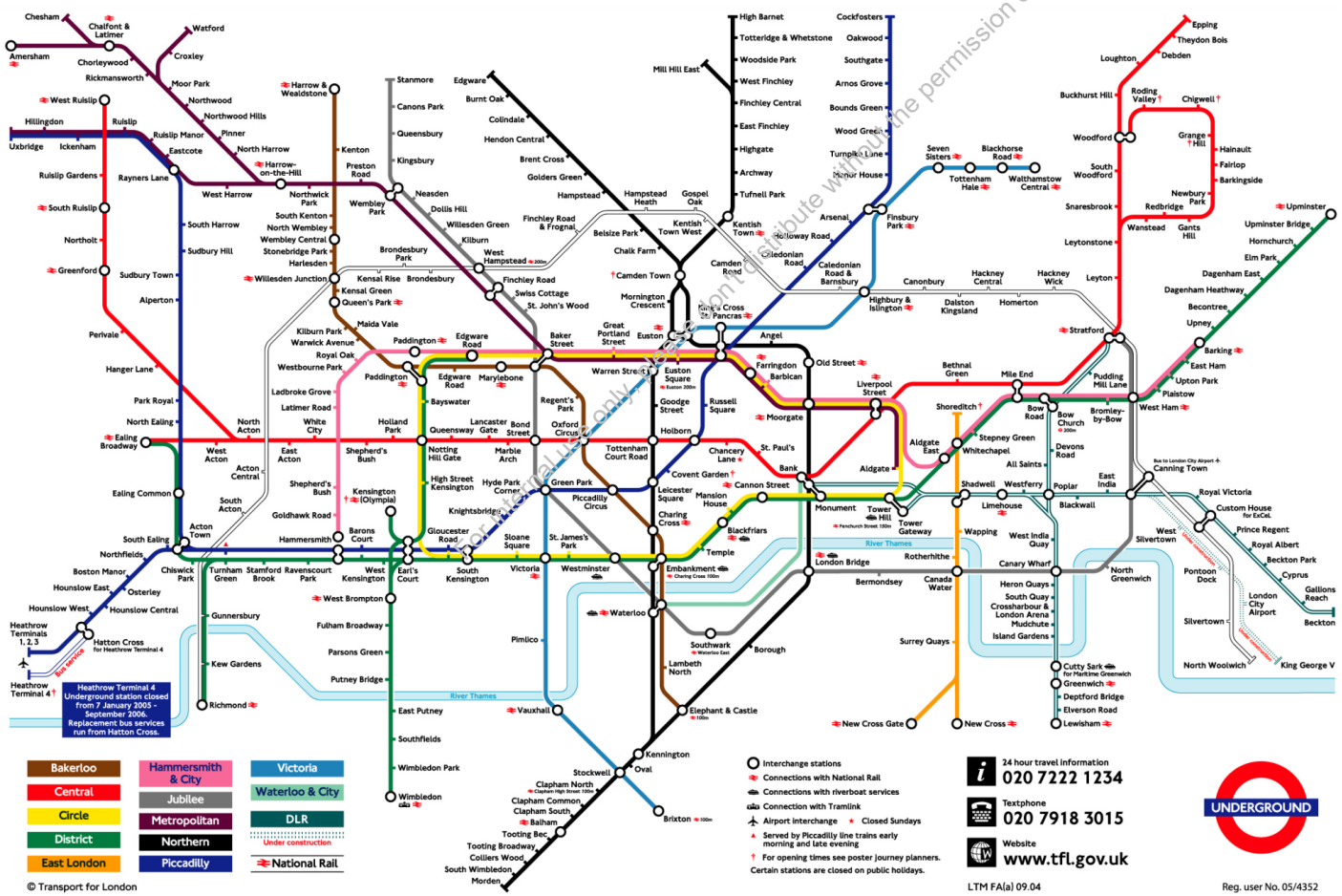
- Phenomenologically
  - 字面意思：现象学角度下的
  - Phenomenology: how we experience
  - Meaning: 由个人经验和意识的结构角度下的（强调主观视角）
- Situated
  - 字面意思: 位于…
  - Meaning: 设身处地的
- Put them together: 现象学角度下的情境设计
  - Interaction is determined by who the user is, what the user knows, where the user is, what the user is doing, with whom the user is, ….
    - Must consider the complexity of user, his/her experience/view/knowledge/skill, task, environment, and other relevant factors.

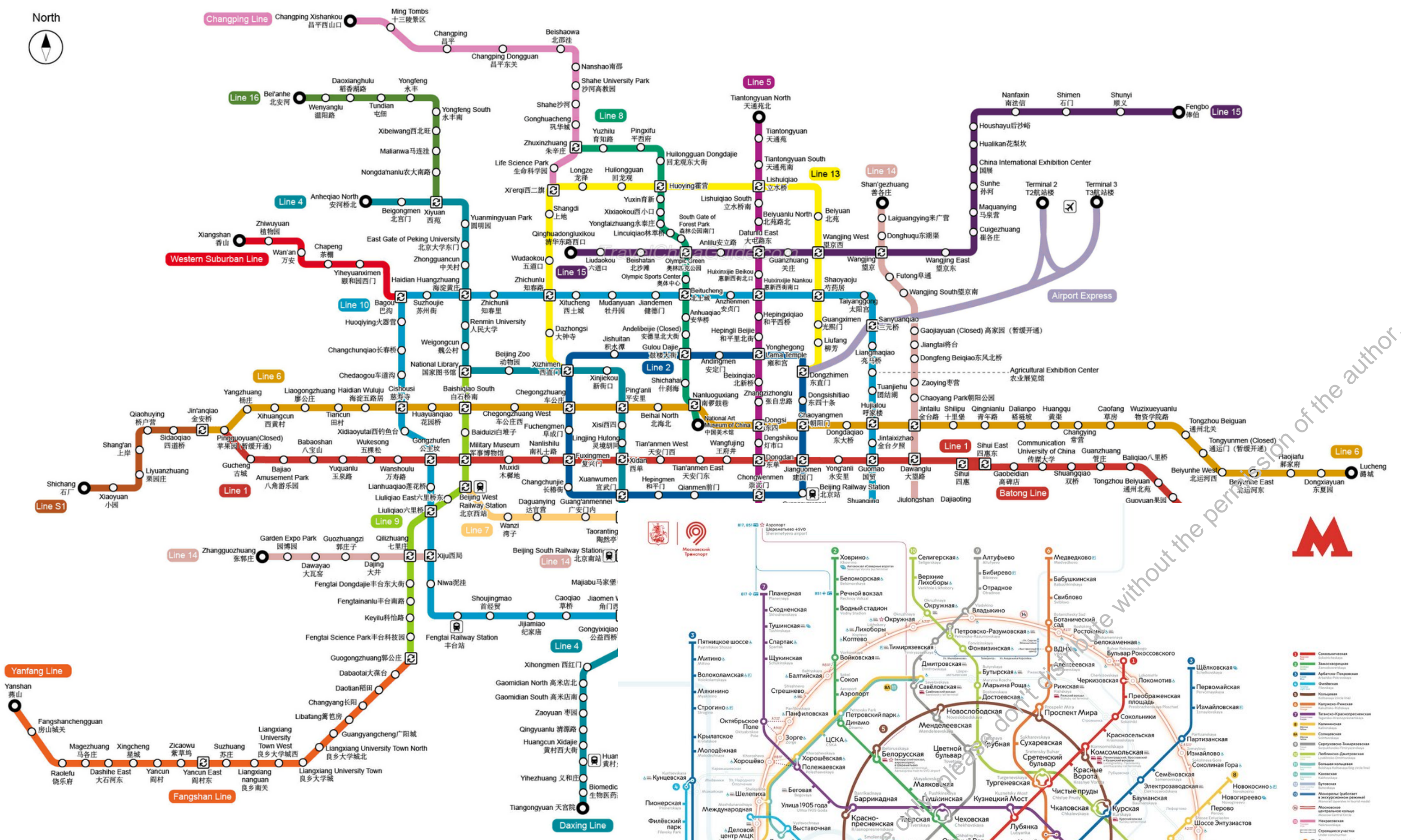
Fundamental Difference in Design between the 3rd and the Previous 2 Paradigms

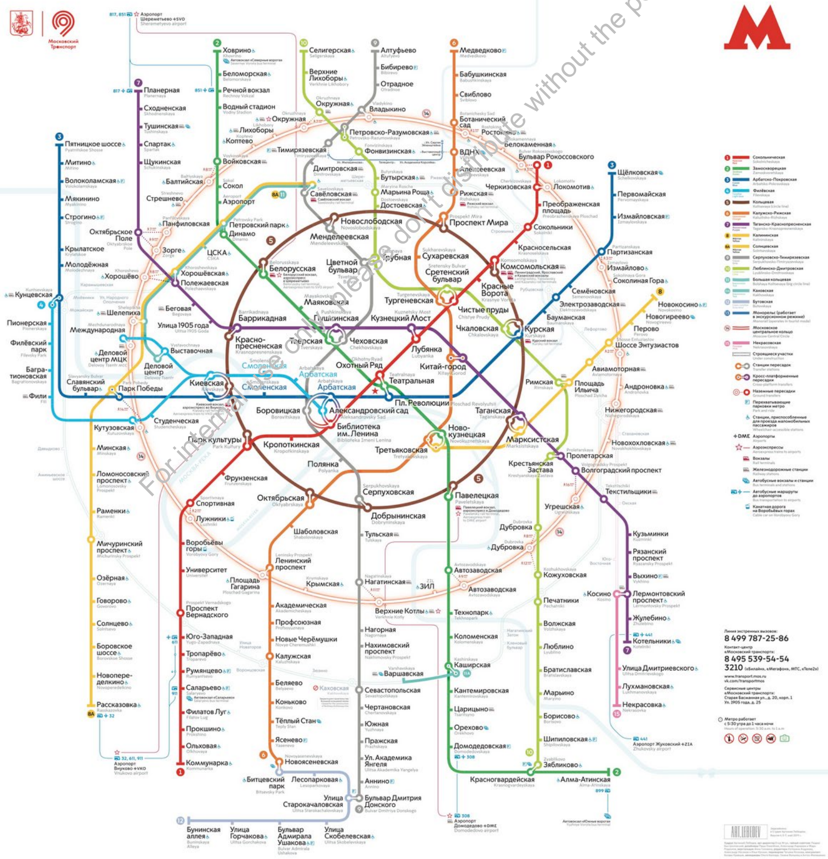
- Research under the first two paradigms usually seeks one single design that can be broadly generalized various situations.
  - Mouse is more efficient for most people in most application domains.
  - Progress bar is preferred by most users to understand the progress of a task.
  - .
- Research under the third paradigm does not seek single answer, but provides “thick description to instigate a design process”, the results of which are open and not necessarily optimal.
  - Each individual is different, so may carry out the same task very differently.

