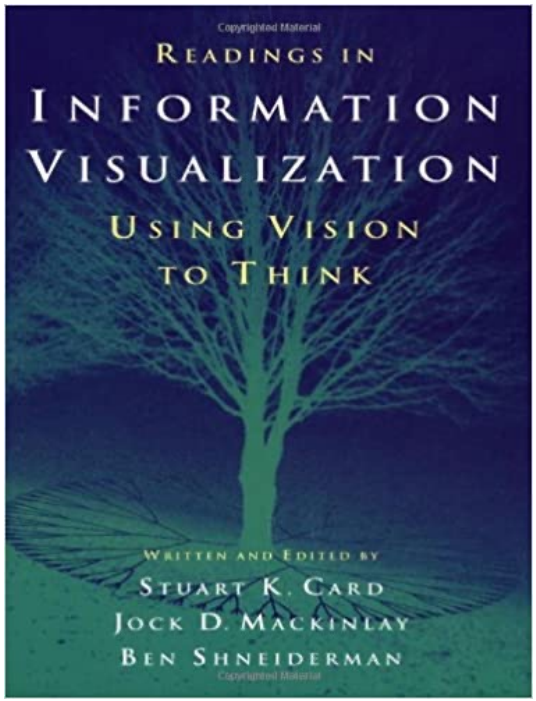
Cognitive Amplification

Card, Mackinlay, Shneiderman (1999), "Information Visualization",
Introduction to "Readings in Information Visualization: Using Vision to Think"

Kerren, A. "Information Visualisation: Perception", Linnaeus Univerty, 2020

Readings in Information Visualization

Editors: Stuart Card, Jock Maclinlay, Ben Shneiderman



"This groundbreaking book defines the emerging field of information visualization and offers the first-ever collection of the classic papers of the discipline"

Morgan Kaufmann; 1st edition (1999)

Chapter 1, pp1-35 (referred to as **CMS**)

Graphical communication…

(a) having an idea, and using graphics to communicate it to someone else

or

(b) using graphics to create, discover, explore an idea; thus "Using vision to think"

Computers make (b) easier than in the past

External cognition

Internal representations: in the mind (cognitive)

External representations: outside the mind (physical)

External cognition: how these two representations "weave together in thought" (CMS,p1)

Using external artefacts thus enhances our power of thought

- multiplication tables
- UML or ER diagrams
- statistical charts
- maps

Insight

Simple graphical communication is straightforward

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"Insight" is a more sophisticated goal:

discovery, decision making, explanation

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Visualisation increases our ability to perform these activities…

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Simple graphical communication is straightforward

"Insight" is a more sophisticated goal:

