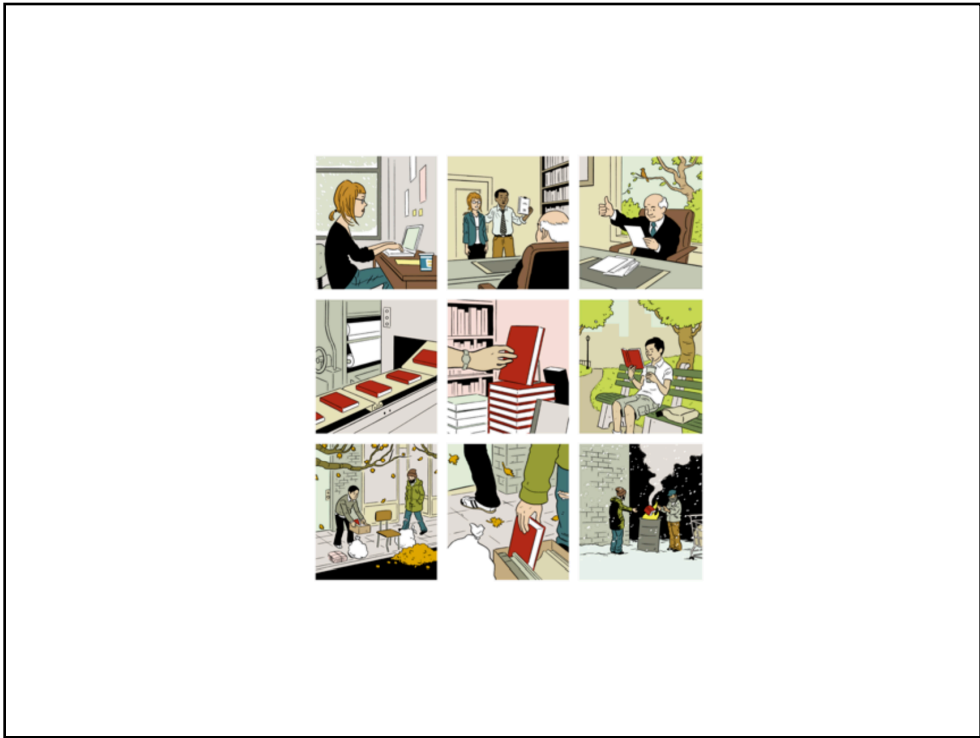


# Narrative Visualization

*Jessica Hullman*



Cave painting [Ennedi Plateau, Chad]



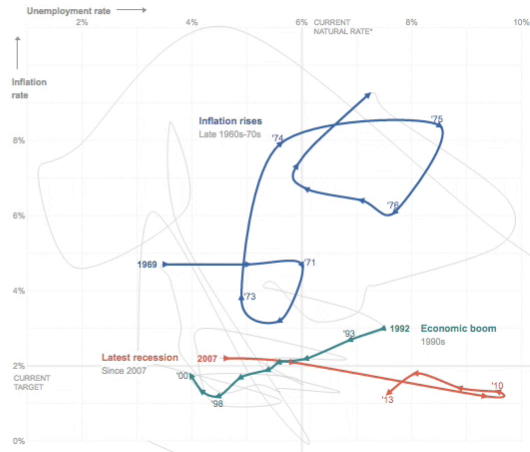
### Janet L. Yellen, on the Economy's Twists and Turns

1 2 3 4 5 6 7 NEXT >

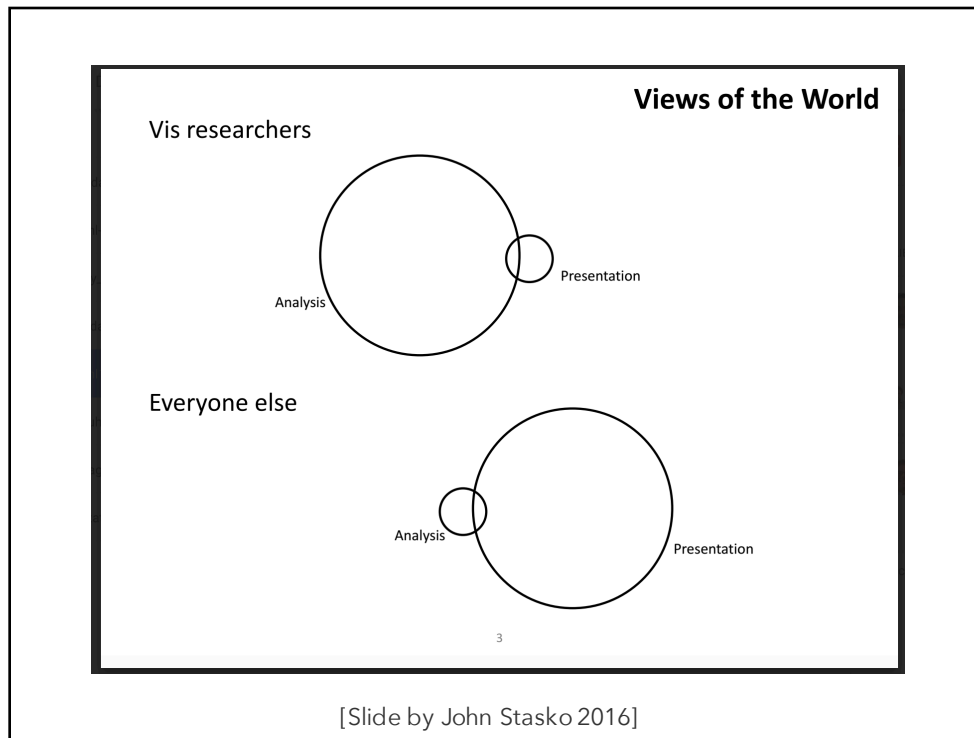
#### Inflation and unemployment

The Federal Reserve is said to have a "dual mandate": keeping inflation in check and the unemployment rate low. These measures, which tend to change cyclically and in concert with each other, are charted for every year since the Great Depression.

In speeches and in meetings, Ms. Yellen, the nominee for the next Fed leader, has commented on the Fed's actions during significant periods, providing a window into her views and priorities.