An Example:
Subway Map vs. High-Speed Rail Map

- London underground map as the exemplar for subway maps



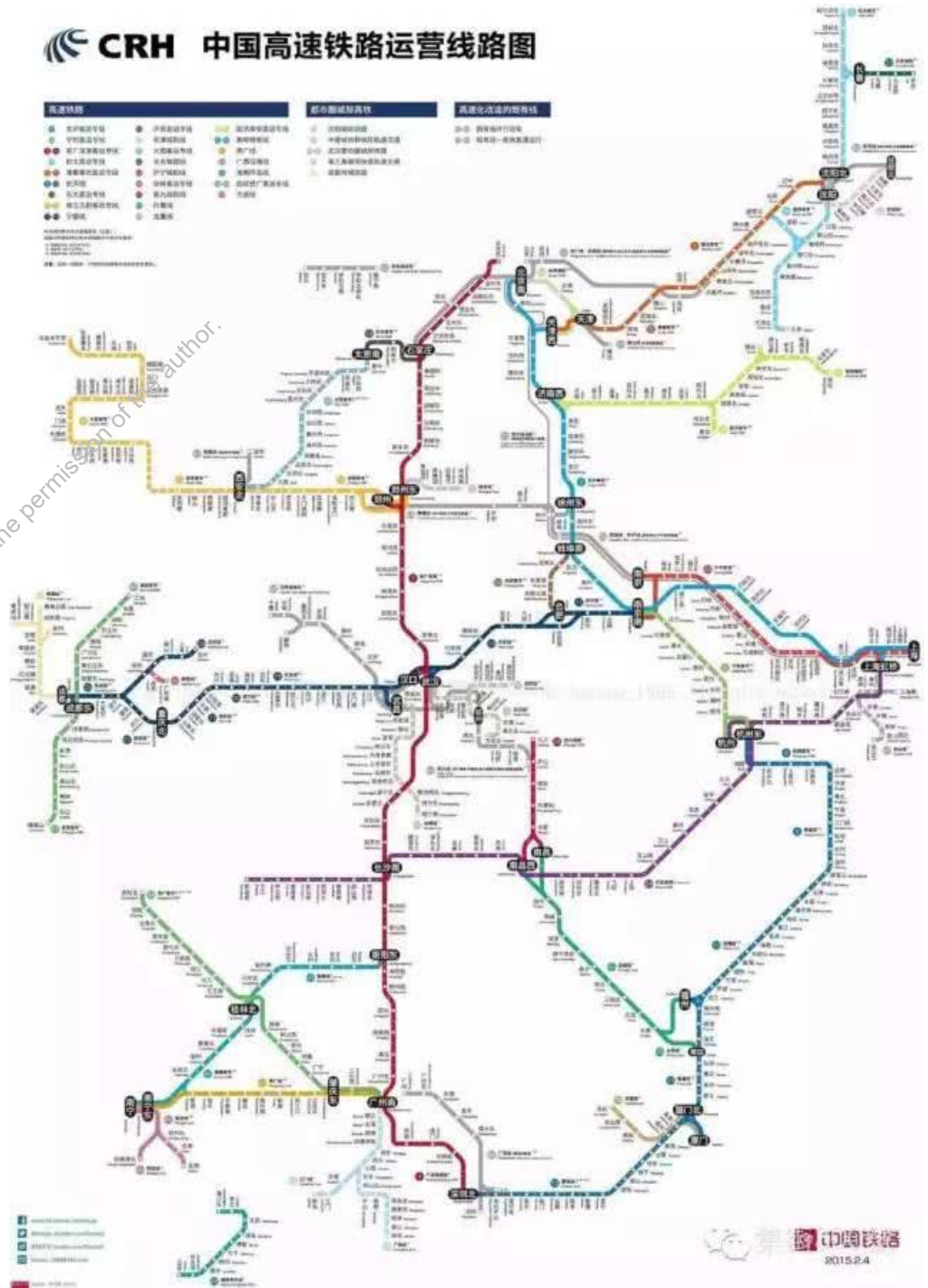

North
Changping Line
Line 16
Line 4
Western Suburban Line
Line 10
Line 6
Line 1
Line S1
Line 9
Line 7
Line 14
Line 5
Line 8
Line 13
Line 15
Line 2
Airport Express
Batong Line
Yanfang Line
Fangshan Line
Daxing Line
Terminal 2
Terminal 3


Киевская
Белорусская
Комсомольская
Курская
Таганская
Октябрьская
Парк культуры
Театральная
Охотный Ряд
Лубянка
Китай-город
Пл. Революции
Библиотека им. Ленина
Александровский сад
Боровицкая
Арбатская
Смоленская


New York City Subway Diagram
The Bronx
Manhattan
Queens
Brooklyn
Staten Island
Stations and connections
Subway Services

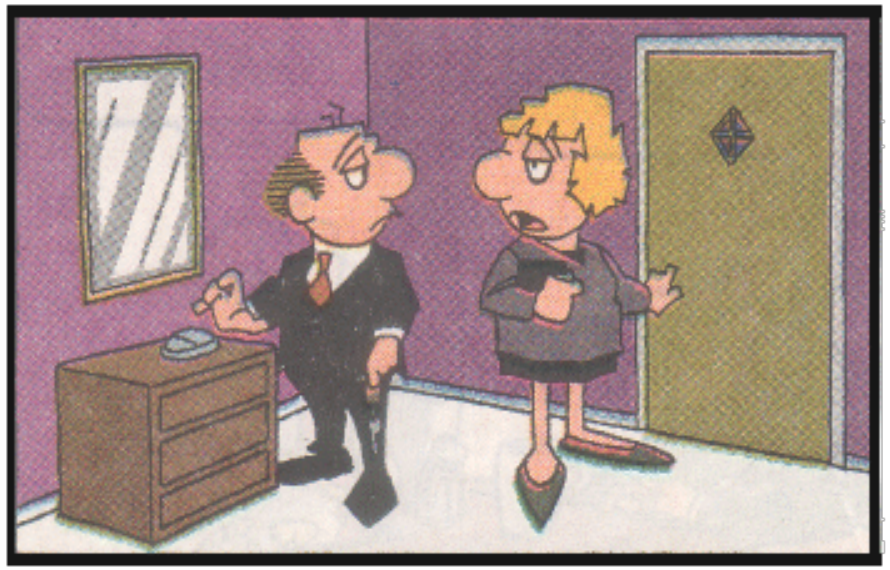
【分享】终于有神人把全国高铁图画得像坐地铁一样方便，赶紧收藏了！

Really?



Another Example

- While touch-based interaction lets senior citizens enjoy smart phones, why is it so hard for them to be the master of their phone?



"Leave the cell phone . . . if it rings, people will see you don't know how to answer it."

Design Methods

- Requirement acquisition
  - Becoming the most important component in the whole process
  - Heavily qualitative-oriented
    - No hypothesis, no pre-determined position, extracting meaning from subjects from interview/field study)
  - Thick description on the first-hand experience of subjects
    - Who they are, what they usually do, what vocabulary they use, how they interact with technologies, etc.
  - Outcomes are often a set of design requirements that are generated from the perspective of subjects, indeterminate, and results of compromise.
- Design
  - Integrating complex contextual factors
    - No longer just a device, a widget, a page, a single task.
    - Often a process, a series of tasks, …
  - Drawing on theories from social science, humanity, etc.
    - Social cognition becomes one of the foundations for design.
- Evaluation
  - Usability study is inadequate, because efficiency is no longer the focus.
    - Experience, emotion, user adherence, …
  - Long term evaluation is preferred.

Contribution of This Paradigm

- Fully recognizing the complexity of human activities and inadequacy of engineering-oriented, computer-science-oriented approaches in interaction design
  - No silver bullet
- Promoting the integration of engineering, computer science, social science, design, and other relevant disciplines

Success of This Paradigm

- Not necessarily consciously adopted by designers
- iPhone vs. Android
  - Considering user experience, user knowledge, …
  - Function difference is minimal, but with very different interaction experience.
- Facebook vs. WeChat
  - Considering the social and cultural characteristics
  - Both are about social networking, but under different cultural considerations.
    - Strangers vs. Friends
- Mobile payment in USA and China
  - Considering the infrastructure factors.
  - Mobile payment in USA
    - Credit card on a phone: convenience is insignificant.
    - The earliest mobile payment system I saw was around 2006 in USA
      - Using SMS
  - Mobile payment in China
    - Skipping the credit card stage.
    - Support from banks (?).

More and More Successful Products and Services

- Due to the intentional or unintentional use of this paradigm
- Companies can collect more high-quality data.
  - To understand users and their situations
  - To understand they needs and performances
- Companies can iterate designs more quickly and frequently.
  - Mobile apps in particular.

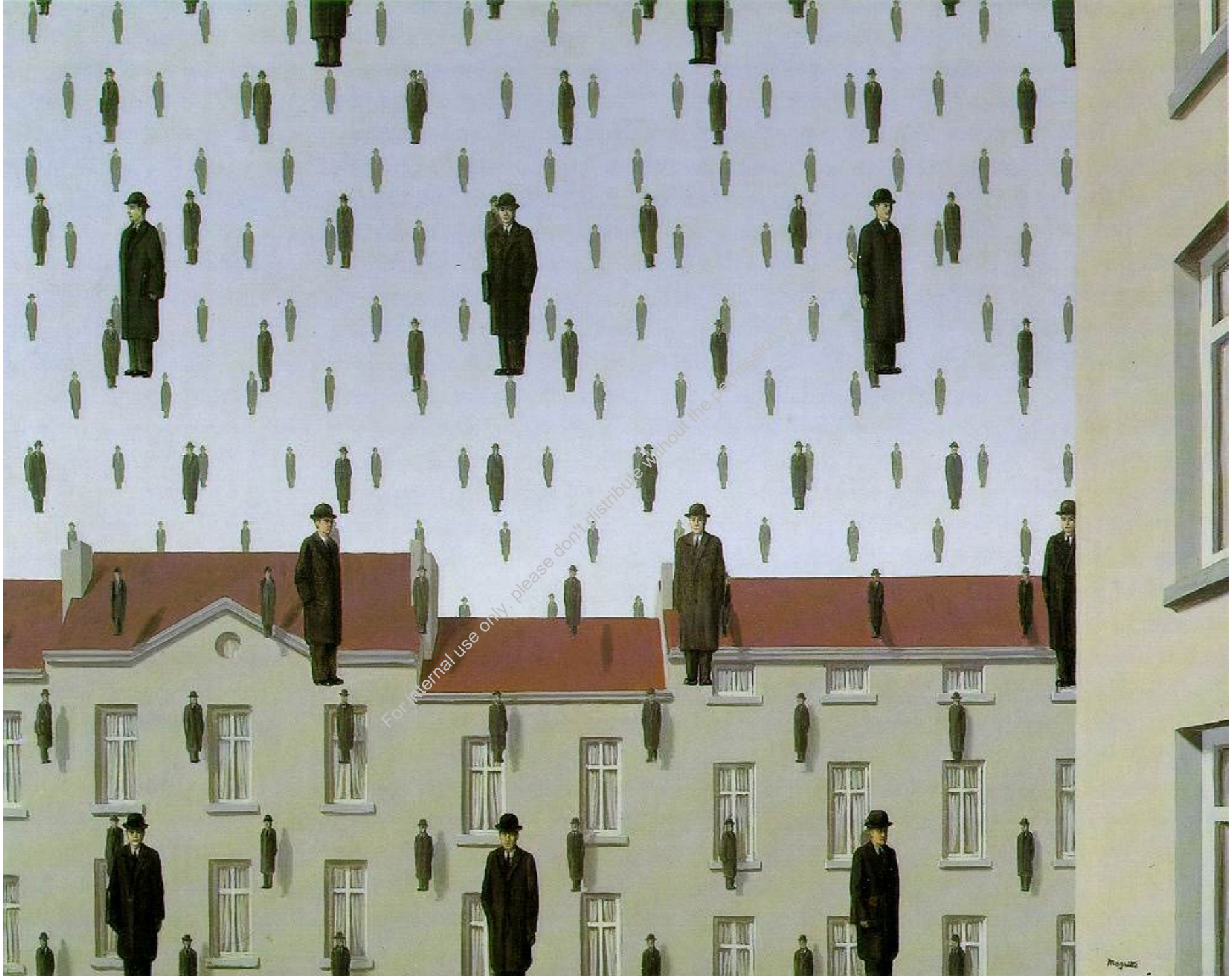
- In a sense, the paradigm becomes data-driven, phenomenologically-situated
  - Potential dangers: data may not reflect the truth.