discovery, decision making, explanation

Visualisation increases our ability to perform these activities…

… through the provision of external representations

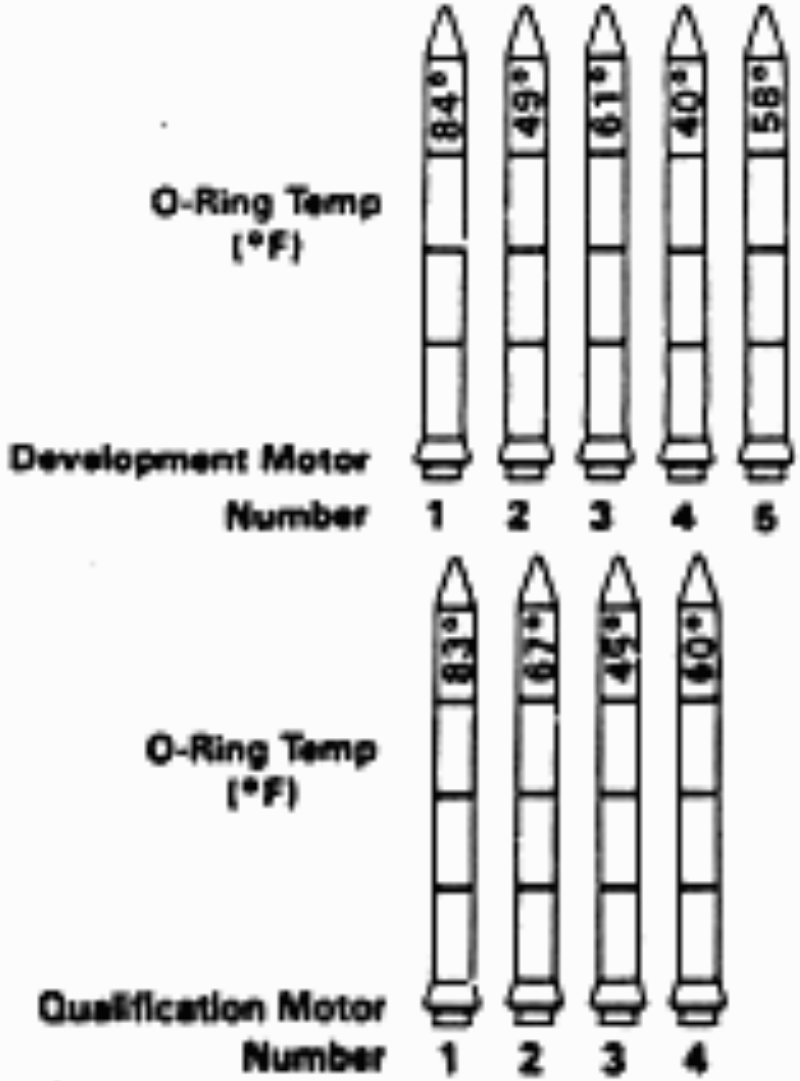
Visualisation insight example

Challenger shuttle disaster (January 28, 1986)

- Caused by failure of O-rings in extreme cold

Exploded 73 seconds after lift-off, killing seven astronauts

History of O-Ring Damage in Field Joints



Code

- S = Heating of Secondary O-Ring
- B = Primary O-Ring Blowby
- E = Primary O-Ring Erosion
- H = Heating of Primary O-Ring
- □ = No Damage

