



Sensemaking and Bias

Stuart Card

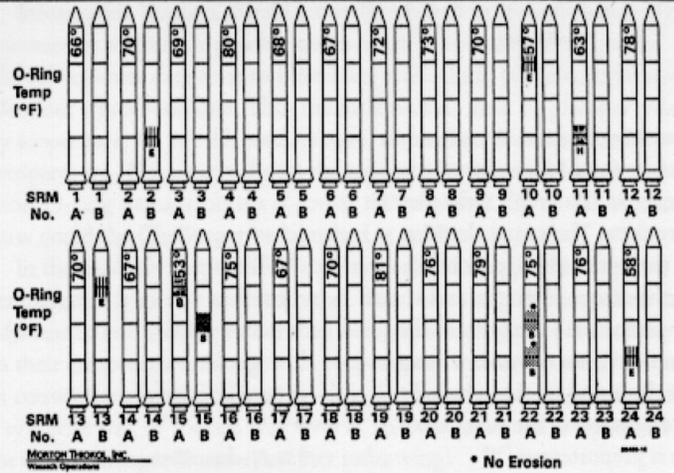
30 March 2011

<http://hci.stanford.edu/courses/cs448g/>



Launch?

History of O-Ring Damage in Field Joints (Cont)



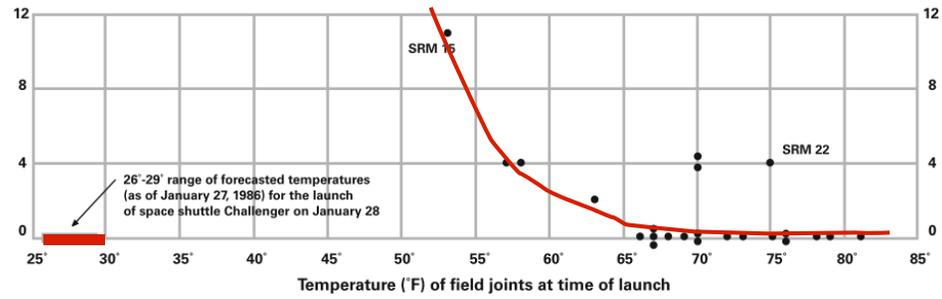
MORTON THOMAS, INC.
Vehicle Operations

* No Erosion

INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

No!

O-ring damage
index, each launch



Tufte

Information Visualization:

“ The use of
**computer-supported,
interactive,
visual representations**
of **abstract data**
to amplify cognition. “

Amplifying cognition

- ✦ Sensemaking
- ✦ Presentation
- ✦ Monitoring

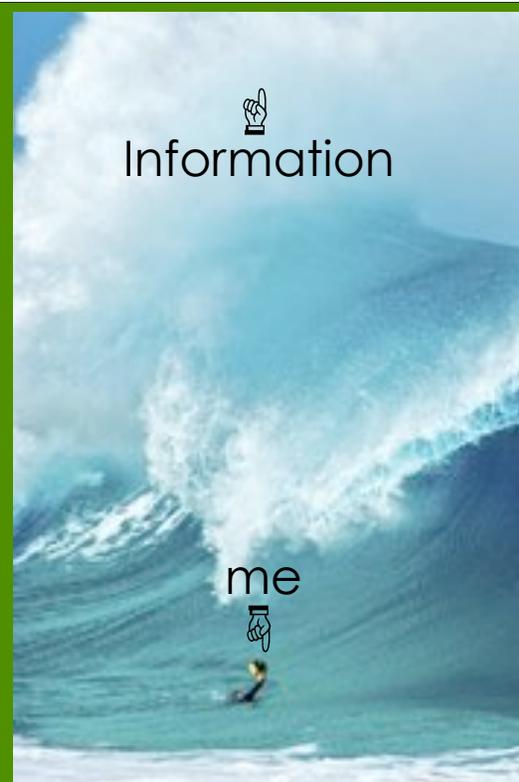
Today we're going to concentrate on sensemaking.

Behavioral foundations of visualization: Outline

- ❖ Basic Problem
- ❖ Bounded Rationality
- ❖ Rationality: Sensemaking
- ❖ Bounds: Proximal mechanisms & their limits

Basic Problem:

The sea
(of information)
is so big and my
(mental) boat is so
small.



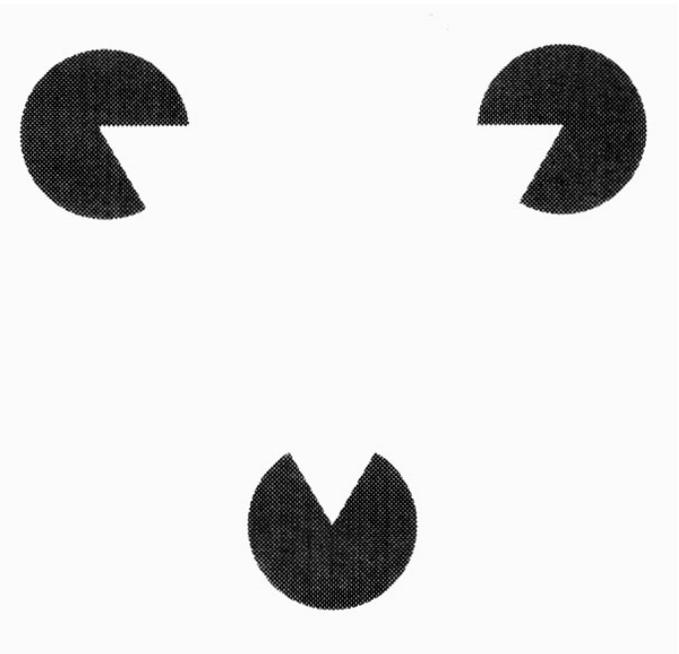
Solution: The Selective Omission and Re-representation of Information.

[T]here appears to be a general Principle of **selective omission of information** at work in all biological information processing systems. The sensory organs **simplify and organize their inputs**, supplying the higher processing centers with **aggregated forms of information** which, to a considerable extent, **predetermine the patterned structures that the higher centers can detect**. The higher centers in their turn reduce the quantity of information which will be processed at later stages by further organization of the partly processed information into **more abstract and universal forms** [Resnikoff, 1987, p. 19]

➤ Better representation

➤ Aggregation

➤ Cues to action



THE PAOMNNEHAL PWEOR OF THE
HMUAN MNID. Aoccdrnig to a rscheearch
at Cmabrigde Uinervtisy, it deosn't
mttaer in waht oredr the ltteers in a wrod
are, the olny iprmoatnt tihng is taht the
frist and lsat ltteer be in the rghit pclae.
The rset can be a taotl mses and you can
sitll raed it wouthit porbelm. Tihs is
bcuseae the huamn mnid deos not raed
ervey lteter by istlef, but the wrod as a
wlohe.