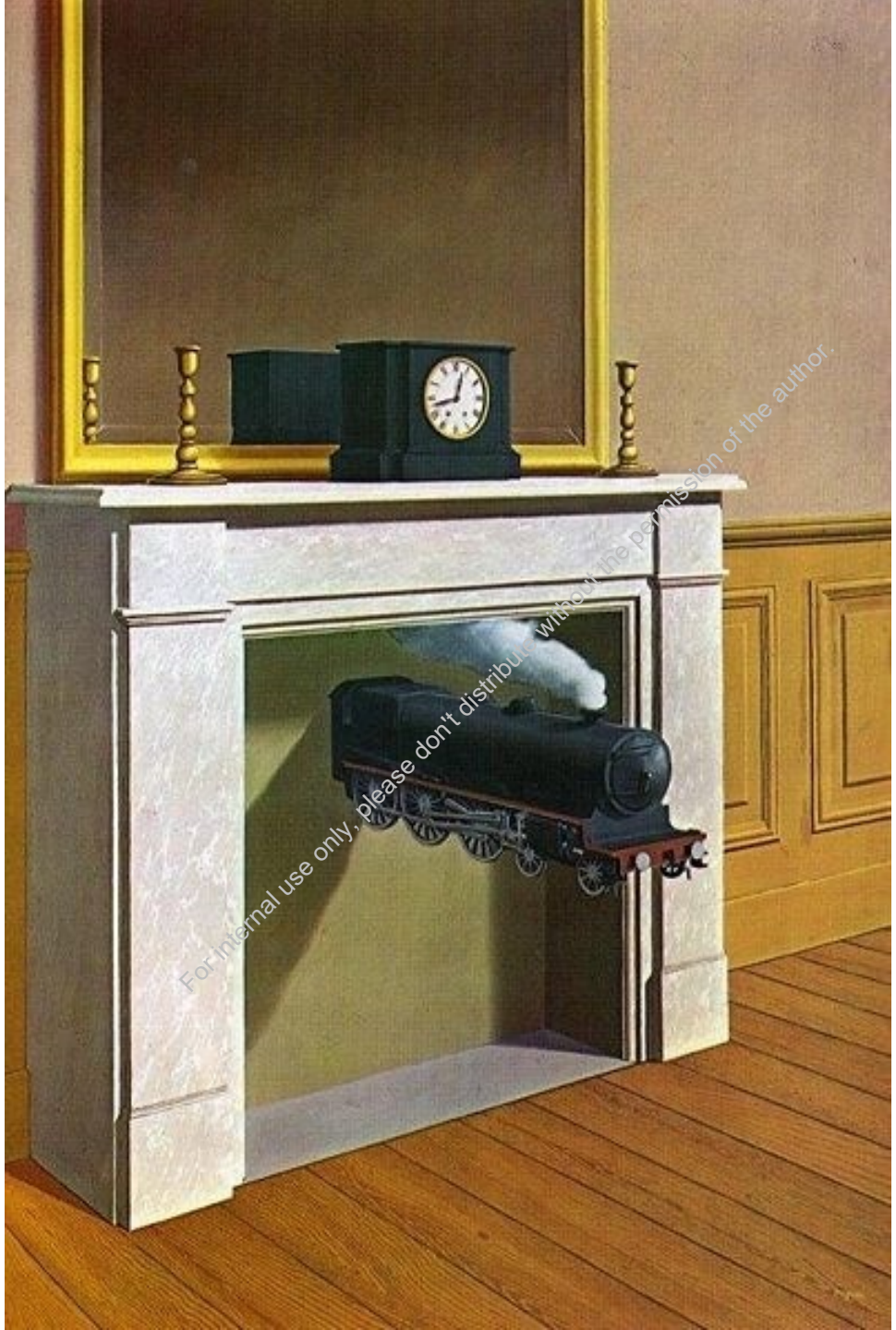
Challenges of This Paradigm

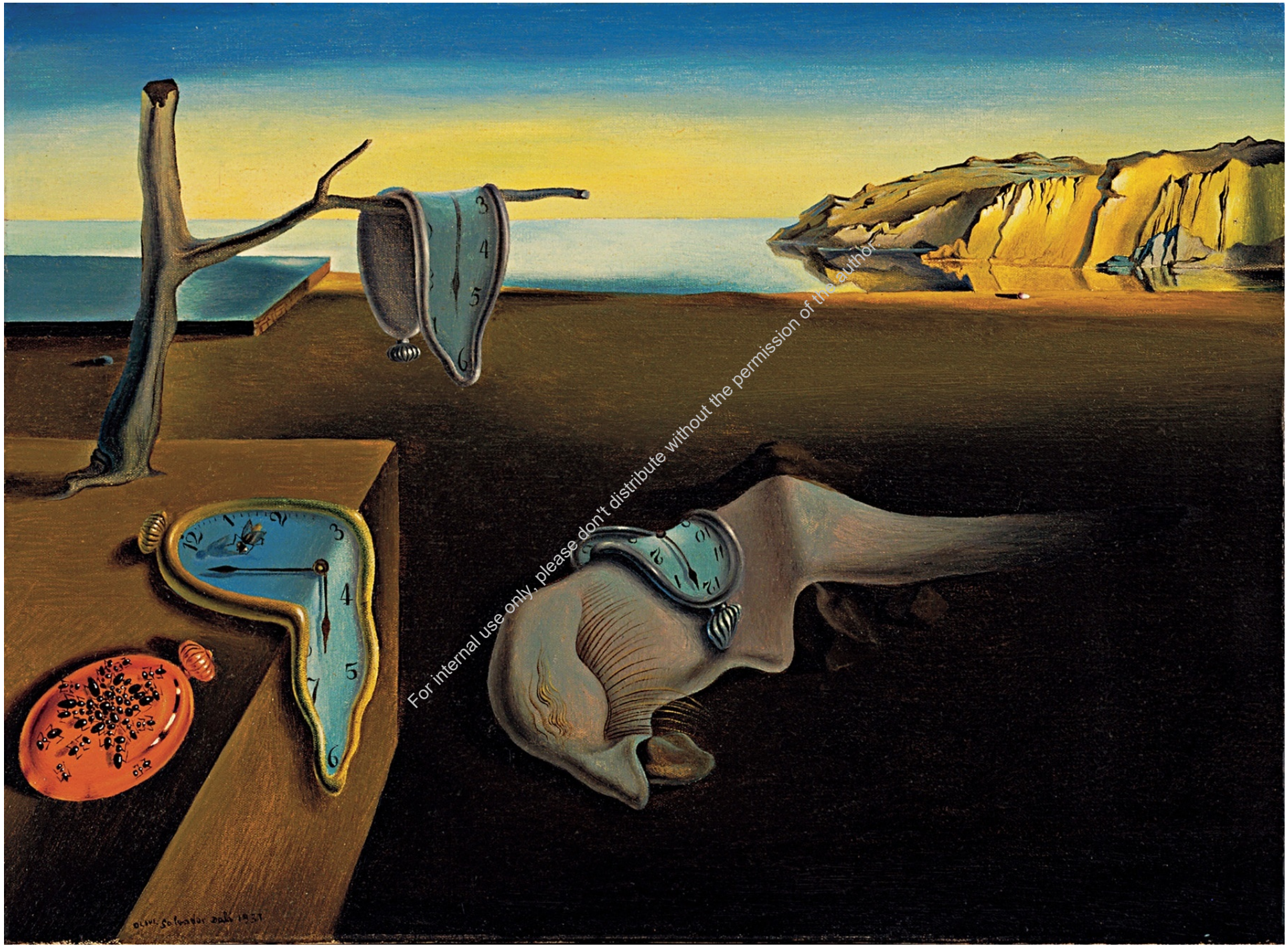
- Most complicated methods
  - Hard for an individual to master all necessary methods
    - Qualitative methods for interview and field study
    - Interaction design and implementation
- Indeterminate results
  - Many people have problems with results from non-positivism methods.
    - Not hard matrix for comparison: subjective or objective
    - Personal interpretations: bias
    - Limited generality: science is about true knowledge that can be generalized.

