

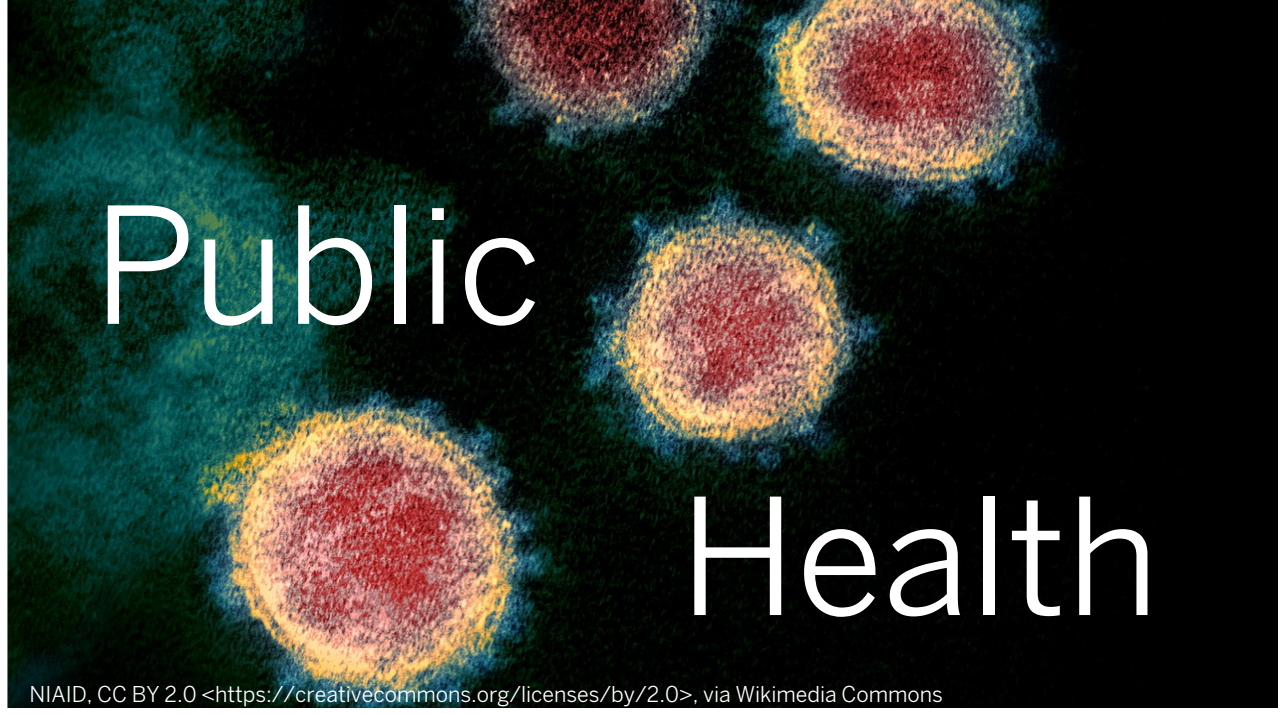
Analytical Conversation

Jock Mackinlay, Technical Fellow, Tableau/Salesforce



Climate

Nepenthes, CC BY-SA 3.0 <<https://creativecommons.org/licenses/by-sa/3.0/>>, via Wikimedia Commons



Public Health

NIAID, CC BY 2.0 <<https://creativecommons.org/licenses/by/2.0/>>, via Wikimedia Commons



Education

Capt. John Severns, U.S. Air Force, Public domain, via Wikimedia Commons

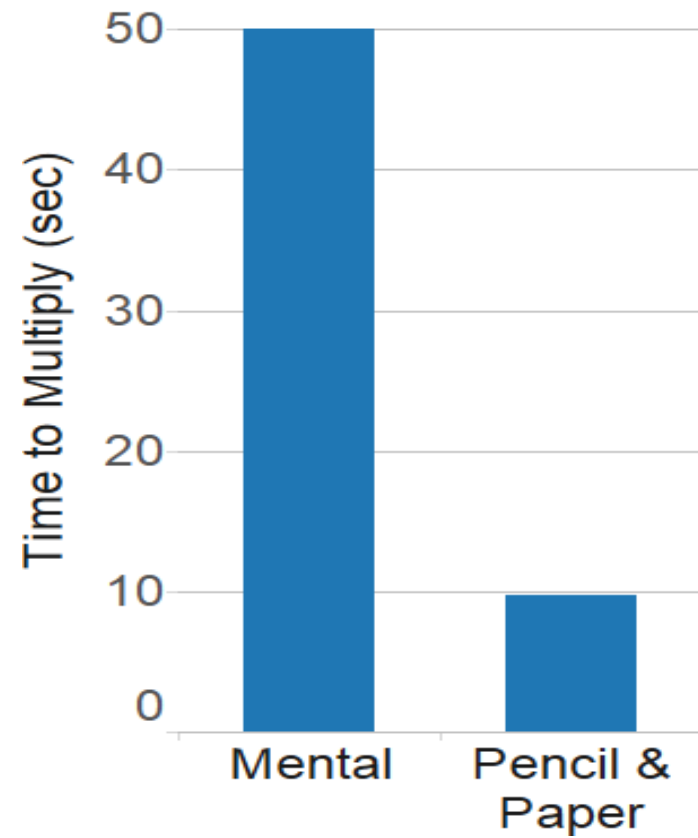


Rickmouser45, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons

$$\begin{array}{r} 34 \\ \times 72 \\ \hline \end{array}$$

$$\begin{array}{r} 34 \\ \times 72 \\ \hline 68 \\ 2380 \\ \hline 2448 \end{array}$$

$$\begin{array}{r} 34 \\ \times 72 \\ \hline 68 \\ \overset{1}{2}380 \\ \hline 2448 \end{array}$$