Errors and Bias

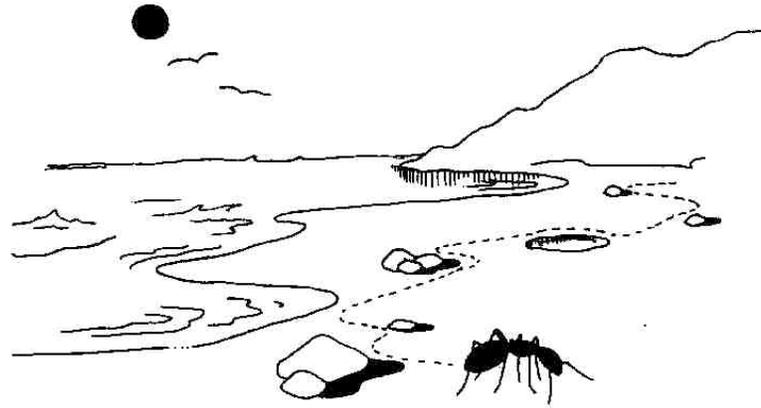
- ❖ Implications of Principle of Selective Omission and Re-representation of Information:
 - ❖ Can handle more information, but flip side is
 - ❖ Bias and Error

Bounded Rationality

An agent behaves as nearly optimal relative its goals as its resources will allow. -Herbert Simon



Simon's Parable of the Ant



Rationality (Adaptiveness)

- “An ant, viewed as a behaving system, is quite simple. The apparent **complexity of its behavior** over time is largely a **reflection of the complexity of the environment** in which it finds itself.”

–Herbert Simon

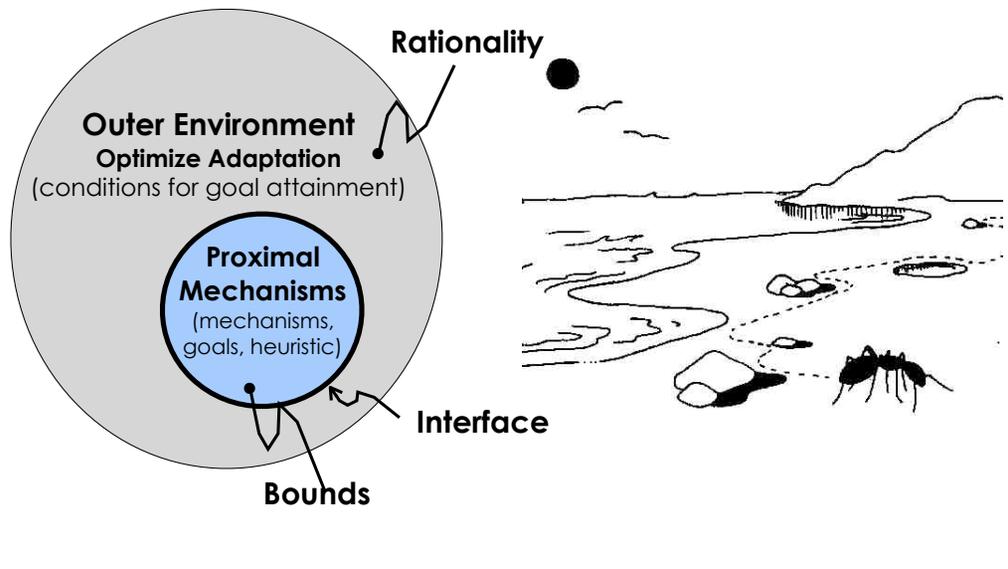
Bounded Rationality

RATIONALITY:

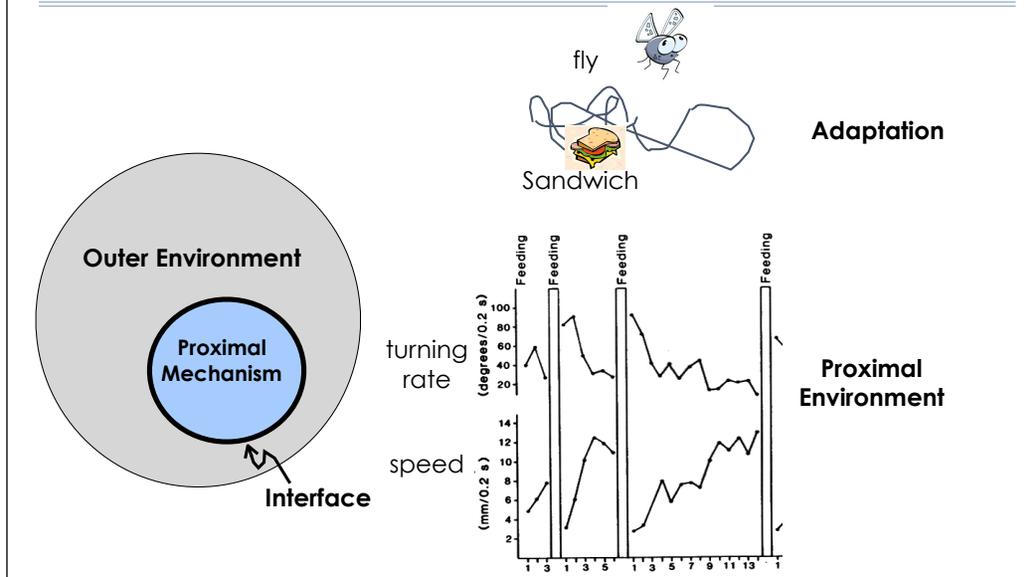
- ✦ Organisms will do the logical thing to obtain their goals.
- ✦ “Economic Man”
 - ✦ Completely informed of goals and alternatives
- ✦ **Optimize utility**

BOUNDED:

- ✦ There are limits:
 - ✦ Problems are complex
 - ✦ Perception and cognition are limited
 - ✦ Resources are limited
 - Incomplete information
 - limited decision-making time
 - ✦ Conflicting preferences
- ✦ **Use heuristics**
Satisfice (“good enough”)