STATIC TEST MOTORS

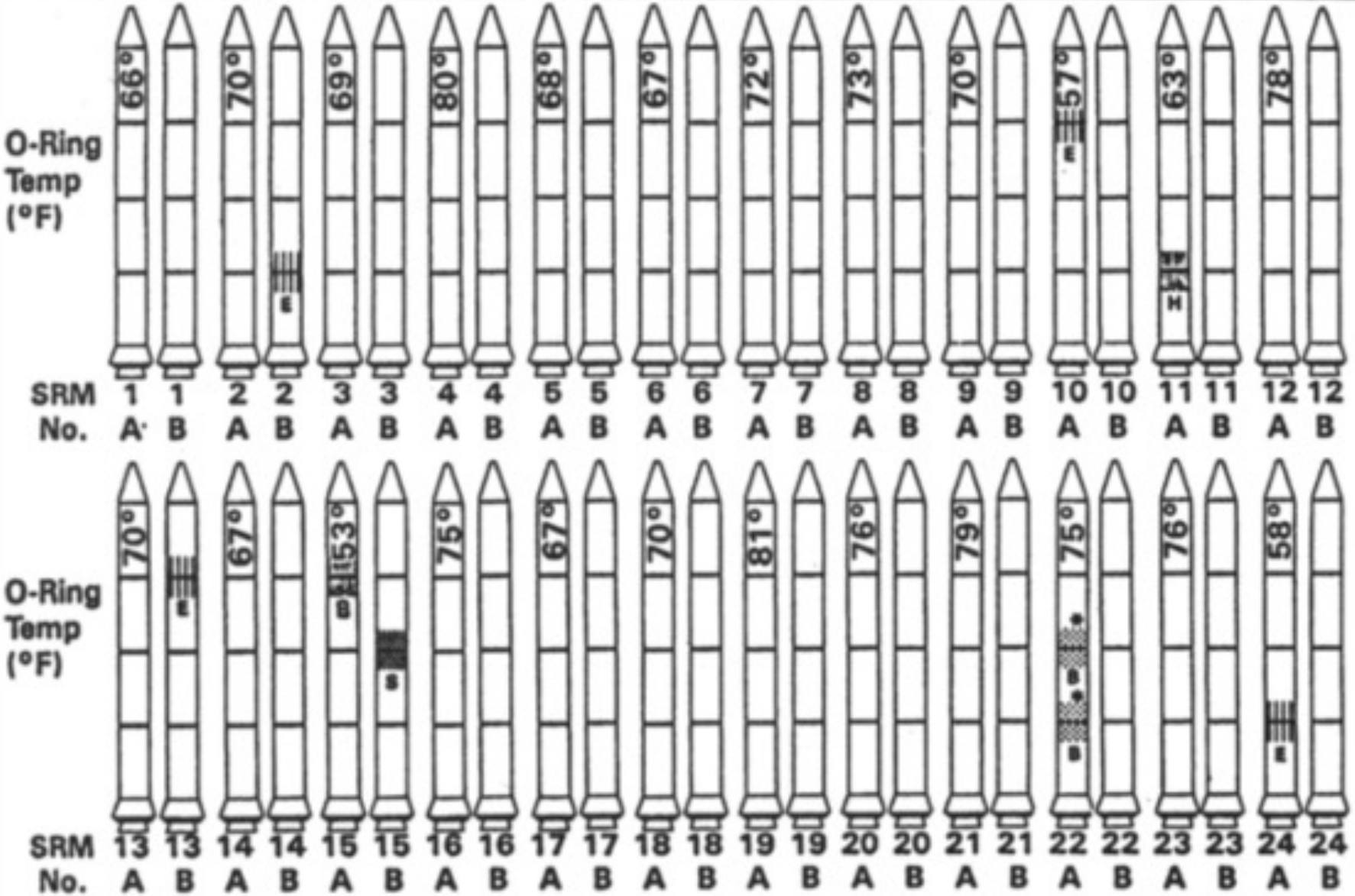
- HORIZONTAL ASSEMBLY
- SOME PUTTY REPAIRED

