CPSC 481:
Beyond Simple Screen Design

Creating visual representations

Bertin's Visual variables: creating visual representations

Tufte's guidelines: assessing visual representations

Sheelagh Carpendale

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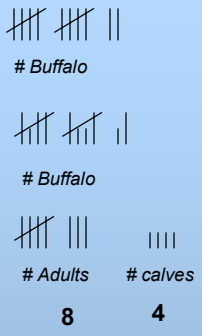
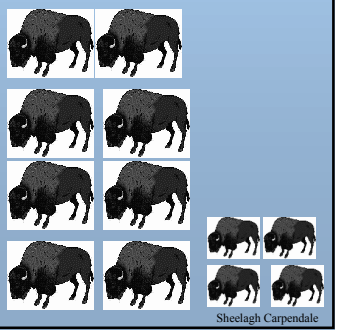
Representations

Good representations

- captures essential elements of the event / world
- deliberately leaves out / mutes the irrelevant
- appropriate for the person and their interpretation
- appropriate for the task, enhancing judgment ability

How many buffalo?





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Representation

A representation is

- **a formal system or mapping by which the information can be specified** (D. Marr)
- **a sign system in that it stands for something other than its self**.

for example: the number thirty-four *or* the buffalo example

decimal: 34,
binary: 100010,
roman: XXXIV

different representations reveal different aspects of the information

decimal: counting & information about powers of 10,
binary: counting & information about powers of 2,
roman: counting

presentation

how the representation is placed or organized on the screen

34, 34, **34**

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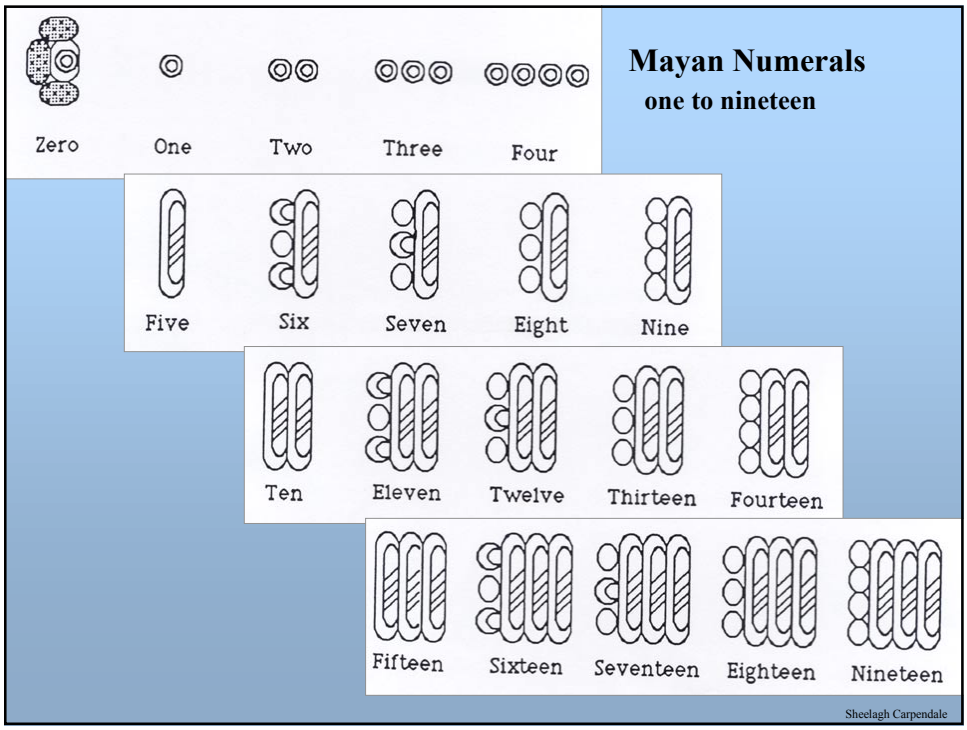
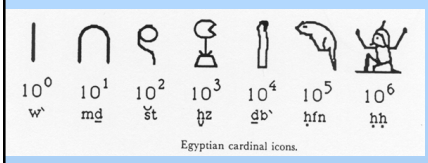
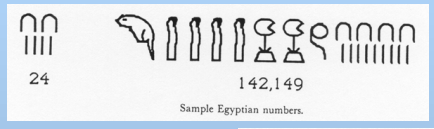


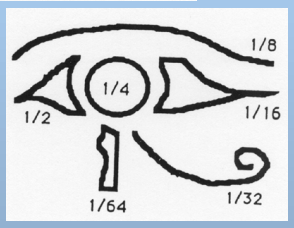
Egyptian Numerals

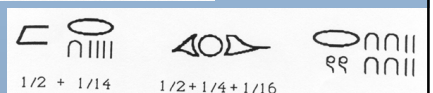


Egyptian cardinal icons.



Sample Egyptian numbers.





Sample Egyptian fractions.

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Representations

Solving a problem simply means representing it so as to make the solution transparent … *(Simon, 1981)*

Good representations

- allow people to *find* relevant information
  - information may be present but hard to find
- allow people to *compute* desired conclusions
  - computations may be difficult or "for free" depending on representations

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When do I take my drugs?