Example of a Proximal Mechanism



TIME SCALE OF HUMAN ACTION

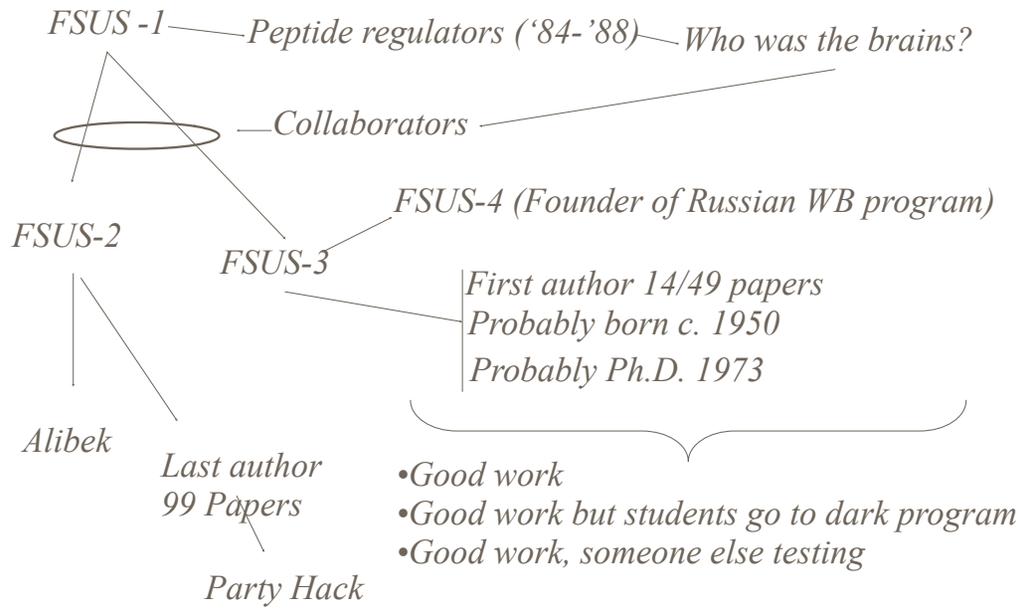
<u>Scale</u> (sec)	<u>Time Units</u>	<u>System</u>	<u>World</u> (theory)
10^7	months		SOCIAL BAND
10^6	weeks		
10^5	days		
10^4	hours	Task	RATIONAL BAND
10^3	10 min	Task	
10^2	minutes	Task	
10^1	10 sec	Unit task	COGNITIVE BAND
10^0	1 sec	Operations	
10^{-1}	100 ms	Deliberate act	
10^{-2}	10 ms	Neural circuit	BIOLOGICAL BAND
10^{-3}	1 ms	Neuron	
10^{-4}	100 μ s	Organelle	



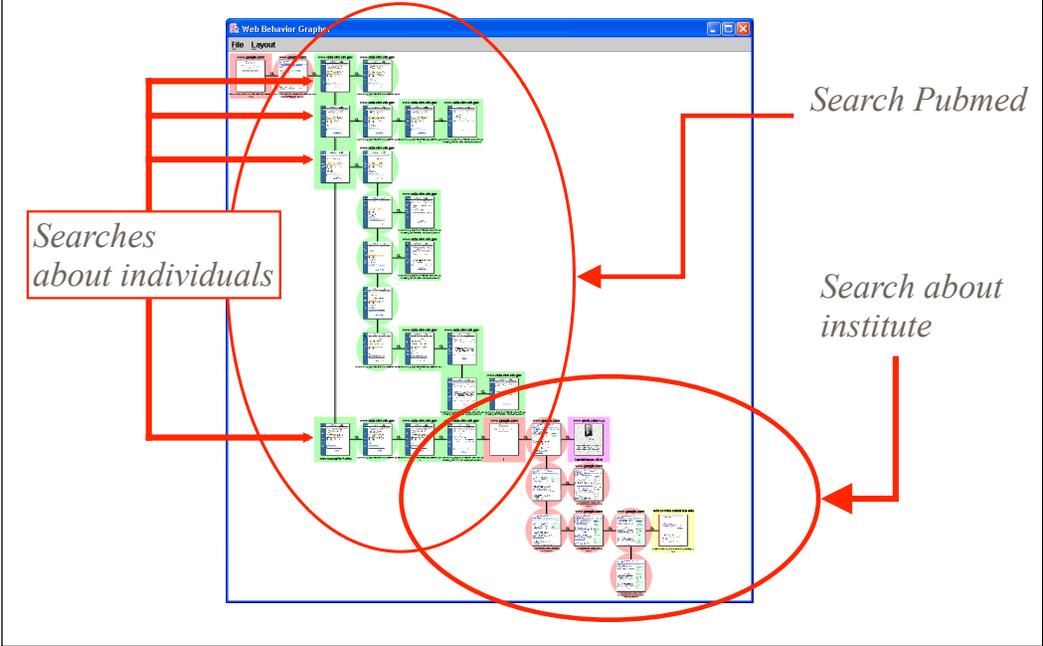
Figure 3-3. Time scale of human action.

