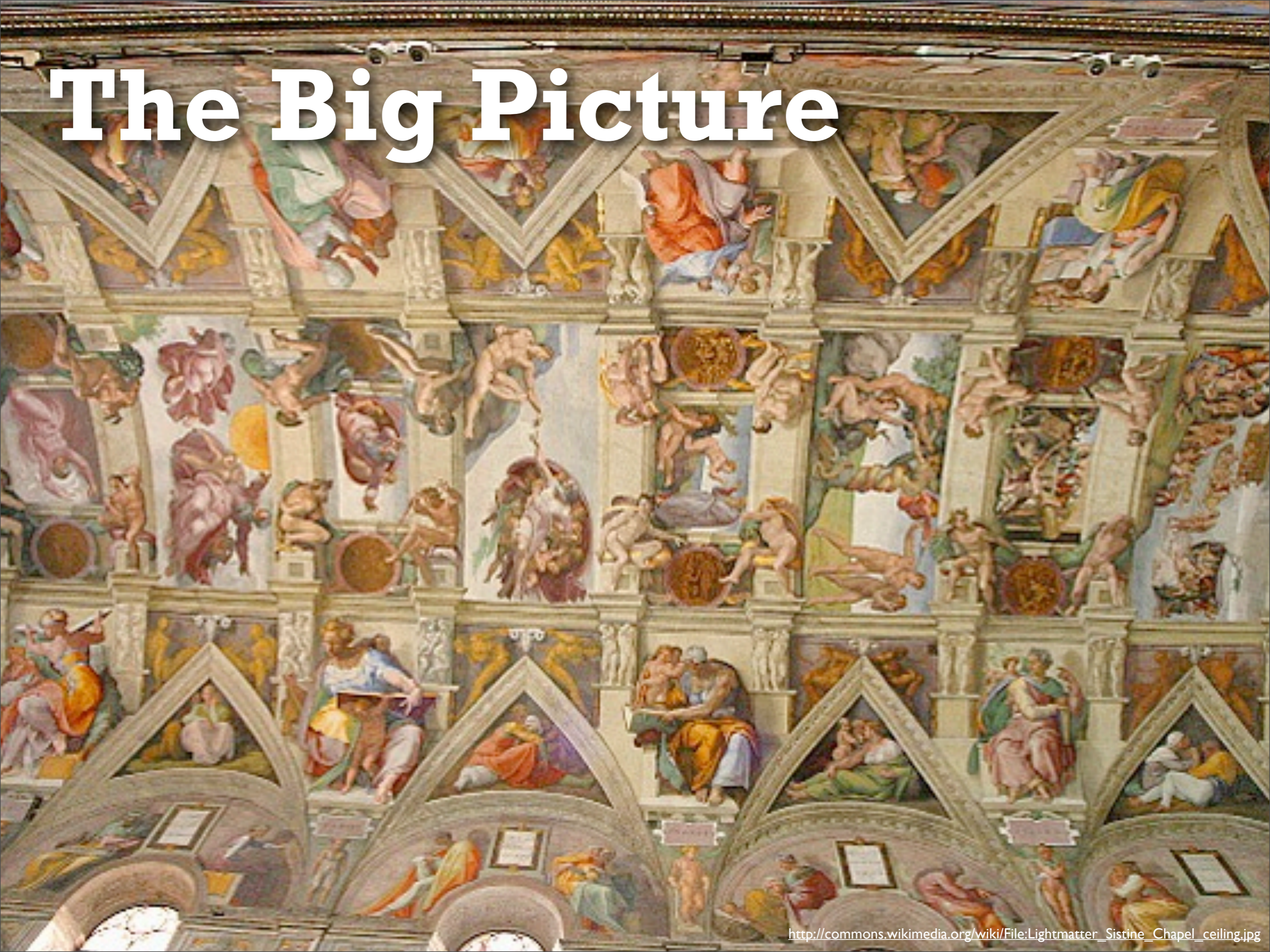


# **Data ↔ Visualization**

**From Data To Visualization**

# The Big Picture



# The Big Picture

From Data to Image

**Data**

**Abstract type**

nominal, ordinal, etc.

**Physical type**

int, float, etc.