[Giratikanon and Parlapiano 2013]



## Topics

---

Design space

Theories of interpretation

Construction

Manual

Automated

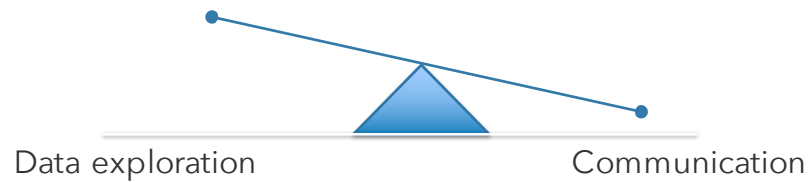
# Design Space

## Value of storytelling [Gershon and Page 2001]

---

### **A way of structuring information**

- Easier to understand than lists
- Uncertainty, conflict, resolution
- Text and visuals can be complementary



# Human Development Trends 2005



Interactive presentation of some of the messages in the Human Development Report 2005

- English
- Dansk
- Portuguese
- Suomi
- Français
- Deutsch

Produced in collaboration with:  
**GAPMINDER**  
www.gapminder.org

English translation: Claes Johansson, UNDP

**1 Income**

**2 Regions**

**3 Poverty**

**4 Health**

**5 Countries**

**6 Differences**

**7 Trends**

**8 Gaps**

**9 Deaths**

Human Development Trends [Gapminder 2005]

## Storytelling techniques

build in picture

continuity

animate events

increasing attention

redundancy

**Figure 2. Two-part script for the visual representation of information (sorted by location); visual operations are in red.**

Time	Image	Voice	Time
	<b>Begin Part 1:</b> Show overview (map)	It is now early in the morning. The time is H+8.	
	<b>Zoom in</b> to show the school building. Show the school building; make it transparent and <b>superimpose</b> a picture of children.	Our schoolhouse is in the center.	
	<b>Zoom out.</b> Highlight NE/SE entities.	Enemy is strongest in NE/SE direction. Enemy (SE) became active between H+2 to H+4.	
	<b>Zoom in</b> the G-shaped building. <b>Add lines of fire</b> to the G-shaped building.	G-shape building; not as strong as enemy in SE. Direction of fire toward the schoolhouse and other directions (SW/E). G-shape building, weak fire, thinner lines.	
	<b>Highlight</b> the thin lines of fire of the G-shaped building.	G-shape building, active between H to H+2, H+2 to H+4.	
	<b>Zoom out.</b>		
	<b>Zoom in</b> to NW enemy position. <b>Add lines of fire</b> while zooming out.	NW enemy position, direction of fire SW/SE. NW enemy has been active between H to H+6.	
	<b>Zoom out.</b> Show overview while <b>highlighting</b> two little enemy objects.	Two little enemy activities in the center. UAV reported yesterday.	
	<b>Begin Part 2:</b> <b>Animate</b> the overview from the beginning (time H) to show time dependence.		
	Show overview	<b>Commander's Perceptions</b> Enemy is oriented toward the center. No shift in the flanks of any magnitude. One relatively strong flank (SE-NE).	

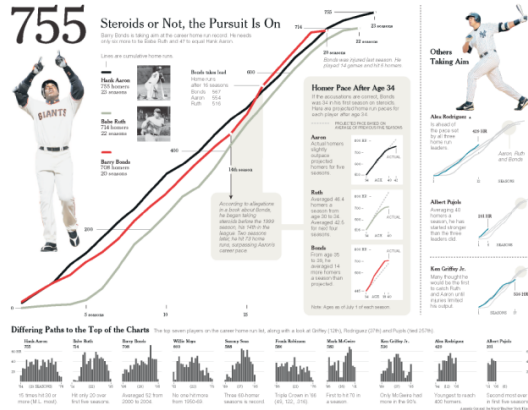
[Gershon and Page 2001]

5

# Narrative Visualization [Segel and Heer 2010]

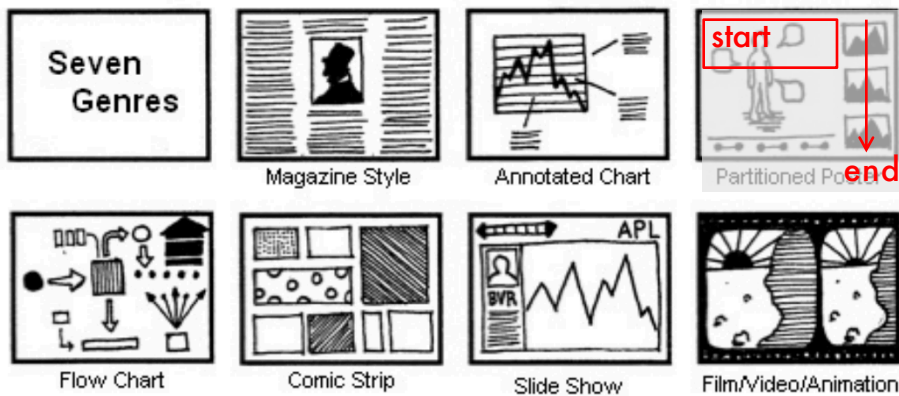
Studied 58 examples, characterized design space

- News media, blogs, instructional videos, research



[Cox and Ward 2006]

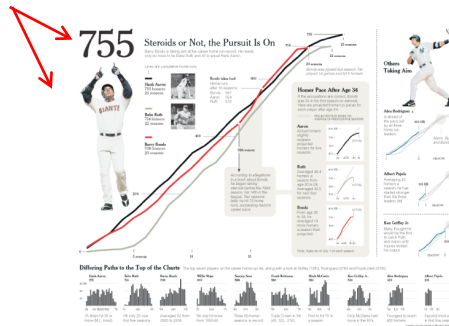
## Design space dimensions: 1. Genre



more linear  
[Slide adapted from Segel 2010]

## 2. Visual narrative tactics

### Highlighting



### Transition guidance



## 3. Narrative structure tactics

### Ordering

### Messaging

### Interactivity

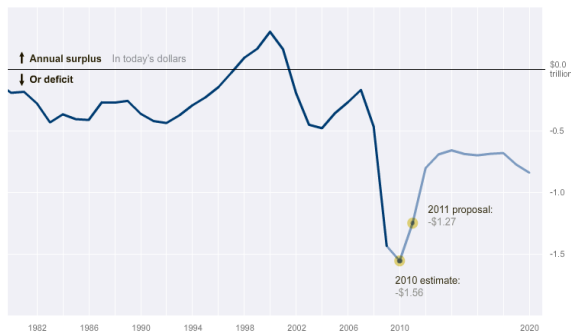
#### Budget Forecasts, Compared With Reality

Just two years ago, surpluses were predicted by 2012. How accurate have past White House budget forecasts been?