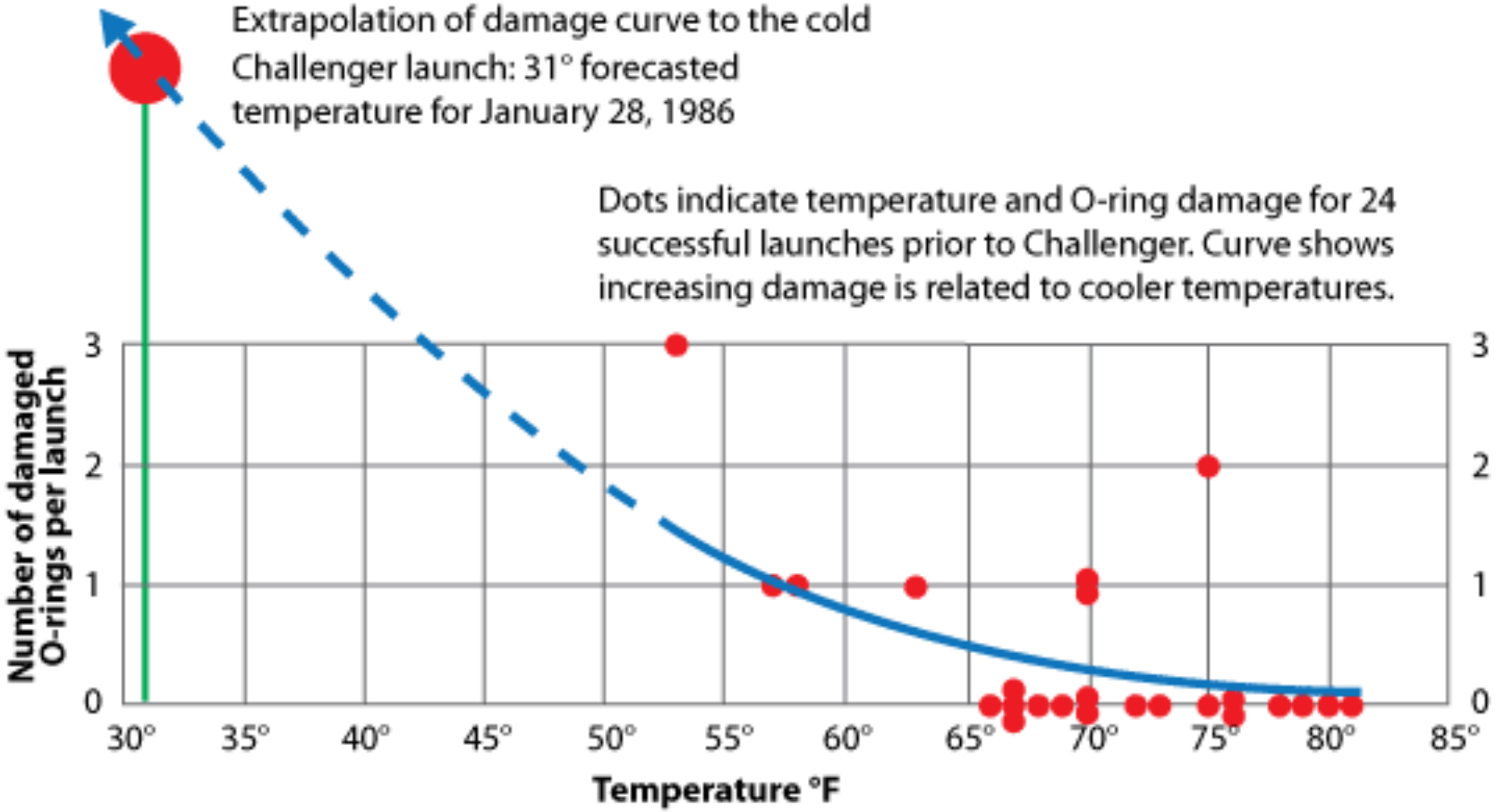
Morton Thiokol, Inc.
Wasatch Operations

[illegible]