Rationality

1. Analysts Work Chains of Entities

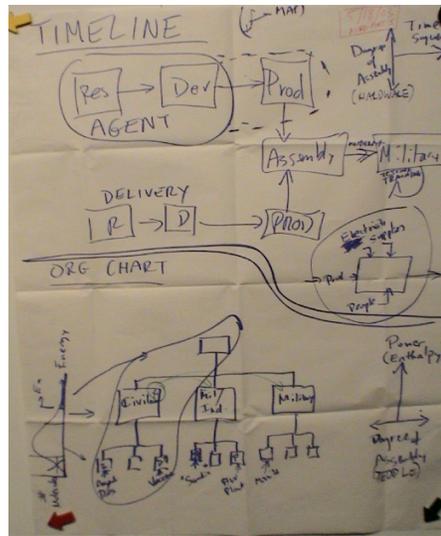


Web Behavior Graph

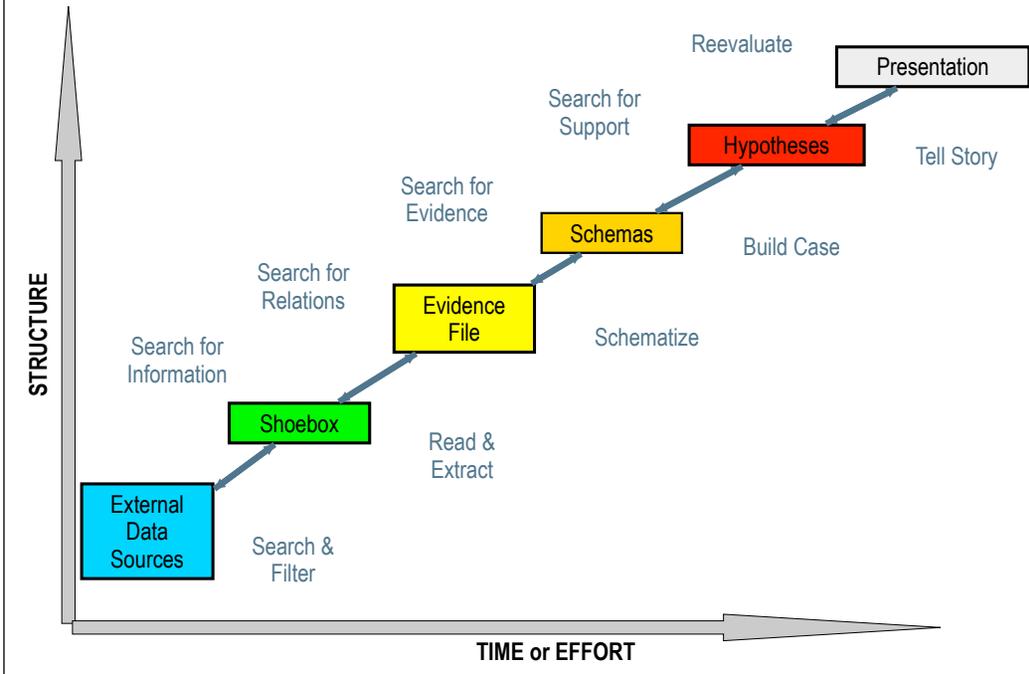


What is in an Expert's schema?