Mapping



**Visual Encoding**

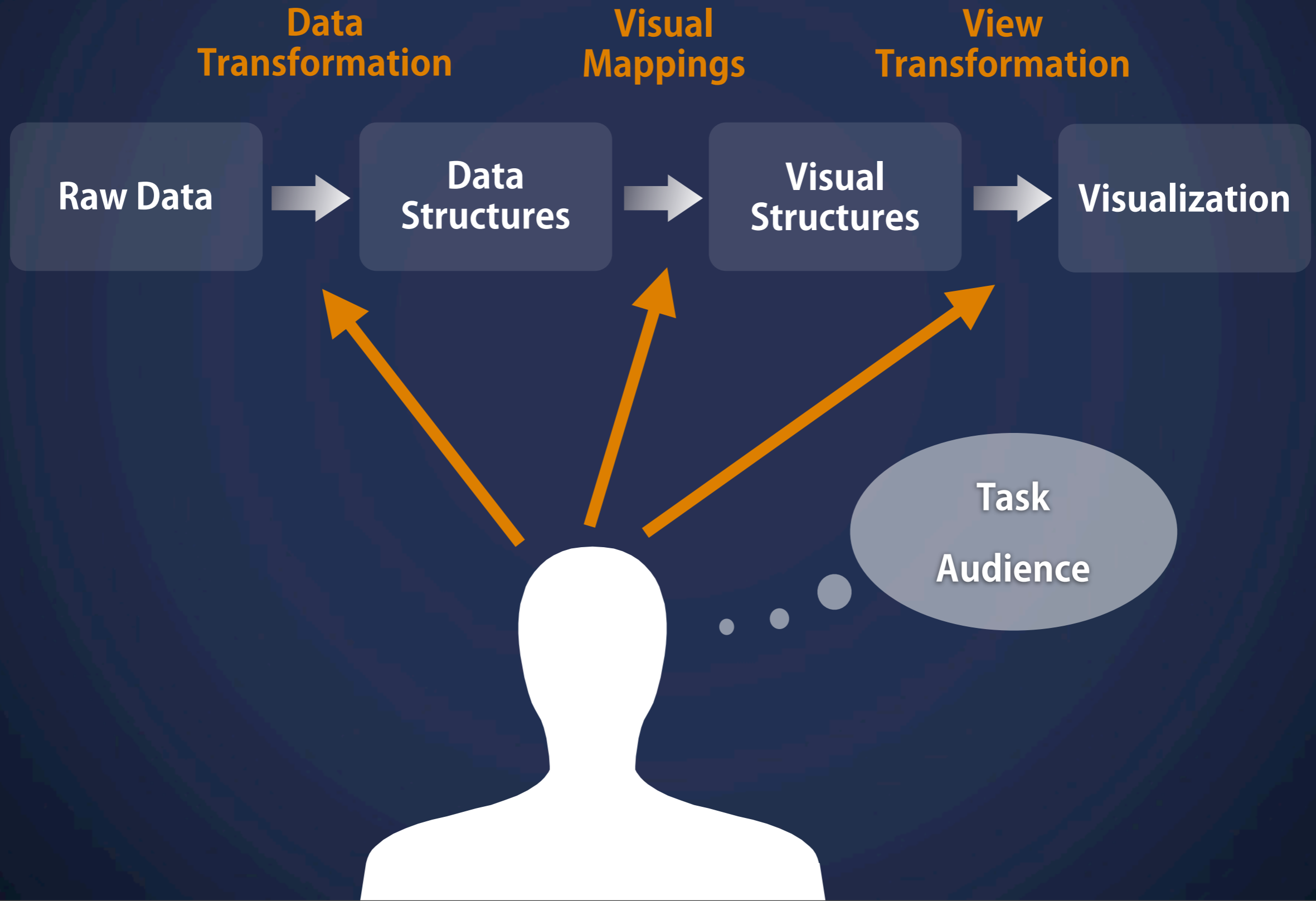
**Visual Metaphor**

**Image**

**Visual channel**

Retinal Variables

# The Interaction Model



# Properties of Data

# Statistical Data Models

Month	Control	Placebo	300mg	450mg
March	165	163	166	168
April	162	159	161	163
May	164	158	161	153
June	162	161	158	160
July	166	158	160	148
August	163	158	157	150

# Statistical Data Models

Observations  
Cases



Month	Control	Placebo	300mg	450mg
March	165	163	166	168
April	162	159	161	163
May	164	158	161	153
June	162	161	158	160
July	166	158	160	148
August	163	158	157	150

# Statistical Data Models

## Categories

Observations  
Cases



Month	Control	Placebo	300mg	450mg
March	165	163	166	168
April	162	159	161	163
May	164	158	161	153
June	162	161	158	160
July	166	158	160	148
August	163	158	157	150



# Statistical Data Models

Categories

Variables

Observations  
Cases



Month	Control	Placebo	300mg	450mg
March	165	163	166	168
April	162	159	161	163
May	164	158	161	153
June	162	161	158	160
July	166	158	160	148
August	163	158	157	150

# Statistical Data Models

**Categories**



**Variables**

**Dimensions**



**Measures**

**Independent**



**Dependent**

Discrete variables  
describing data

Values that can be  
aggregated

# Relational Data Models

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
Jan 13, 2012 18:40	School of Information	10324324	Terry Gilliam	05/2012	2	4	1	No
Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
Jan 15, 2012 10:06	School of Information	56589321	Eric Idle	05/2013	4	2	2	No
Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Relational Data Models

Schema



Tuples



Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
Jan 13, 2012 18:40	School of Information	10324324	Terry Gilliam	05/2012	2	4	1	No
Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
Jan 15, 2012 10:06	School of Information	56589321	Eric Idle	05/2013	4	2	2	No
Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Relational Data Models

Columns (attributes) have a type

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
Jan 13, 2012 18:40	School of Information	10324324	Terry Gilliam	05/2012	2	4	1	No
Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
Jan 15, 2012 10:06	School of Information	56589321	Eric Idle	05/2013	4	2	2	No
Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Relational Data Models

Columns (attributes) have a type

Date

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
Jan 13, 2012 18:40	School of Information	10324324	Terry Gilliam	05/2012	2	4	1	No
Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
Jan 15, 2012 10:06	School of Information	56589321	Eric Idle	05/2013	4	2	2	No
Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Relational Data Models

Columns (attributes) have a type

Date

String

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
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Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
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Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Relational Data Models

Columns (attributes) have a type

Date

String

Number

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
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Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes



# Relational Data Models

Columns (attributes) have a type

Date

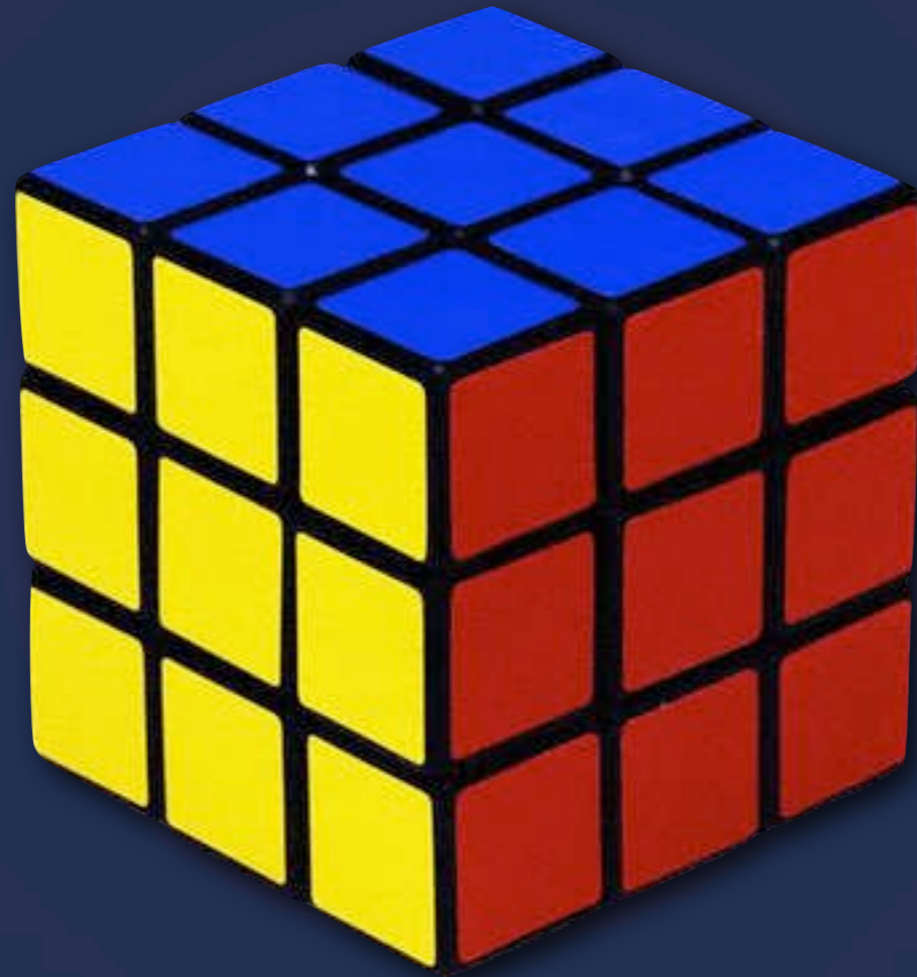
String

Number

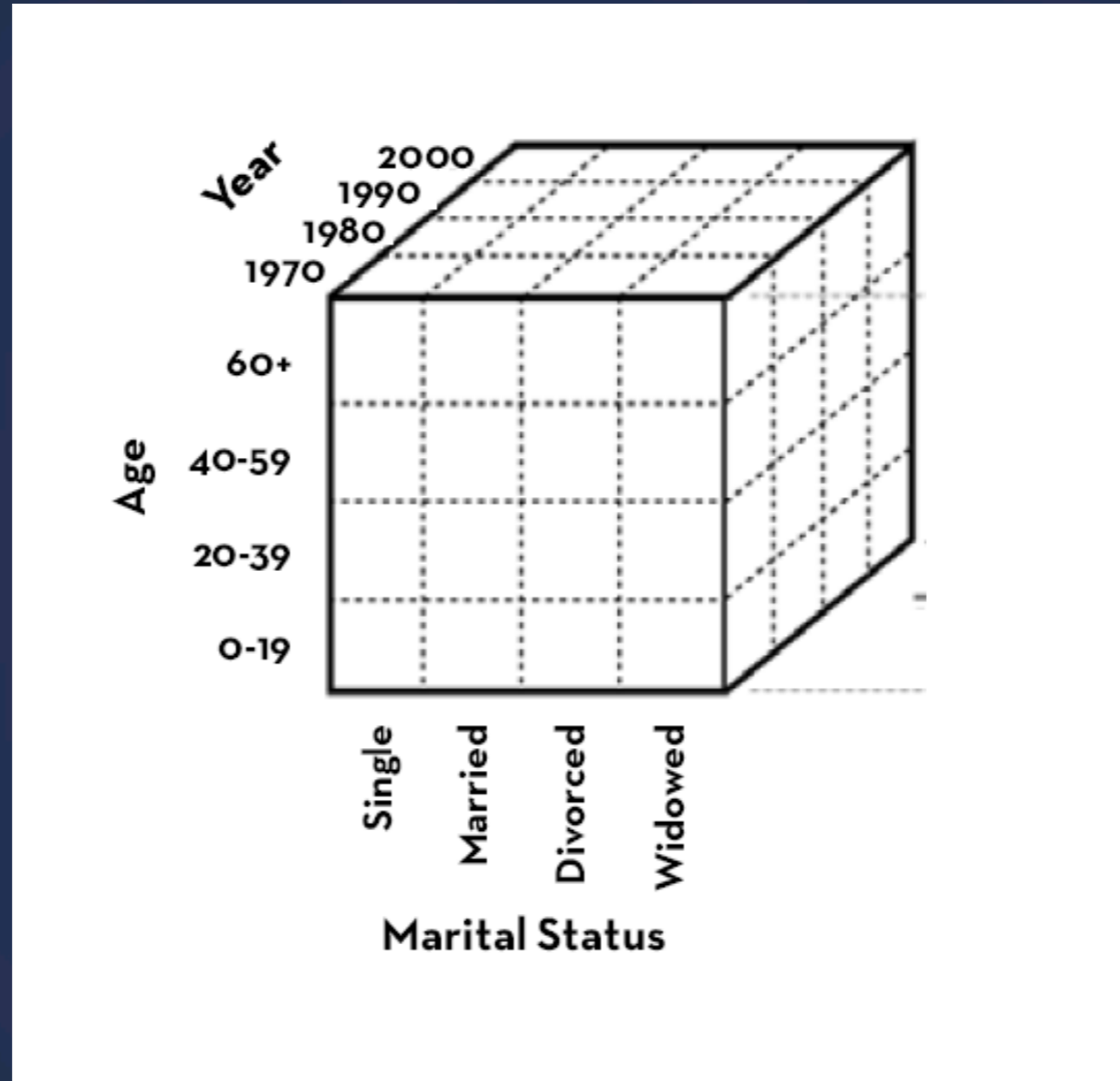
Binary

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
Jan 13, 2012 18:40	School of Information	10324324	Terry Gilliam	05/2012	2	4	1	No
Jan 14, 2012 11:08	Haas Business School	3546424	Terry Jones	05/2013	3	3	4	No
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Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# Cube