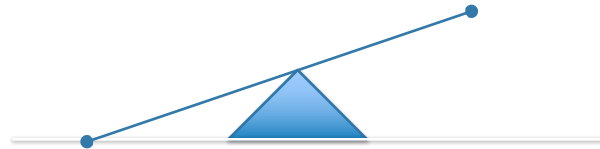
1 2 3 4 5 6 NEXT

#### Falling short

President Obama's budget proposal estimates a deficit of \$1.6 trillion for the current fiscal year and \$1.3 trillion in 2011.



# Author vs. reader driven stories

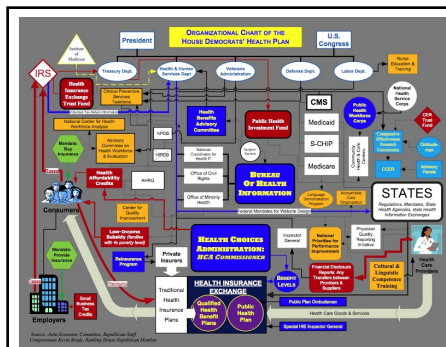
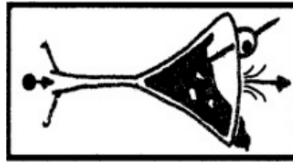


## Author driven

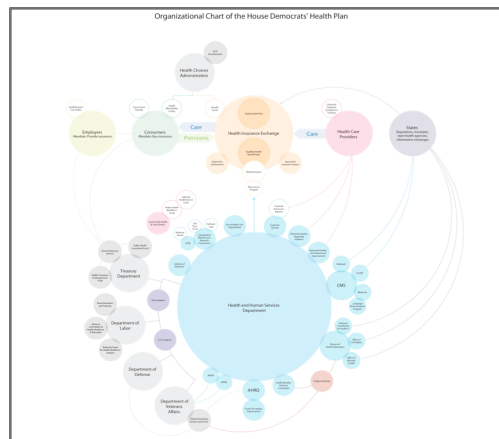
Prescribed ordering  
Stronger messaging  
Limited interactivity

## Reader driven

Multiple orderings  
Less messaging  
More open interactivity



How do we make sense of these examples?



An Organizational Chart of the House Democrat's Health Plan [GOP 2008, Robert Palmer 2008]



## Visualization rhetoric [Hullman & Diakopoulos 2011]

---

Using data and visualization to persuade users to adopt certain interpretations (explicitly or implicitly)

Framing effects: small changes in presentation of an issue result in significant changes in opinion

### Method

- 51 professional produced narrative visualizations
- NYT, BBC, Economist, local news, political outlets
- Iterative qualitative coding, seeded scheme with semiotics, persuasion concepts

## Taxonomy of rhetorical strategies

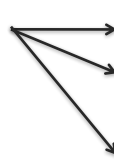
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### Rhetorical Categories

Information Access  
Provenance  
Mapping  
Procedural  
Linguistic

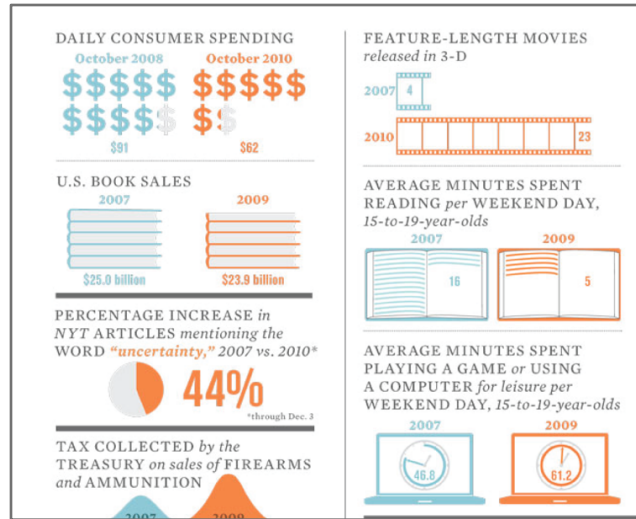
### Editorial Layers

Data  
Visual Representation  
Annotation  
Interactivity



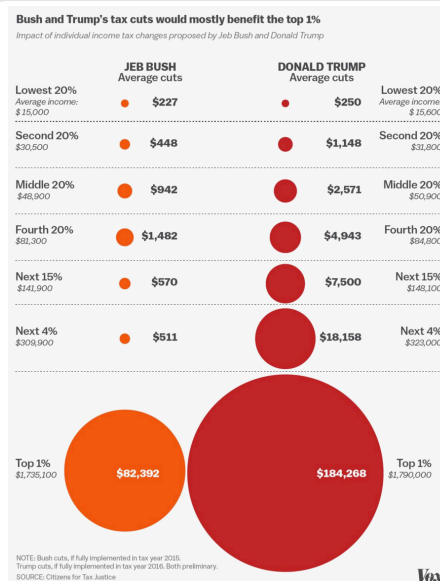
- Omission (variable selection)
- Metonymy (aggregation, categorization)

# Enthymeme (information access)



How the Recession Changed Us [The Atlantic 2009]

# Metonymy (information access)



Donald Trump wants massive tax cuts for the rich [Vox 2015]

# Taxonomy of rhetorical strategies

## Rhetorical Categories

Information Access

Provenance

Mapping

Procedural

Linguistic

## Editorial Layers

Data

Visual Representation

Annotation

Interactivity



- Citing sources, methodology
- Exceptions, corrections
- Acknowledging uncertainty

# Citing sources /methods (provenance)

## Mapping America: Every City, Every Block

Browse local data from the Census Bureau's American Community Survey, based on samples from 2005 to 2009. Because these figures are based on samples, they are subject to a margin of error, particularly in places with a low population, and are best regarded as estimates.

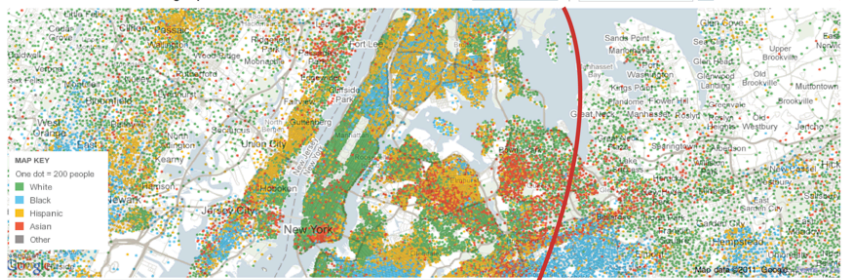
Find something interesting? Share this view on [Twitter](#) or [Facebook](#)

[View Readers Maps \(49\)](#)

### Distribution of racial and ethnic groups

[View More Maps](#)

Address, ZIP code or city



By MATTHEW BLOCH, SHAN CARTER and ALAN MCLEAN | Source: 2005-9 American Community Survey, Census Bureau; socialexplorer.com

Note: Dots are evenly distributed across each Census tract or county. Dollar amounts are adjusted for inflation.