Note: 10 - 30% error rate in taking pills, same for pillbox organizers

Inderal -1 tablet 3 times a day
Lanoxin -1 tablet every a.m.
Carafate - 1 tablet before meals and at bedtime
Zantac - 1 tablet every 12 hours (twice a day)
Quinag - 1 tablet 4 times a day
Couma - 1 tablet a day

	Breakfast	Lunch	Dinner	Bedtime
Lanoxin	O			
Inderal	O	O		O
Quinag	O	O	O	O
Carafate	O	O	O	O
Zantac		O		O
Couma				O

Breakfast	Lunch	Dinner	Bedtime
Lanoxin			
Inderal	Inderal		Inderal
Quinag	Quinag	Quinag	Quinag
Carafate	Carafate	Carafate	Carafate
	Zantac		Zantac
			Couma

Organized by both time of day and by drug

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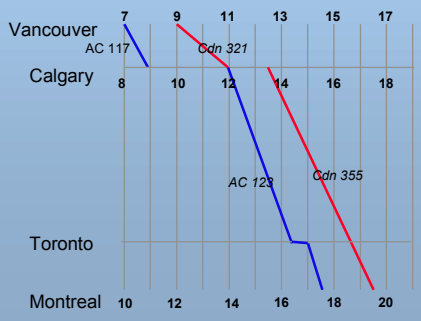
Which is the best flight?

length, stop-overs, switches...

		depart	*arrive*
AC 117	Vancouver - Calgary	7:00	9:00
Cdn 321	Vancouver - Calgary	9:00	12:00
Cdn 355	Calgary - Montreal	13:30	19:30
AC 123	Calgary - Toronto	12:30	16:30
AC 123	Toronto - Montreal	16:45	17:30

*time zone: +1 van-cal, +2 cal-tor, mtl



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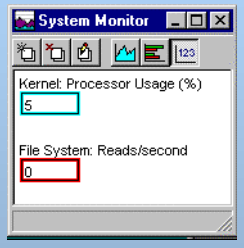
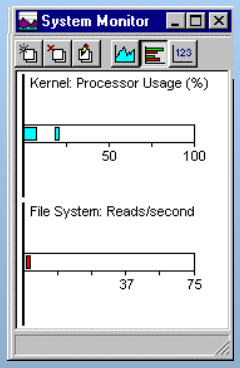
Which representation is best?

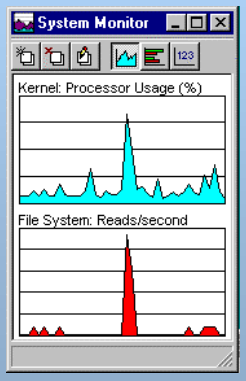
depends heavily on task



What is precise value?



How does the performance now compared to its peak?



How does performance change over time?

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Creating Visual Representations

Where does one start?

with marks!

- **for us, pixels?**

Visual Variables: how can we vary marks?

- **by where we place them**
- **by how we place them (Bertin calls this 'implantation')**
- **by their visual characteristics (Bertin calls these retinal variables)**

Jacques Bertin,
Semiology of Graphics: Diagrams, Networks, Maps.
Translated by W. J. Berg. University of Wisconsin Press 1983 (in French 1967)

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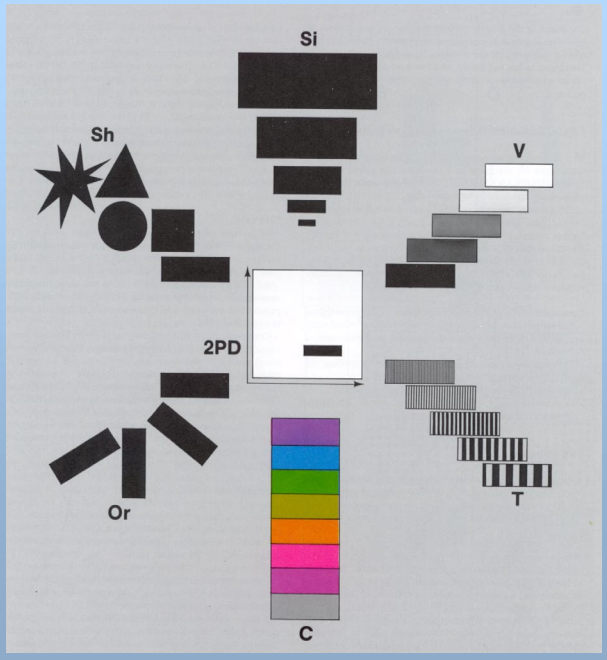
Visual Variables



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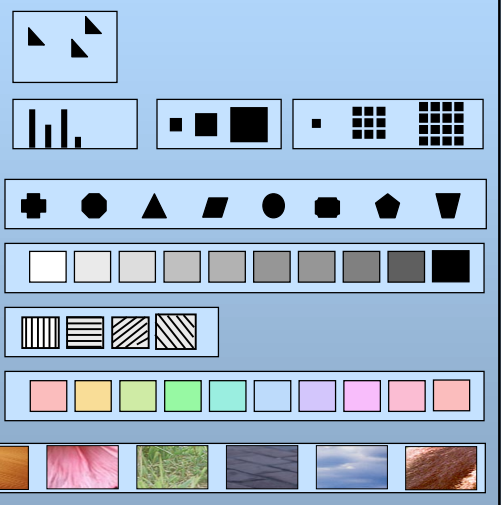
Visual Variables

Attributes

- **position**
  - changes in the x, y (z) location
- **size**
  - change in length, area or repetition
- **shape**
  - infinite number of shapes
- **value**
  - changes from light to dark
- **orientation**
  - changes in alignment
- **colour**
  - changes in hue at a given value
- **texture**
  - variation in pattern
- **motion**



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Visual Variables

Characteristics of visual variables can be

- **selective**
  is a change in this variable enough to allow us to select it from a group?
- **associative**
  is a change in this variable enough to allow us to perceive them as a group?
- **quantitative**
  is there a numerical reading obtainable from changes in this variable?
- **order**
  are changes in this variable perceived as ordered?
- **length**
  across how many changes in this variable are distinctions perceptible?