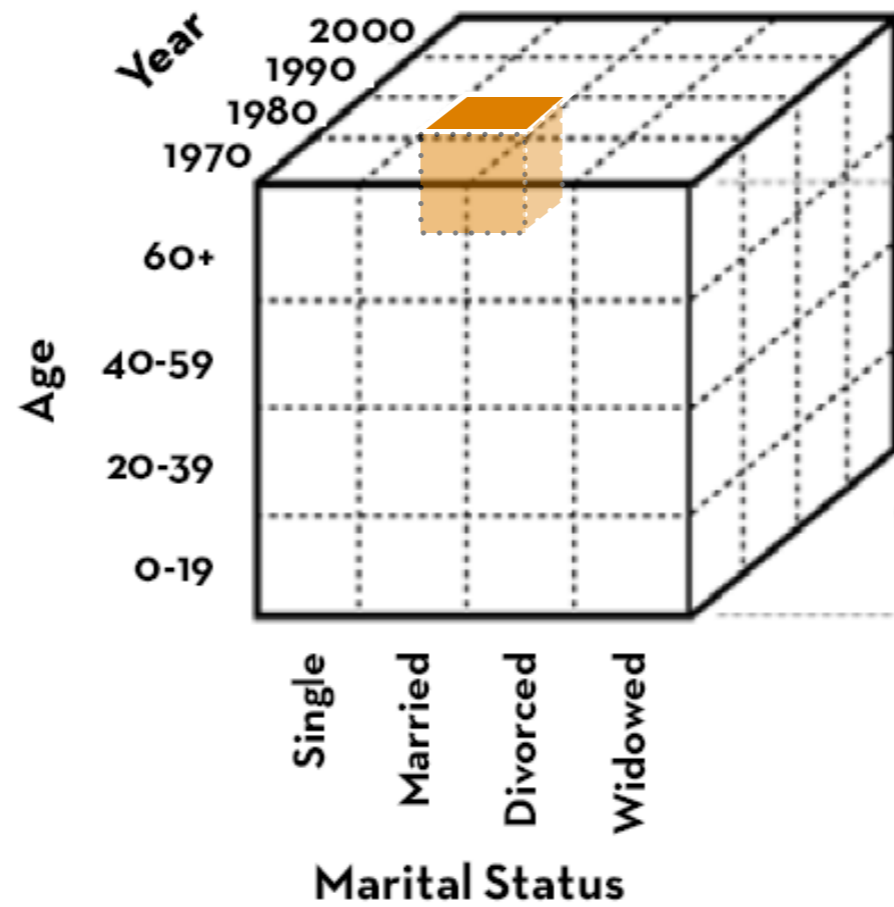


# Cube



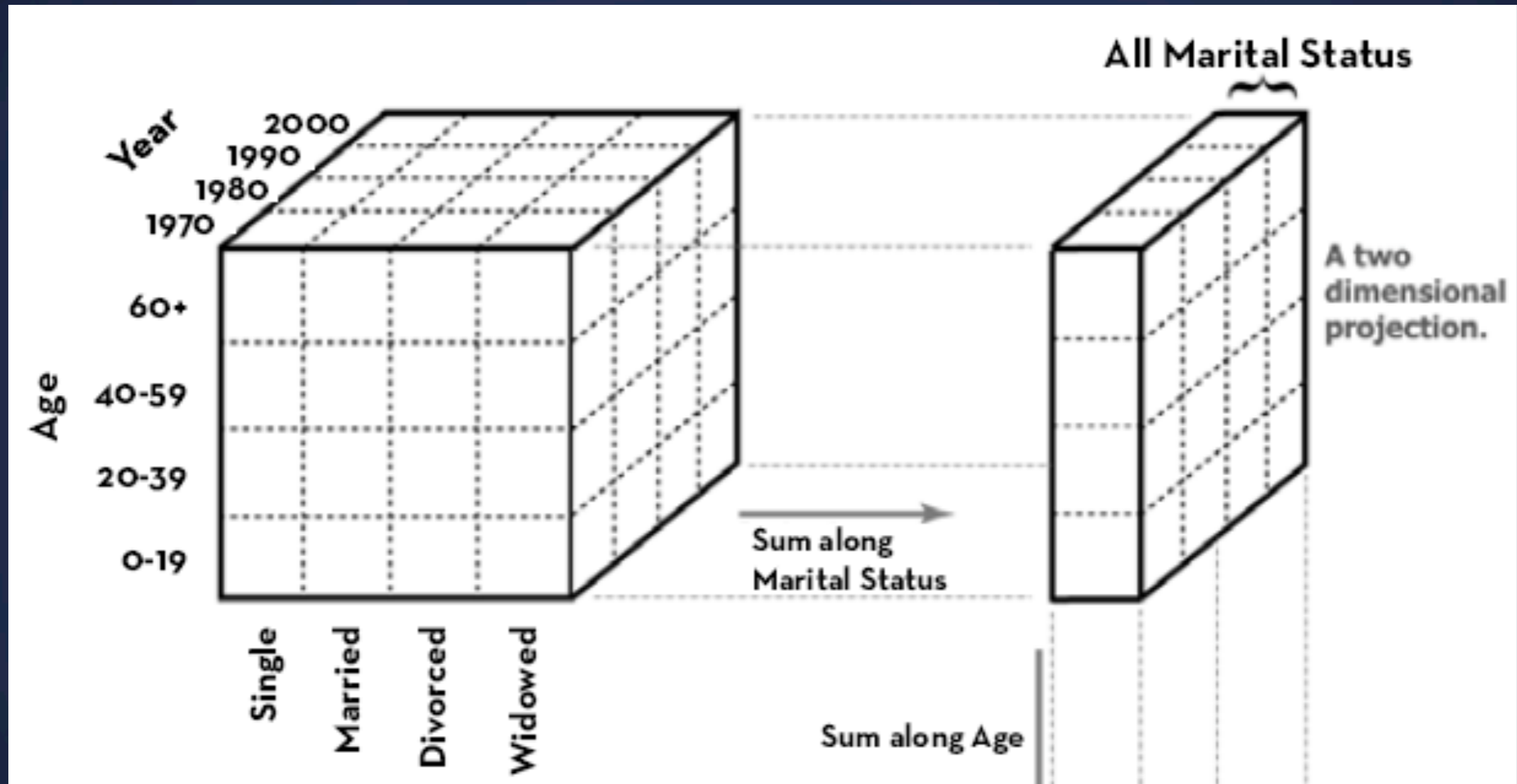
Adapted from Heer

# Cube



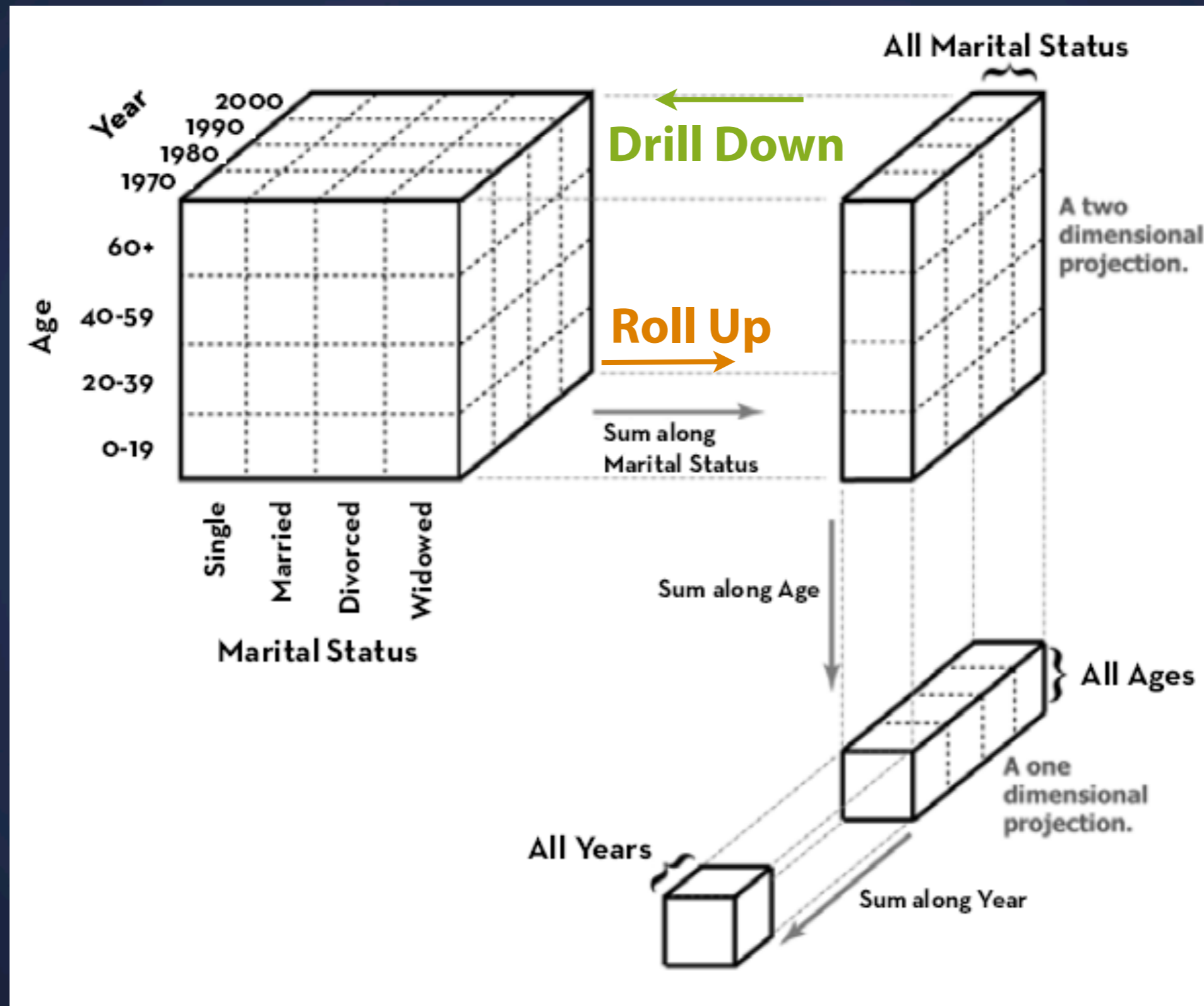
Adapted from Heer

# Cube



Adapted from Heer

# Cube



# Cube - Rolling Up

Grouping along desired dimension

```
SELECT year, marital_status, SUM(people)
FROM census
GROUP BY year, marital_status
```

# Taxonomy: Data Types

- 1D (sets, sequences, text)
- 2D (maps)
- 3D (shapes)
- Temporal
- Multidimensional (relations)
- Tree (hierarchies)
- Network (graphs)

Each data type allows for a specific set of tasks

*Shneiderman: "The Eyes Have It"*



# Taxonomy: Attribute Quality

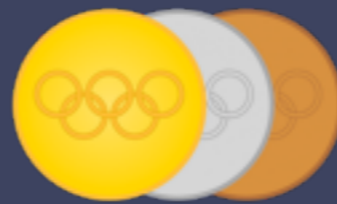
## Nominal

Labels (unordered)



## Ordinal

ordered



A, AA, AAA

1st, 2nd, 3rd

## Quantitative

### Interval

Gap comparison

*lat/lng, °F*

### Ratio

Size comparison  
(0 is fixed)

*inches*

# Taxonomy: Attribute Quality

## Nominal

Labels (unordered)

## Ordinal

ordered

## Quantitative

### Interval

Gap comparison

### Ratio

Size comparison

# Taxonomy: Attribute Quality

## Nominal

Labels (unordered)

= ≠

## Ordinal

ordered

= ≠

## Quantitative

### Interval

Gap comparison

### Ratio

Size comparison

# Taxonomy: Attribute Quality

## Nominal

Labels (unordered)

= ≠

## Ordinal

ordered

= ≠  
< > ≤ ≥

## Quantitative

= ≠ < > ≤ ≥

### Interval

Gap comparison

### Ratio

Size comparison

# Taxonomy: Attribute Quality

## Nominal

Labels (unordered)

$=$   $\neq$

## Ordinal

ordered

$=$   $\neq$   
 $<$   $>$   $\leq$   $\geq$

## Quantitative

$=$   $\neq$   $<$   $>$   $\leq$   $\geq$

### Interval

Gap comparison

—

### Ratio

Size comparison

# Taxonomy: Attribute Quality

## Nominal

Labels (unordered)