## Mapping America: Every City, Every Block

Browse local data from the Census Bureau's American Community Survey, based on samples from 2005 to 2009. Because these figures are based on samples, they are subject to a margin of error, particularly in places with a low population, and are best regarded as estimates.

Find something interesting? Share this view on [Twitter](#) or [Facebook](#)

[View Readers Maps \(49\)](#)

### Distribution of racial and ethnic groups

[View More Maps](#)

Address, ZIP code or city



[Bloch, Carter, and McLean 2010]

# Taxonomy of rhetorical strategies

## Rhetorical Categories

Information Access

Provenance

Mapping

Procedural

Linguistic

## Editorial Layers

Data

Visual Representation

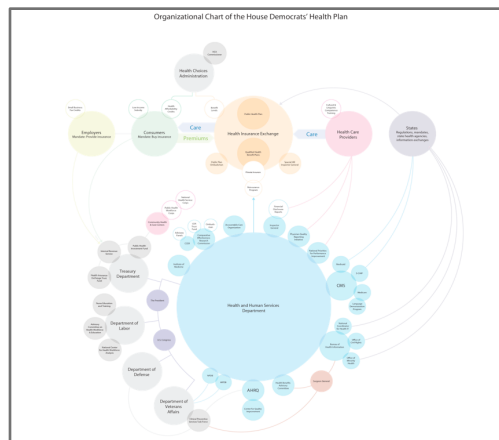
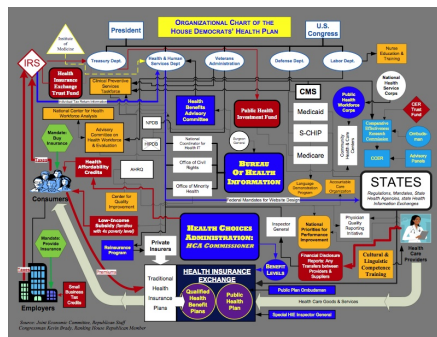
Annotation

Interactivity



- Visual metaphor
- Semantic encodings (e.g., red:Rep, blue:Dem)

# Visual metaphor (mapping rhetoric)



# Taxonomy of rhetorical strategies

## Rhetorical Categories

Information Access

Provenance

Mapping

Procedural

Linguistic

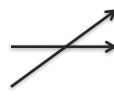
## Editorial Layers

Data

Visual Representation

Annotation

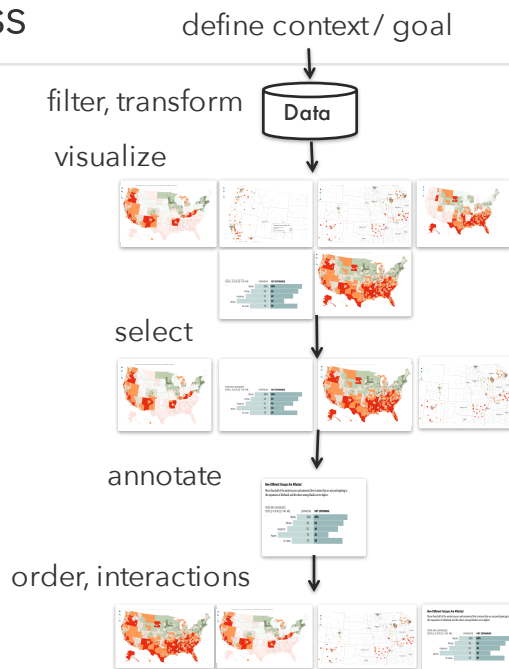
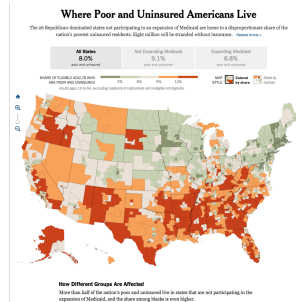
Interactivity



- Rhetorical question, "scare quotes"
- Labeling choices
- Analogy, simile, double entendre

# Design process

An editorial process characterized by rhetorical decisions at various points.



## Scope of narrative visualization

---

- Visualization genres that employ visual and narrative structures to guide attention
- Visualizations that use rhetorical devices to persuade

### **Discuss with 1 or 2 other people near you:**

In your own research or papers you've read/cited, is narrative visualization occurring? How do persuasion and rhetoric occur in these contexts?

## Theories of Interpretation

# Semiotics

---

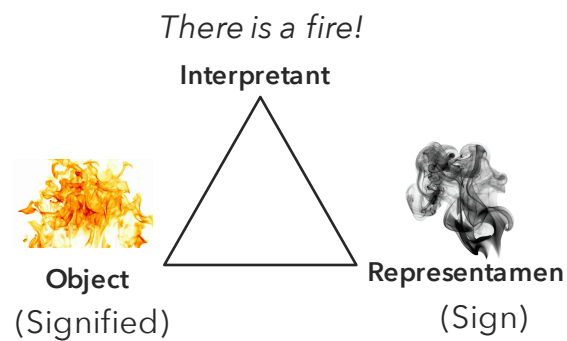
"TREE"  
Sign

  
Signified

# Semiotics

---

Viewing codes: the perceptual mechanisms, cognitive mechanisms, conventions and other prior knowledge that influence how we interpret signs.