Curate data

Authoring

Modeling

Manage

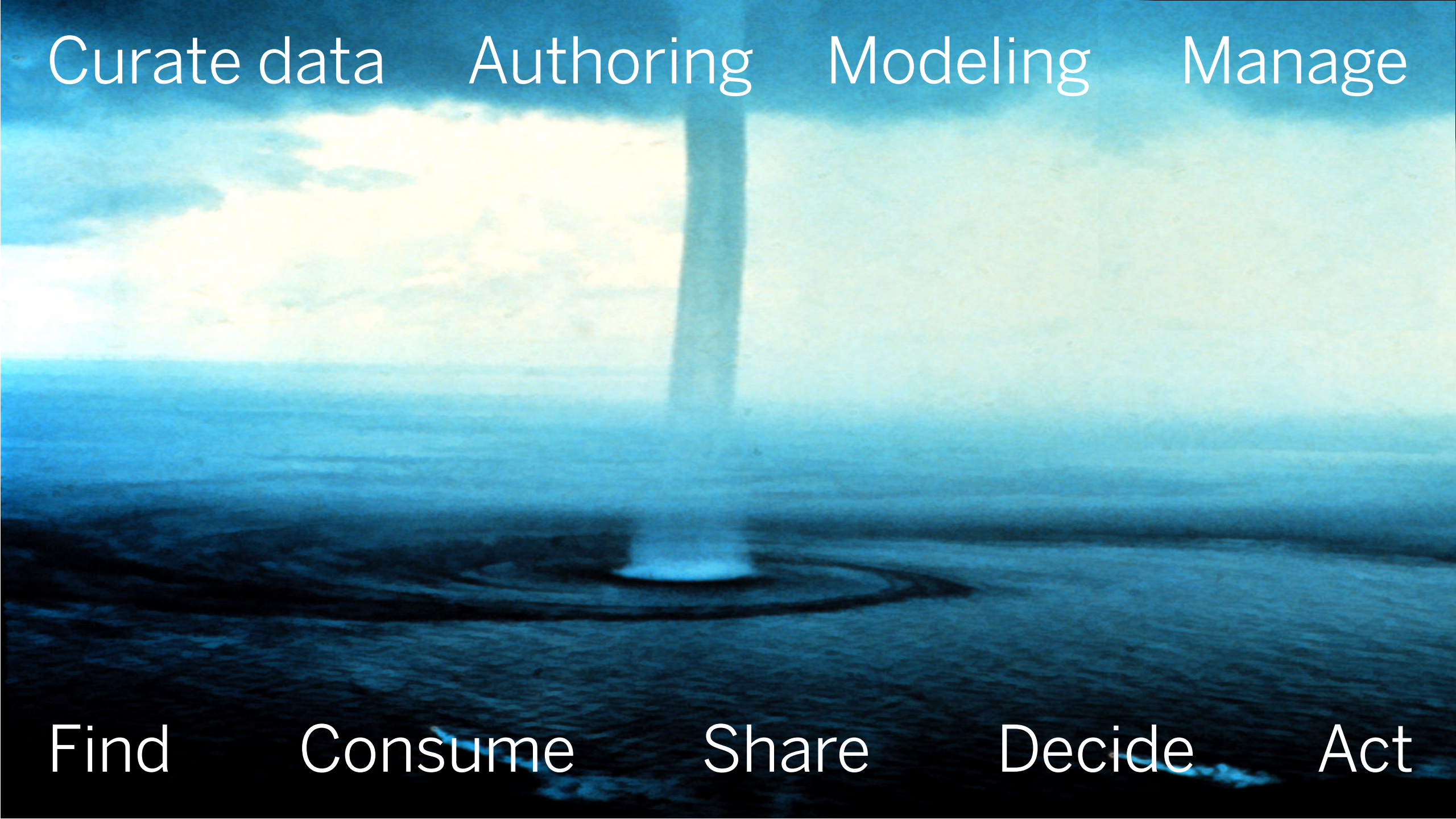
Find

Consume

Share

Decide

Act



Curate data

Authoring

Modeling

Manage

Self-service Analysis

Find

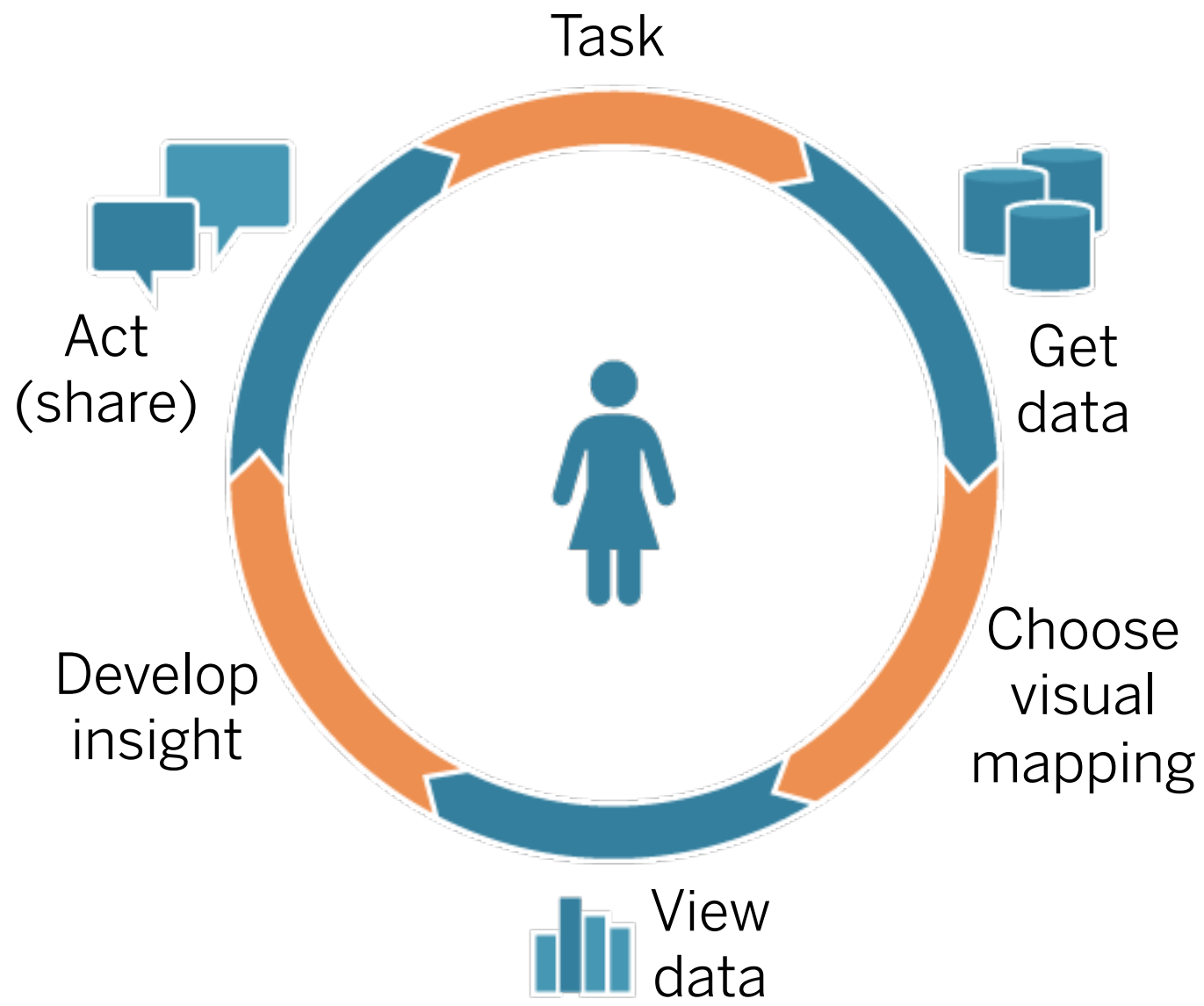
Consume

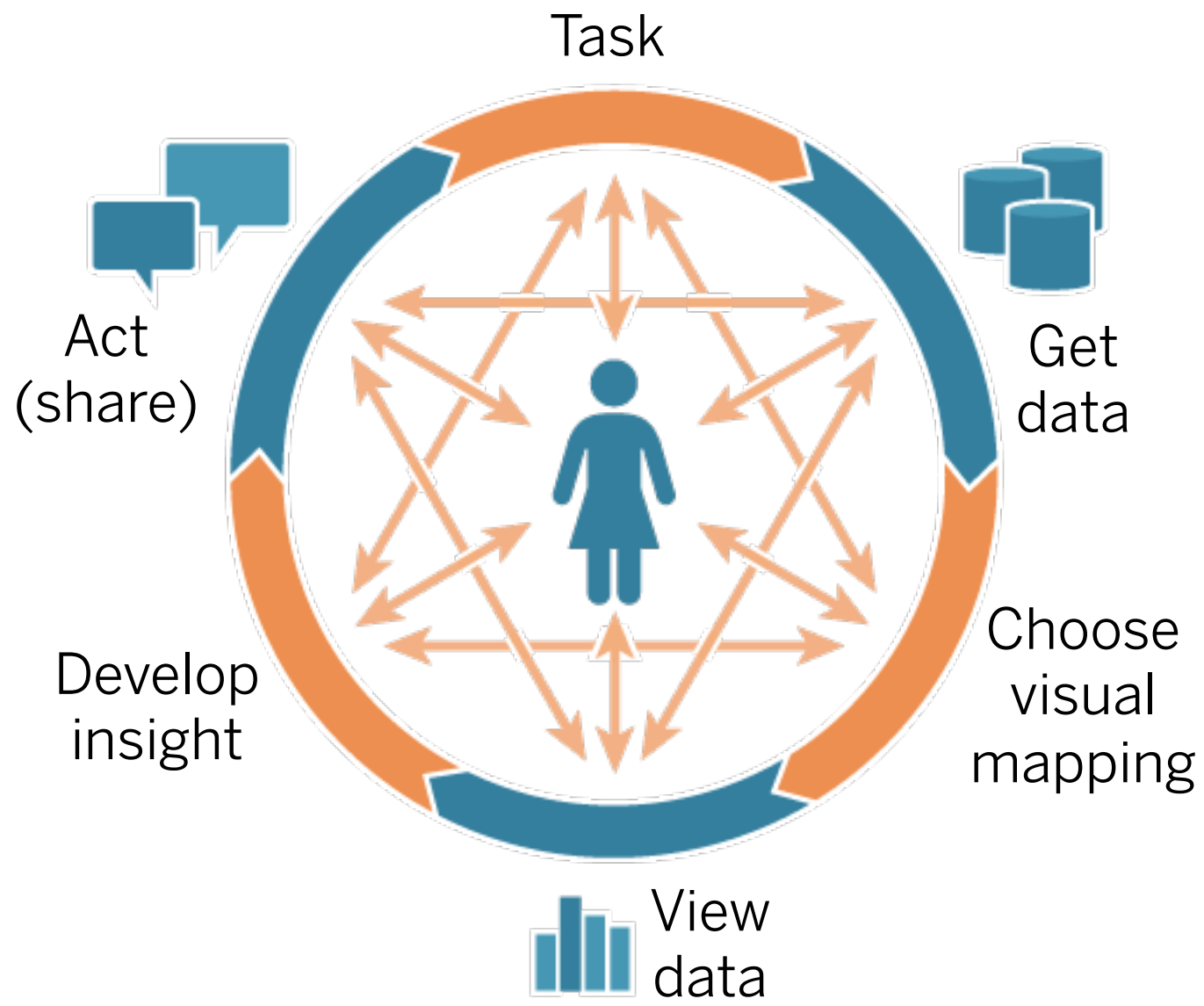
Share

Decide

Act











US AIRWAYS EXPRESS

Republic Airlines

EMBRAER 175



US AIRWAYS

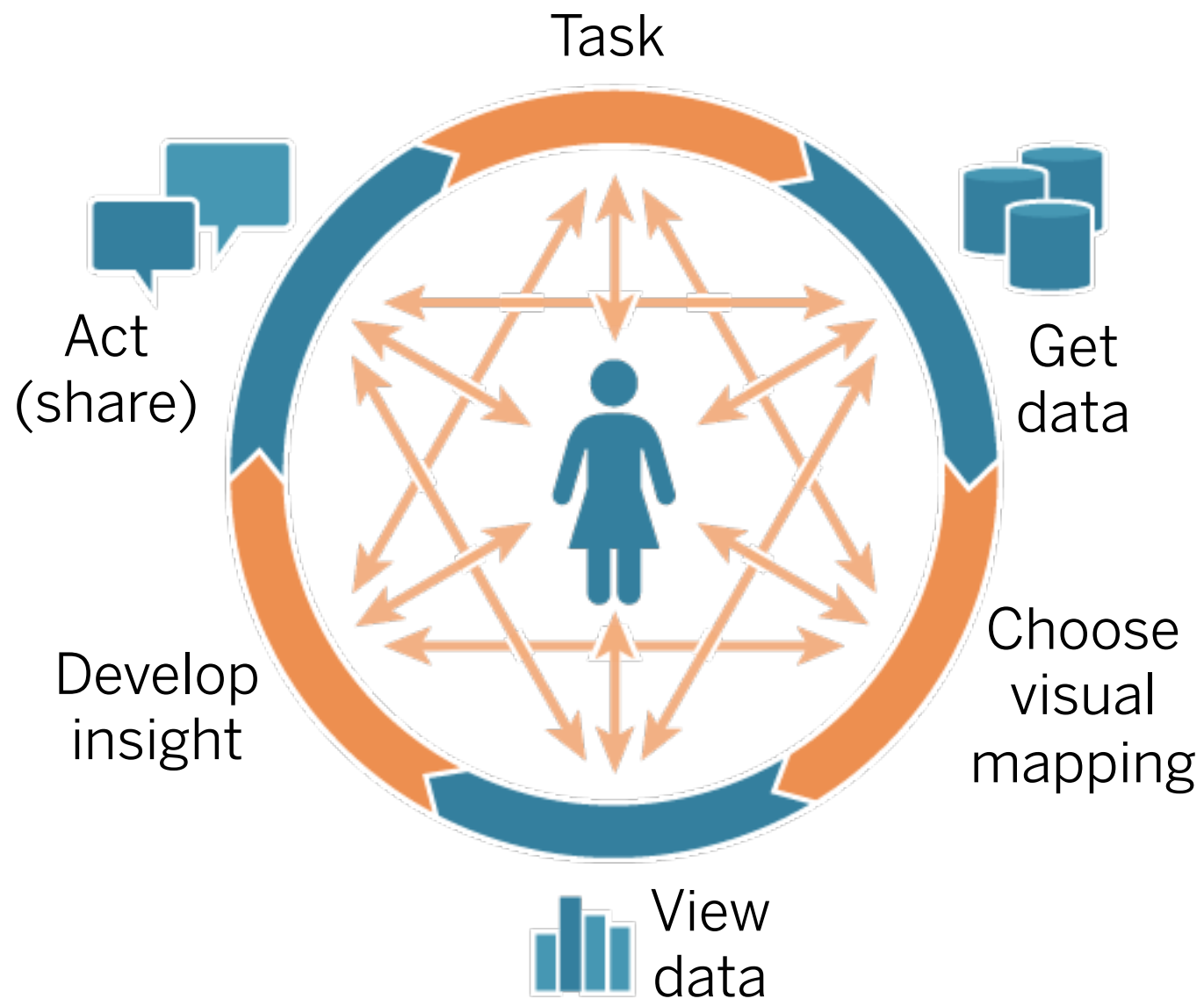
FAA Wildlife Strike Database

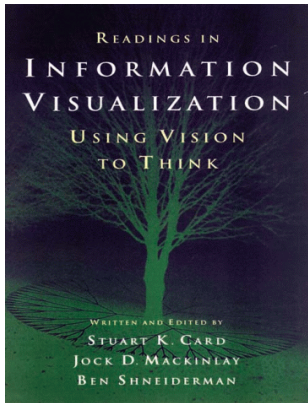
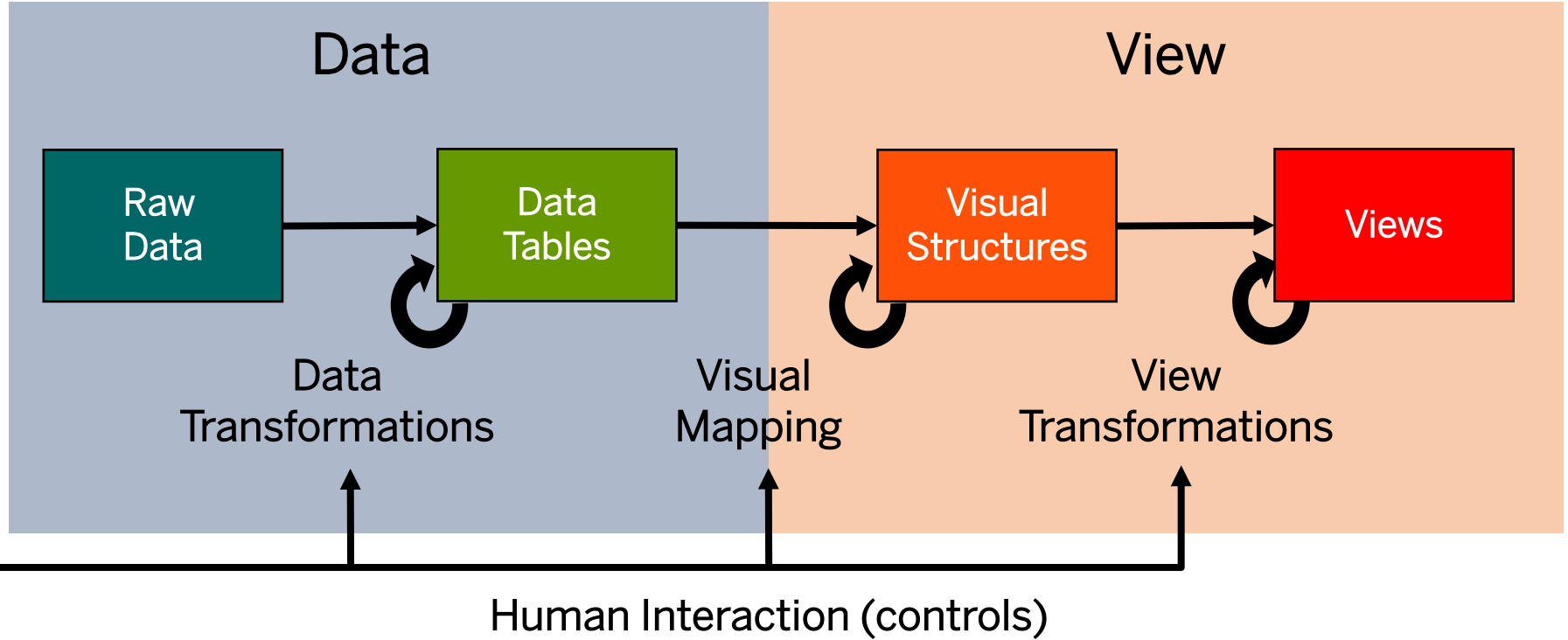
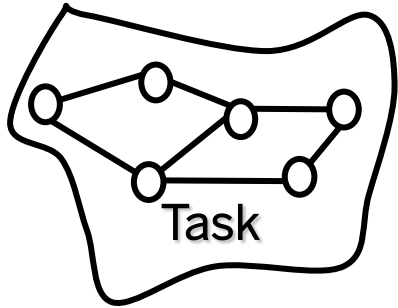
http://wildlife-mitigation.tc.faa.gov/public_html/index.html

INCIDENT_DAT	AIRPORT	STATE	SPECIES	TIME	HEIGHT	SPEED	INDE	OPID	OPERATOR
1/1/1990	CINCINNATI/NO KY INTL	KY	GULLS				79416	DAL	DELTA AIR LINES
1/7/1990	UNKNOWN	AL	UNKNOWN BIRD				79417	EME	METRO EXPRESS
1/8/1990	ORLANDO INTL	FL	GULLS	Day	60	150	53443	USA	US AIRWAYS
1/11/1990	NEW ORLEANS INTL	LA	ROCK PIGEON	Day	0	140	53703	SWA	SOUTHWEST AIRLINES
1/11/1990	JOHN C. TUNE ARPT	TN	WHITE-TAILED DEER	Night	0	100	64040	BUS	BUSINESS
1/19/1990	LOUISVILLE INTL ARPT	KY	SPARROWS	Day	300	150	52859	UPS	UPS AIRLINES
1/19/1990	UNKNOWN	CA	UNKNOWN BIRD	Night			79418	PVT	PRIVATELY OWNED
1/19/1990	JACK BARSTOW	MI	WHITE-TAILED DEER	Dusk	0		79450	PVT	PRIVATELY OWNED
1/20/1990	MORRISTOWN MUNI ARPT	NJ	GEESE	Day	0		79419	BUS	BUSINESS
1/23/1990	ST. PAUL DOWNTOWN HOL	MN	WHITE-TAILED DEER	Night	0		79451	USC	AIRNET EXPRESS
1/26/1990	KALAMAZOO/BATTLE CREEK	MI	GEESE	Dusk			79420	PVT	PRIVATELY OWNED
1/26/1990	UNKNOWN		GEESE				79421	PVT	PRIVATELY OWNED
2/8/1990	JOHN F KENNEDY INTL	NY	HERRING GULL				75946	BUS	BUSINESS
2/8/1990	UNKNOWN	CA	UNKNOWN BIRD				79422	BUS	BUSINESS
2/9/1990	UNKNOWN		UNKNOWN BIRD				75984	UPS	UPS AIRLINES
2/10/1990	JOHN F KENNEDY INTL	NY	MALLARD		20	175	70238	DLH	LUFTHANSA
2/11/1990	UNKNOWN		UNKNOWN BIRD				73391	AAL	AMERICAN AIRLINES
2/13/1990	GREATER PITTSBURGH	PA	UNKNOWN BIRD				73486	USA	US AIRWAYS
2/14/1990	SACRAMENTO INTL	CA	UNKNOWN BIRD		0		73390	UAL	UNITED AIRLINES
2/19/1990	ROBT J MILLER AIR PARK	NJ	WHITE-TAILED DEER	Night	0		79452	PVT	PRIVATELY OWNED
2/22/1990	ATLANTIC CITY INTL	NJ	GULLS	Day	12000		59287	GOV	GOVERNMENT