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Visual Variable: Position

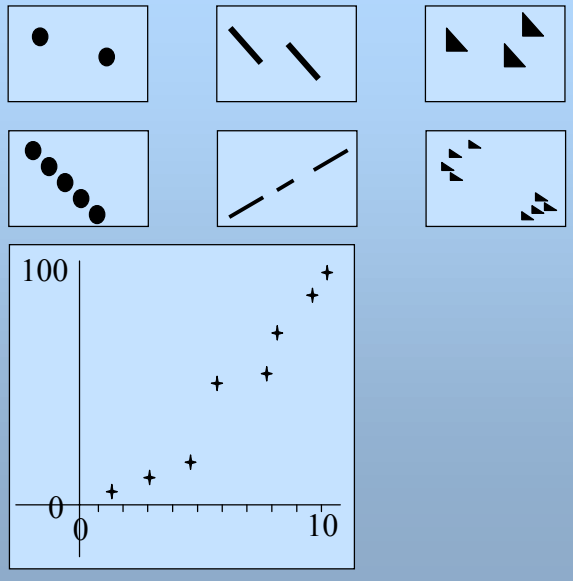
✓ **selective**

✓ **associative**

✓ **quantitative**

✓ **order**

✓ **length**



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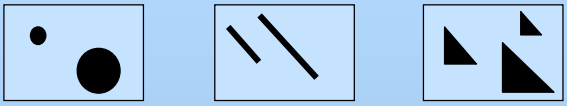
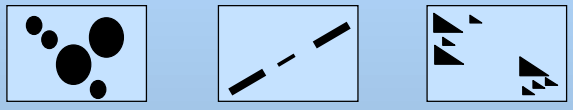
Visual Variable: Size

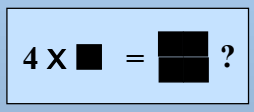
✓ selective



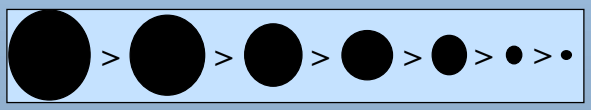
✓ associative



≈ quantitative



✓ order



✓ length

- theoretically infinite but practically limited
- association and selection ~ 5 and distinction ~ 20

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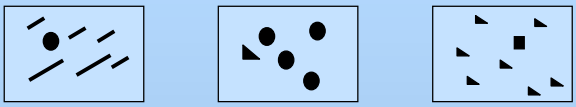
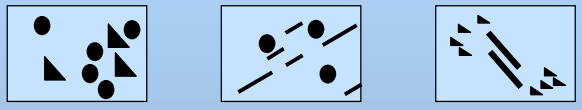
Visual Variable: Shape

≈ Selective



≈ associative



≠ quantitative

≠ order

✓ length - infinite variation

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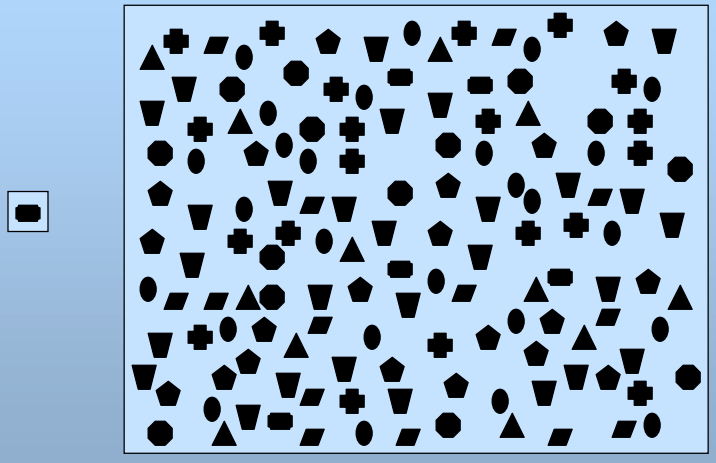
Shape



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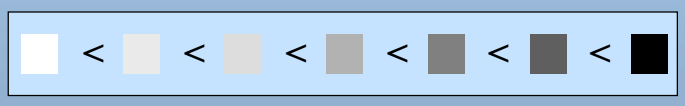
Visual Variable: Value

✓ **selective**

✓ **associative**

≠ **quantitative**

✓ **order**



✓ **length**

- theoretically infinite but practically limited
- association and selection ~ < 7 and distinction ~ 10

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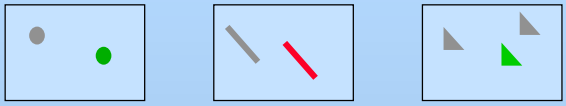
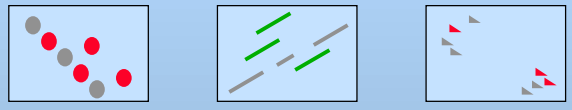
Visual Variable: Colour

✓ **Selective**



✓ **associative**



≠ **quantitative**

≠ **order**

✓ **length**

- theoretically infinite but practically limited
- association and selection ~ < 7 and distinction ~ 20

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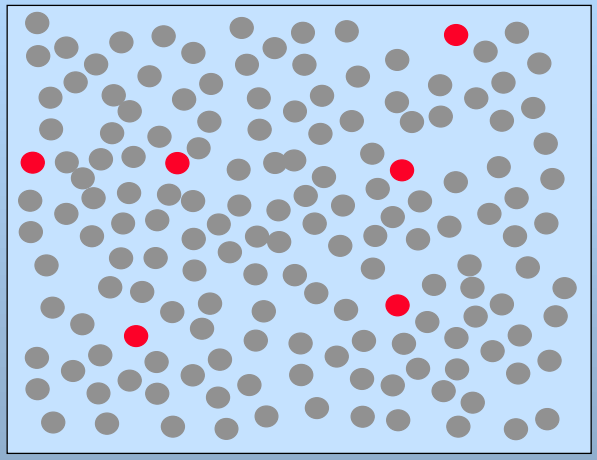
Colour