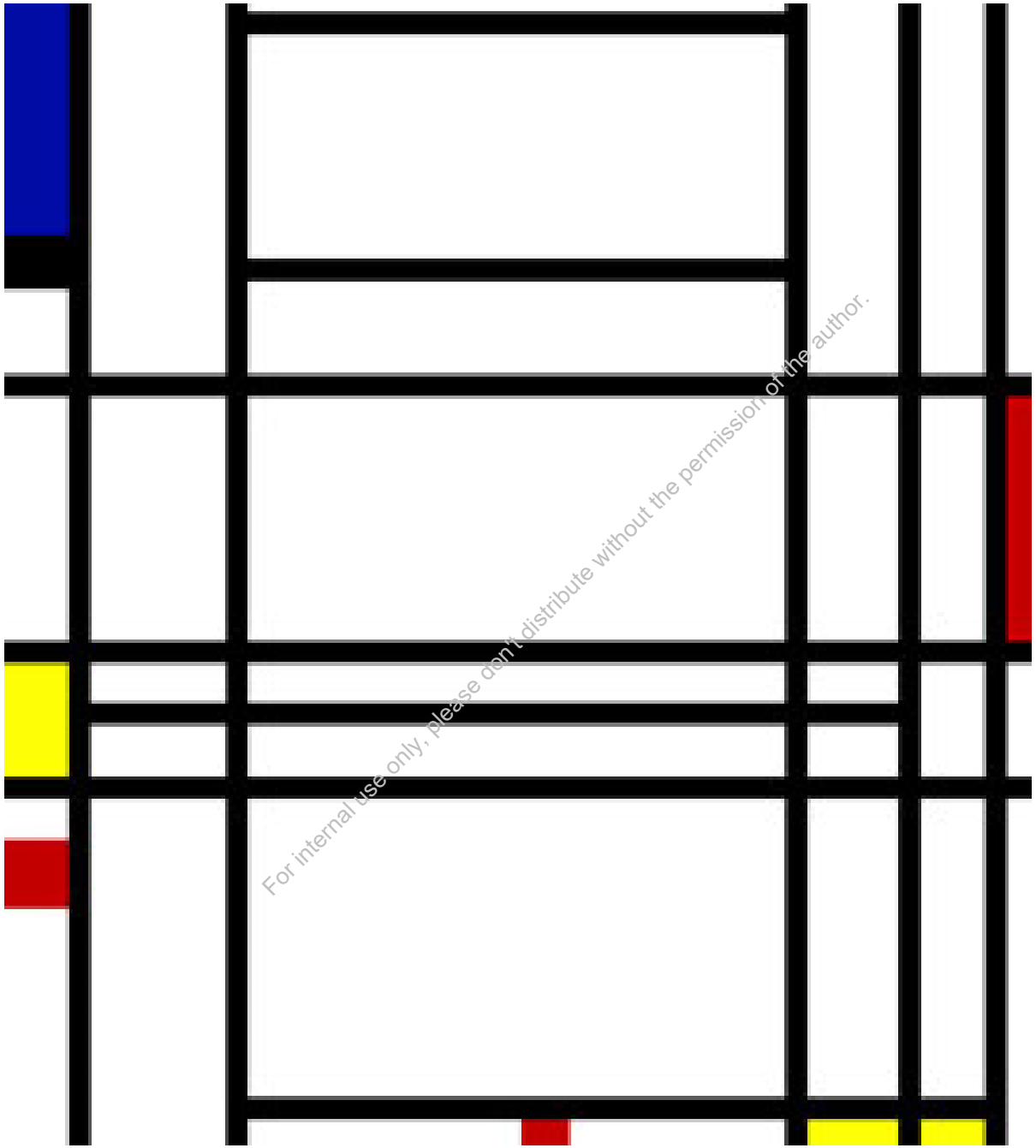
Relevance of This Paradigm to Visualization System Design?

Embedding Meaning in Visualization









"A picture is worth a thousand words"

- We human beings are very good at picking up the meaning of visual objects.
  - A small fraction of a second.
- However, not every picture can be quickly picked up.

Design Implications

- Making objects easy to identify
  - Using typical members or instances of their class
  - Showing from a typical viewpoint
  - Presenting structural relationships clearly.

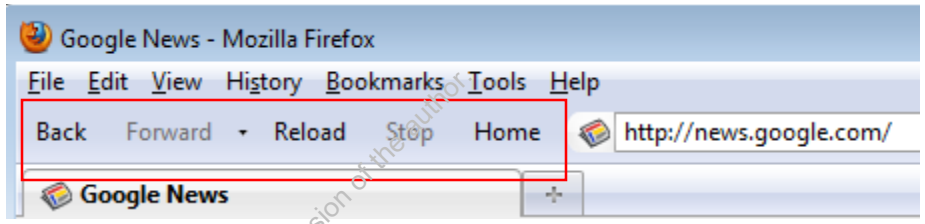
- E.g., Icon design
  - Don't invent new icons unless it is absolute necessary.

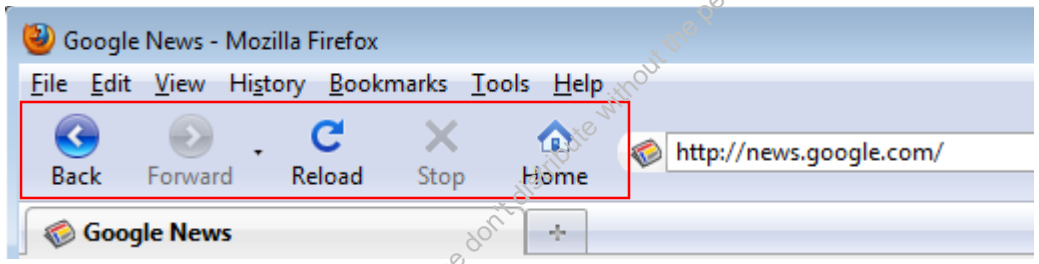
Sometimes, it is very hard to come up with a picture to describe an object, an action, a property, etc.

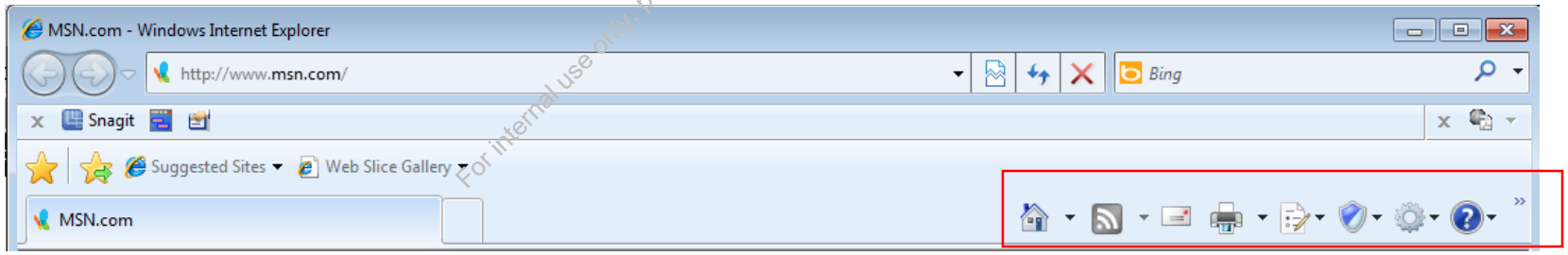
Visual vs. Verbal Language

- Visual representations are not always the best choices.
- Often, we need help from verbal language!
  - When are images most effective?
  - When are words and other formal symbols most effective?
  - If both images and words are used, how should they be combined?

Hybrid Approach: Visual + Verbal



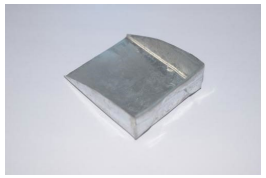




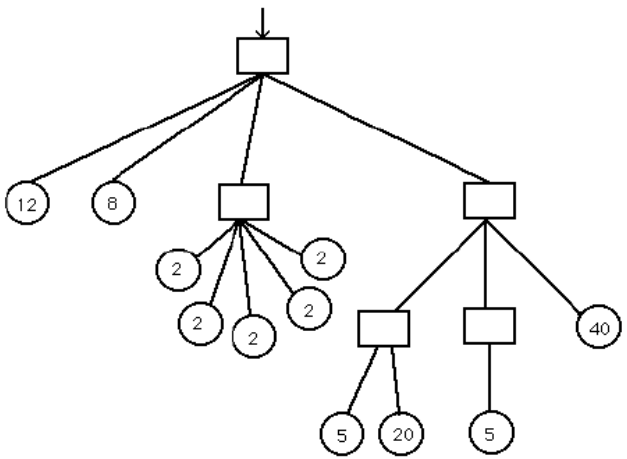
Novelty vs. Consistency

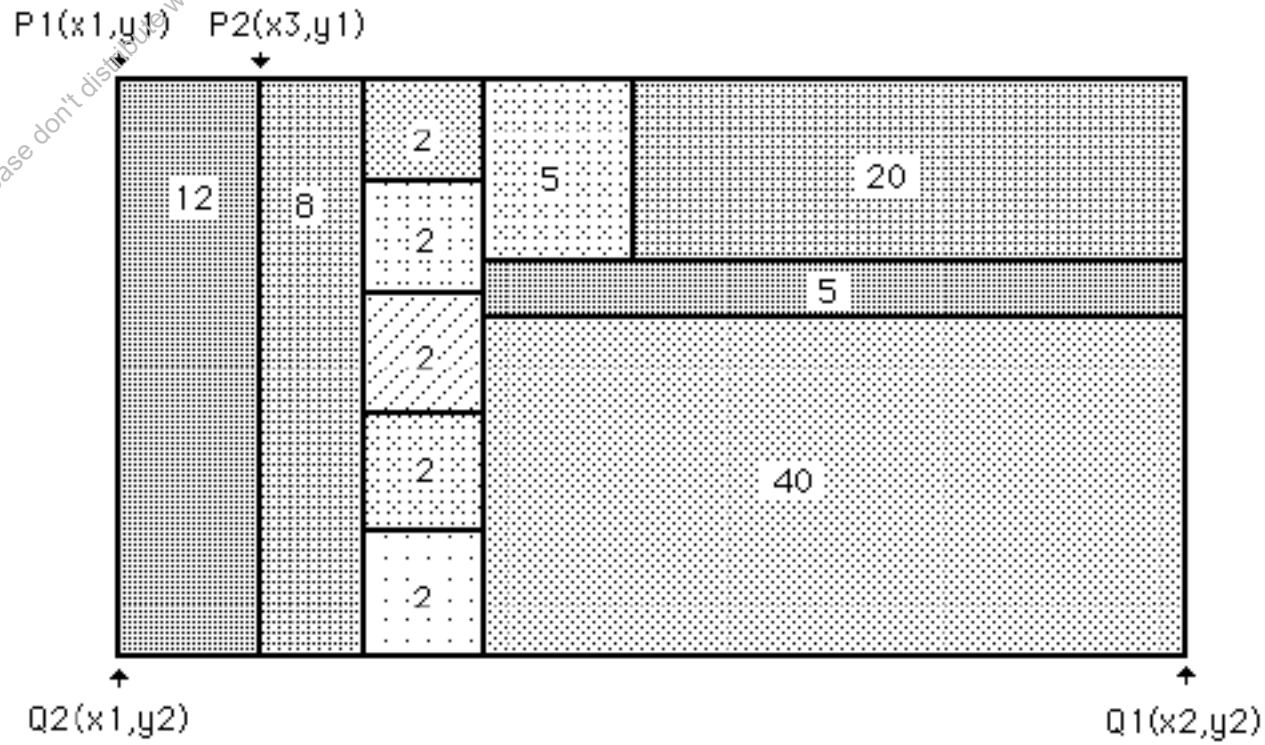
- Evolutionary design is better than revolutionary design.