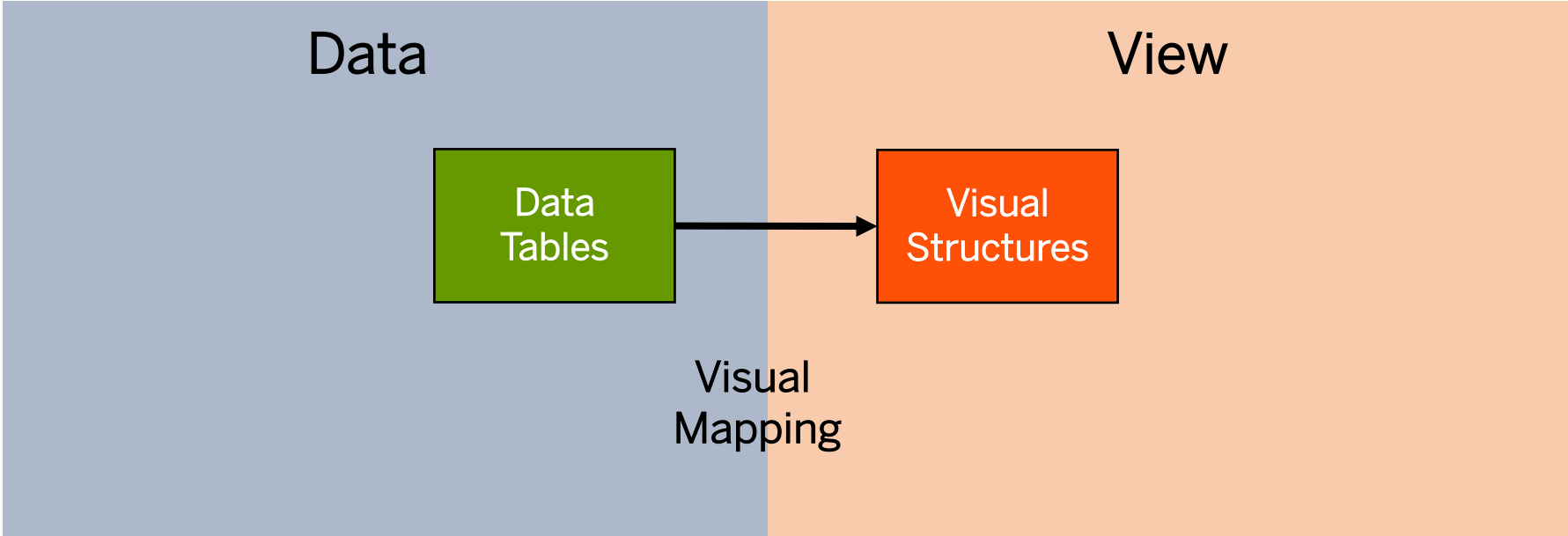


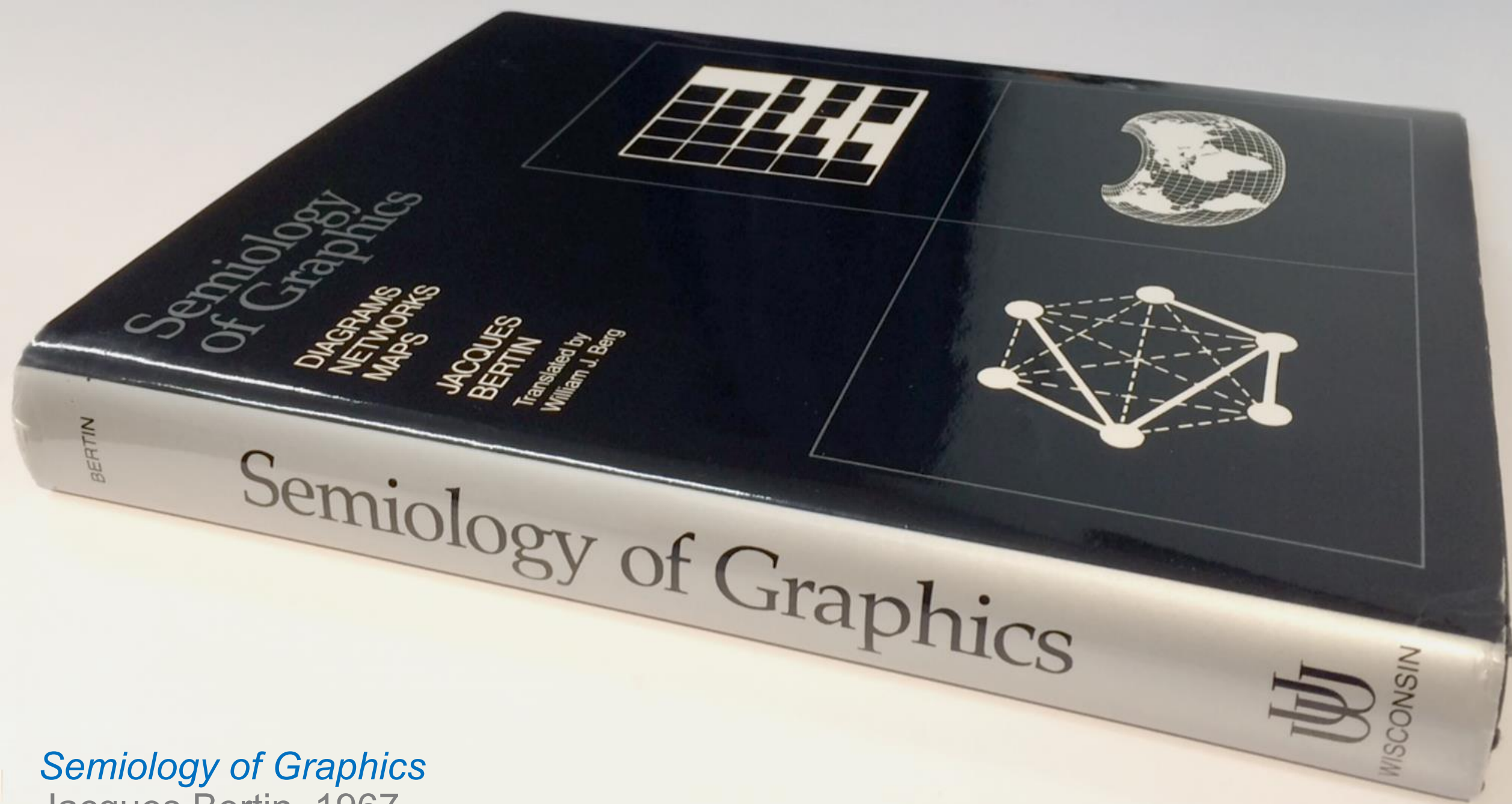






From
Readings in Information Visualization: Using Vision to Think
Card, Mackinlay, Shneiderman, 1999





Semiology of Graphics
Jacques Bertin, 1967

Bertin's Graphical Vocabulary

Marks

Points



Lines



Areas



Position

Cartesian

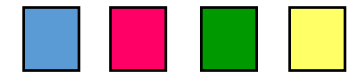


Polar



Retinal

Color



Size



Shape



Gray

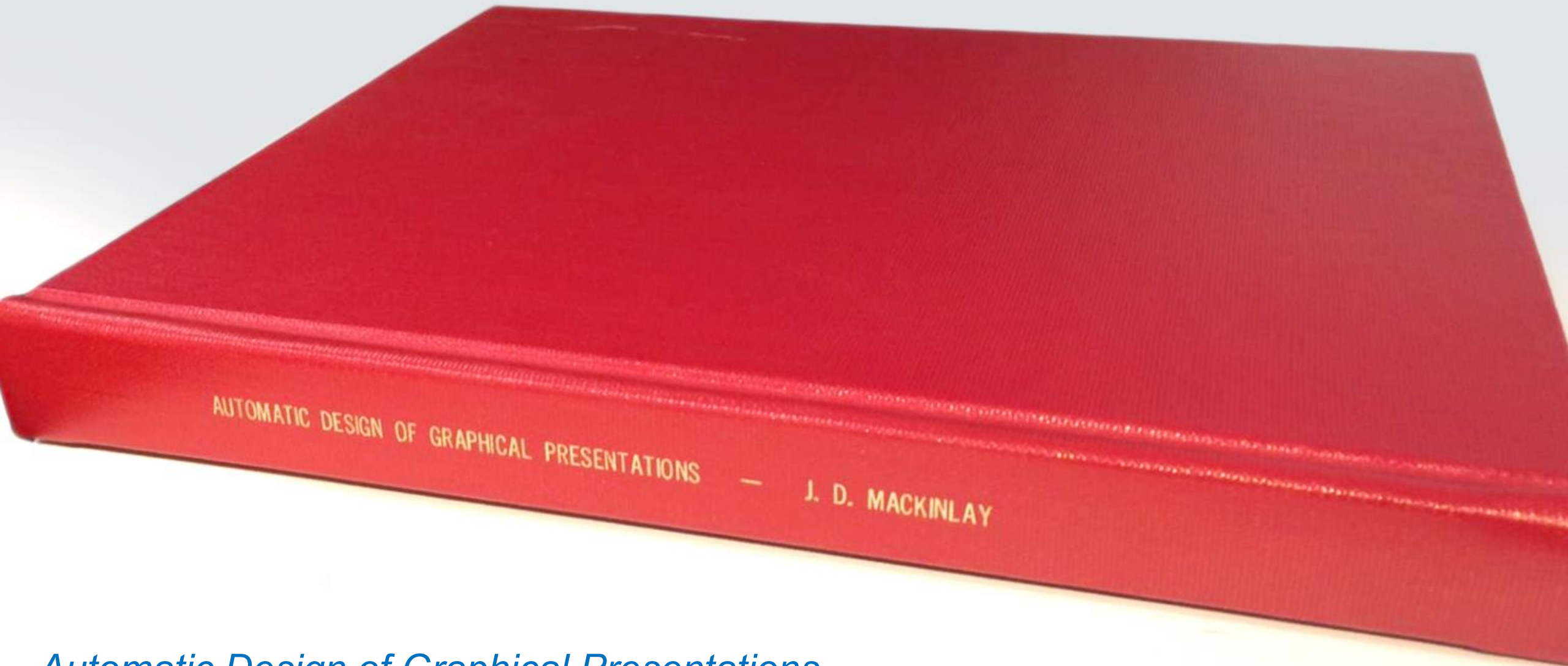


Orientation



Texture





Automatic Design of Graphical Presentations
Jock Mackinlay, 1968

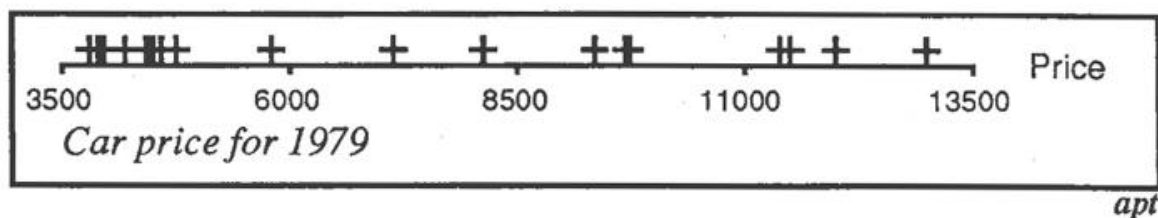


Figure 2.3: A Horizontal Position Sentence for the Price Relation.

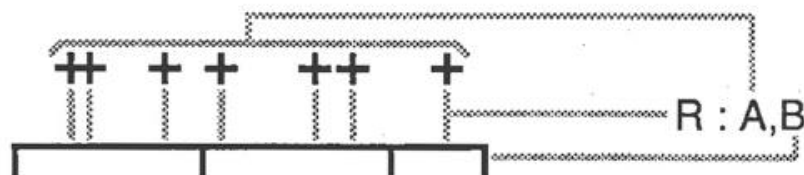


Figure 2.4: The Encodes Relationships for the Horizontal Position Language. The graphical sentence is on the left and the relation is on the right. The gray lines indicate that the domain sets are encoded by the objects and the tuples of the relation are encoded by the relative positions of the marks.

$r(a_i, b_i)$, the following is a formal description of the three basic *Encodes* relationships for a sentence of the *HorzPos* language. The axis h encodes the second domain of the relation, $Dom_2(r)$ ⁶:

$$\text{Encodes}(h, Dom_2(r), \text{HorzPos}). \quad (2.1)$$

⁵The name of the *Encodes* relation could just as easily have been “Represents” or “Denotes”.

⁶The notation $Dom_i(r)$ and $\pi_i(r)$ is defined in Section 2.3.

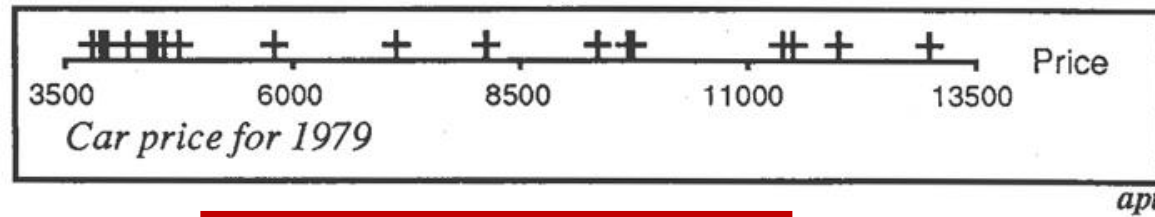


Figure 2.3: A **Horizontal Position Sentence** for the Price Relation.

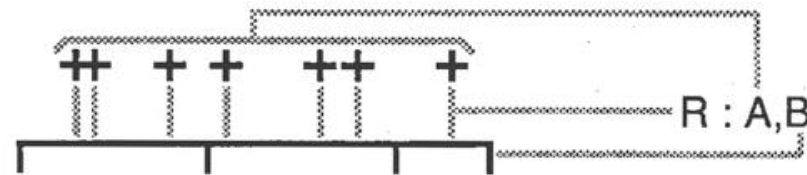


Figure 2.4: The Encodes Relationships for the Horizontal Position Language. The graphical sentence is on the left and the relation is on the right. The gray lines indicate that the domain sets are encoded by the objects and the tuples of the relation are encoded by the relative positions of the marks.

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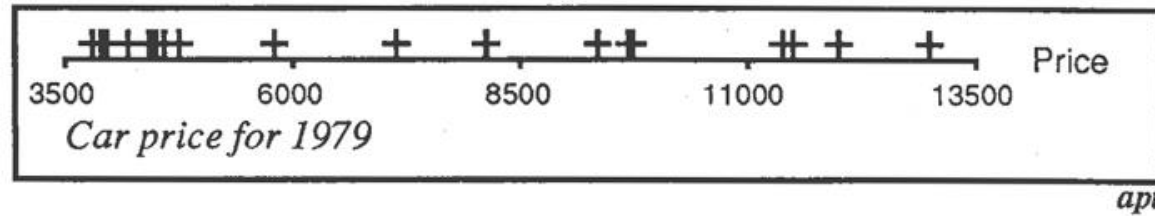


Figure 2.3: A Horizontal Position Sentence for the Price Relation.

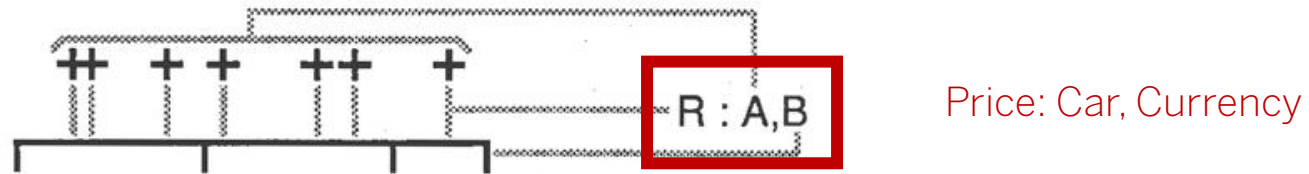


Figure 2.4: The Encodes Relationships for the Horizontal Position Language. The graphical sentence is on the left and the relation is on the right. The gray lines indicate that the domain sets are encoded by the objects and the tuples of the relation are encoded by the relative positions of the marks.

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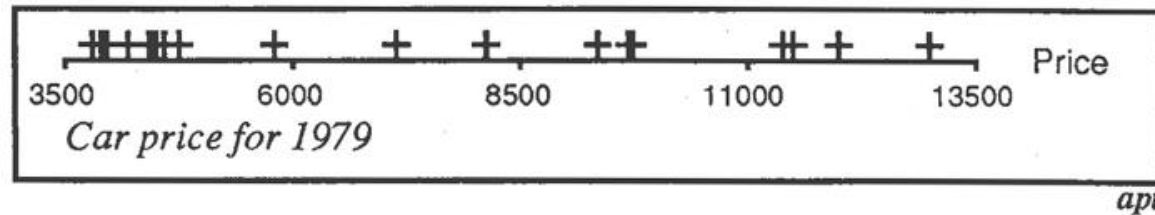


Figure 2.3: A Horizontal Position Sentence for the Price Relation.

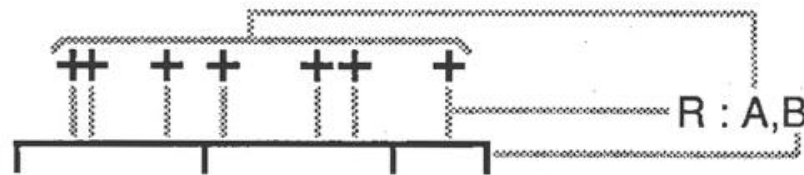


Figure 2.4: The Encodes Relationships for the Horizontal Position Language. The graphical sentence is on the left and the relation is on the right. The gray lines indicate that the domain sets are encoded by the objects and the tuples of the relation are encoded by the relative positions of the marks.

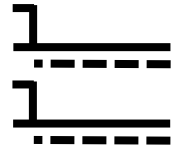
$r(a_i, b_i)$, the following is a formal description of the three basic *Encodes* relationships for a sentence of the *HorzPos* language. The axis h encodes the second domain of the relation, $Dom_2(r)$ ⁶:

$$\text{Encodes}(h, Dom_2(r), \text{HorzPos}). \quad (2.1)$$

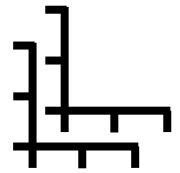
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⁶The notation $Dom_i(r)$ and $\pi_i(r)$ is defined in Section 2.3.