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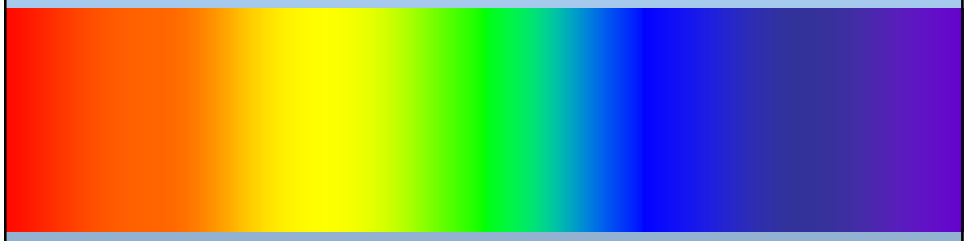
Encoding

Common advice says use a rainbow scale

- Marcus, Murch, Healey
- problems with rainbows



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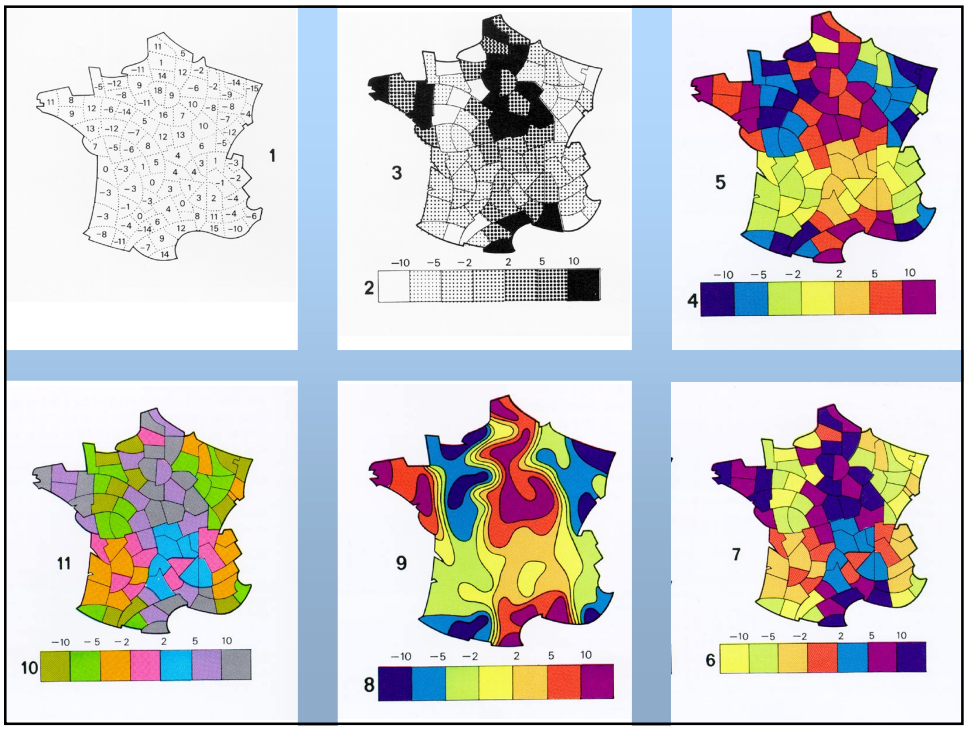