$=$   $\neq$

## Ordinal

ordered

$=$   $\neq$   
 $<$   $>$   $\leq$   $\geq$

## Quantitative

$=$   $\neq$   $<$   $>$   $\leq$   $\geq$

### Interval

Gap comparison

—

### Ratio

Size comparison

÷

# Transformations

Nominal

Ordinal

Quantitative



Ignore ordering



Movie length to  
short, medium, long



Sort  
e.g. alphabetical

# Example

Temperature (Conceptual Model)

## Data Model

$^{\circ}F$ : 32.5, 54.0, -17.3

$^{\circ}C$ : 0.2, 12.2, -27.3

**Nominal**

**Ordinal**

**Quantitative**



# Example

Temperature (Conceptual Model)

## Data Model

°F: 32.5, 54.0, -17.3

°C: 0.2, 12.2, -27.3

**Nominal**

*Burned*  
vs  
*Not burned*

**Ordinal**

**Quantitative**

# Example

Temperature (Conceptual Model)

## Data Model

°F: 32.5, 54.0, -17.3

°C: 0.2, 12.2, -27.3

### Nominal

*Burned*  
vs  
*Not burned*

### Ordinal

*Hot*  
*Warm*  
*Cold*

### Quantitative

# Example

Temperature (Conceptual Model)

## Data Model

°F: 32.5, 54.0, -17.3

°C: 0.2, 12.2, -27.3

### Nominal

*Burned*  
vs  
*Not burned*

### Ordinal

*Hot*  
*Warm*  
*Cold*

### Quantitative

*Continuous range  
of values*

# Example

Class Survey: Your turn.

Timestamp	Department	Student ID	Name	Graduation	Design Skills	Coding Skills	Data Skills	Waitlisted?
Jan 13, 2012 12:11	School of Information	35489234	Michael Palin	05/2014	4	2	3	No
Jan 13, 2012 17:00	EECS	23456325	John Cleese		3	5	4	Yes
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Jan 15, 2012 10:17	School of Information	78962218	Carol Cleveland	05/2012	5	3	3	No
Jan 17, 2012 17:04	Psychology	95185633	Graham Chapman	12/2015	1	3	5	Yes

# The Big Picture

From Data to Image

**Data**

**Abstract type**

nominal, ordinal, etc.

**Physical type**

int, float, etc.

Mapping

**Visual Encoding**

**Visual Metaphor**

**Image**

**Visual channel**

Retinal Variables

# **Properties of The Image**

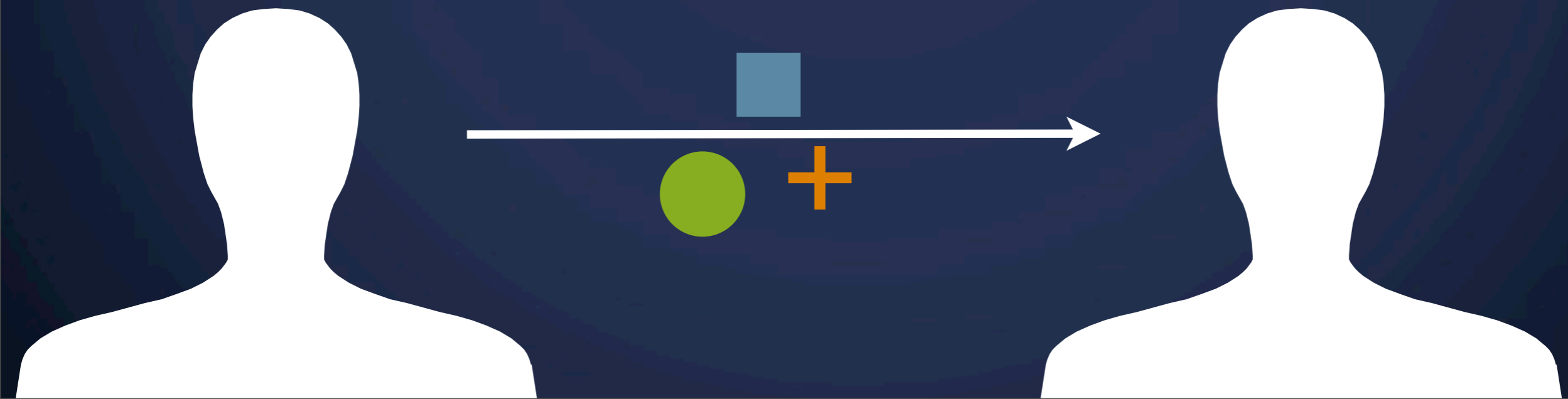
# Bertin's Semiology of Data

Visual language is a sign system

- Images perceived as a set of signs
- Sender encodes information in signs
- Receiver decodes information from signs