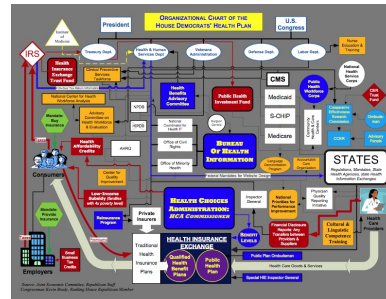


# Denotation vs. connotation

(Make explicit)

*The Democrats proposed health-plan is disorganized and inefficient.*

(Imply)

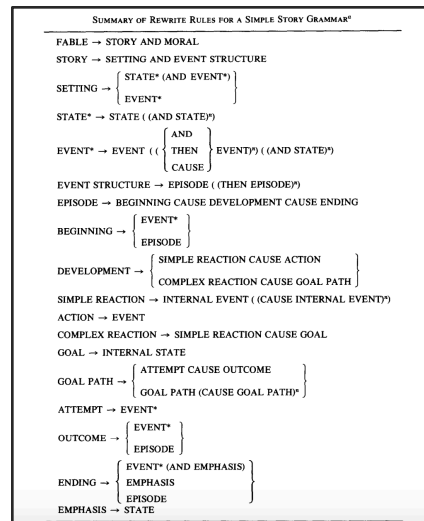


# Narrative theory

## Story grammars:

Models of narrative cognition based on systematic studies of what impacts peoples' ability to recall parts of a story

Reader mentally indexes events by time, space, protagonist, causality, intention [Zwaan 1995]



Remembrance of Things Parsed [Mandler and Johnson 1977]



# Narrative theory applied

## European Alliances before World War I (1836-1914)

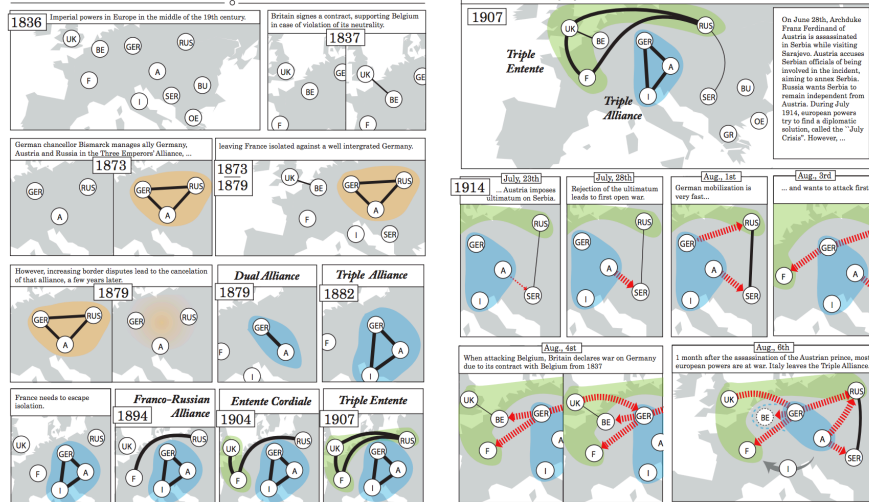


Figure 3. Graph comic example illustrating historical events preceding WWI, targeted to a general audience.

Graph Comics [Bach et al. 2016]

# Narrative theory applied

**C1. Element identity**—Characters in traditional comics are recognizable via their distinct visual features. In graph visualization, nodes and edges are usually represented by circles, sometimes using labels for identifications. Variations in shape and color reflect attributes in the data.

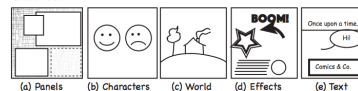
**C2. Depicting change**—In comics, readers can infer changes even if not shown explicitly. For example, a baby being shown implies it has been born. In graphs, a (new) node being shown does not mean it was not there before.

**C3. Order of events**—Many changes exhibit a natural order (e.g. humans grow old, objects fall down, day turns into night). Changes in graphs do not have a natural order nor duration; a cluster can grow or shrink, divide or merge.

**C4. Spatial context**—In comics, the spatial context of a scene is usually indicated by the panel background: the same background means the same place and often the same scene. Switching spatial context from one cluster to another may not be recognized by a reader (both consists of nodes and links).

**C5. Number of elements**—Comics usually show a small set of characters in every panel. Changes in graphs, may involve many more elements than it is possible to show in a panel.

### 1) Traditional Comics



### 2) Designing for Graph Changes



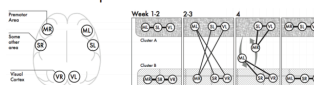
### 3) Design Principles



### 4) Creating Comics



### 5) Discussion with Domain Experts



### 6) Readability Study (see Section "Readability Study")

Graph Comics [Bach et al. 2016]

# Narrative theory applied

Presentation sequence → recall, interpretation

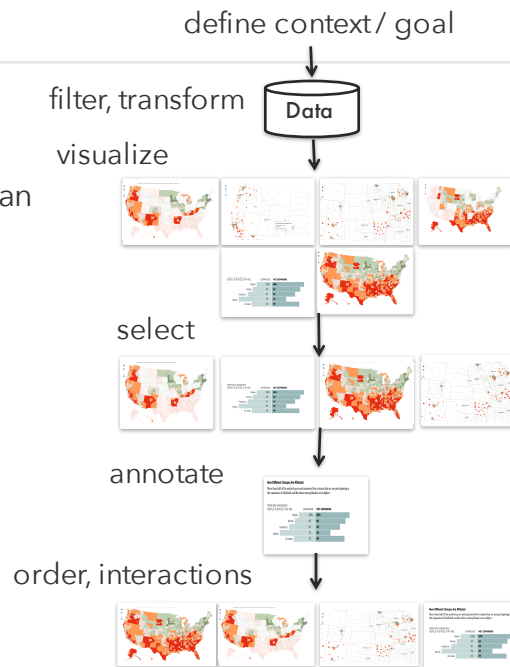
[Black & Bower 1979, Pennington & Hastie 1982]



[Hullman et al. 2013]

# Design tools

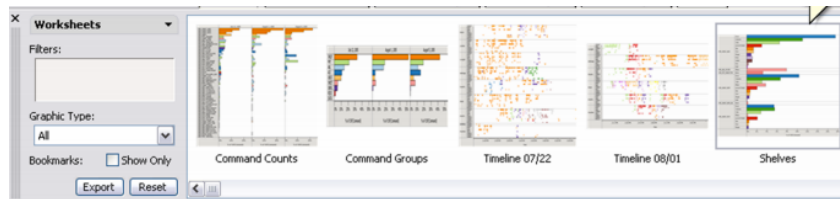
Can we automatically identify sequences to recommend to a human designer?



## Discovery order $\neq$ presentation order

---

Interactive dynamics in analysis: Filter, derive, etc.  
[Shneiderman 1996, Heer & Shneiderman 2012]



Provenance: How did I get to this result?  
[Heer et al. 2008, Bavoli et al. 2005, Scheidegger et al. 2007]

## What makes an effective sequence?

---

What do designers and  
journalists do?