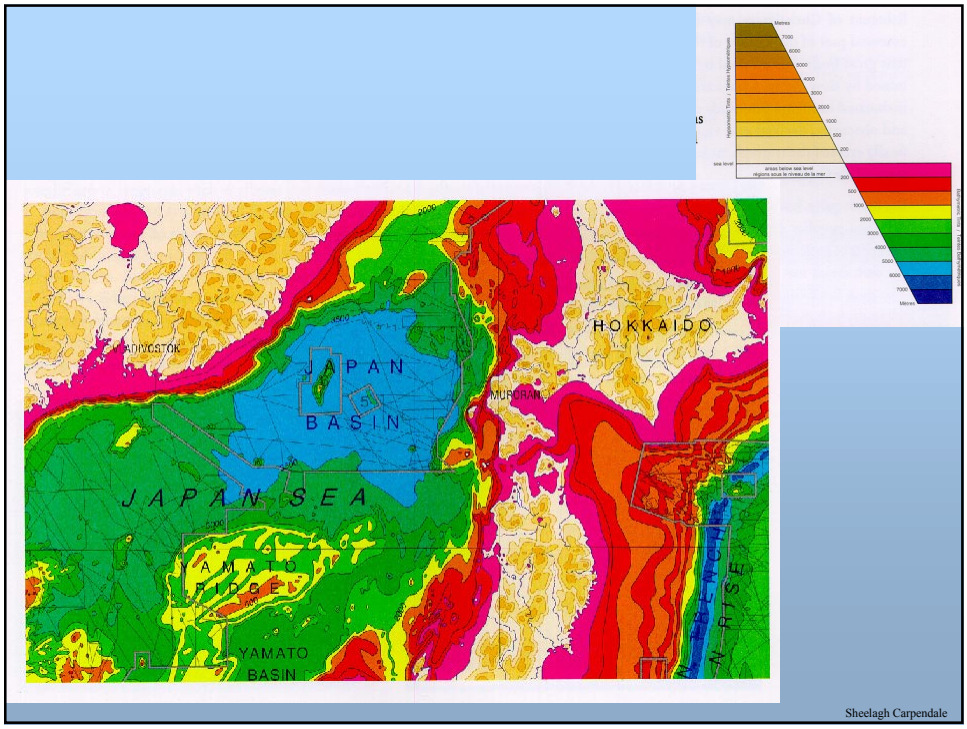
HOKKAIDO
JAPAN
BASIN
JAPAN SEA
YAMATO
RIDGE
YAMATO
BASIN
MURORAN
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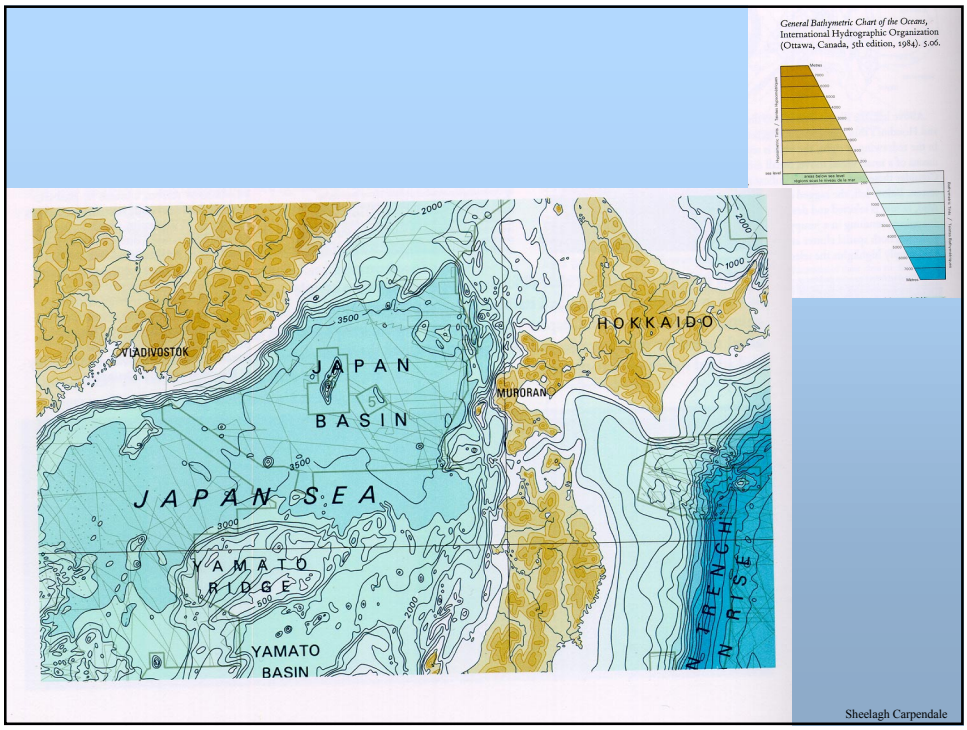
General Bathymetric Chart of the Oceans,
International Hydrographic Organization
(Ottawa, Canada, 5th edition, 1984). 5.06.
HOKKAIDO
JAPAN
BASIN
JAPAN SEA
YAMATO
RIDGE
YAMATO
BASIN
MURORAN
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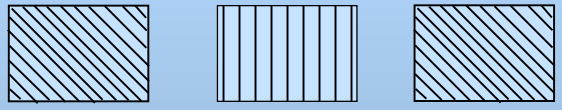
Visual Variable: Orientation

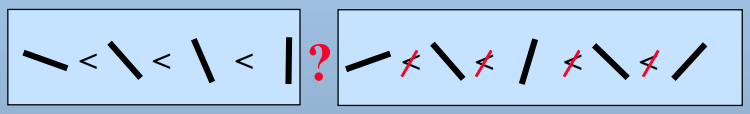
✓ selective

✓ associative



≠ quantitative

≠ order



✓ length
- ~5 in 2D; ? in 3D

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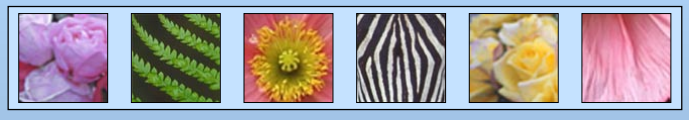
Visual Variable: Texture

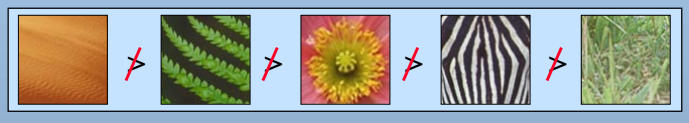
✓ Selective

✓ associative



≠ quantitative

≠ order



✓ length
- theoretically infinite

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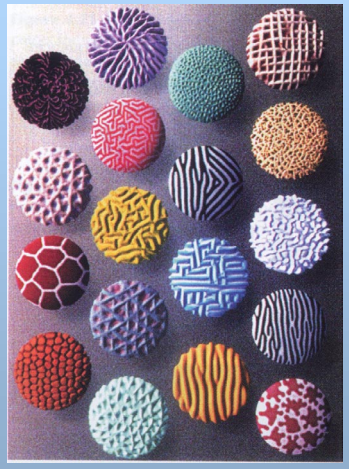
Textures



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Visual Variable: Motion

✓ **selective -** motion is one of our most powerful attention grabbers

✓ **associative -** moving in unison groups objects effectively

≠ **quantitative -** subjective perception

≠ **order -**

? **length - distinguishable types of motion?**

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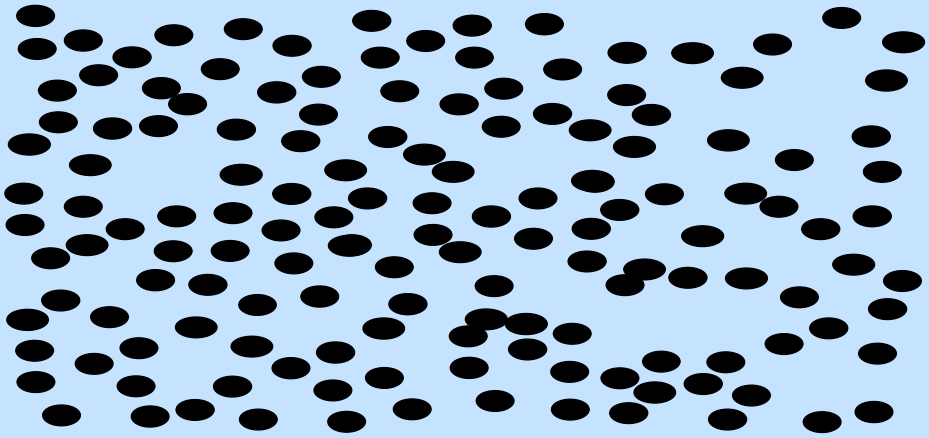
Motion