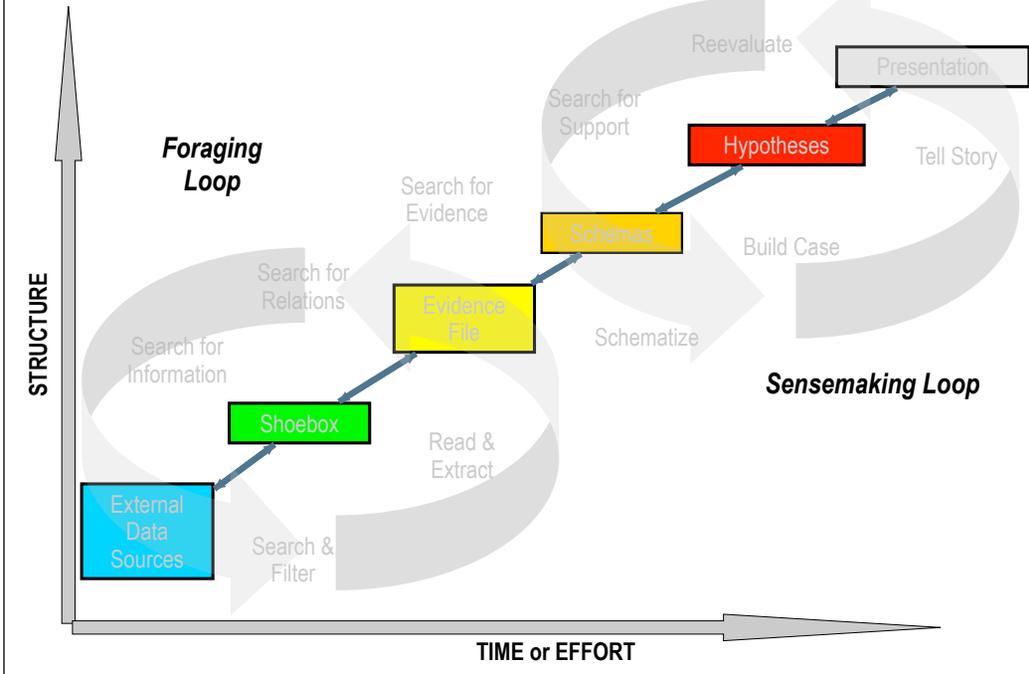
SME-WMD Task Diagram



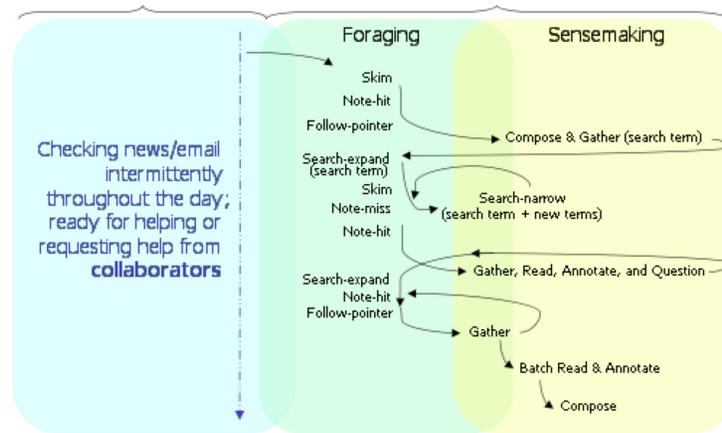
Notional Model

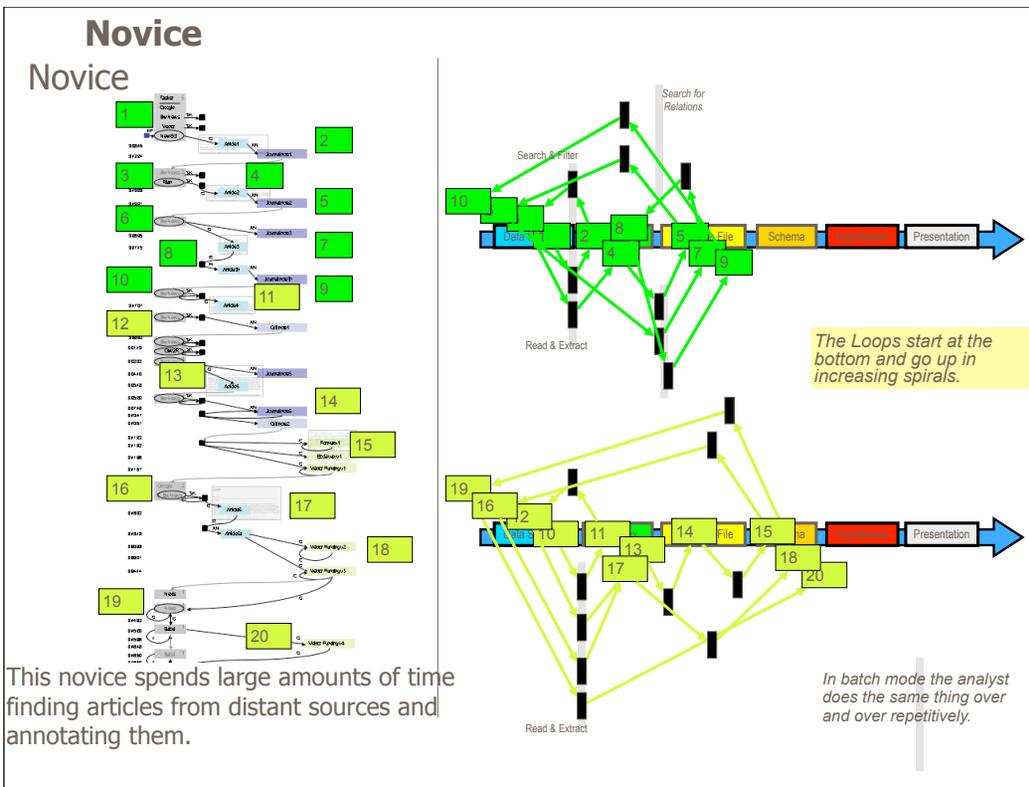


The Two Loops



Knowledge Assembly Loops

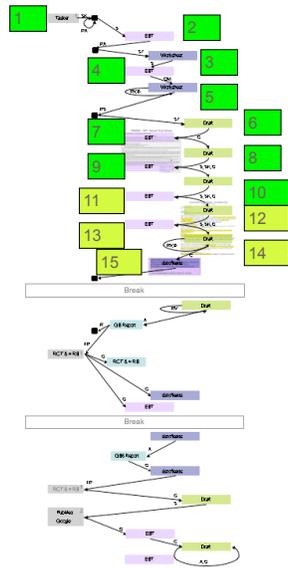




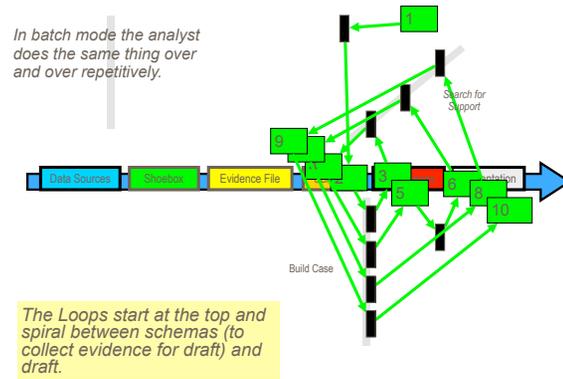
This depicts a zoomed out view of task analyses of both novice and expert intelligence analysts.

You can see differences between the novice, who spends the majority of time looking at external sources (grey boxes), and the expert, who spends the majority of time looking at his own familiar sources (purple boxes).

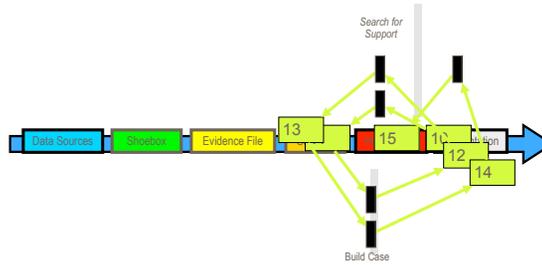
Expert



In batch mode the analyst does the same thing over and over repetitively.



The Loops start at the top and spiral between schemas (to collect evidence for draft) and draft.



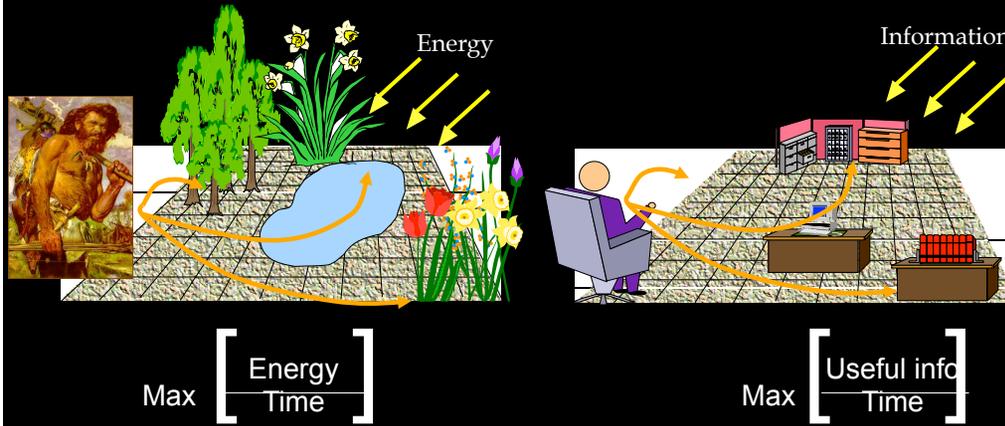
BUT IF the Expert Analyst has time...

1. INFORMATION FORAGING THEORY

30

So much for present input devices and their effect on computer design.

Optimal Foraging Theory



Similar to Human & Animal Foraging

Food Foraging

Biological, behavioral, and cultural designs are adaptive to the extent they optimize the rate of energy intake.

Information Foraging

Information access and visualization technologies are adaptive to the extent they optimize the rate of gain of valuable information

Basic Equation

- Human-computer interaction is adaptive to the extent:

$$\begin{aligned} \text{MAXIMIZE} & \left[\frac{\text{Net Knowledge Gained}}{\text{Costs of Interaction}} \right] \\ & = \left[\frac{\text{Net Knowledge Gained}}{T_s + (T_p + T_h)} \right] \\ & = \left[\frac{\lambda I - T_s}{1 + T_h} \right] \end{aligned}$$

T_s = Search time, T_p = Pursuit time, T_h = Handling time
 I = Ave Information gained per encounter

Shift of Point of View

■ Information Retrieval

– Figures of Merit:

- » Precision - Percentage of stuff you retrieved that's good.
- » Recall - Percentage of good stuff that's out there you retrieved.

– If you can find it 1000 times faster, it doesn't count for IR.

■ Information Foraging Theory

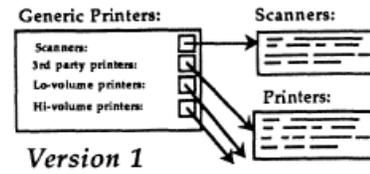
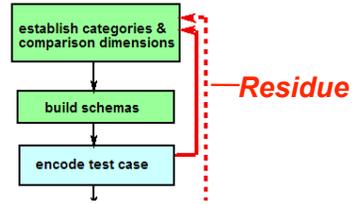
- Speed (a kind of cost) matters
- So does quality of result

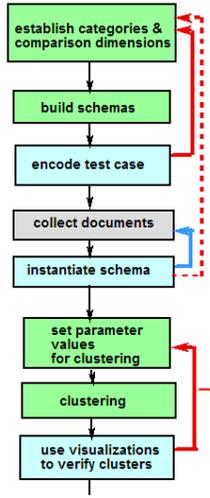
2. SENSEMAKING THEORY

35

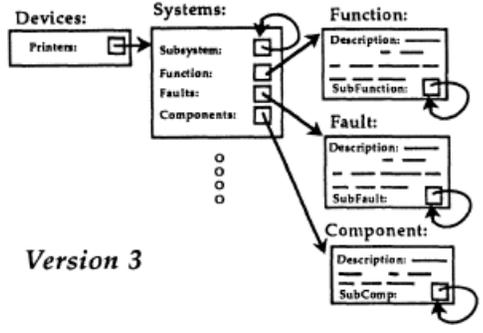
So much for present input devices and their effect on computer design.