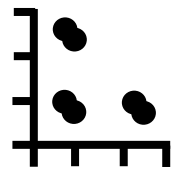
Composition Algebra



Single Axis: each axis encodes the same domain



Double Axis: both pairs encode the same domain



Mark: each set of marks encode the same domain

Chris Stolte's Dissertation, 2003



STANFORD UNIVERSITY



Computer Graphics

Human Computer Interaction



Databases

United States Patent
State et al.
Patent No.: US 7,089,266 B2
Date of Patent: Aug. 8, 2006

(34) COMPUTER SYSTEMS AND METHODS FOR THE QUERY AND VISUALIZATION OF MULTIDIMENSIONAL DATABASES

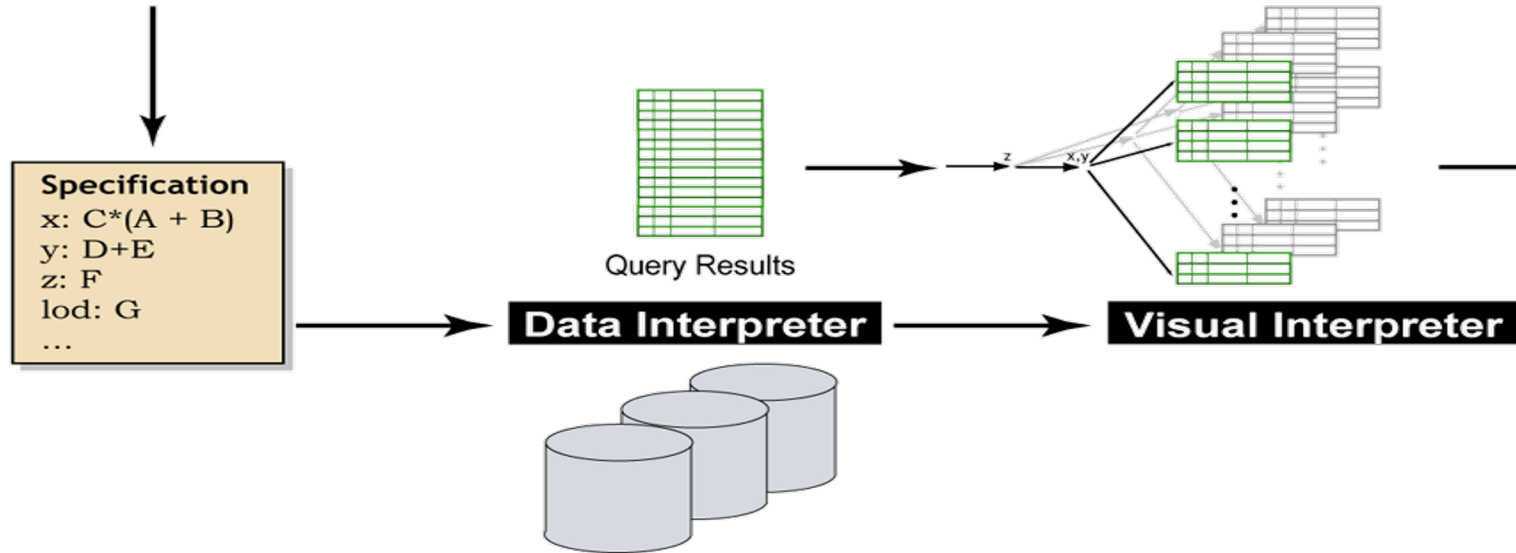
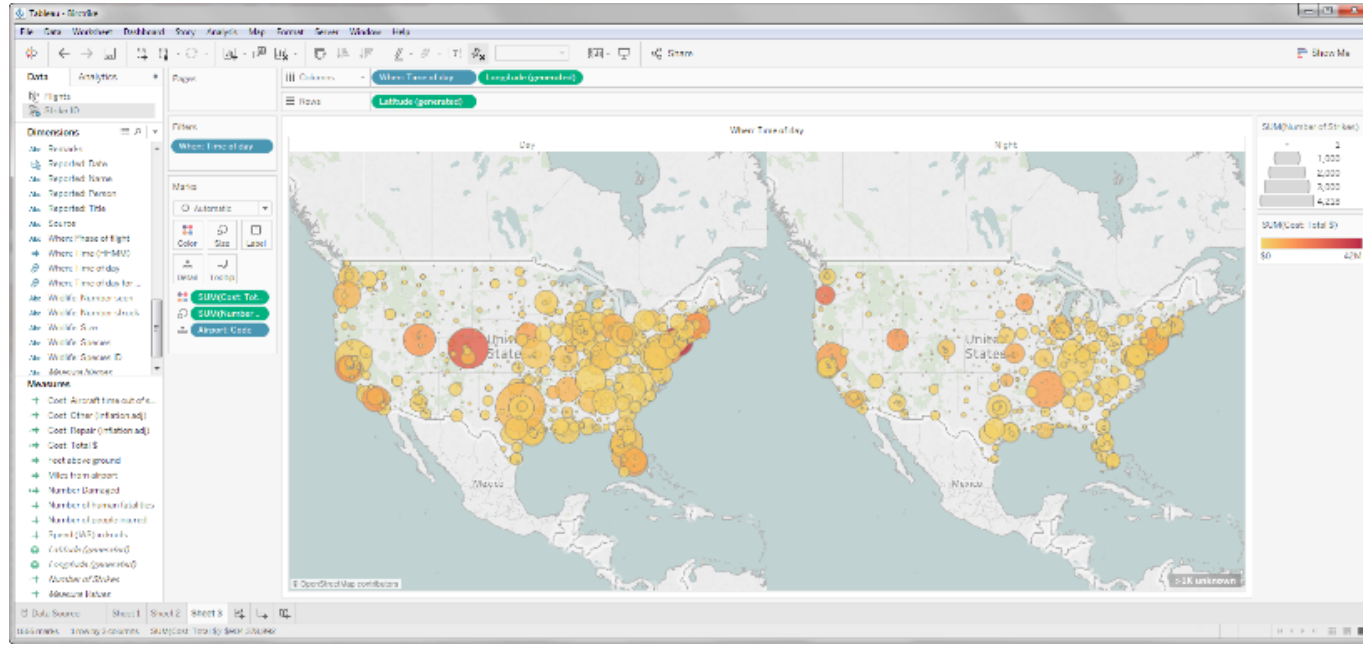
(71) Inventors: Chris Stolte, Palo Alto, CA (US); Diane Tang, Palo Alto, CA (US); Patrick Hamilton, Florida Valley, CA (US)

(72) Assignee: The Board of Trustees of the Leland Stanford Jr. University, Palo Alto, CA (US)

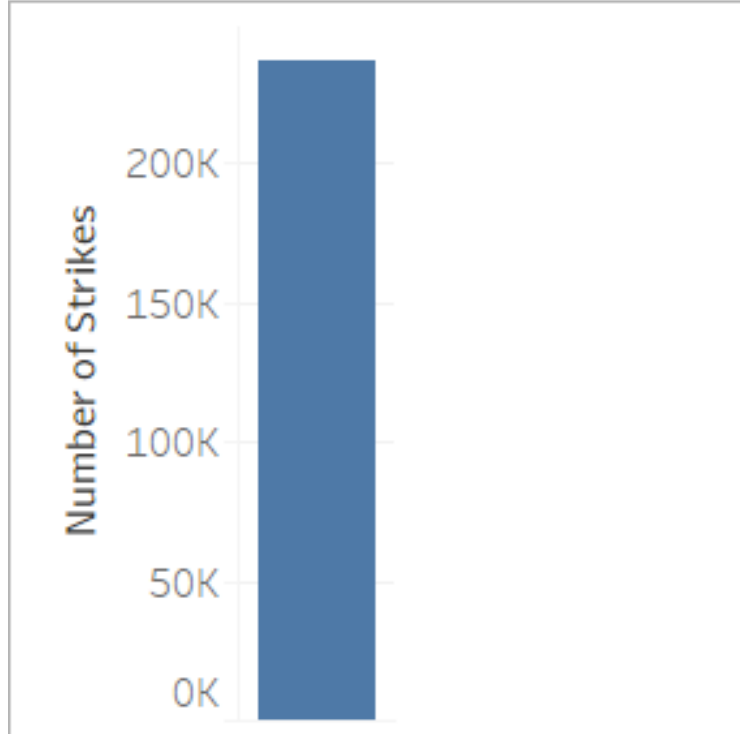
Publications

- Design Choices when Archiving Information Visualization, October 2003.
- Multiscale Visualization of Hierarchically Structured Data using Query, Analysis, and Polaris, Proceedings of the Eighth International Conference on Knowledge Discovery and Data Mining, October 2002.





Columns	
Rows	SUM(Number of Stri..)



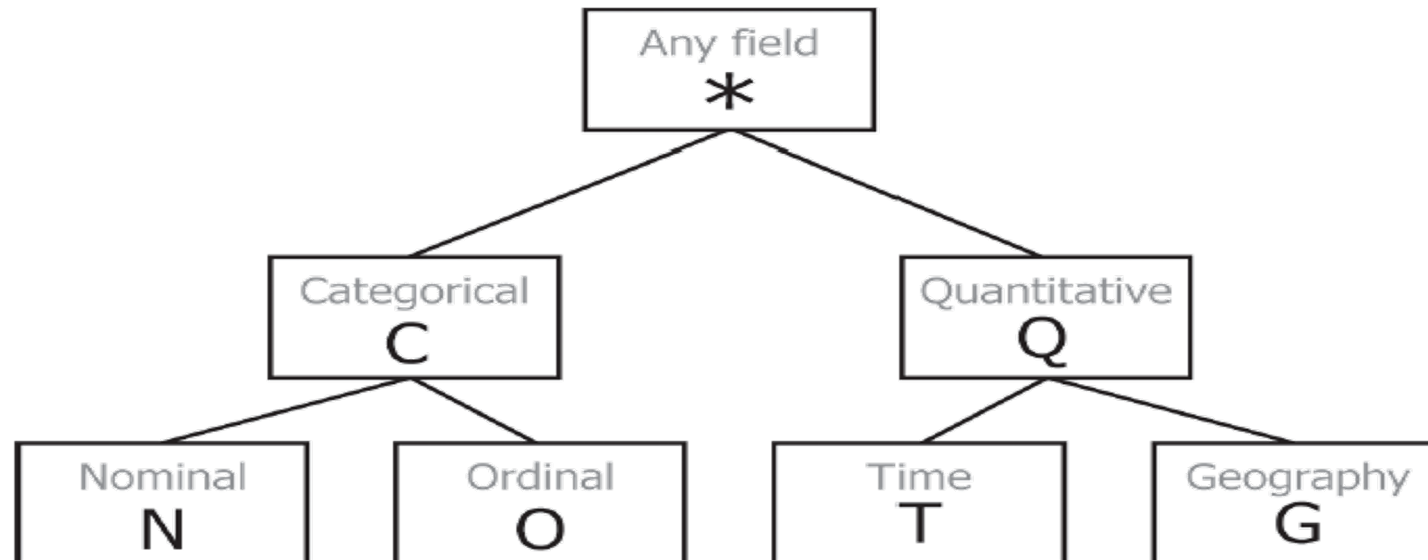
DISPLAY SUM(Number of Strikes) **ON ROWS**
FROM database

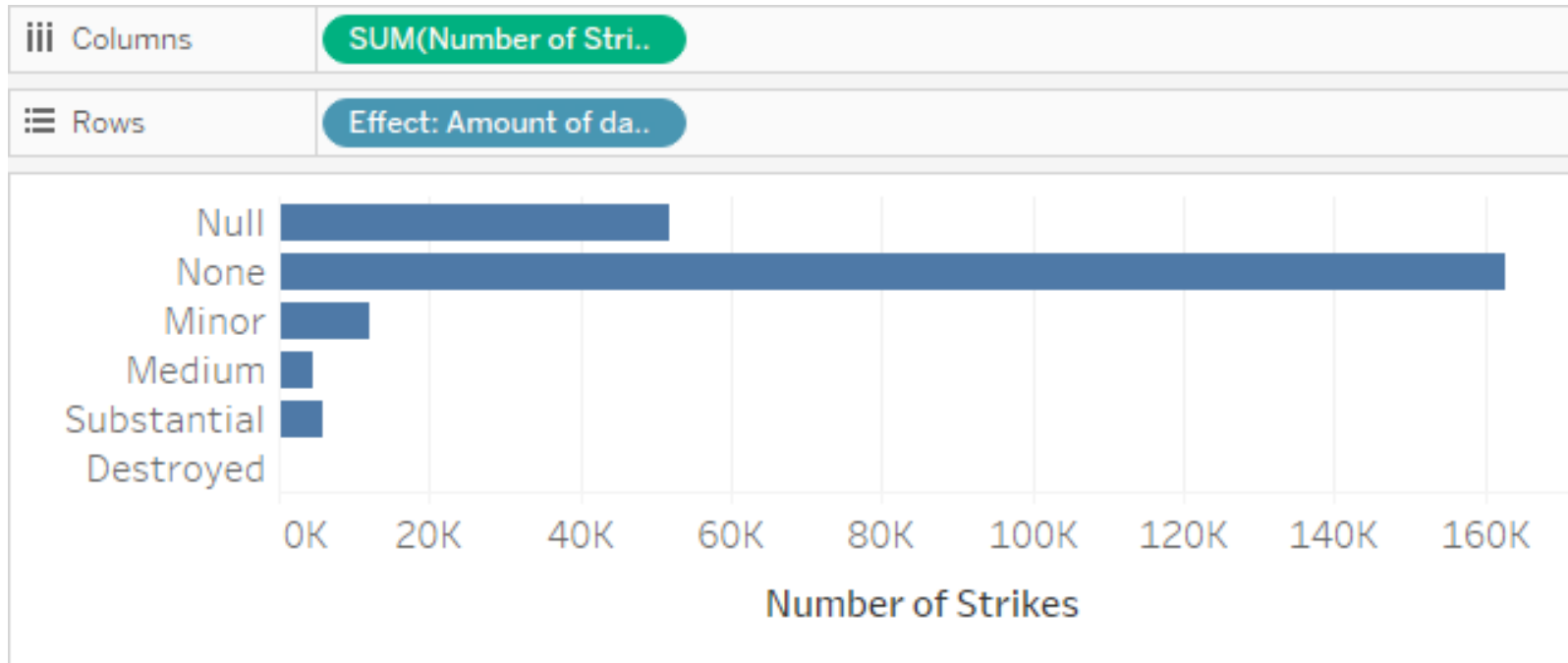
iii Columns	
☰ Rows	Effect: Amount of da..