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Information Visualization

Graphics should reveal the data

- show the data
- not get in the way of the message
- avoid distortion
- present many numbers in a small space
- make large data sets coherent
- encourage comparison between data
- supply both a broad overview and fine detail
- serve a clear purpose

E. Tufte
Visual Display of Quantitative Information

note:
many visual examples are taken from Tufte's books

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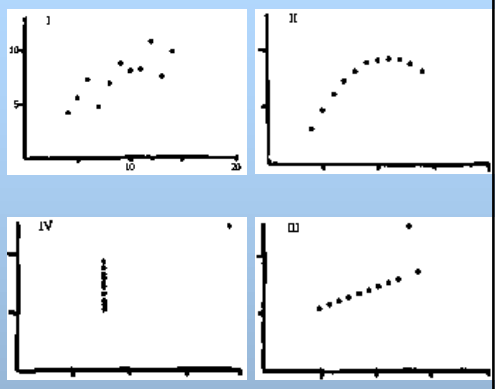
Anscombe's Quartet

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89



N:	11.0
mean X's :	9.0
mean Y's :	7.5
standard error of slope estimate:	0.1
sum of squares:	110.0
regression sum of squares:	27.5
residual sum of squares of Y:	13.8
correlation coefficient:	0.8
r squared:	0.7
regression line:	Y=3+0.5X

Graphics Reveal the Data

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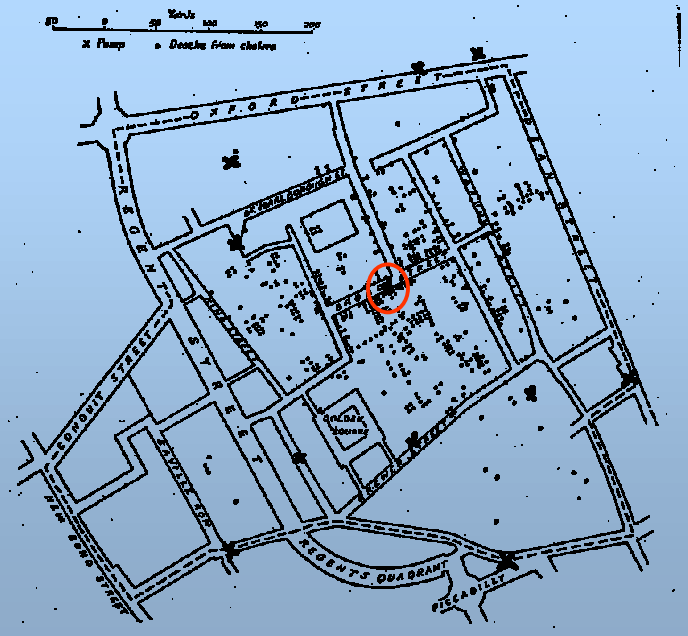
Deaths by Cholera

Dr John Snow
1854



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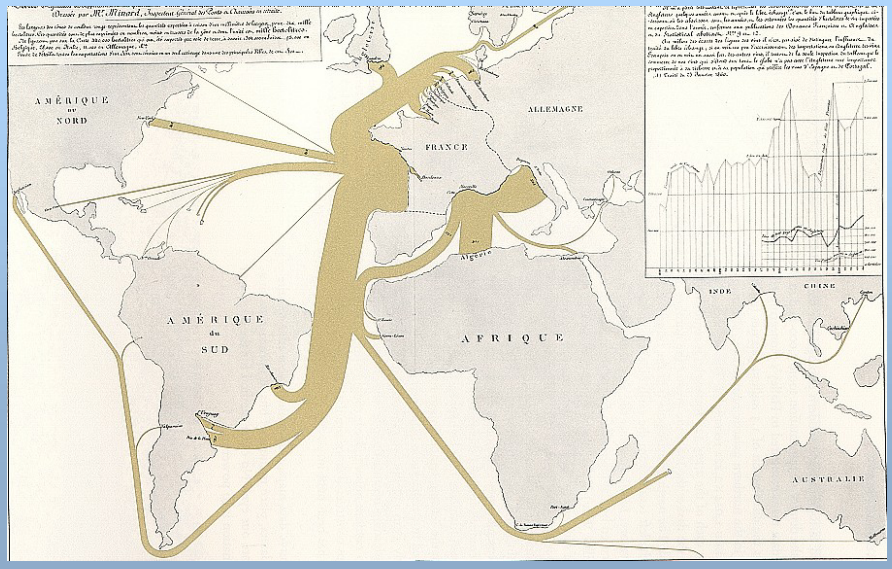
1864 Exports of French Wine