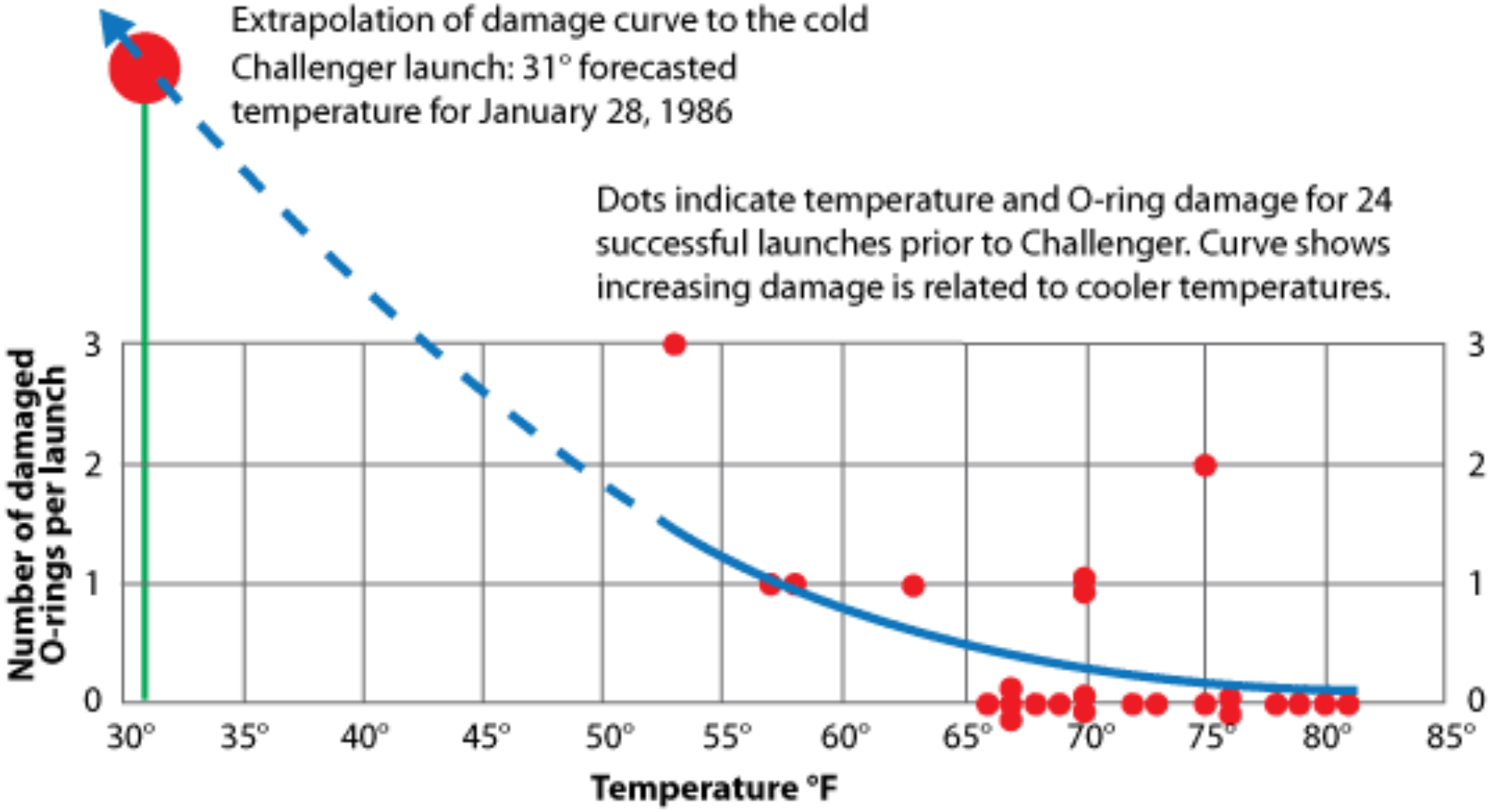
[Ref. 2/26-2 1 of 3]

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





https://stanfordmag.org/contents/elemental-evidence (13/05/21)



Thus: Visualisation can support external cognition and insight
– but only if used appropriately

https://stanfordmag.org/contents/elemental-evidence (13/05/21)

Visualization, by definition

"The use of computer-supported, interactive, visual representations of data to amplify cognition" (CMS, p6)

"*…visualization is an activity which a human being engages in… a cognitive activity… it goes on in the mind."* (Spence, p1)

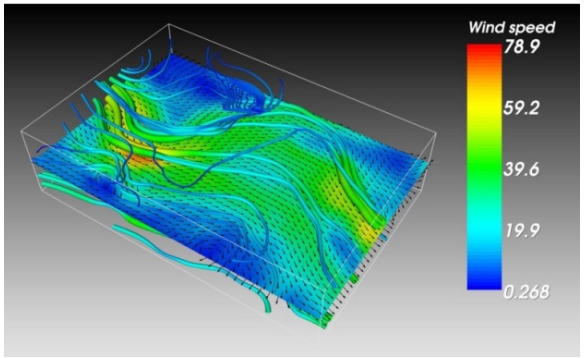
R. Spence, "Information Visualization", Addison Wesley, 2001

Scientific Visualisation *vs* Information Visualisation

SciViz: direct spatial relationship with concrete phenomena

based on physical data, e.g.

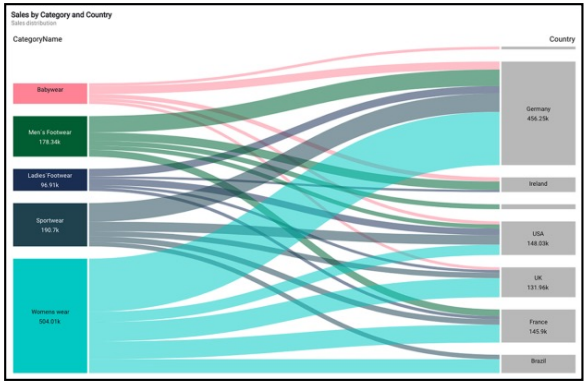
- human body
- the earth
- molecules
- liquid flow



InfoViz: devised relationship with abstract phenomena

based on abstract ideas, e.g.