DISPLAY [Effect: Amount of damage] **ON ROWS**
FROM database

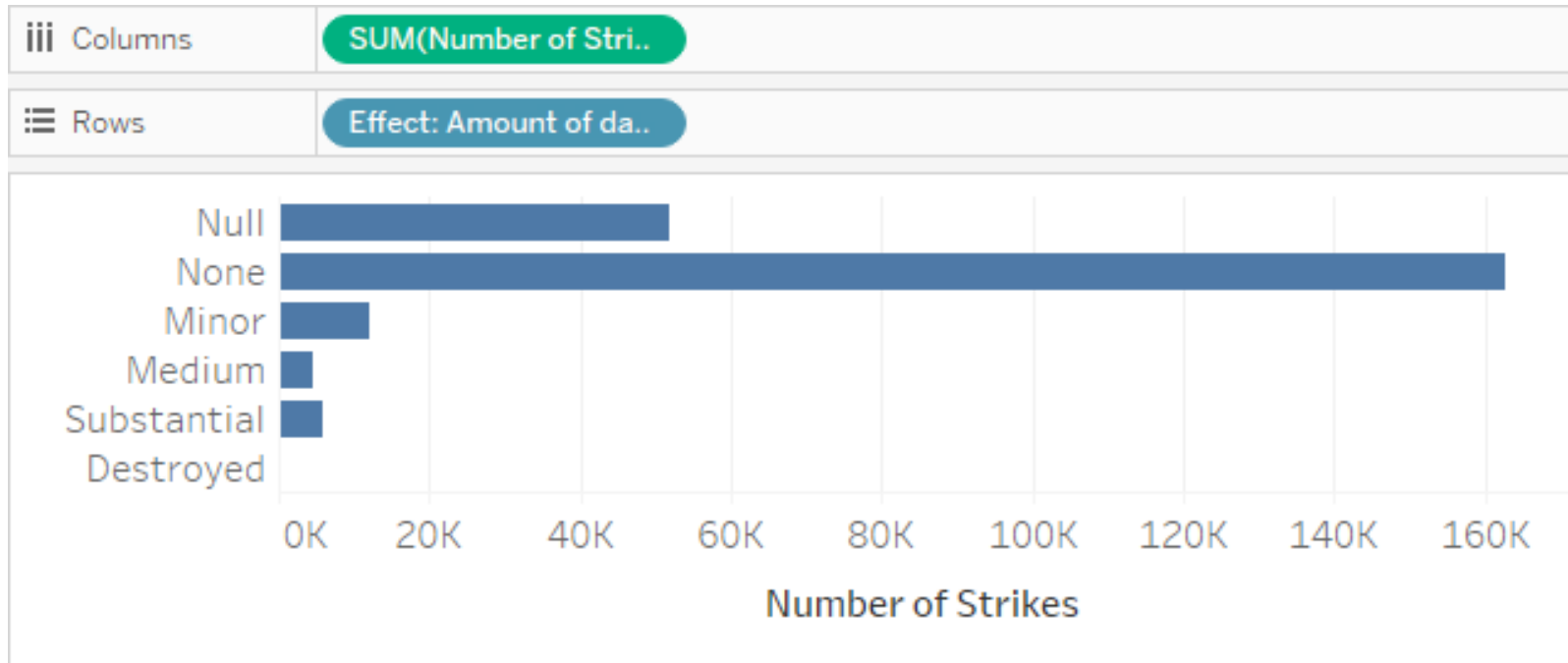
Effect: Amount of damage

Null	Abc
None	Abc
Minor	Abc
Medium	Abc
Substantial	Abc
Destroyed	Abc





DISPLAY [Effect: Amount of damage] **ON ROWS**,
SUM(Number of Strikes) **ON COLUMNS**
FROM database

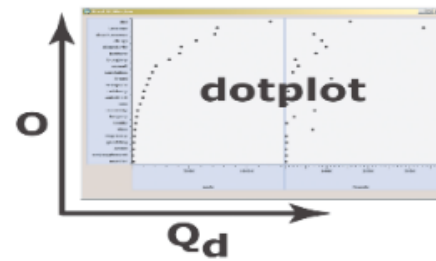
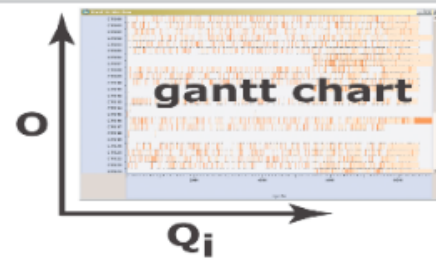


DISPLAY [Effect: Amount of damage] **ON ROWS**,
SUM(Number of Strikes) **ON COLUMNS**
AS BAR
FROM database

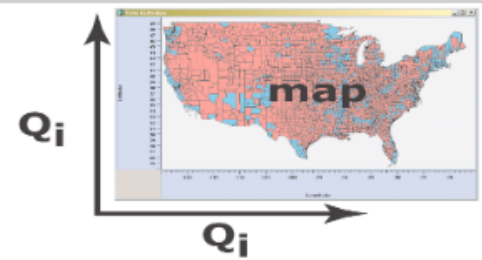
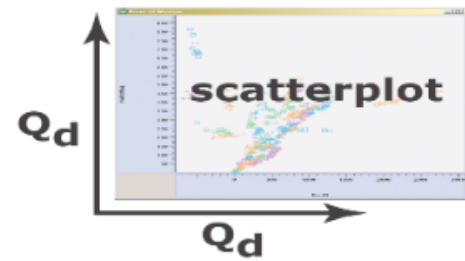
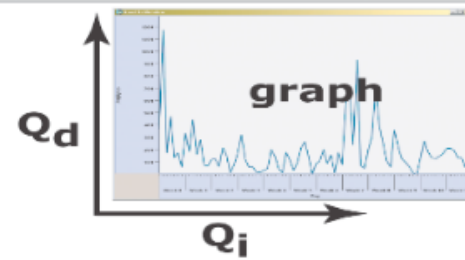
Ordinal-Ordinal



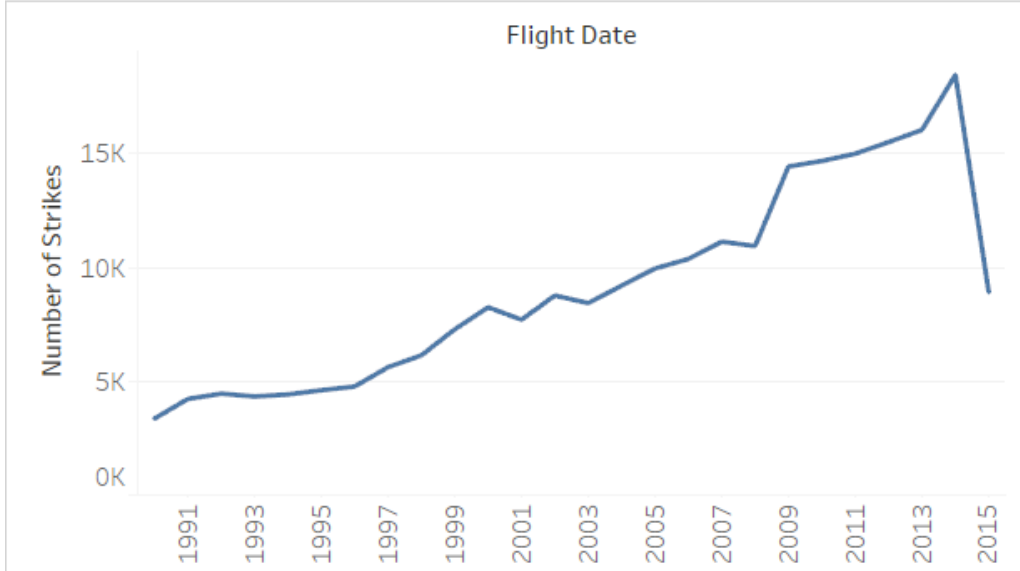
Ordinal-Quantitative



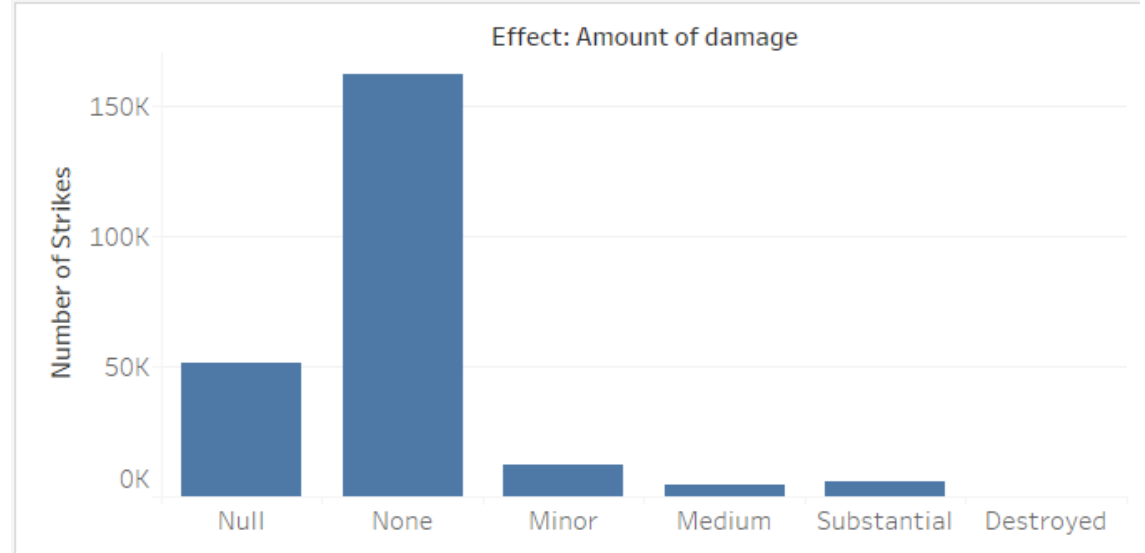
Quantitative-Quantitative



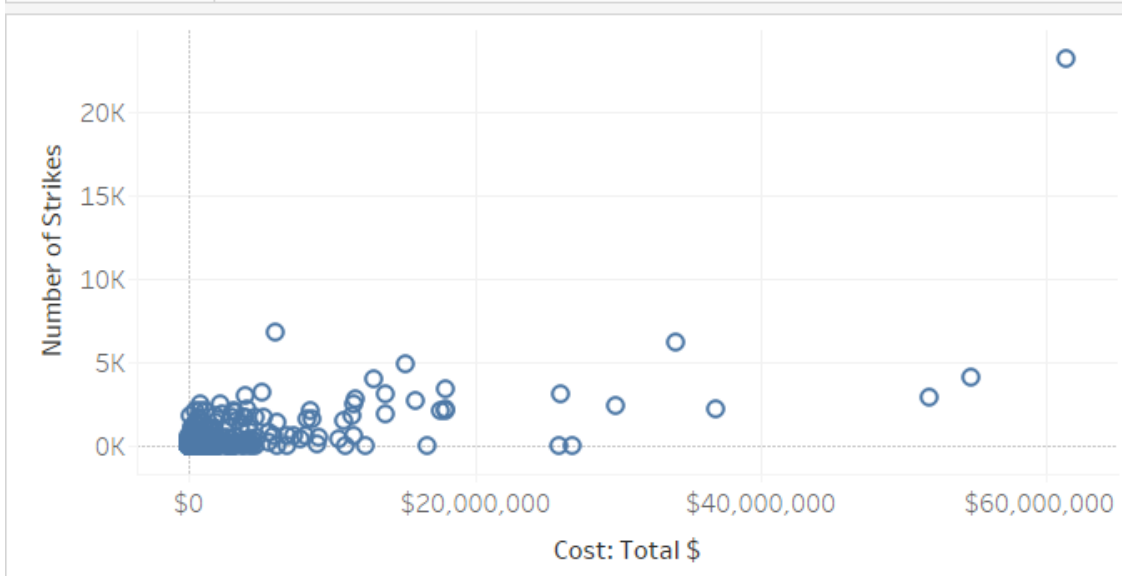
Columns	YEAR(Flight Date)
Rows	SUM(Number of Stri..)

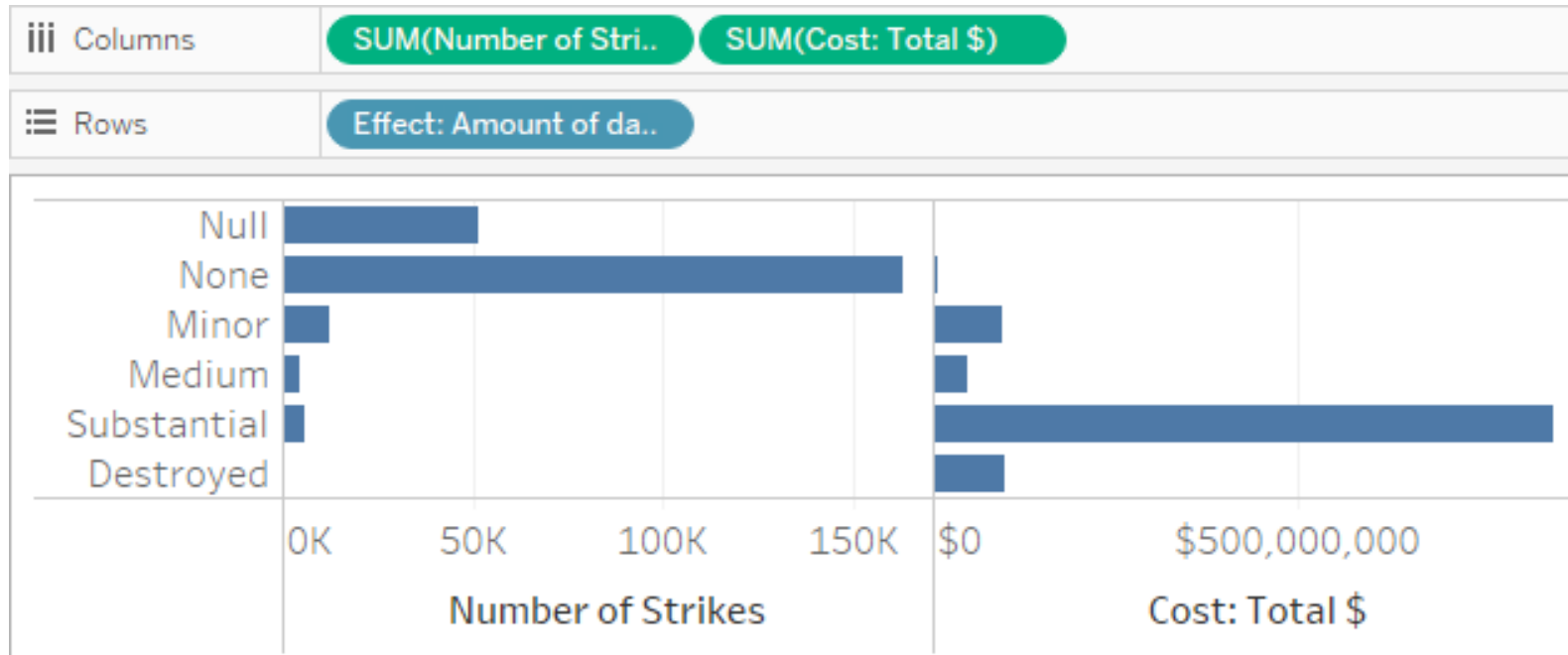


Columns	Effect: Amount of da..
Rows	SUM(Number of Stri..)

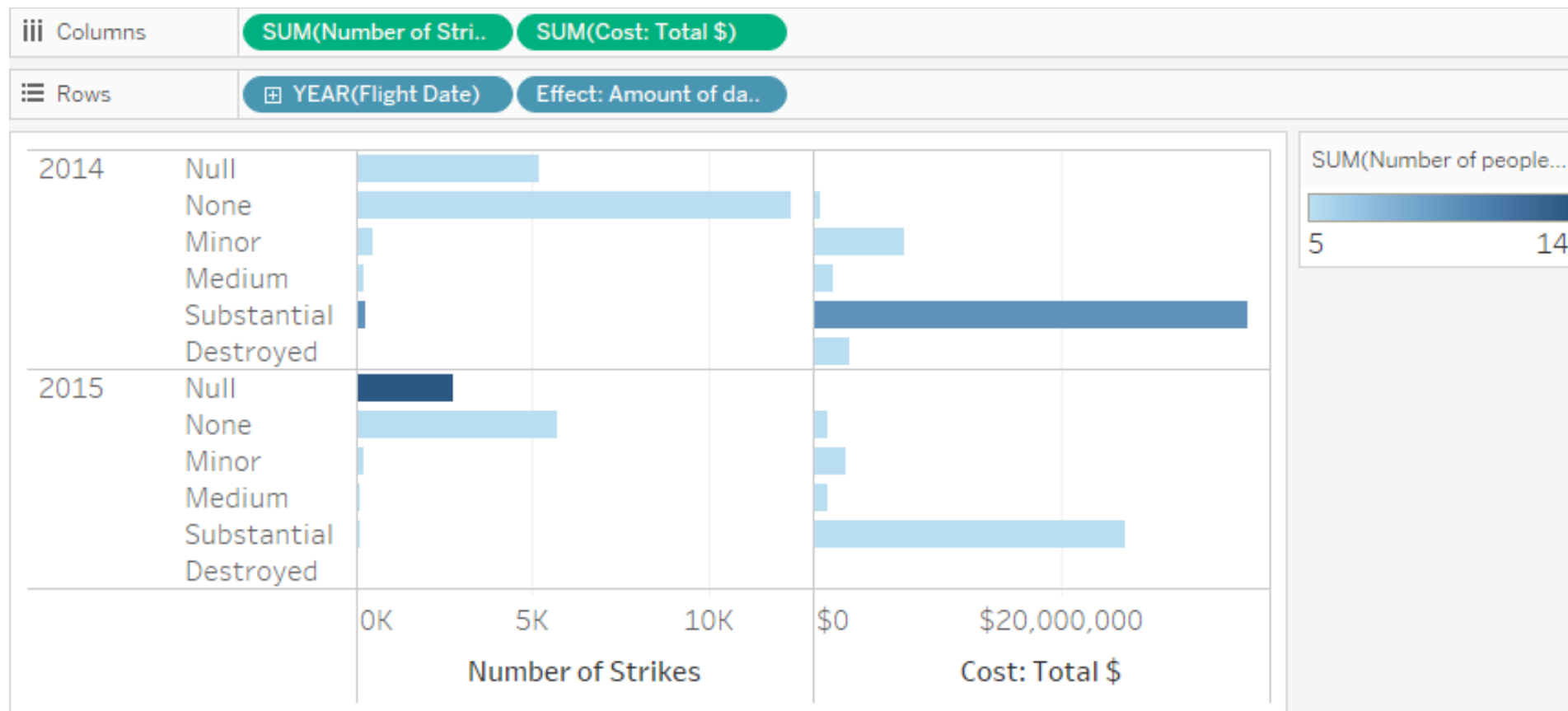


Columns	SUM(Cost: Total \$)
Rows	SUM(Number of Stri..)