Examined 400+ transitions in  
explicitly ordered visualizations

- Interactive slideshows
- Scrollable visualizations
- Animated videos
- Analysis presentations



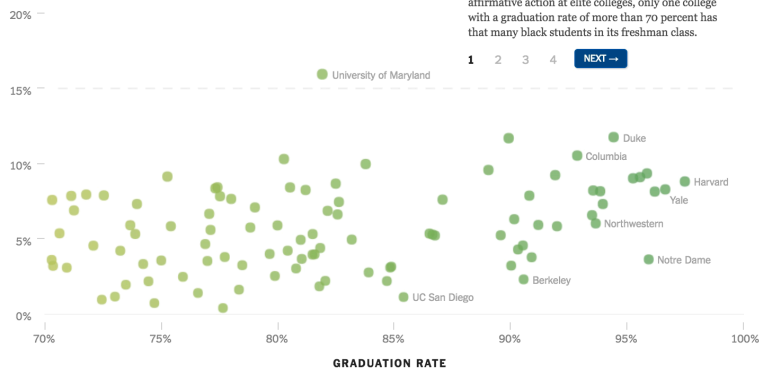
# Patterns of Transition types

- Dialogue (e.g., question/answer)
- Causal
- Temporal (e.g., chronology, future)
- Hierarchy (general-to-specific)
- Comparative Data (Dimension walk, Measure walk)
- Spatial (e.g., cardinal directions)

# Dimension walk – change I.V.

## At Top Colleges, an Admissions Gap for Minorities

**BLACKS**  
as a percentage of  
2011–12 freshmen



Note: For-profit colleges and colleges with fewer than 5,000 undergraduates are omitted from the chart.

By JOSH KELLER

Source: National Center for Education Statistics, 2011

## Some observations about transitions

Some types (time, hierarchy, comparative) more common  
Defined by a single change to data schema

- Implies a goal of minimizing *cognitive cost*

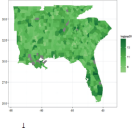
## Examining the cost of transitions

Crowd workers decided between pairs of transitions  
and explained choices

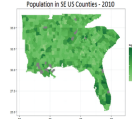
Lower cost transitions are preferred.

**\*Help Choose Graphs for a Data Presentation\* - Scored Task**

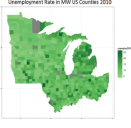
Graph 1  
Population in SE US Counties - 2010



Graph 2a  
Population in SE US Counties - 2010



Graph 2b  
Unemployment Rate in SE US Counties 2010



Question 1: Which of the following are true?  
 Graph 1 shows data from 2010.  
 Graph 1 shows data from 2010.  
 Graph 2a shows data from 2010.  
 Graph 2b shows data from 2010.  
 None of the above statements are true.

Question 2: Which of the following are true?  
 Graph 1 shows data on ONLY the Northeast US.  
 Graph 1 shows household income data.  
 Graph 2a shows unemployment data.  
 Graph 2b shows presidential election data.  
 None of the above statements are true.

Question 3: Which of the two graphs is better to appear directly after Graph 1 in the presentation?  
 Graph 2a  
 Graph 2b

Question 4: Why did you choose the graph you chose for question 3?

## Examining the cost of transitions

Type preferences among equal cost transitions preferred over others:

*Temporal > (Dimension | Measure) > Hierarchy*

**\*Help Choose Graphs for a Data Presentation\* - Scored Task**

Graph 1  
Population in 36 US Counties - 2010

Graph 2a  
Population in 36 US Counties - 2010

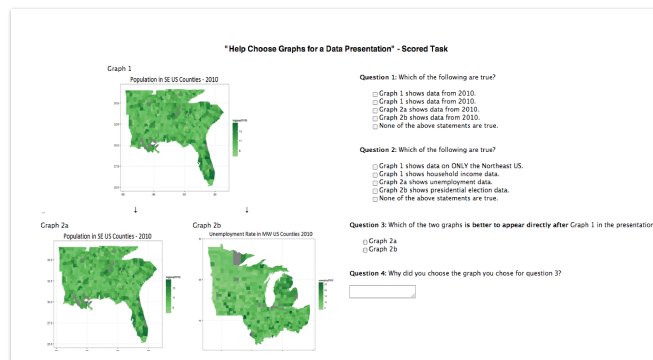
Graph 2b  
Unemployment Rate in 36 US Counties - 2010

Question 1: Which of the following are true?  
 Graph 1 shows data from 2010.  
 Graph 1 shows data from 2015.  
 Graph 2a shows data from 2010.  
 Graph 2b shows data from 2010.  
 None of the above statements are true.

Question 2: Which of the following are true?  
 Graph 1 shows data on ONLY the Northeast US.  
 Graph 1 shows household income data.  
 Graph 2a shows unemployment data.  
 Graph 2b shows presidential election data.  
 None of the above statements are true.

Question 3: Which of the two graphs is better to appear directly after Graph 1 in the presentation?  
 Graph 2a  
 Graph 2b

Question 4: Why did you choose the graph you chose for question 3?



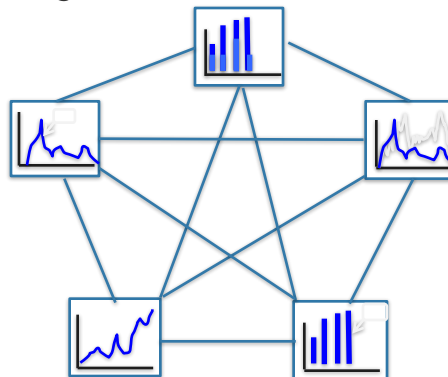
## Some observations about transitions

Graph-based approach

Minimize cost between adjacent visualizations

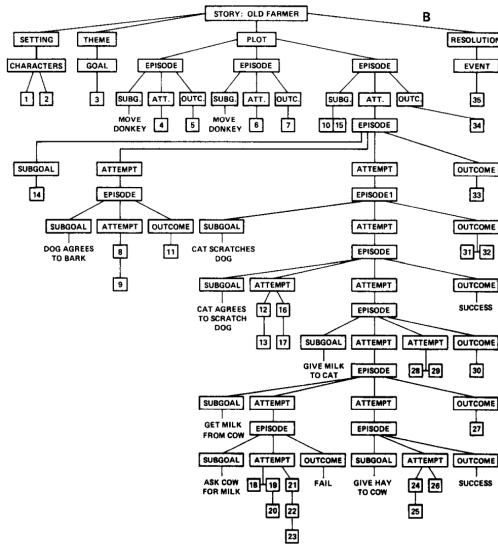
Cost model should account for preferences between types of transitions and changes to data schema

Goal:  
Automatic detection  
of effective sequences



# Micro- vs. macrostructure

Fictional stories are described in terms of how *larger events* are organized (macro-), each of which is comprised of *sub-events* (micro-).