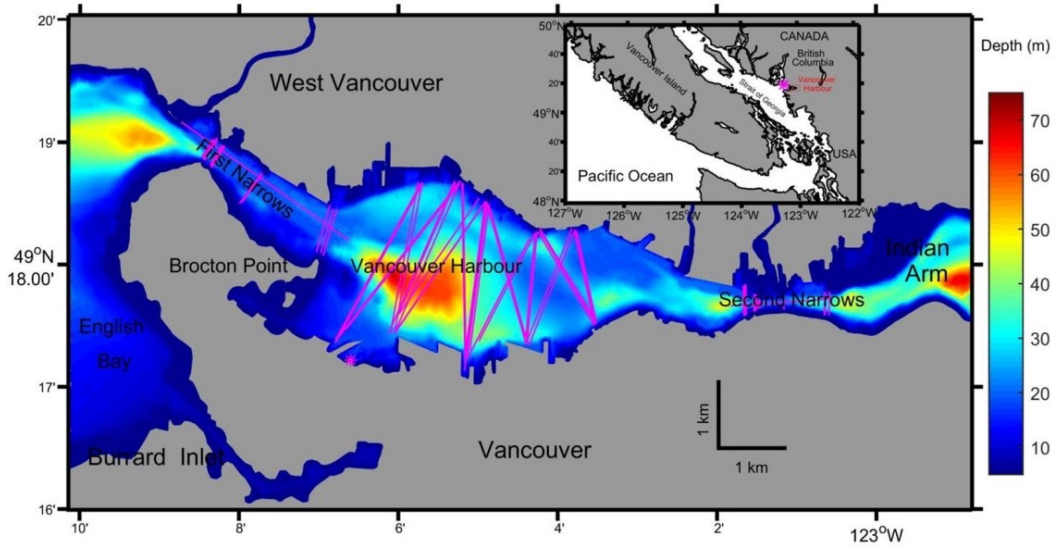
- organisation hierarchies
- scatter plots
- periodic table
- financial time series data

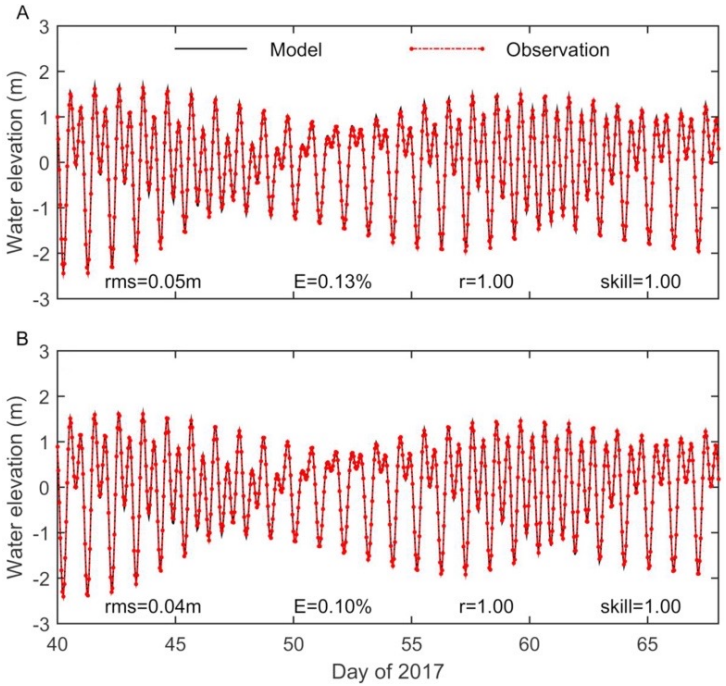


Wind speed image: https://quppler.com/visualization-toolkit-vtk-volume-rendering-pipeline/