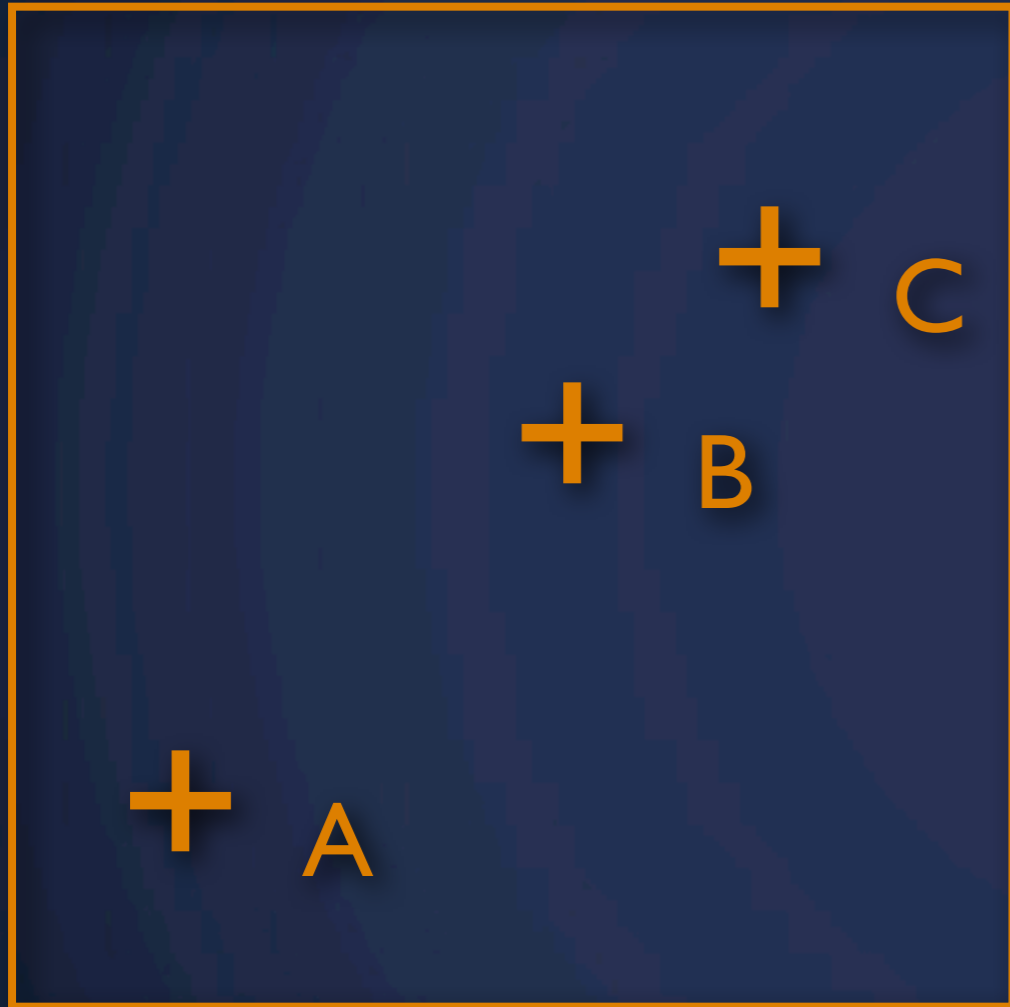
Sender

Receiver



# Bertin's Semiology of Data

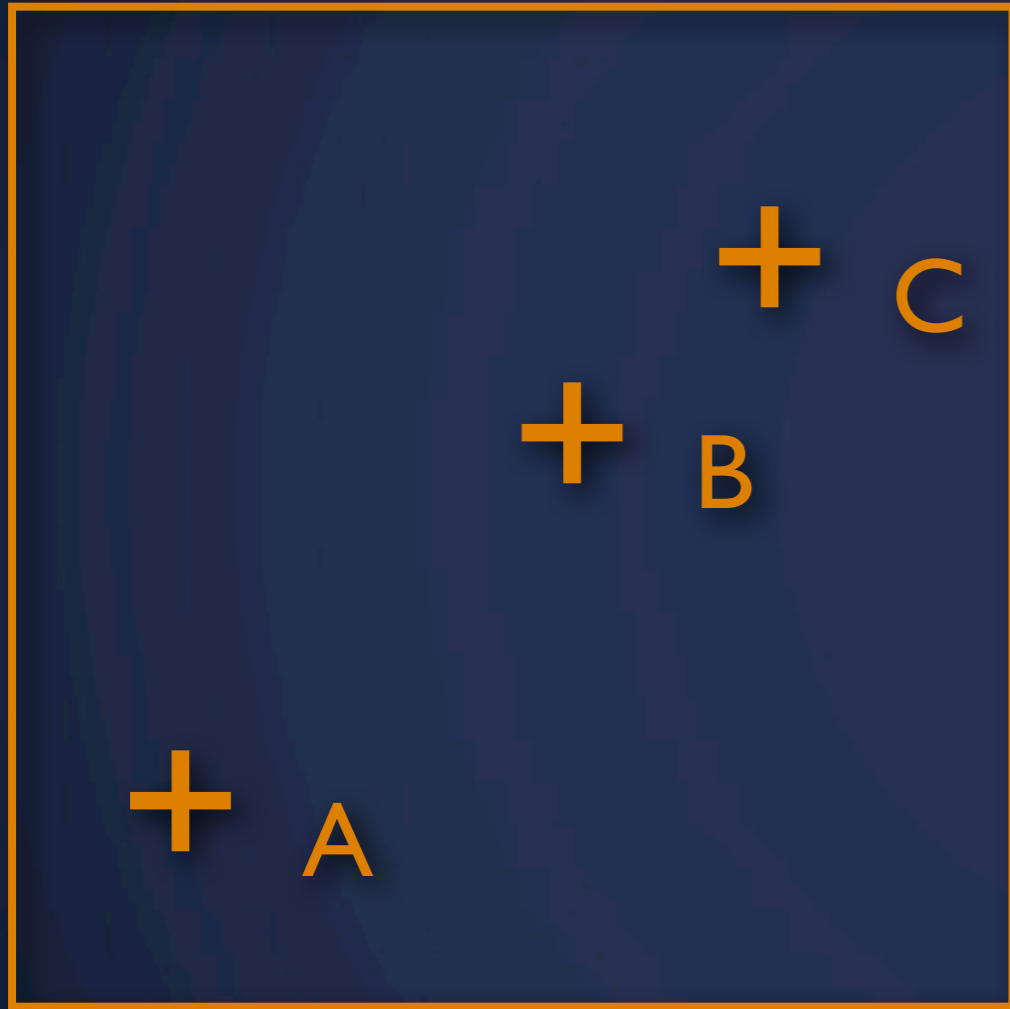
Information in the position





# Bertin's Semiology of Data

Information in the position



- **A**, **B**, and **C** are distinguishable
- **B** is between **A** and **C**
- **AB** is twice as long as **BC**

*"Resemblance, order and proportion are the three signfields in graphics." - Bertin*

# Bertin's Semiology of Data

## Visual Variable Encodings

LES VARIABLES DE L'IMAGE									
		POINTS			LIGNES			ZONES	
XY	2 DIMENSIONS DU PLAN								
Z		TAILLE							
	VALEUR								
LES VARIABLES DE SÉPARATION DES IMAGES									
	GRAIN								
	COULEUR								
	ORIENTATION								
	FORME								

# Bertin's Semiology of Data

## Visual Variable Encodings

- Position (2D)
- Size
- Value
- Texture
- Color
- Orientation
- Shape

### Also

- Movement (Time)
- 3D
- Transparency
- Blur
- etc.