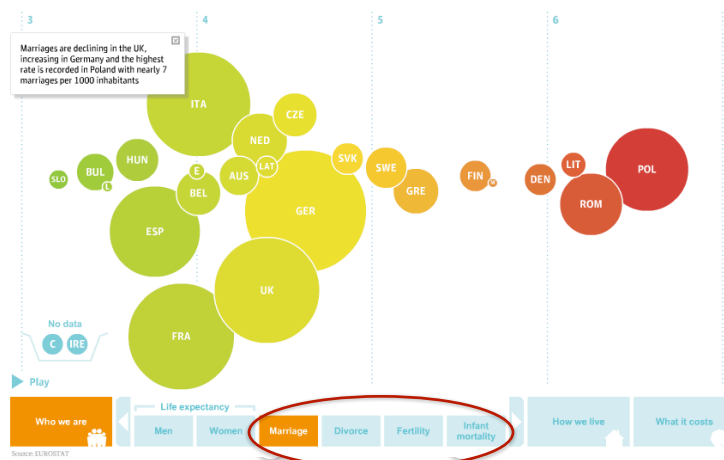


Remembrance of Things Parsed [Mandler and Johnson 1977]

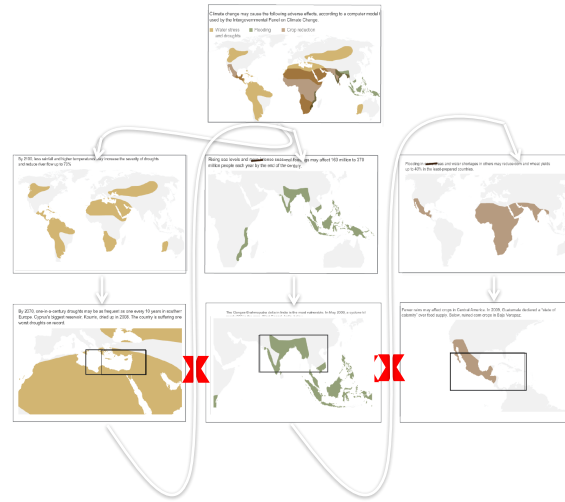
# Multiple transition patterns

## Marriages

(per 1000 population) 2009

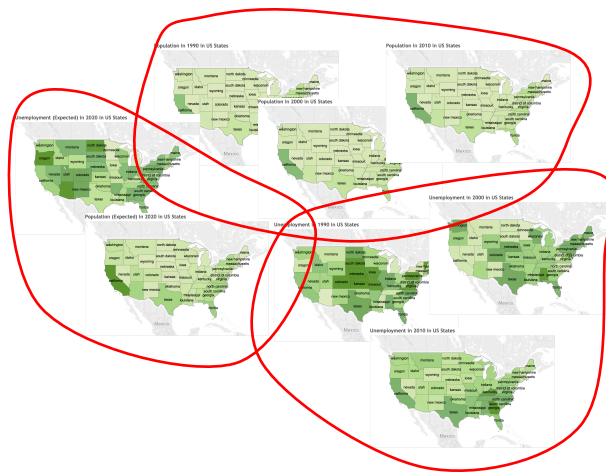


# Parallel structure



# Are groupings preferred despite cost?

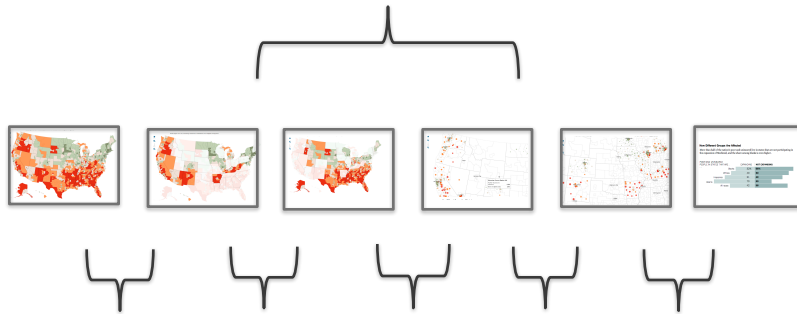
How do authors balance high-level and low-level structuring strategies?





# Narrative structure in visualization: model

Top-down: parallel structure, semantic groupings



Bottom-up: cognitive cost of transitions

# Narrative patterns to support EDA



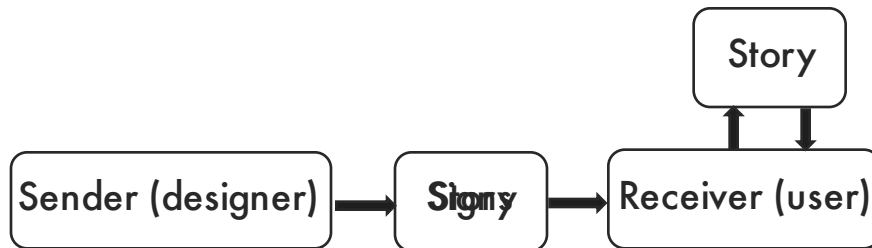
Voyager [Wongsuphasawat et al. 2015]

Suggest paths through recommended visualizations

## Theories: Narrative as constructive

---

Presentation sequence influences the stories we tell ourselves (Wilensky 1997)



## Theories: Narrative as constructive

---

### Theories of Data Analysis: From Magical Thinking Through Classical Statistics

**Persi Diaconis**  
*Stanford University*



Exploratory data analysis (EDA) seeks to reveal structure, or simple descriptions, in data. We look at numbers or graphs and try to find patterns. We pursue leads suggested by background information, imagination, patterns perceived, and experience with other data analyses.

## A fix for base-rate neglect?

---

1 out of 100

~~1%~~ of the women had breast cancer at the time of the screening.

80 out of 100

Of those with breast cancer, ~~80%~~ received a positive result on the mammogram.

15 out of 100

Of those without breast cancer, ~~15%~~ received a positive result on the mammogram.

All others received a negative result.

Suppose a woman gets a positive result during a routine mammogram screening. Without knowing any other symptoms, what are the chances she has breast cancer?