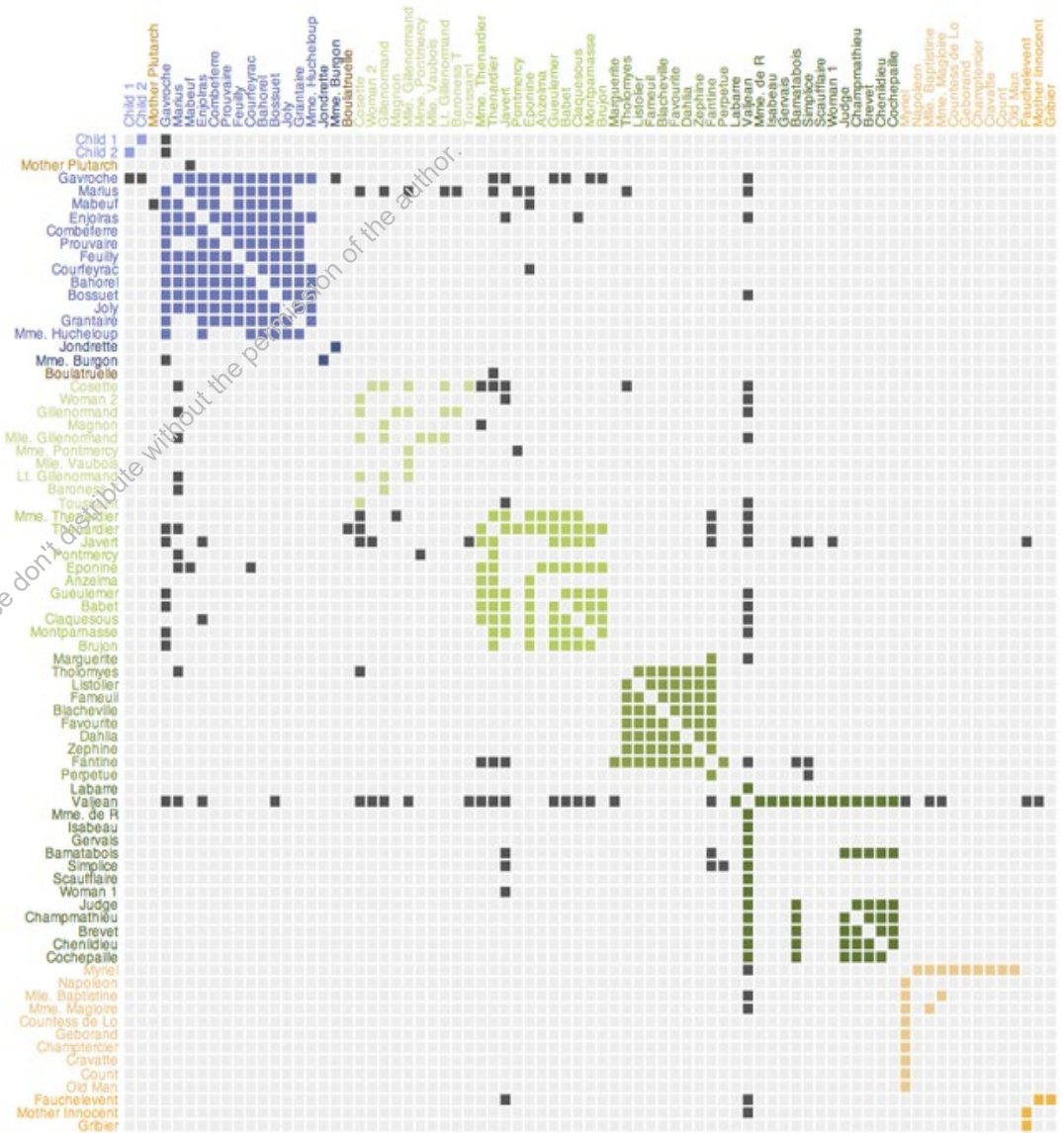
Cultural Background of Users



Knowledge and Skills of Users

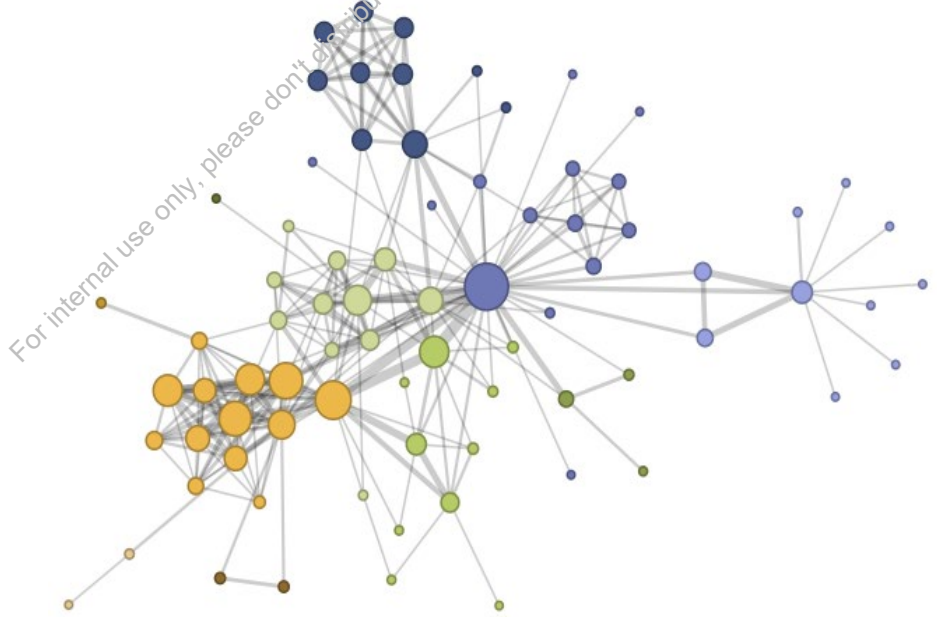


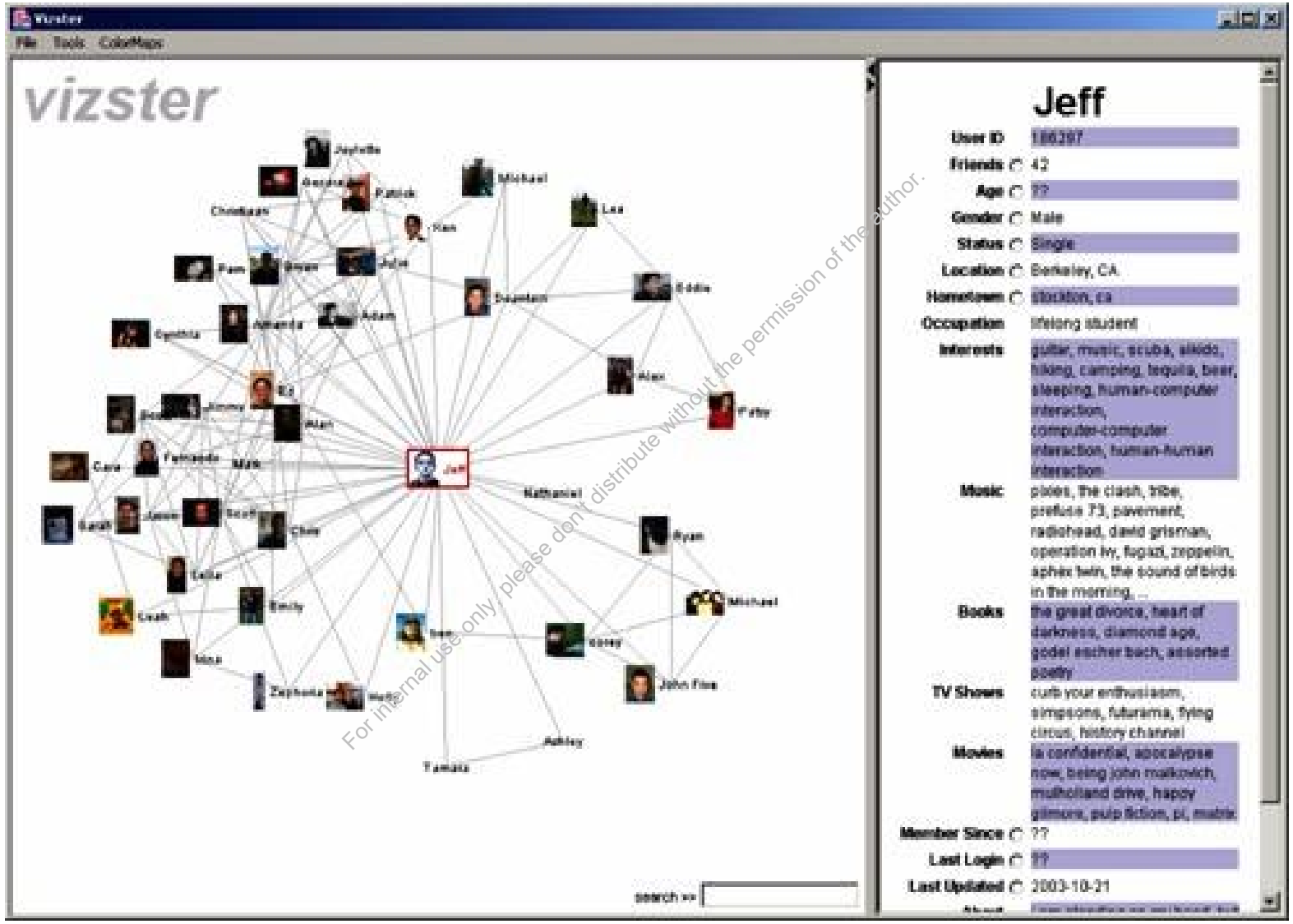




Task Considerations:
Examples of Social Network Visualization

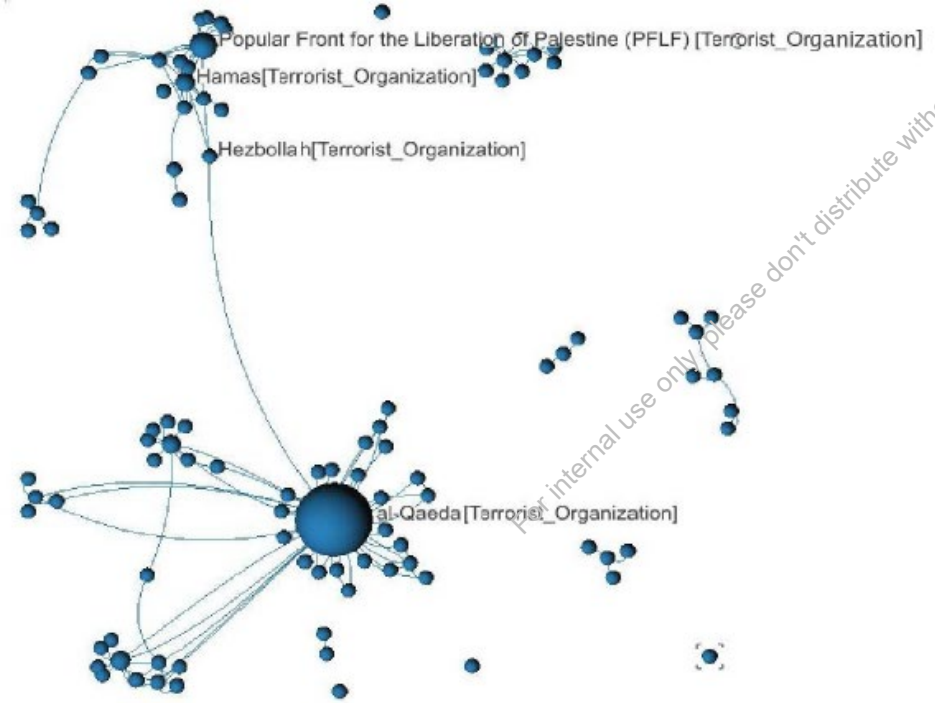
- Beyond abstract nodes and edges
  - Want to know what social factors may contribute to the relationships.
- Network data
- Attribute data