Sensemaking--Creating a Course on Printing

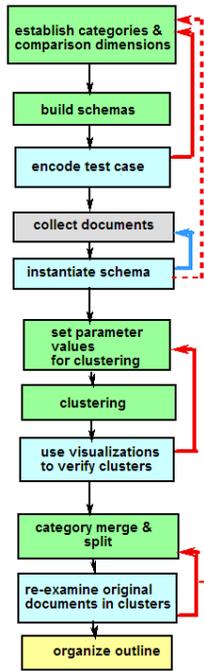




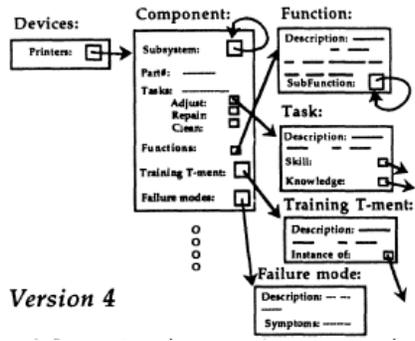
Residue



Version 3

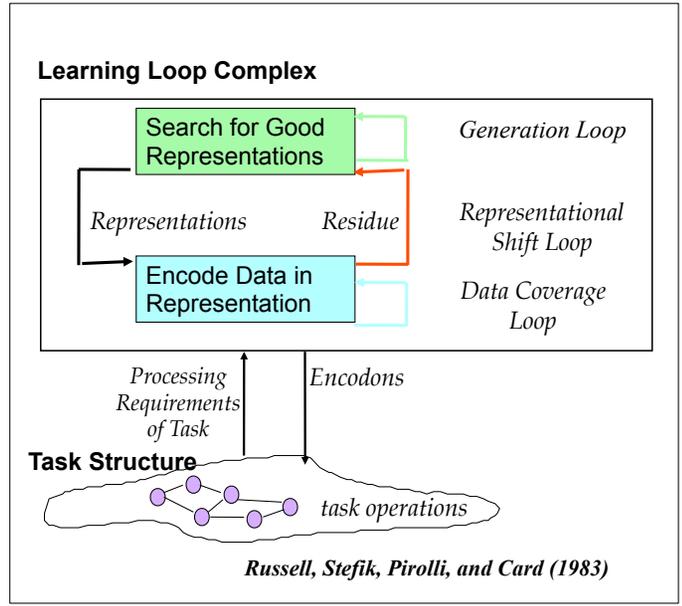
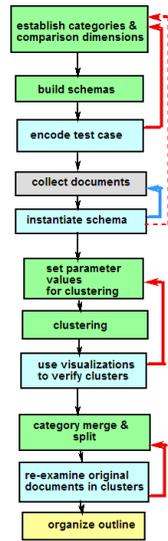


Residue



Version 4

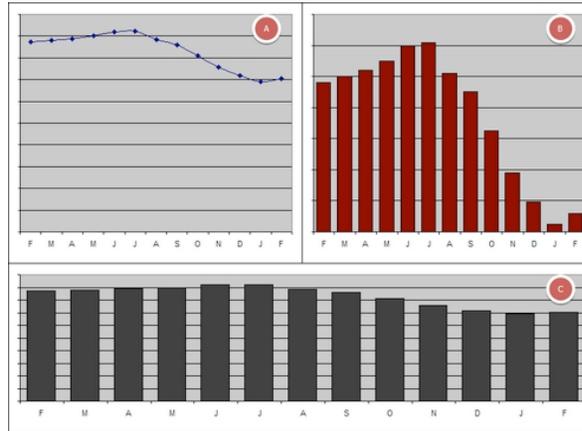
Sensemaking Learning Loop



Bounds

Axis Stretching

Microsoft Office Market Share
2008 Data



Which graph shows the worst trend?

Judgement Relativity

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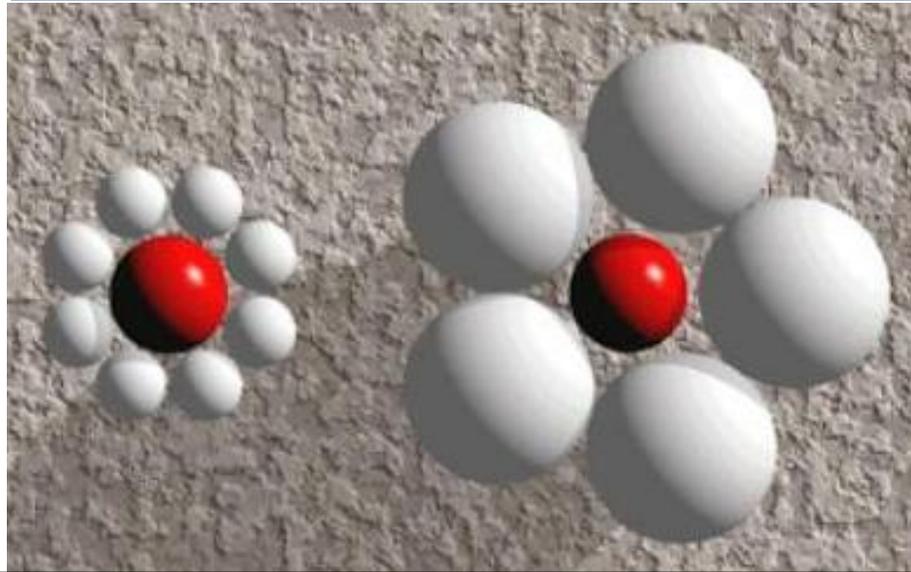
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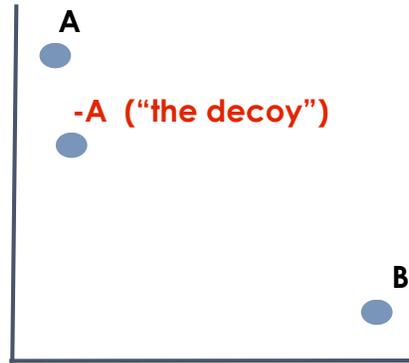
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68%

32%

We're set up to make relative judgements





Ariely

Williams-Sonoma Home Bakery

Sales



\$275



\$412

Anchoring

Sales



Black Peals
from Tahiti.