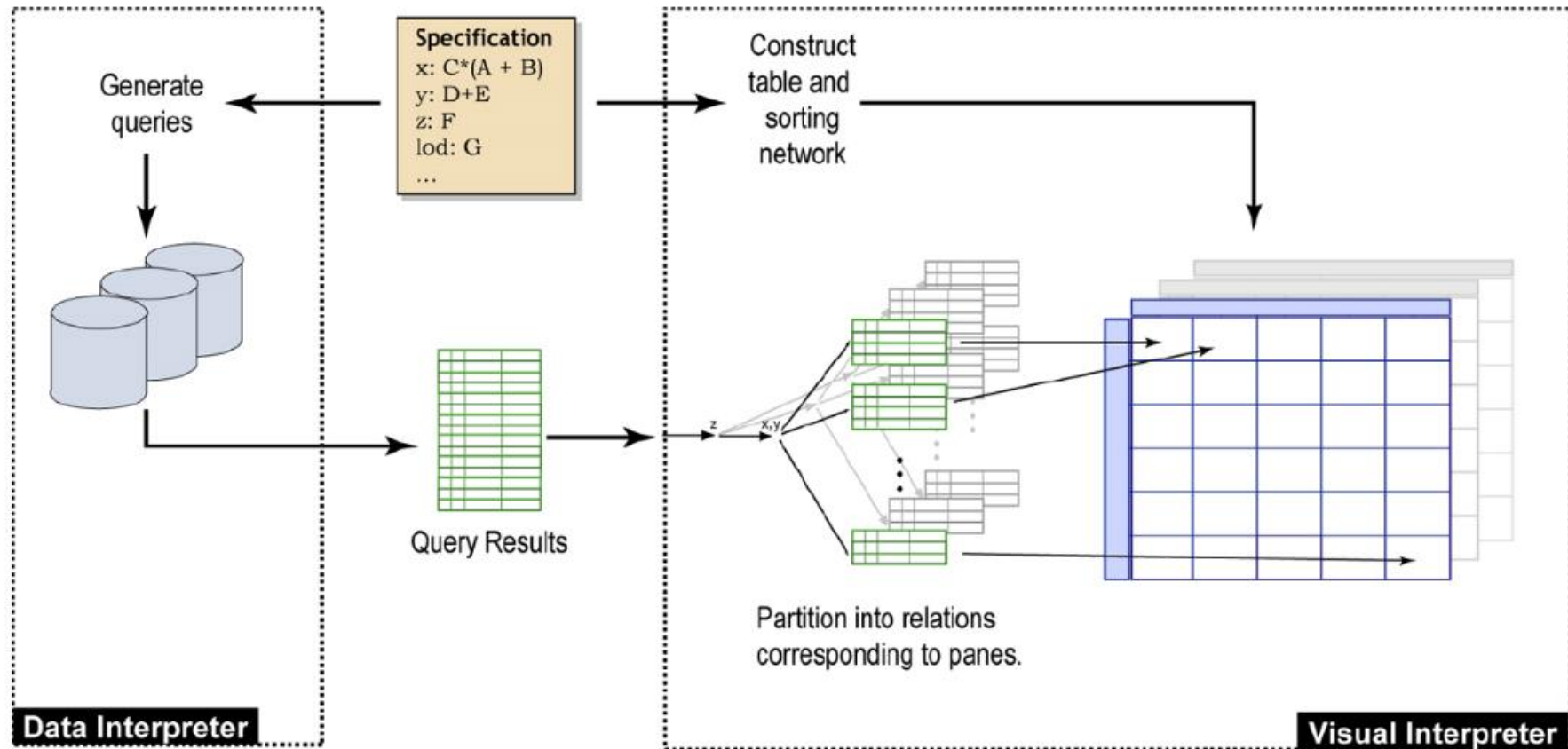


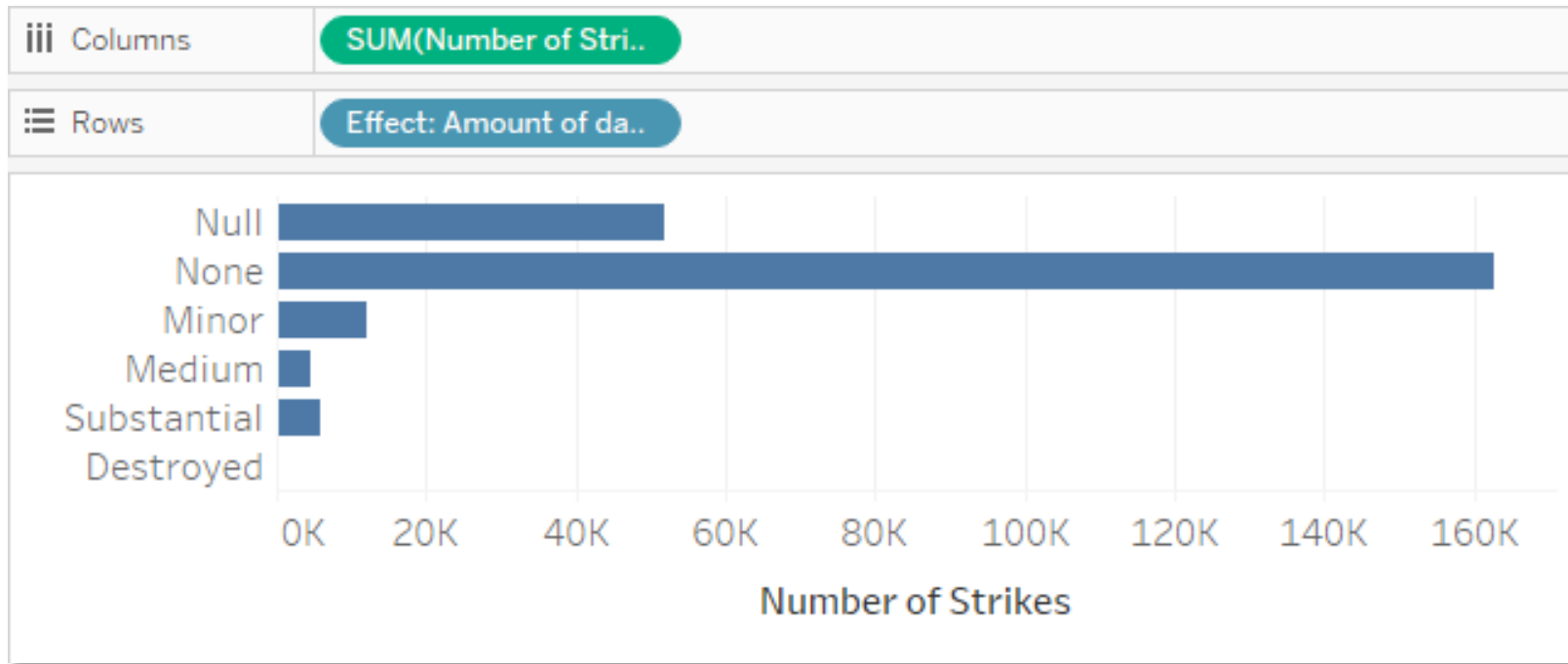
DISPLAY [Amount of damage] **ON ROWS,**
SUM(Number of Strikes) + SUM(Cost: Total \$) **ON**
COLUMNS
FROM database



DISPLAY **[Year(Flight Date)] x [Amount of damage]** ON ROWS,
 SUM(Number of Strikes) + SUM(Cost: Total \$) ON COLUMNS
 WITH SUM(Number of people injured) ON COLOR
 FROM database

Interpreters compile algebraic specifications into visualizations **and database queries**

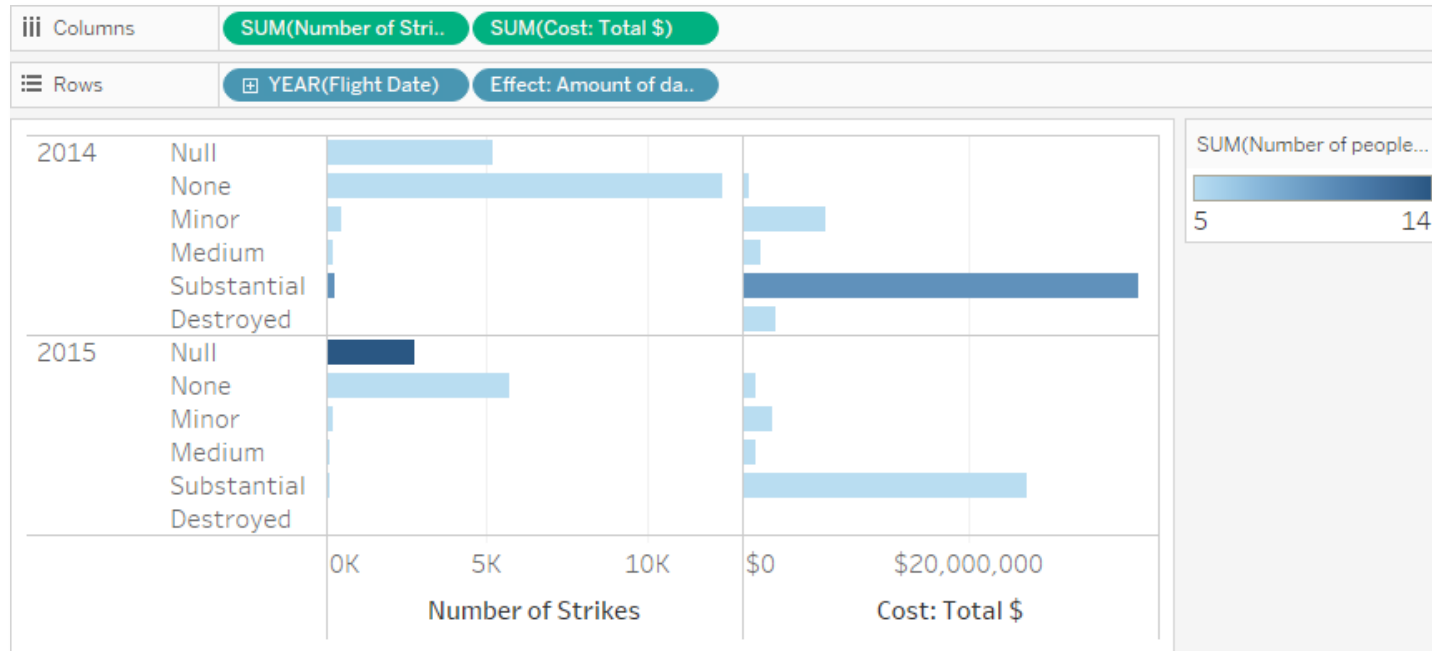




DISPLAY [Effect: Amount of damage] **ON ROWS**,
 SUM(Number of Strikes) **ON COLUMNS**
AS BAR
FROM database



SELECT [Effect: Amount of damage],
 SUM(Number of Strikes)
FROM [Strikes]
 INNER JOIN [Airport] ON
 ([Strikes].[Airport ID] = [Airport].[Airport ID])
 (...rest of join structure...)
GROUP BY [Effect: Amount of damage]



SELECT ["Effect: Amount of damage"], TRUNC(EXTRACT(YEAR FROM [Date])) AS [Year(Date)],
 SUM([Cost: Total \$]), SUM([Number of people injured]), SUM([Number of records])

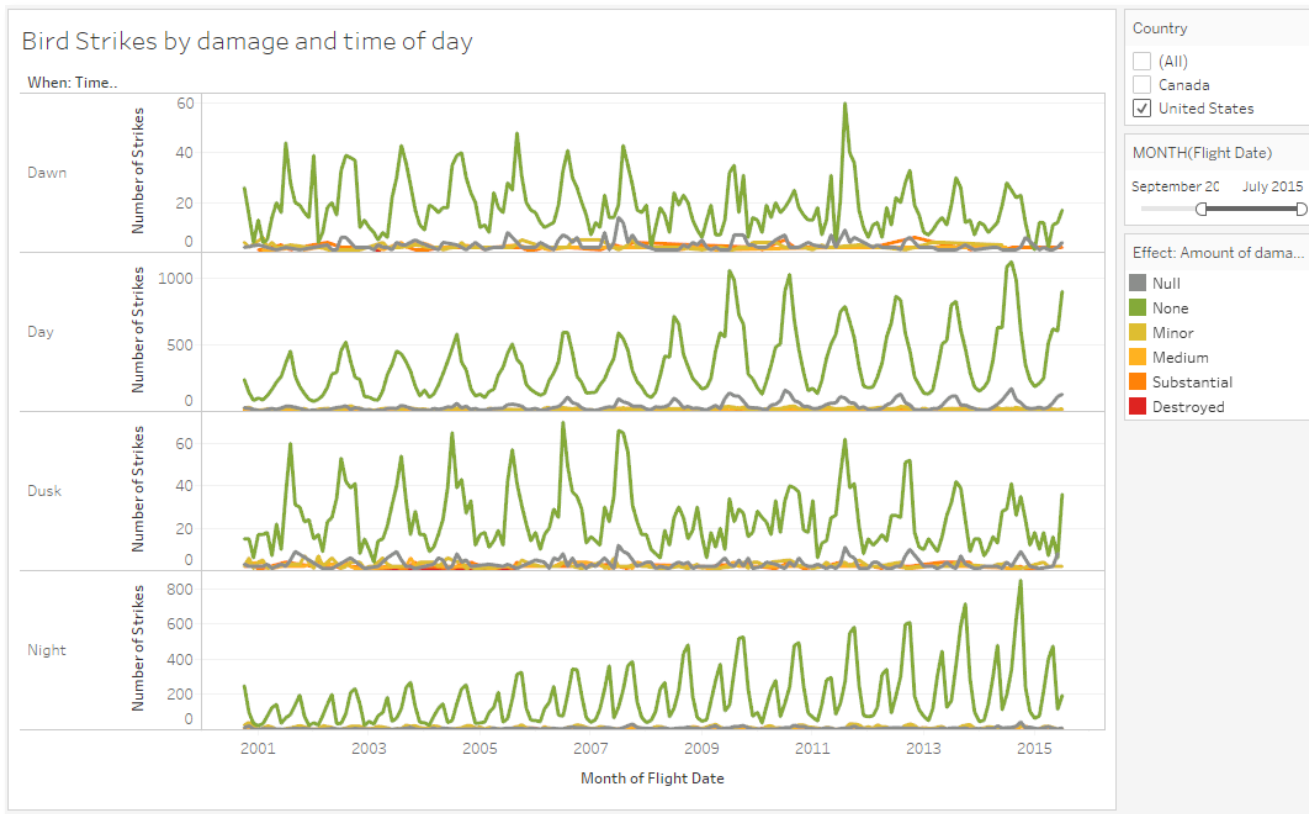
FROM [Strikes]

INNER JOIN [Airport] ON ([Strikes].[Airport ID] = [Airport].[Airport ID])

(...rest of join structure...)