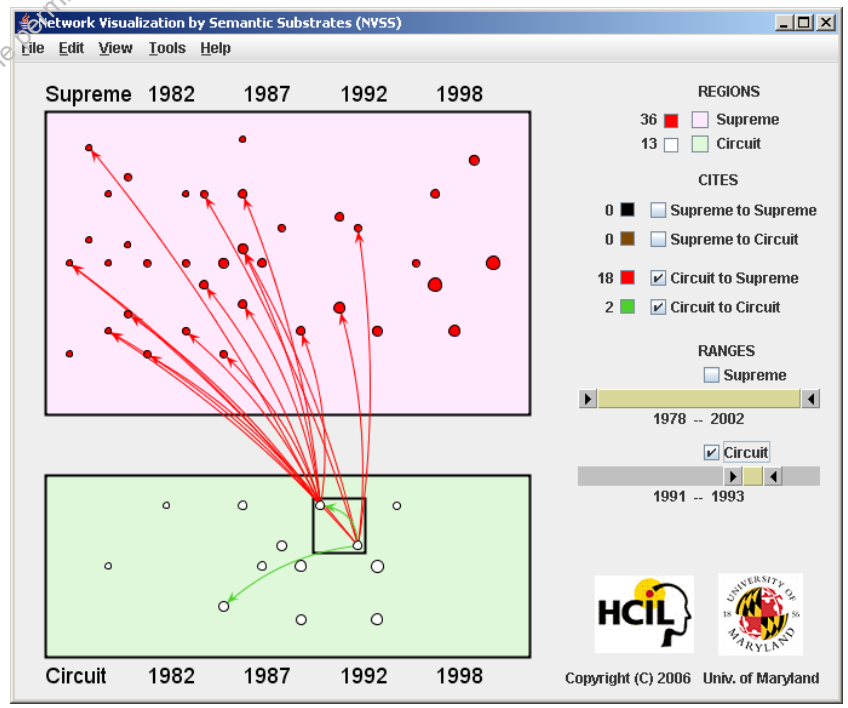


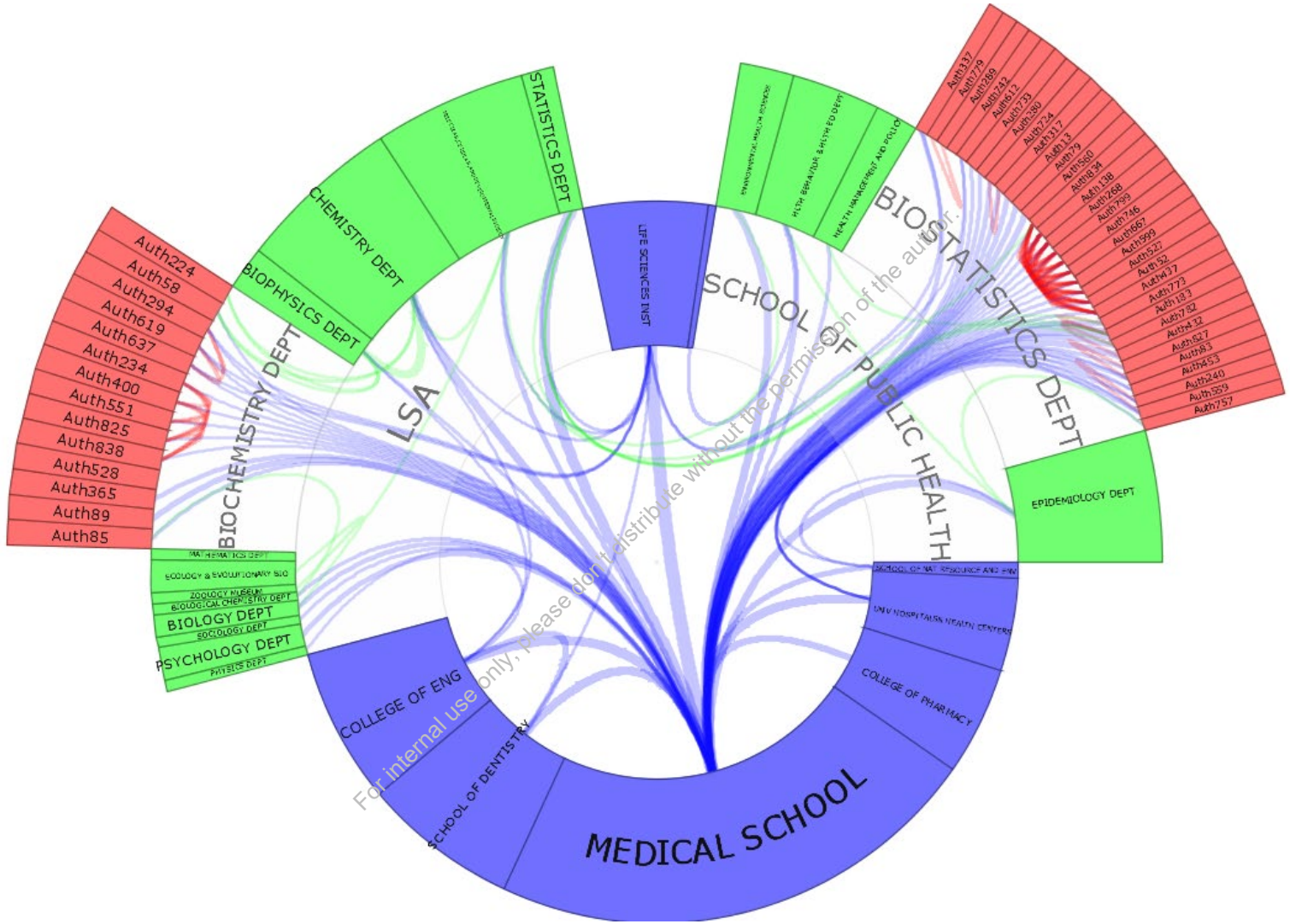


Other Issues

- How to represent social activities?







Task Considerations: Text Visualization

- What Comes to Your Mind?


presentation
Cloudagg
T
words
text
show
like
frequently
audio
used
recording
Clouds
talk
fun
everything
twitter
thought
dinner
look
Conference
Generation
Broadlook
summary
first
shown
List
presenting
PDA's
cyberspace
many
Information
Internet
tools
entire
Publishers
far
laws
often
topic
applied
start
simple
Create
recent
post
larger
next
going
blogs
situations
postings
transcribed
select
food
interesting
avoid
smaller
Specialized
thoughts
listening
thinking
fact
people
results
tweets
24/7
transcript
summation
eHarmony
started
shows
vs
less
life
Tag
powerful
stored
PowerPoint
frequent
people's
great
crap
tool
slide
move
wondered
ate
website
becoming
non-traditional
followed
DC
point
blog
sections
follow
yield
stay
ways
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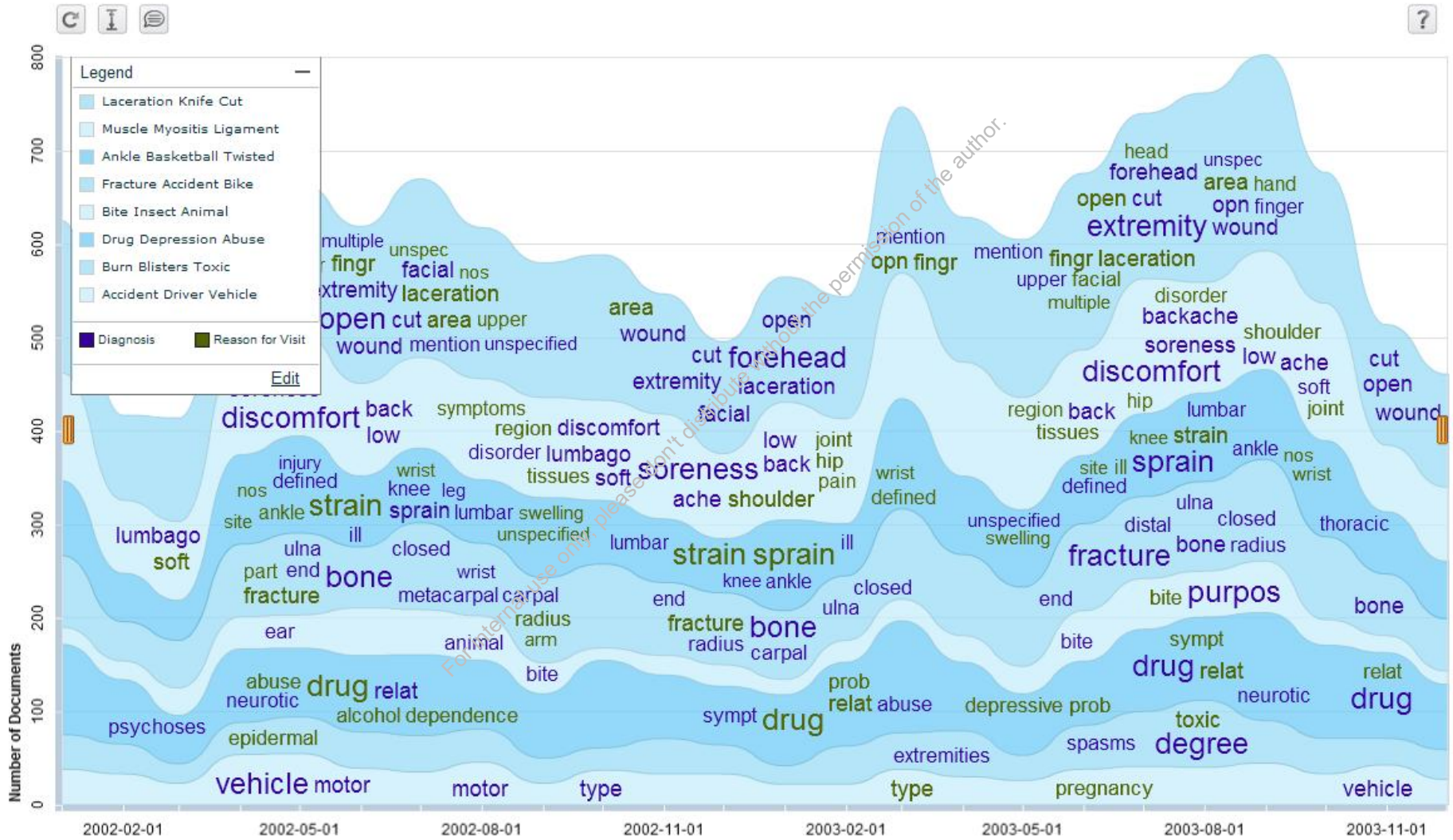
Legend
Laceration Knife Cut
Muscle Myositis Ligament
Ankle Basketball Twisted
Fracture Accident Bike
Bite Insect Animal
Drug Depression Abuse
Burn Blisters Toxic
Accident Driver Vehicle
Diagnosis
Reason for Visit
Edit
Number of Documents
0
100
200
300
400
500
600
700
800
2002-02-01
2002-05-01
2002-08-01
2002-11-01
2003-02-01
2003-05-01
2003-08-01
2003-11-01
lumbago soft
discomfort back low
injury defined nos
wrist knee leg
site ankle strain sprain lumbar swelling
ill unspecified
ulna closed
part end bone fracture
wrist metacarpal carpal
radius ear
animal arm
bite
abuse drug relat neurotic
alcohol dependence
psychoses
epidermal
vehicle motor
motor
type
multiple fingr unspec facial nos
xtremity laceration
open cut area upper
wound mention unspecified
symptoms
region discomfort
disorder lumbago
tissues soft soreness
ache shoulder
lumbar strain sprain ill
knee ankle
end closed
ulna
fracture bone
radius carpal
sympt drug
prob relat abuse
extremities
type
area wound
open cut forehead
extremity laceration
facial
low joint back hip pain
wrist defined
mention opn fingr
head forehead unspec area hand
open cut opn finger extremity wound
mention fingr laceration
upper facial multiple
disorder backache shoulder
soreness low ache cut
discomfort open
soft joint wound
region back hip lumbar
tissues knee strain ankle nos
site ill sprain wrist
defined ulna
unspecified swelling distal closed thoracic
fracture bone radius
end bite purpos bone
bite sympt
drug relat relat
neurotic drug
depressive prob toxic
spasms degree
pregnancy vehicle
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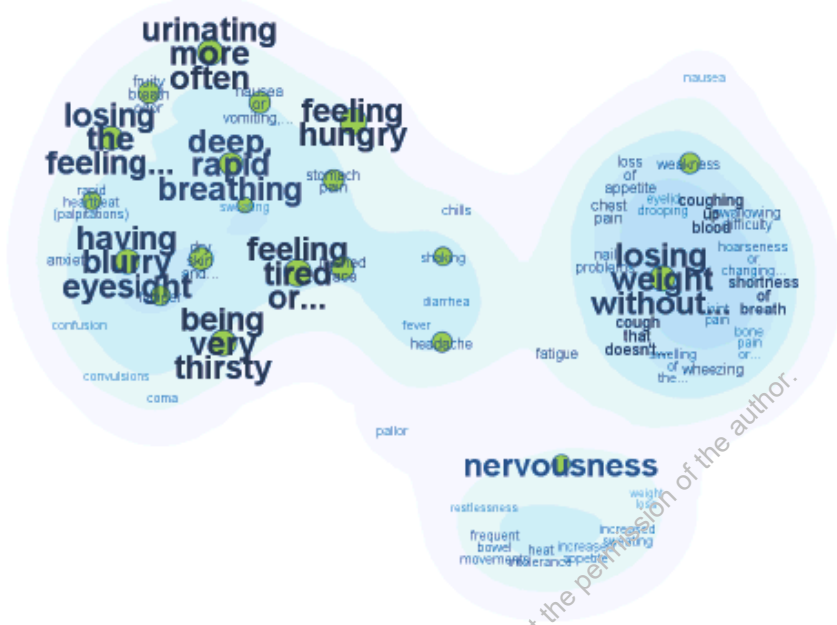
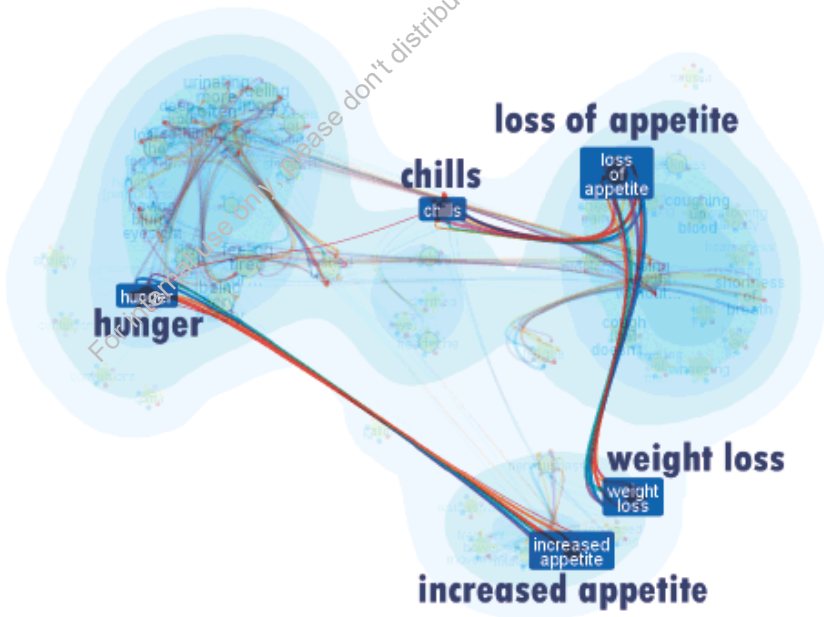