LES VARIABLES DE L'IMAGE											
POINTS                      LIGNES                      ZONES											
XY 2 DIMENSIONS DU PLAN	x	x	x	/	~	/	14 15 9	2 1 8 2			
Z TAILLE	█	█	█	/	~	/	16 21 2 2	1 21 15 1			
VALEUR	█	█	█	/	~	/	14 15 1	1 2 9			
LES VARIABLES DE SÉPARATION DES IMAGES											
GRAIN	█	█	█	/	~	/	14 15 1	1 2 9			
COULEUR	█	█	█	/	~	/	14 15 1	1 2 9			
ORIENTATION	█	█	█	/	~	/	14 15 1	1 2 9			
FORME	█	█	█	/	~	/	14 15 1	1 2 9			

# The Big Picture

From Data to Image

**Data**

**Abstract type**

nominal, ordinal, etc.

**Physical type**

int, float, etc.

**Mapping**

**Visual Encoding**

**Visual Metaphor**

**Image**

**Visual channel**

Retinal Variables

# **From Data to Image**

**Mapping and (not so much) Magic**

# Mappings

Information in size, color, and value

**Categorical**

Nominal

**Ordered**

Ordinal

**Continuous**

Quantitative

# Mappings

Information in size, color, and value

Size

**Categorical**  
Nominal



(in some cases)

**Ordered**  
Ordinal




**Continuous**  
Quantitative



# Mappings



Information in size, color, and value

	Size	Color
<b>Categorical</b> Nominal	 (in some cases)	
<b>Ordered</b> Ordinal		
<b>Continuous</b> Quantitative		



# Mappings

Information in size, color, and value

	Size	Color	Value
<b>Categorical</b> Nominal	 (in some cases)		
<b>Ordered</b> Ordinal			
<b>Continuous</b> Quantitative			

# Bertin's Semiology of Data

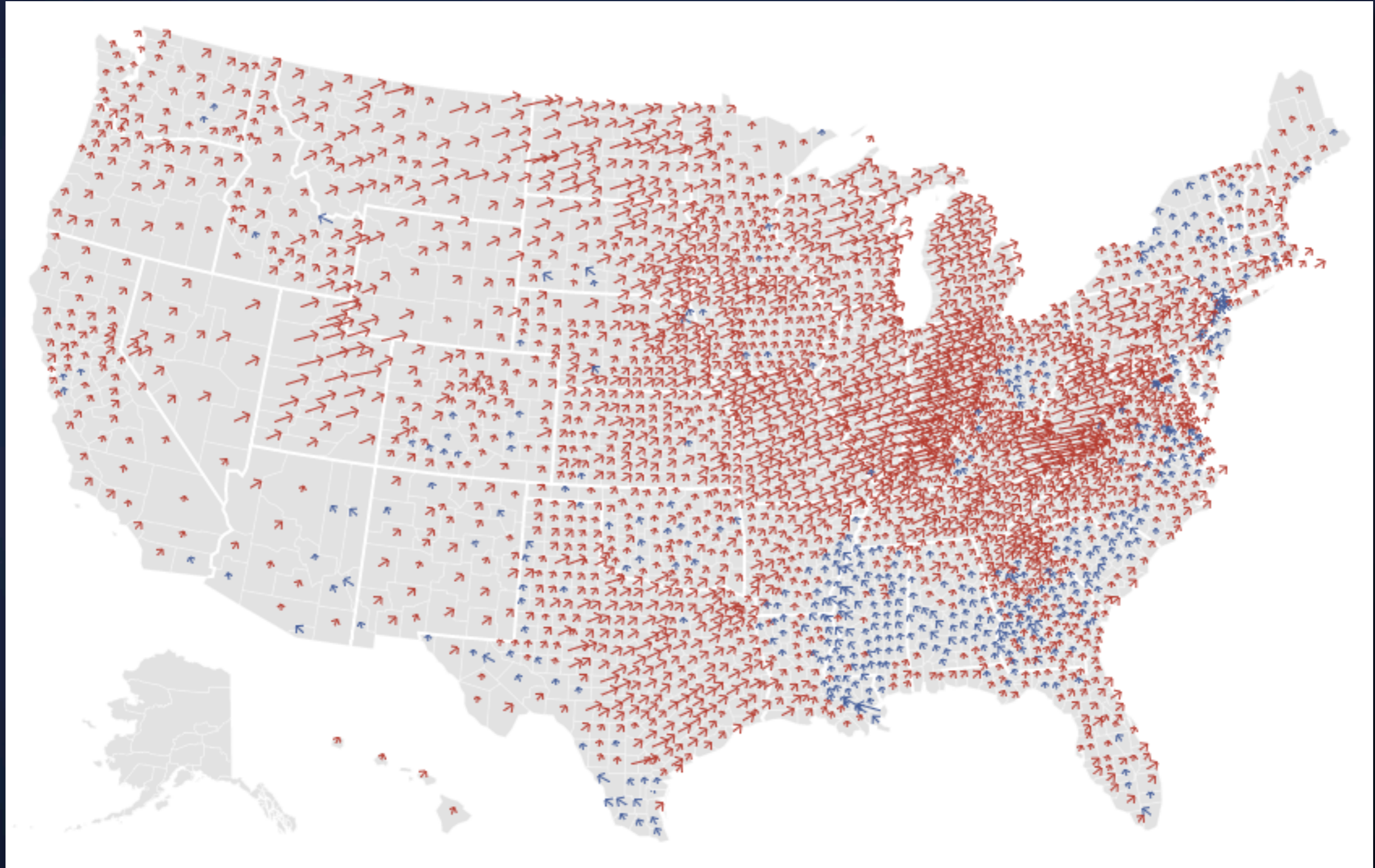
## Levels of Organization

Position	N	O	Q
Size	N	O	Q
Value	N	O	Q
Texture	N	O	
Color	N		
Orientation	N	O	
Shape	N		

- N = Nominal
- O = Ordinal
- Q = Quantitative

# Election 2012 Results

Shift from 2008



# Election 2012 Results

Shift from 2008



**Recap**

# Labs

**This Thursday: Tableau**

# **Next Lecture**

**Multivariate Visualizations**