Sales image: https://www.qlik.com/us/data-visualization

SciViz vs InfoViz:
Tides in the Port of Vancouver





Wu, Y. et al. (2019) A modeling study on tides in the Port of Vancouver. Anthropocene Coasts 2(1)

External cognition	The use of the external world to accomplish cognition
Information design	Design of external representations to amplify cognition
Data **graphics**	Use of abstract, nonrepresentational visual representations of data to amplify cognition
Visualisation	Use of computer-based, interactive visual representations of data to amplify cognition
Scientific Visualisation	Use of computer-based, interactive visual representations of scientific data, physically based, to amplify cognition
Information Visualisation	Use of computer-based, interactive visual representations of abstract data, non-physically based, to amplify cognition

Thus, the purpose of IV is to use the perception of external representations to amplify cognition

(slightly) adapted from CMS, Table 1.1, p7

Larkin & Simon (1987)

"*Why a Diagram is (Sometimes) Worth Ten Thousand Words*", Cognitive Science 11: 65-99

Compared the process of solving physics problems using information presented

- in a 'diagrammatic' form
- in a 'sentential' form

Larkin & Simon (1987)

"Why a Diagram is (Sometimes) Worth Ten Thousand Words", Cognitive Science 11, 65-99

Compared the process of solving physics problems using information presented

- in a 'diagrammatic' form
- in a 'sentential' form

Computed the **cognitive effort** of solving the problem for tasks: search, recognition, inference

Identified the ways in which diagrams make problem-solving more efficient than using the sentential form

2.1. The Given Data Structure and Program

Consider a problem given in the following natural language statements. We have three pulleys, two weights, and some ropes, arranged as follows:

1. The first weight is suspended from the left end of a rope over Pulley A. The right end of this rope is attached to, and partially supports, the second weight.
2. Pulley A is suspended from the left end of a rope that runs over Pulley B, and under Pulley C. Pulley B is suspended from the ceiling. The right end of the rope that runs under Pulley C is attached to the ceiling.
3. Pulley C is attached to the second weight, supporting it jointly with the right end of the first rope.

The pulleys and ropes are weightless; the pulleys are frictionless; and the rope segments are all vertical, except where they run over or under the pulley wheels. Find the ratio of the second to the first weight, if the system is in equilibrium.

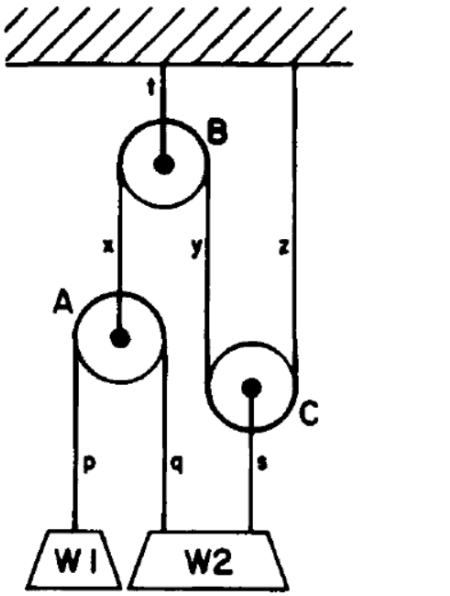


Figure 1. Diagram of the pulley problem.

Larkin & Simon (1987), p73-74

How (and why) IV amplifies Cognition

Increased resources

- extension of short term memory (STM), parallel perception …

Reduced search

- e.g. by grouping of information

Enhanced recognition of patterns

- e.g. by abstraction or aggregation, recognition over recall

Perceptual inference

- some information is more obvious when presented visually

Perceptual monitoring

- simultaneous perception of large data sets (e.g. by animation)

Manipulable medium

- exploration of data space by parameter manipulation, interaction…

CMS p16, edited

Cognitive Amplification