(a)

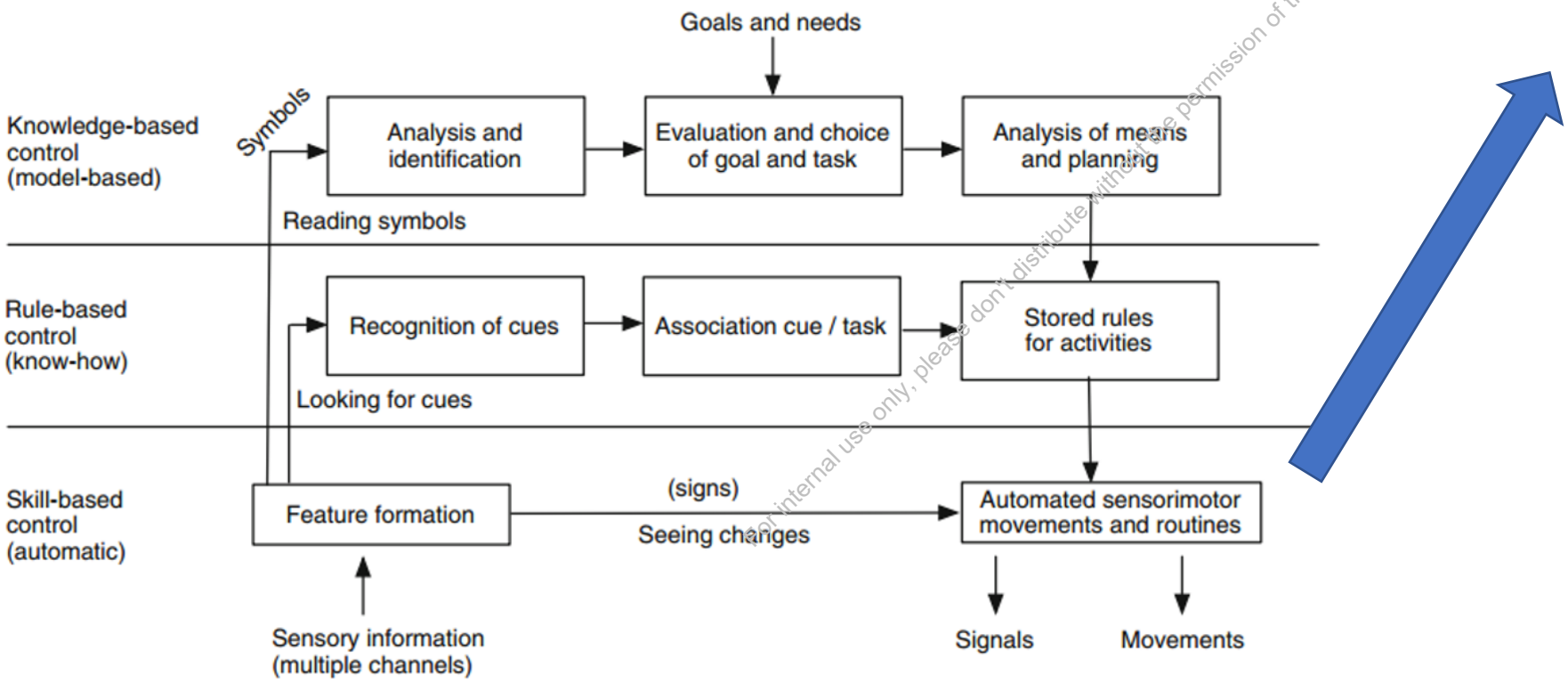


(b)

Considerations of Analytics Processes: A Good Interactive System Should Match Users' Habits.

How Can We Offer A Smooth Analytical Process?

Three Levels of User Interaction (Based on Learning Theory)



A schematic of Rasmussen's theory of performance. (Adapted from Rasmussen 1983)

We Need to Know Users Better:

- Who they are
- What they usually do
- What tools they use
- How they interact with technologies .
- .
- .
- .

Considerations of Societal Issues

Implications for Visualization Design?

Is This Type of Task Analysis Sufficient?

A Multi-Level Typology of Abstract Visualization Tasks

Matthew Brehmer and Tamara Munzner, *Member, IEEE*

Abstract—The considerable previous work characterizing visualization usage has focused on low-level tasks or interactions and high-level tasks, leaving a gap between them that is not addressed. This gap leads to a lack of distinction between the ends and means of a task, limiting the potential for rigorous analysis. We contribute a multi-level typology of visualization tasks to address this gap, distinguishing *why* and *how* a visualization task is performed, as well as *what* the task inputs and outputs are. Our typology allows complex tasks to be expressed as sequences of interdependent simpler tasks, resulting in concise and flexible descriptions for tasks of varying complexity and scope. It provides abstract rather than domain-specific descriptions of tasks, so that useful comparisons can be made between visualization systems targeted at different application domains. This descriptive power supports a level of analysis required for the generation of new designs, by guiding the translation of domain-specific problems into abstract tasks, and for the qualitative evaluation of visualization usage. We demonstrate the benefits of our approach in a detailed case study, comparing task descriptions from our typology to those derived from related work. We also discuss the similarities and differences between our typology and over two dozen extant classification systems and theoretical frameworks from the literatures of visualization, human-computer interaction, information retrieval, communications, and cartography.

Index Terms—Typology, visualization models, task and requirements analysis, qualitative evaluation

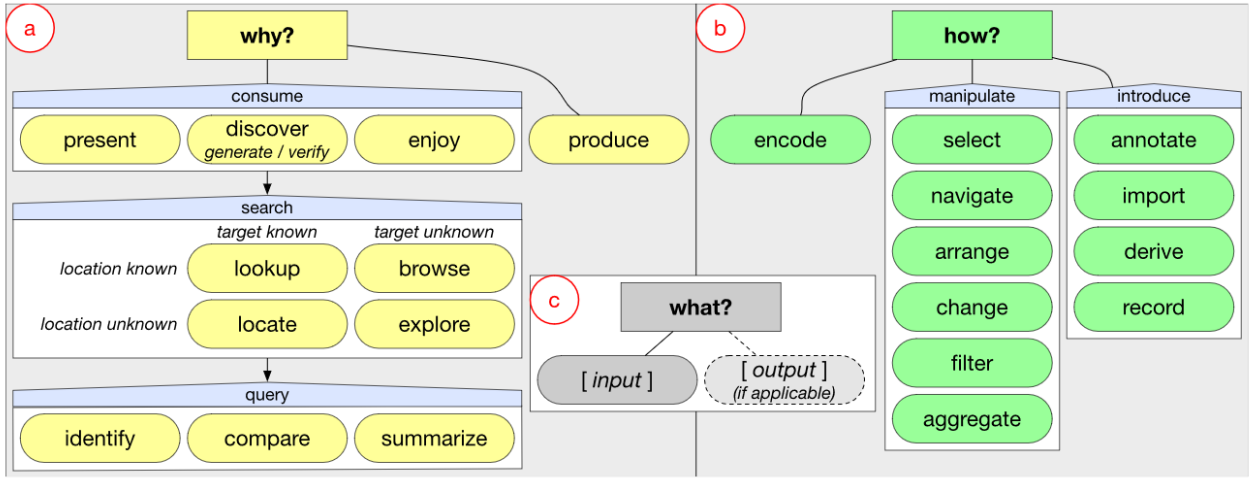


Fig. 1. Our multi-level typology of abstract visualization tasks. The typology spans *why*, *how*, and *what*; task descriptions are formed by nodes from each part: a) *why* a task is performed, from high-level (consume vs. produce) to mid-level (search) to low-level (query). b) *how* a task is executed in terms of *methods*, defined as families of related visual encoding and interaction techniques. c) *what* the task inputs and outputs are.