E. Tufte "Visual Display of Quantitative Information" p 25,

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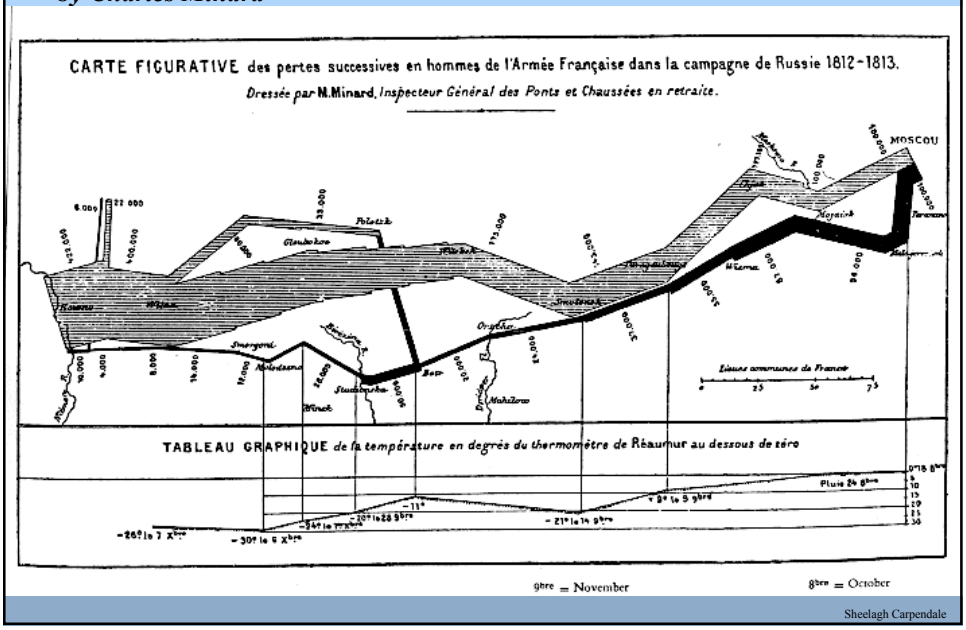
Telling a story: Napolean's march to Moscow

by Charles Minard

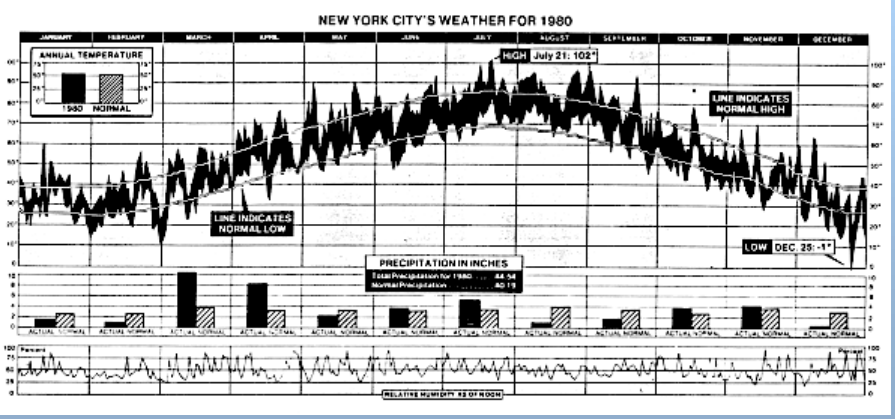


Sheelagh Carpendale

Data Density

New York Weather History

- 181 numbers/sq inch



Sheelagh Carpendale

Chart Junk: A common error

Information visualization is not just pretty graphics

- graphical re-design by amateurs on computers gives us
  - "fontitis," "chart-junk," etc.

Dear **Sir**;
This is a *really* **exciting** opportunity! Take advantage of it !

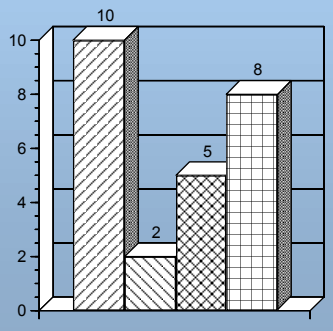


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Chart Junk: Cotton production in Brazil, 1927