WHERE TRUNC(EXTRACT(YEAR FROM [Date])) IN (2014, 2015))

GROUP BY ["Effect: Amount of damage"], TRUNC(EXTRRACT(YEAR FROM [Date])) AS [Year(Date)]



```

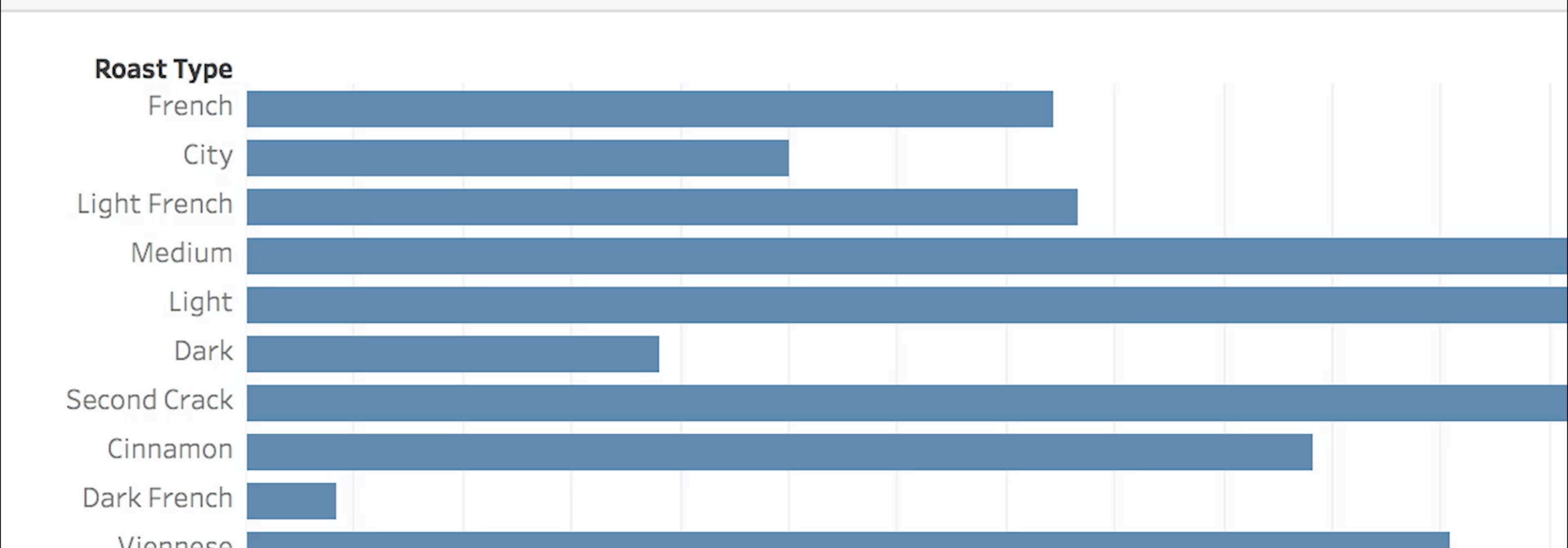
SELECT [Amount of damage],
       [Time of day],
       DATE_TRUNC('MONTH', [Date]) AS "Month(Date)"
SUM(Number of Records),
FROM [Strikes]
  INNER JOIN [Airport] ON
    ([Strikes].[Airport ID] = [Airport].[Airport ID]
    (...rest of join structure...))
WHERE ("Country" = 'US') AND
      ([Time of day] != 'Null') AND
      (((DATE_TRUNC('MONTH', [Date]) >= (DATE '2000-09-21')) AND (DATE_TRUNC('MONTH', [Date]) <= (DATE '2015-07-01'))))
GROUP BY [Amount of damage], [Time of day],
         DATE_TRUNC('MONTH', [Date])

```

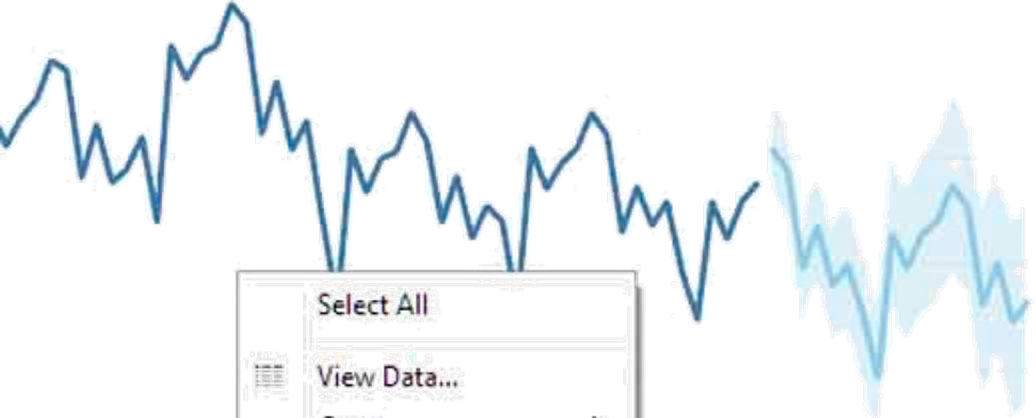
Immediate feedback & incremental construction

Columns: SUM(Sales)

Rows: Roast Type



Smart defaults



- Select All
- View Data...
- Copy
- Format...
- Annotate
- Trend Lines
- Forecast**
 - Show Forecast
 - Forecast Options...
 - Describe Forecast...
- Drop Lines
- Show View Toolbar

- Location
 - Region
 - State
 - City
 - Postal Code

Marks

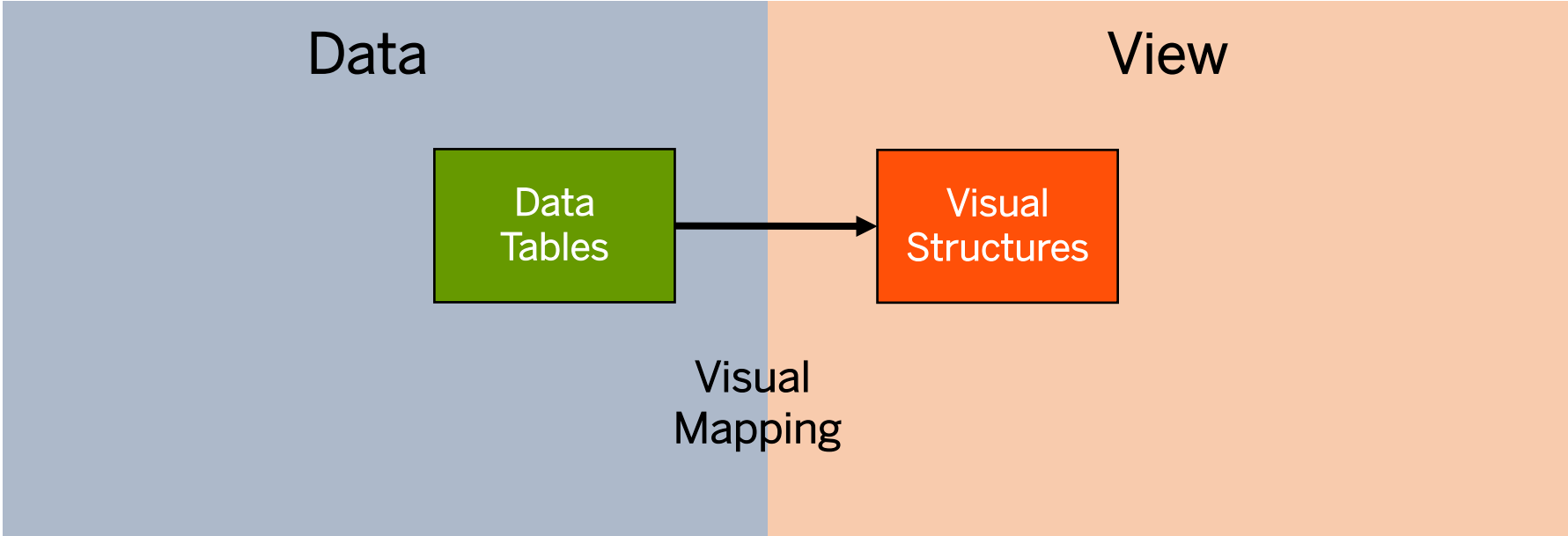
Automatic

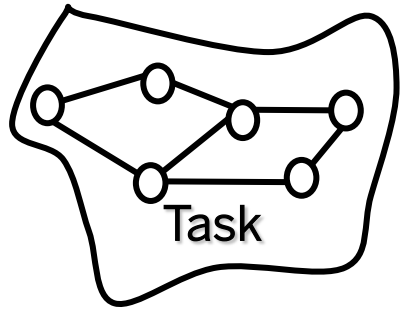
Color Size Label

Detail Tooltip

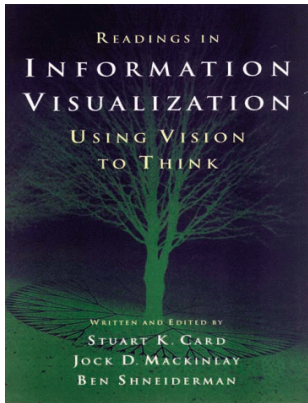
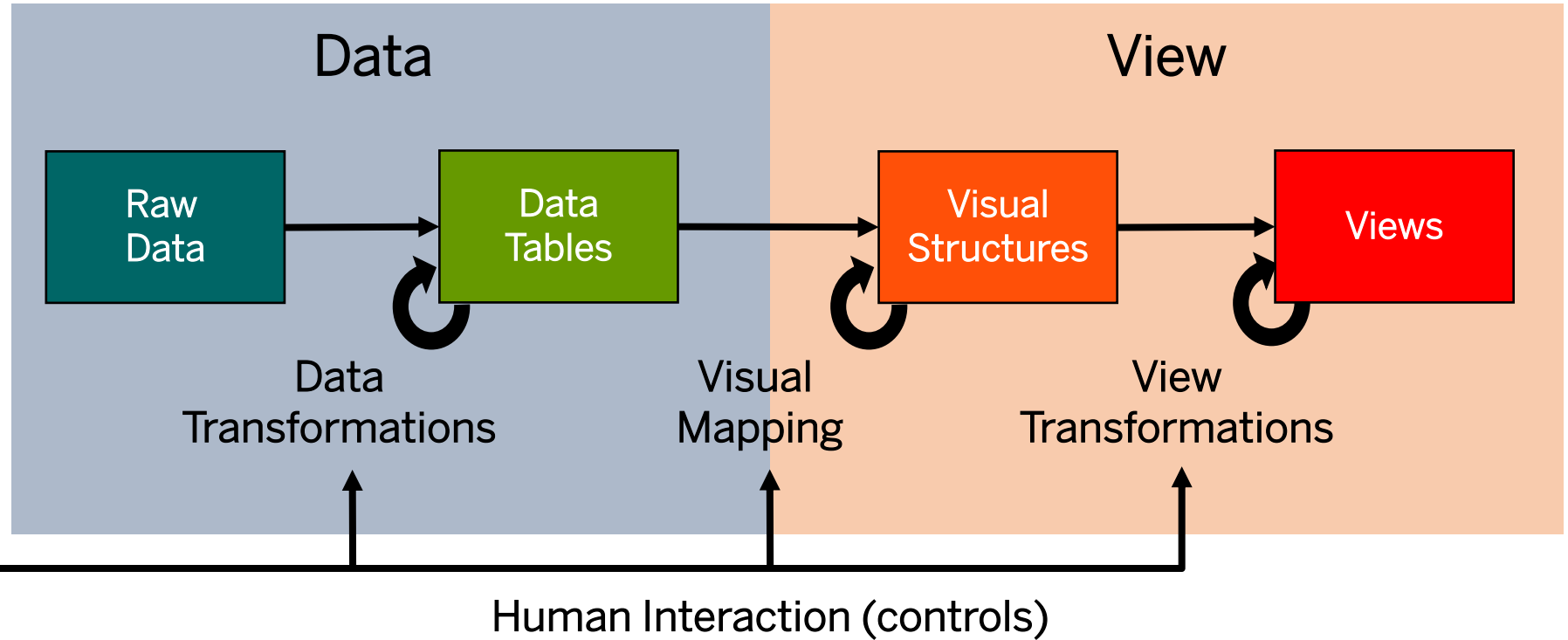
College

- Arts & Sciences
- Business
- Communication
- Education
- Engineering
- Music
- Public Affairs
- Public Health