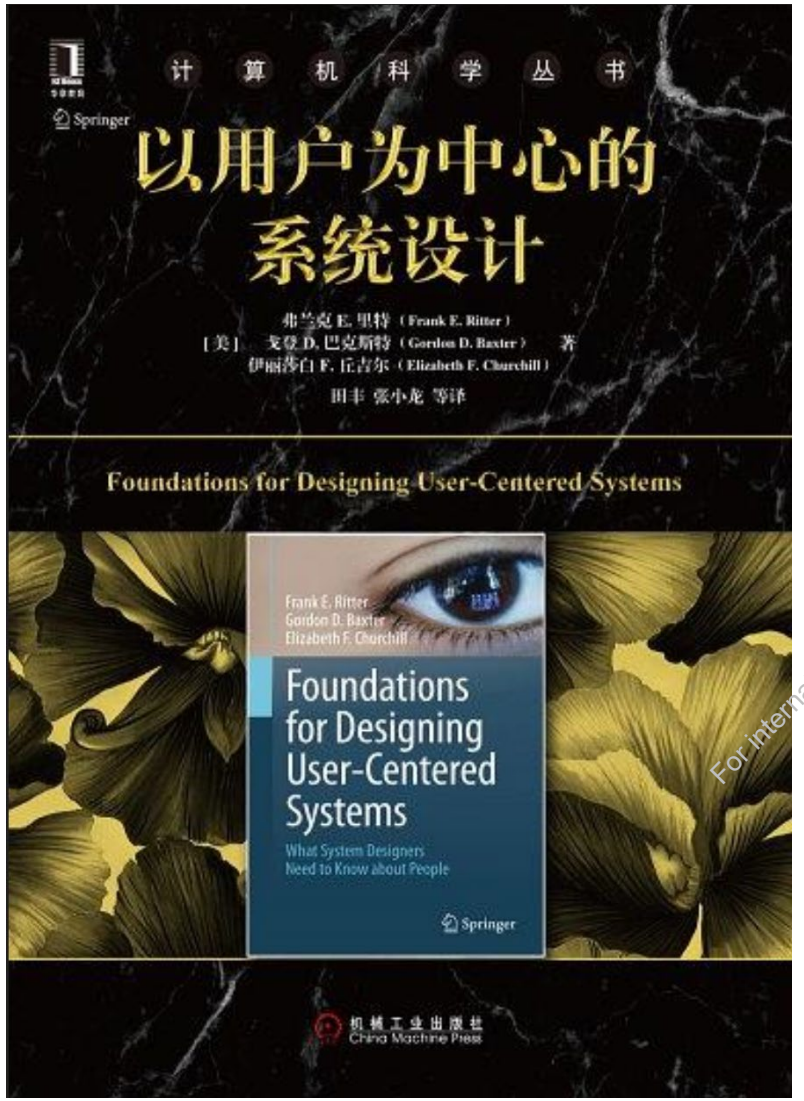
In Summary

- Interaction design concerns different kinds of design goals.
  - Physical devices, user interfaces, a process to carry out a task, a service, etc.
- Different design goals require different methods.
  - Engineering-oriented, user-centered, situated
- Understanding interaction designs in visualization systems can be guided by three research paradigms in HCI
  - Human-factor, cognitive revolution, phenomenologically-situated

In Summary (Cont')

- Three paradigms ask different kinds of questions
  - Human-factor: can people operate a device faster with fewer error?
  - Cognitive revolution: can people interact with a system with less cognitive effort?
  - Phenomenologically-situated: can people carry out a task in the real world with appropriate tools, without being aware of the constraints imposed by technology and environments, and of course with few error and less cognitive effort.
- Design challenges nowadays often require the consideration of the integration of these three paradigms.
  - Specific interaction devices/systems for a particular group of people to carry out a given task
    - E.g., a web browser for blind people
- What you need to do …
  - Understanding the basic characteristics of users, technology, and contextual factors (as much as possible)
  - Being able to Identify the central design tasks and then choose appropriate design methods
  - Grasping necessary skills and methods.

This Book May Be Helpful。



第一部分 导论
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- 第2章 以用户为中心的系统设计：简史

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- 第4章 行为：关于用户的基础心理学
- 第5章 认知：记忆、注意力和学习
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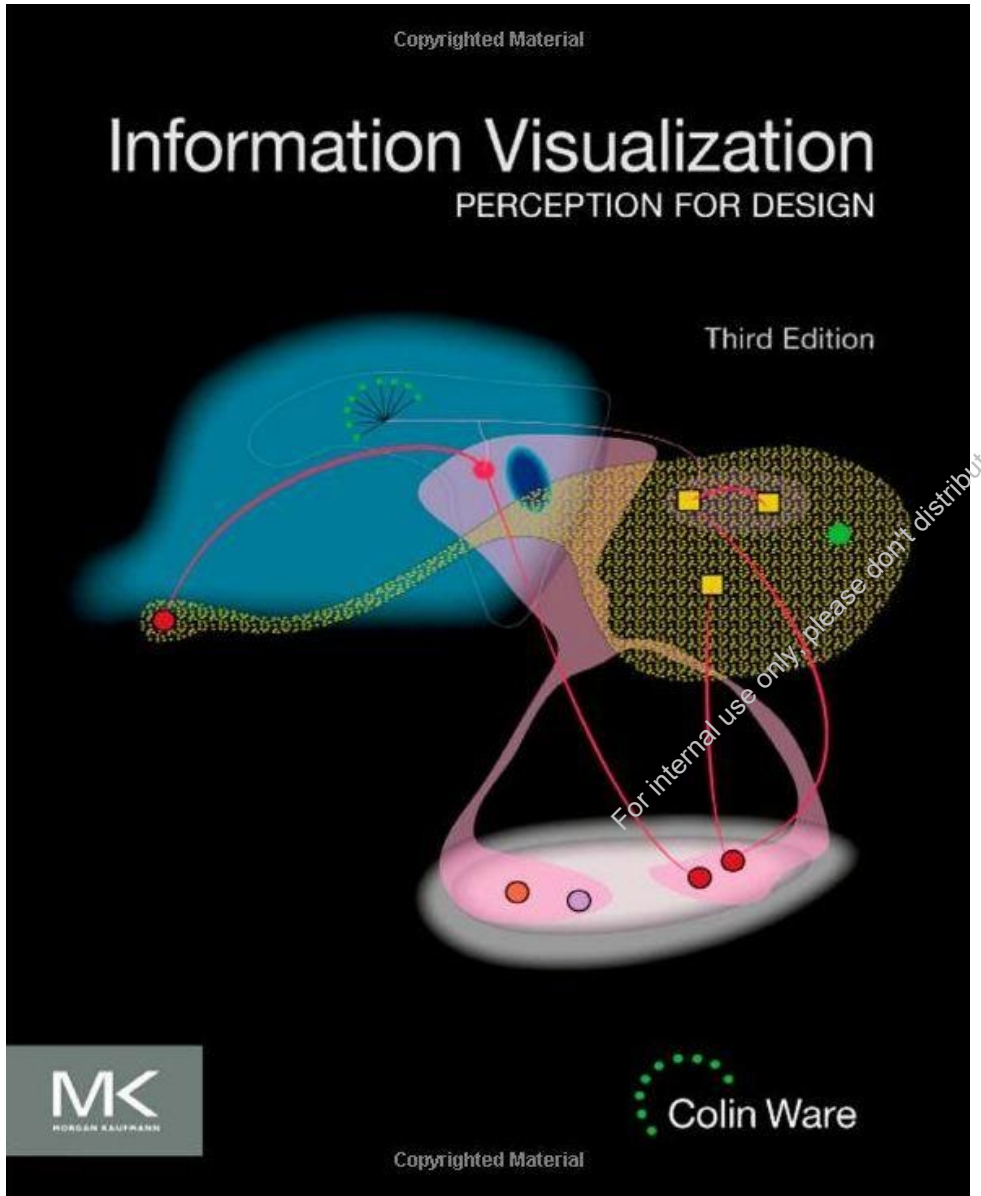
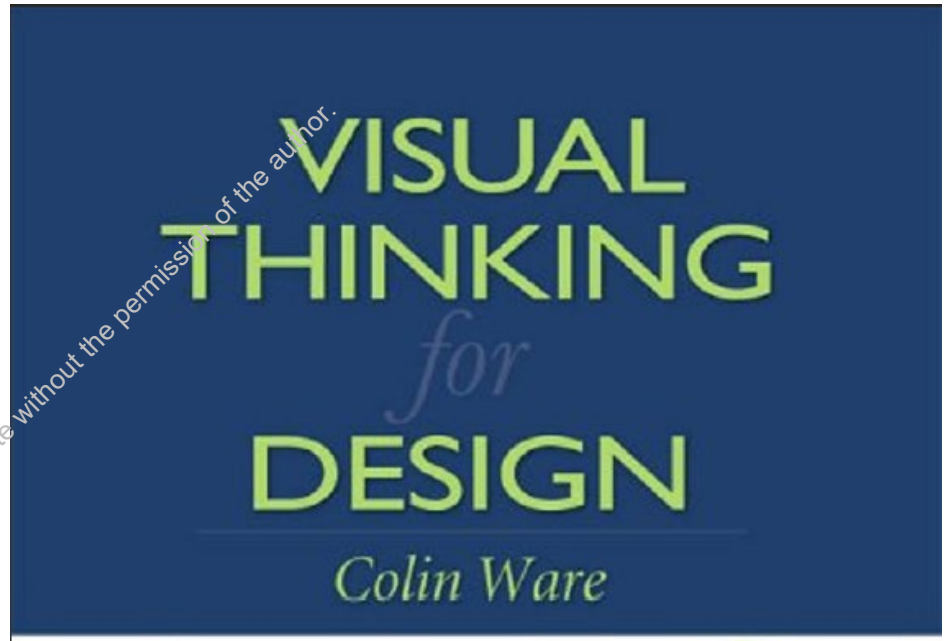
- 第13章 方法Ⅲ：实证评估

第14章 总结

Books on Visual Perception and Visualization





Thanks!