Worthless



Henry Winston



Elizabeth Taylor

Introduce at high price.
Only available at very exclusive stores.
Pair with celebrities and luxury goods.

Arbitrary Coherence

Although initial prices may be arbitrary, once established they will shape present and future prices.

MIT Demonstration



Jot down last 2 digits of SSN



Tell whether you would pay this or more for a number of products.



Bid on products at an auction.

Amazingly, SSN anchors auction price

Products	Range of last two digits of SS number					Correlations
	00-19	20-39	40-59	60-79	80-99	
Cordless trackball	\$8.64	\$11.82	\$13.45	\$21.18	\$26.18	0.42
Cordless keyboard	\$16.09	\$26.82	\$29.27	\$34.55	\$55.64	0.52
Design book	\$12.82	\$16.18	\$15.82	\$19.27	\$30.00	0.32
Neuhaus chocolates	\$9.55	\$10.64	\$12.45	\$13.27	\$20.64	0.42
1998 Côtes du Rhône	\$8.64	\$14.45	\$12.55	\$15.45	\$27.91	0.33
1996 Hermitage	\$11.73	\$22.45	\$18.09	\$24.55	\$37.55	0.33

Heuristics Can Lead to Error

❖ Availability Heuristic

- ❖ Estimate probability by whether examples come to mind.
 - ❖ E.g., Nuclear power accidents seem more likely if one has happened recently.
 - ❖ Stories and examples used instead of statistics.

❖ Salience Heuristic

- ❖ Estimate probability by vividness.
 - ❖ E.g., Terrorist attack on television more salient than attack on TV

❖ Representative Heuristic

- ❖ Judgments of probabilities influenced by whether A looks like B.

Social Aggregation of Information

Compensate for individual error and limited knowledge by social aggregation and reasoning.

Frederich Hayek



Social Aggregation of Information

Each member of society can have only a small fraction of the knowledge possessed by all, and . . . each is therefore ignorant of most of the facts on which the working of society rests . . . **[C]ivilization rests on the fact that we all benefit from knowledge which we do not possess.** And one of the ways in which civilization helps us to overcome that limitation. . . is . . . by **the utilization of knowledge which is and which remains widely dispersed among individuals.**

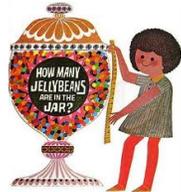
- Frederich Hayek, Law, Legislation, and Liberty, vol. 1.

Statistical Average: “Wisdom of the Crowds”



Galton

Estimate	Actual	
1,197 lbs	1,198 lbs	-.08%



871	850	+2.5%
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Knight

72.4° F	72° F	+0.5%
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Condorcet Jury Theorem



Suppose we know the correct outcome on some issue.

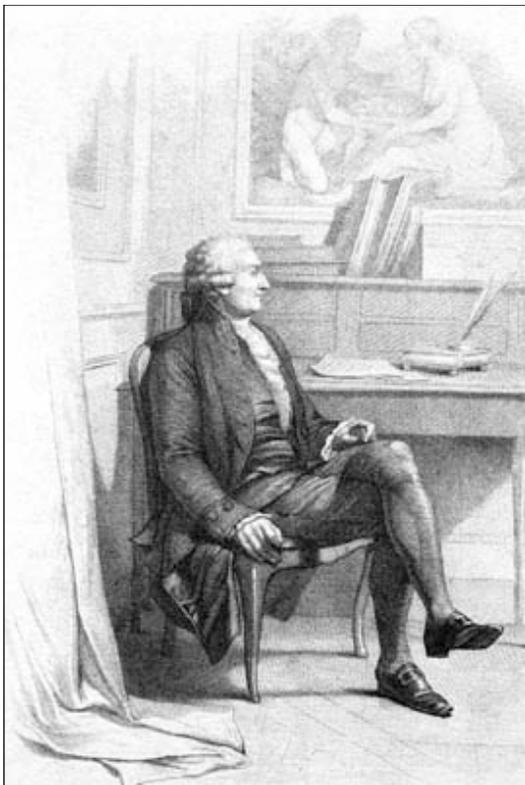


3 person group
Each correct
 $p=0.67$.



Majority vote correct
 $p=0.74$.

Better than the average group member.

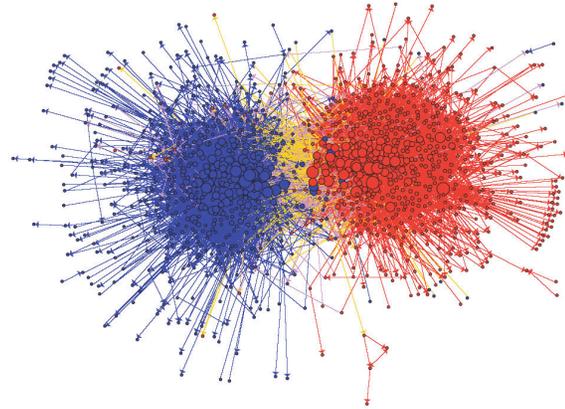


Marquis de Condorcet

When a group of “enlightened” decision makers chooses between two options under a majority rule, then **as the size of the decision making population tends toward infinity, it becomes a certainty that the best choice is rendered.**

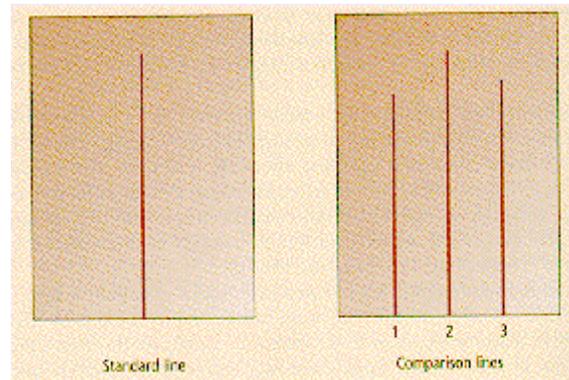
Dark Side of Condorcet Jury Theorem

- ♣ If on average $p < 0.5$ believe the correct way, then voting will produce the wrong answer.
- ♣ E.g., If groups of voters believe different facts are true about world.
- ♣ Condorcet Jury Theorem assumes voters are independent in view and not influence by how others vote.