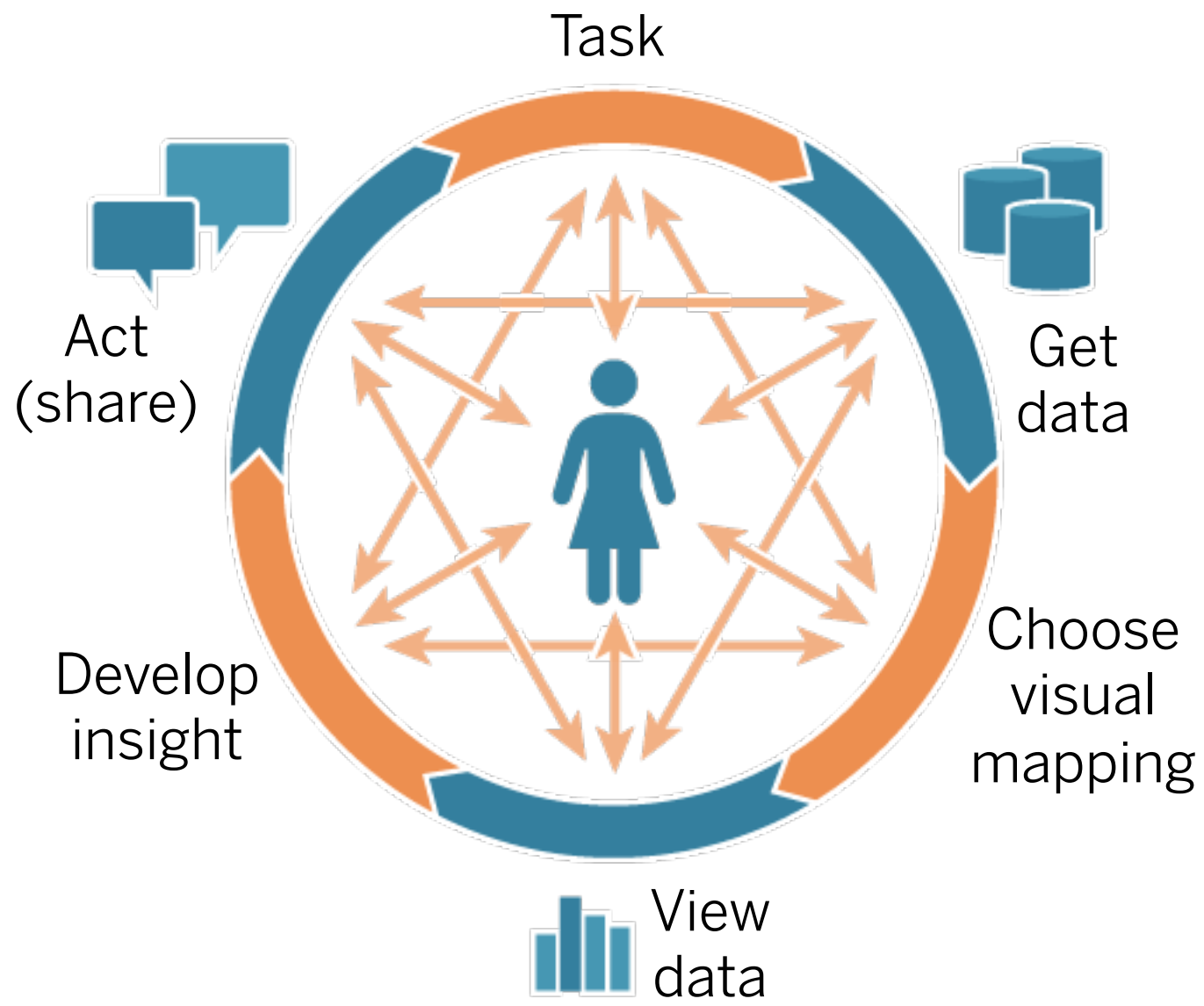
Task



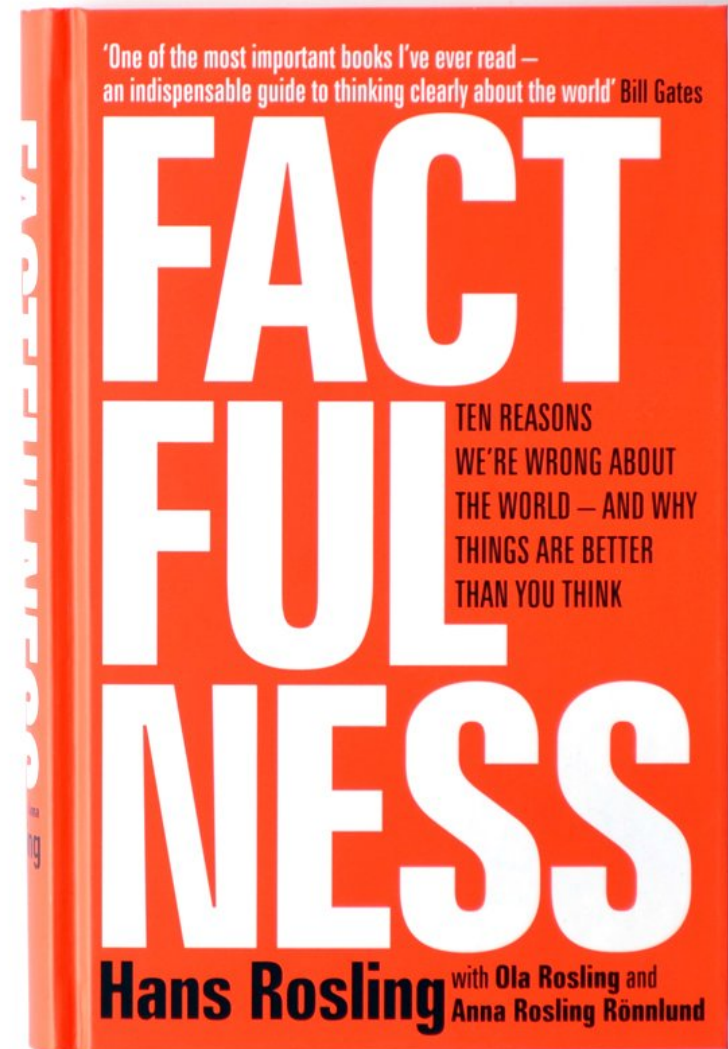
From

Readings in Information Visualization: Using Vision to Think

Card, Mackinlay, Shneiderman, 1999



Hans Rosling



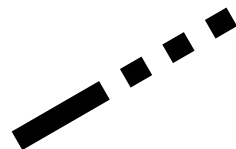
10 DRAMATIC INSTINCTS



GAP



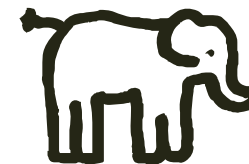
NEGATIVITY



STRAIGHT



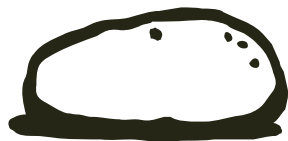
FEAR



SIZE



GENERALIZATION



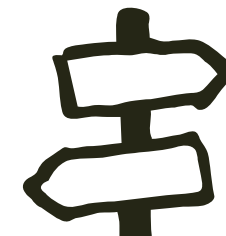
DESTINY



SINGLE



BLAME



URGENCY

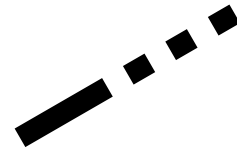
10 DRAMATIC INSTINCTS



GAP



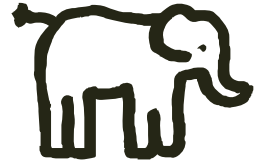
NEGATIVITY



STRAIGHT



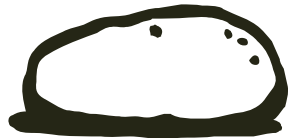
FEAR



SIZE



GENERALIZATION



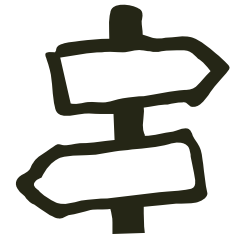
DESTINY



SINGLE



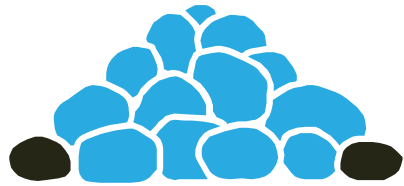
BLAME



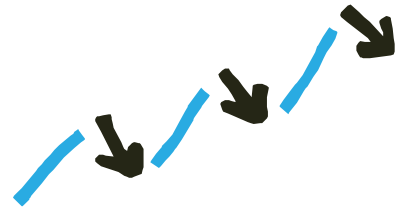
URGENCY

Confirmation Bias

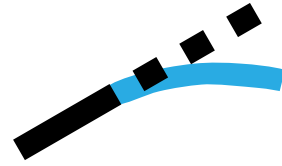
10 FACTFULNESS COMMANDMENTS



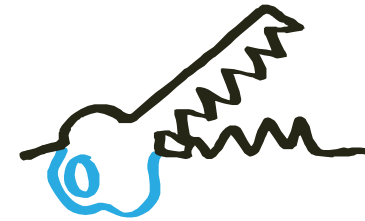
1. Locate the majority



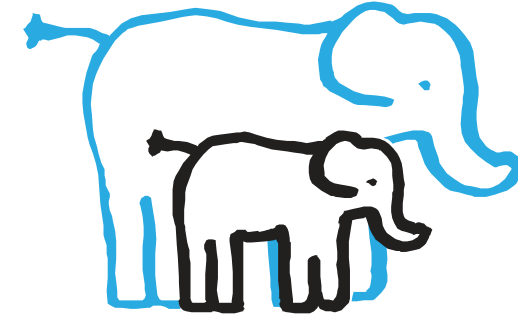
2. Expect negative news



3. Imagine non straight lines



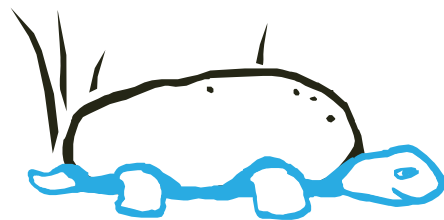
4. Control your fears



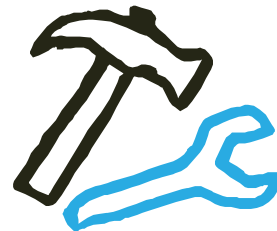
5. Check proportions



6. Question your categories



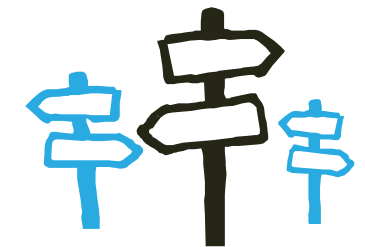
7. Notice slow changes



8. Use multiple tools

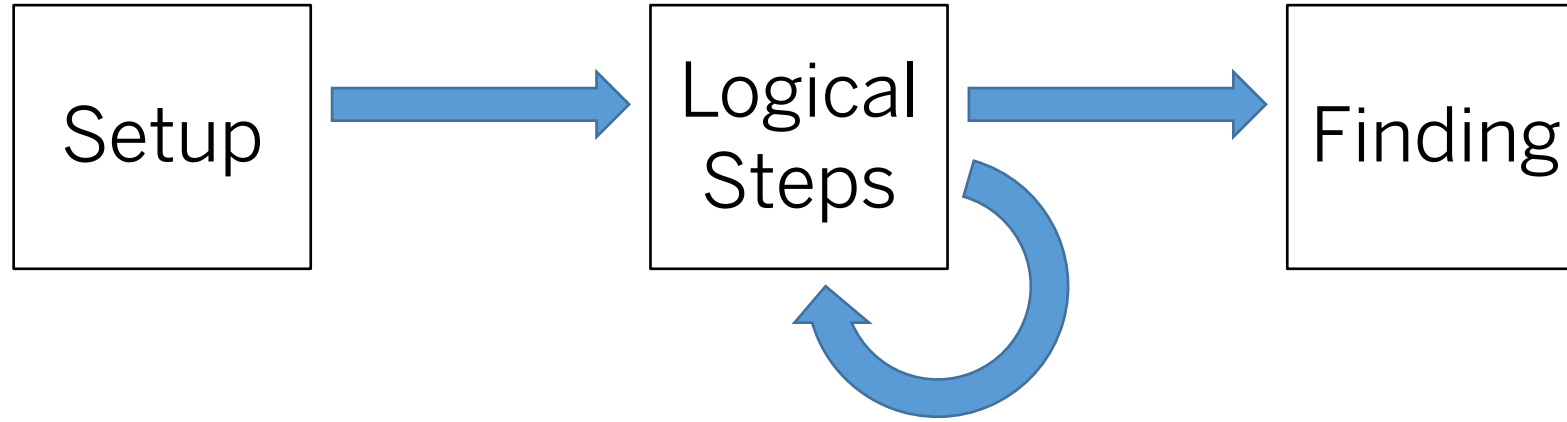


9. Resist blaming

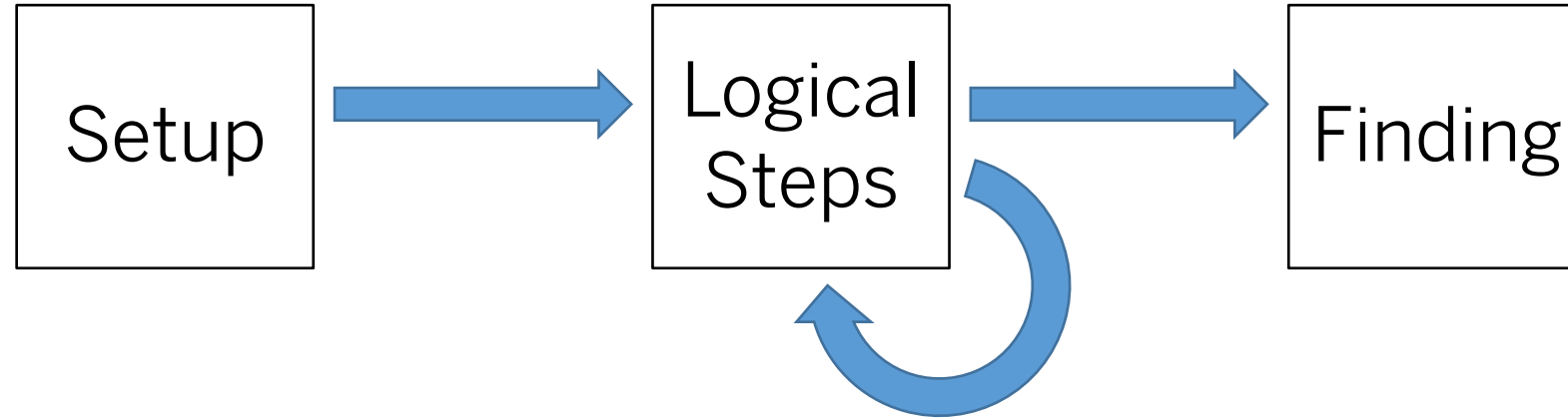


10. Take small steps

Data Stories Include Logical Steps



Data Stories Include Logical Steps



Animation can:

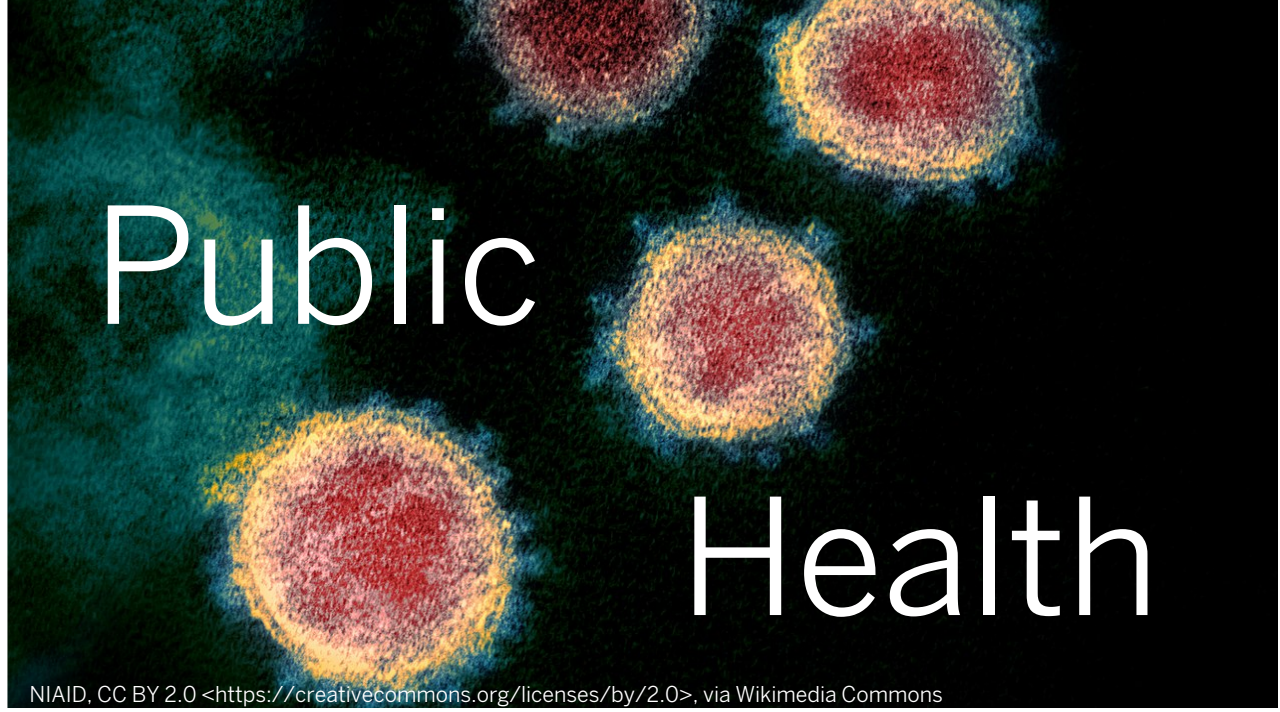
- Make the steps visceral (i.e. wake up the audience)
- Show what
 - Changed
 - Stayed the same
- Illustrate the step's logic (but words are still necessary)

Animation Demo



Climate

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Health

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Education

Capt. John Severns, U.S. Air Force, Public domain, via Wikimedia Commons



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A LIFE ON OUR
PLANET



Conservation Drones



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Thank you

Questions?