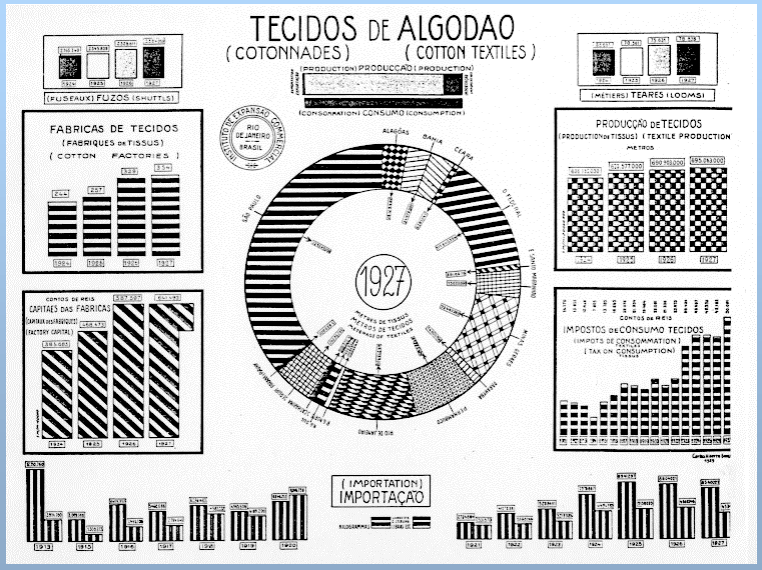

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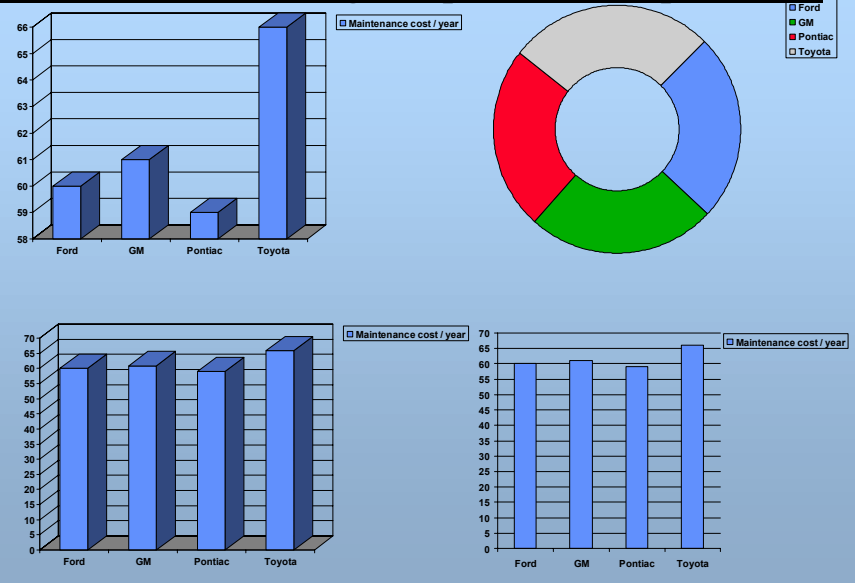
Chart Junk: Removing deception and simplification



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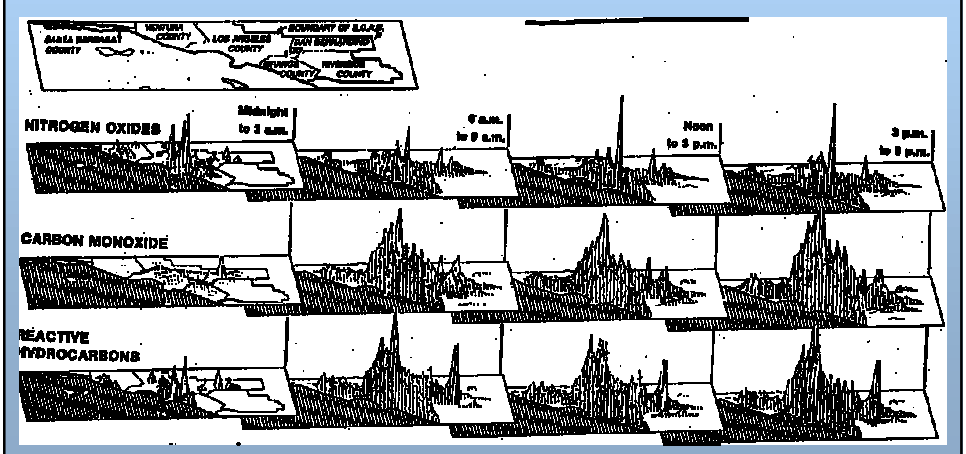
Small Multiples

Learn once

Invite comparisons



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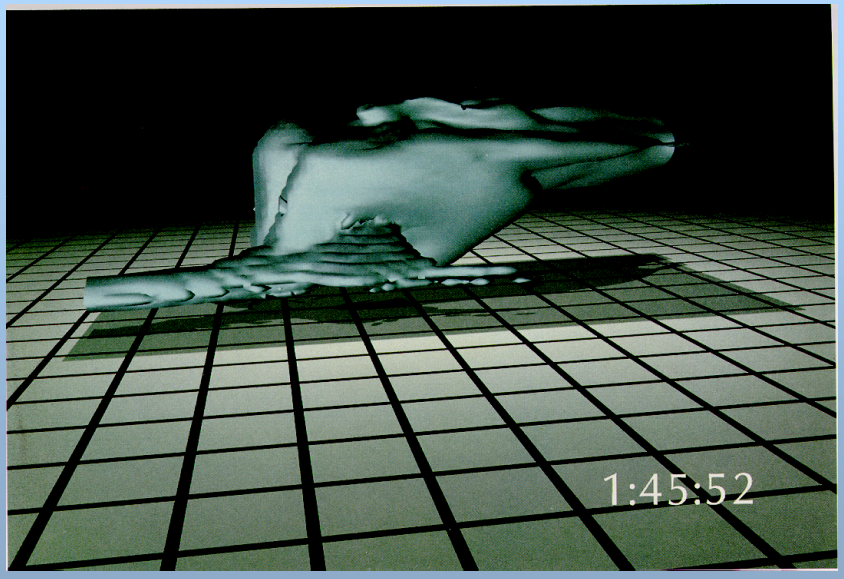
Small Multiples: Showing Time and Change



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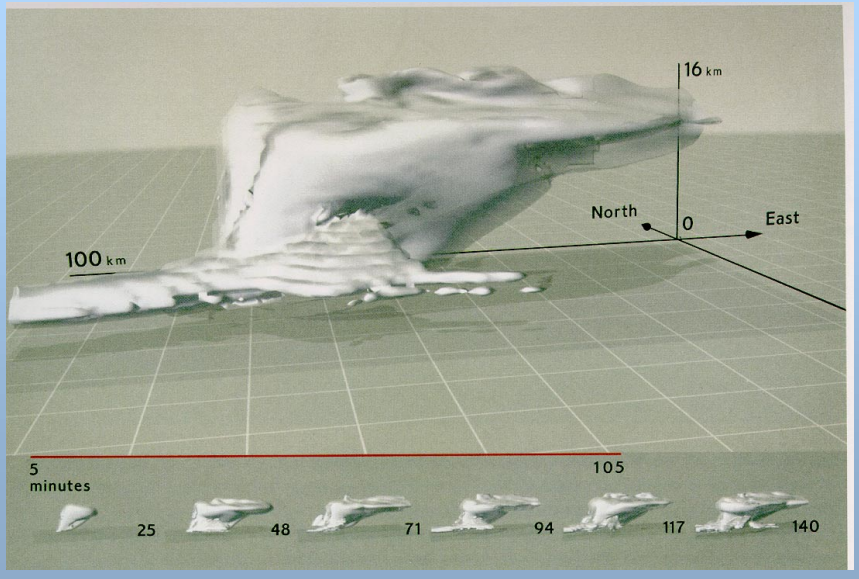
Small Multiples: Showing Time and Change



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