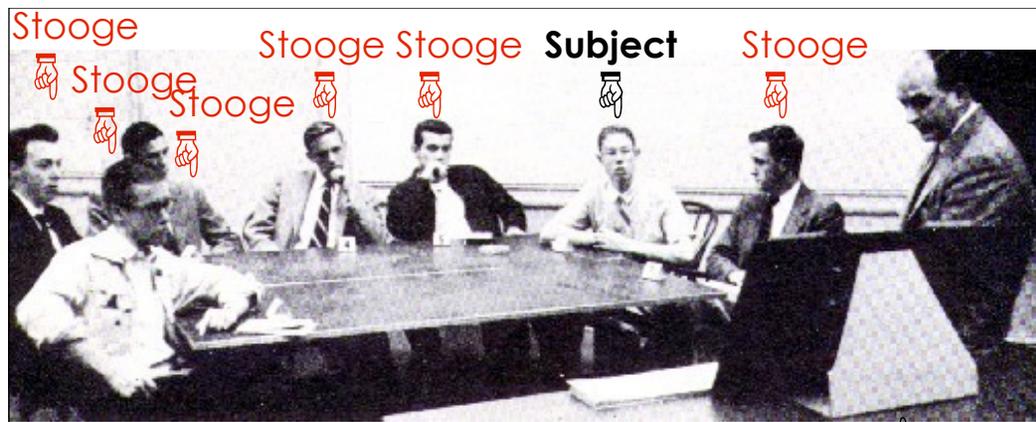


Bloggers mainly cite bloggers with similar beliefs.

Asch Experiment



Which line on right
matches line on left?

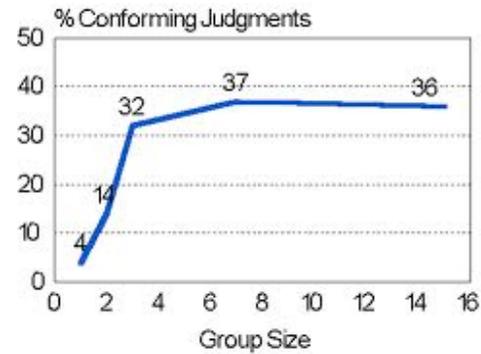


On 12 of 18 trials,
stooges give the same
wrong answer.


Asch
(Experimenter)

Results

- ❖ Subject gives wrong conforming answer 37% of time.
- ❖ 75% of subjects conformed at least once.
- ❖ Larger group, more conforming



Hidden Profiles

- ❖ The understanding groups could have, but don't attain.
- ❖ Group members have information they don't share.
- ❖ Why?

The Common Knowledge Effect

- ✦ Common information shared by all or most group members has biggest effect on group judgments.
 - ✦ Experiment: Selecting a candidate. One obvious best.
 - ✦ Cond. 1. 66% of information distributed to **all** members of 4-person team.
 - ✦ Result: 67% favored best candidate before discussion, 85% after.
 - ✦ Cond. 2. Information parceled out to individual members, but information given to all favored inferior candidates.
 - ✦ Result: 25% favored best candidate before discussion, even fewer after discussion because of influence of common information.

Information Cascades

- ❖ People follow the lead of others who have spoken before even when they have a different view.
 - ❖ Discussion dominated by common information
 - ❖ Low status members increasingly reluctant to share unique information as discussion proceeds.
 - ❖ The longer the cascade, the riskier it appears to oppose it.

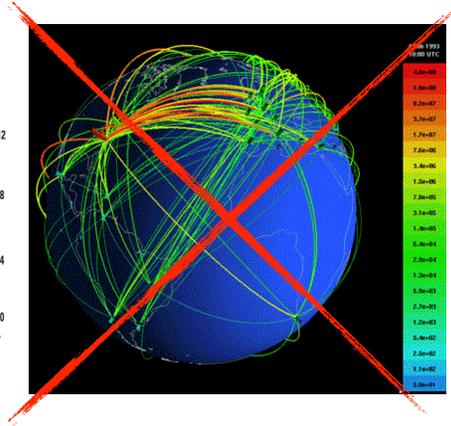
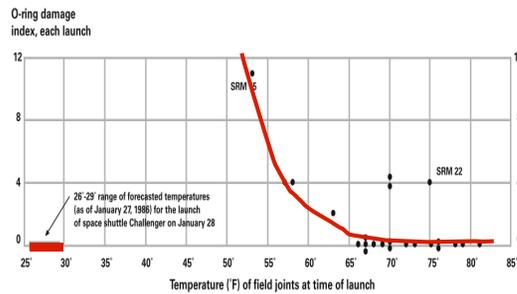
Reputational Cascades

- ❖ People don't contradict the discussion for fear of
 - ❖ Seeming stupid
 - ❖ Incurring hostility
- ❖ The more people who go along, the riskier to oppose.

Group Polarization

- ❖ Deliberation tends to lead to group polarization.
 - ❖ Argumentation. Arguments favoring initial position of group will be more frequent. Have heard more of the arguments.
 - ❖ Social influences. People want to be liked by the group.
 - ❖ Boost of confidence.
 - ❖ Cascade effects

The purpose of Information Visualization is the amplification of cognition not, the creation of pretty pictures.



Summary

- ❖ The basic problem is large information, but small mind and resources.
 - ❖ A solution is the Principle of Selective Omission and Re-representation of Information.
 - ❖ Information visualization uses this principle, often by **aggregating information** in a **better representation** giving **cues to action** relative to a task.
 - ❖ But the flip side of the Principle is that the shortcuts may sometimes lead to illusions, biases, or error.

-
- ❖ Simon's theory of Bounded Rationality encapsulates this tension.
 - ❖ On the one hand, behavior is mostly **adaptive** or "**rational**", meaning the organisms does the logical thing to obtain a goal. Much of the complexity of behavior comes from the complexity of the environment.
 - ❖ On the other hand, processing is "**bounded**", there is often some **proximal mechanism** that uses **heuristics** to **satisfice**--to do good enough.

-
- ❖ For information processing, the **rational** part can be explicated by information foraging theory and sensemaking theory.
 - ❖ **Information foraging theory** says user maximize the rate of information gain.
 - ❖ **Sensemaking theory** says that they try to make sense of information by re-representing it relative to some schema, resulting in a more compact and efficient expression of it relative to some task

-
- ❖ The proximal mechanisms used can lead to errors at all levels. Some of these are
 - ❖ **Perceptual: axis spreading**
 - ❖ **Cognitive: Judgement relativity, anchoring**
 - ❖ **Social: Social distortion of judgment, common knowledge effect, information cascades, reputational cascades, group polarization**
 - ❖ And many more.
 - ❖ Both the facilitative aspect of visualization and the possible routes for error need to be considered in design.



So much for present input devices and their effect on computer design.