[Krynski and Tenenbaum 2007]

## A fix for base-rate neglect?

---

1% of the women had breast cancer at the time of the screening.

Of those with breast cancer, 80% received a positive result on the mammogram.

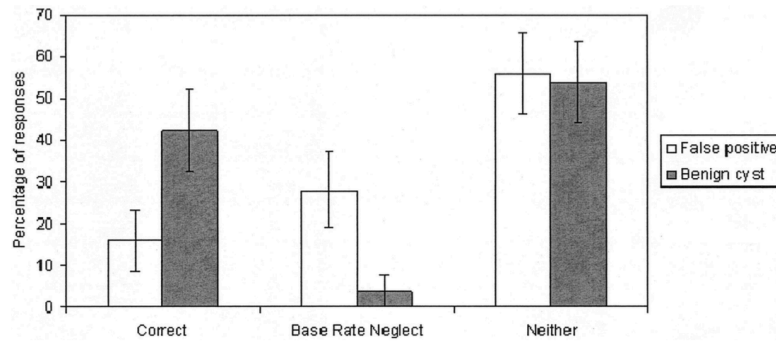
**30% of the women had a benign cyst at the time of the screening. Of those with a benign cyst, 50% received a positive result on the mammogram.**

All others received a negative result.

Suppose a woman gets a positive result during a routine mammogram screening. Without knowing any other symptoms, what are the chances she has breast cancer?

[Krynski and Tenenbaum 2007]

## Causal models matter



*Figure 5.* Histogram of responses to Experiment 2. The correct answer was 5.1%. Responses were classified as correct (5.1%), base-rate neglect ( $\geq 65\%$ ), and other. A significant difference was found between false positive and benign cyst scenarios (Fisher's exact test,  $p < .05$ ). Error bars represent the standard error of the normal approximation to the binomial distribution.

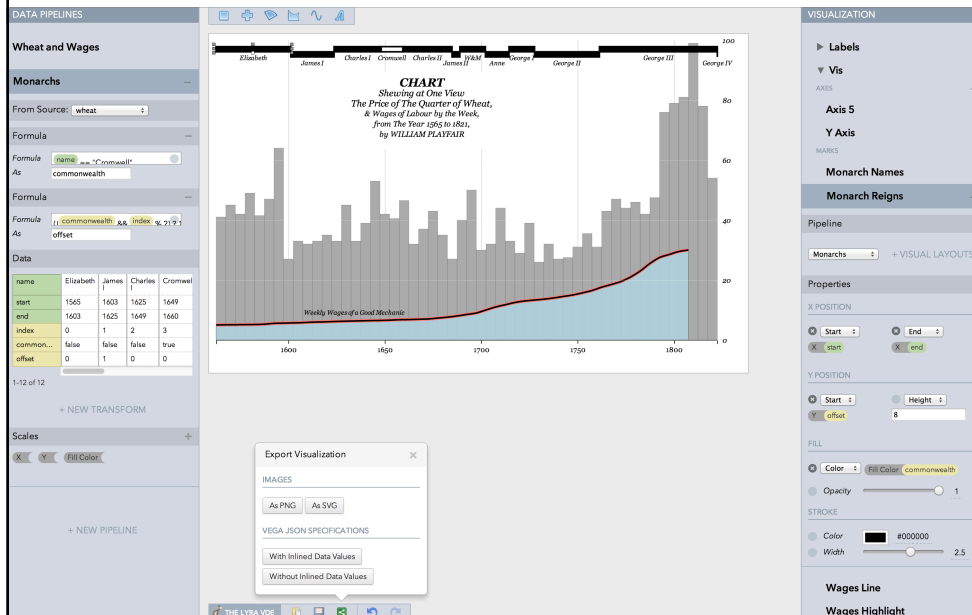
Construction

# Manual design processes

“require skills like those familiar to movie directors, beyond a technical expert’s knowledge of computer science and engineering....”

*Gershon and Page 2001*

# Lyra (Satyanarayan and Heer 2014)

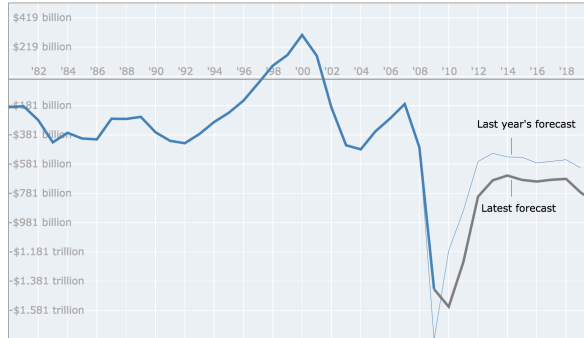


# Ellipsis (Satyanarayan and Heer 2014)

1 2 3 4 5 6

## Forecasts worsen

The forecast for the next decade is somewhat worse than it was a year ago, mostly because of a revised economic outlook. From 2011 to 2020, a total deficit of \$8.5 trillion is expected



# Tableau Story Points

## Austin's Teacher Turnover Problem

Many Austin schools are still struggling to hold onto teachers, despite a multimillion-dollar effort, called Reach, to stem turnover in troubled schools since 2010.

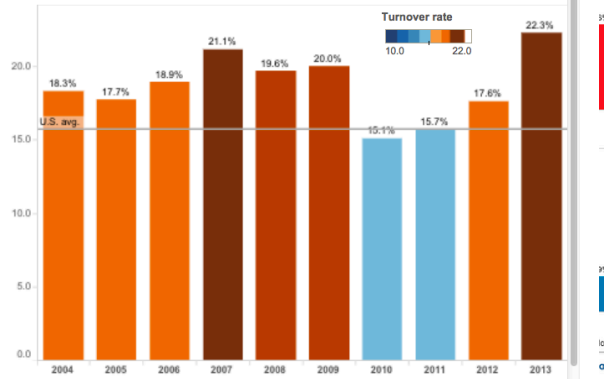
Austin's teacher turnover is above the national average.

Teacher turnover is a city-wide problem.

The problem is particularly acute at some schools.

And city-wide, the problem isn't getting better.

Austin's teacher turnover rate by year. Turnover was above the national average for most years.



# Automated Construction

## Requirements

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A model of effective visual narrative that can be operationalized algorithmically

Examples:

Automated support for chart reading operations

Automated generation of annotated news visualizations

Personalized text stories and graphics

# Brainstorming

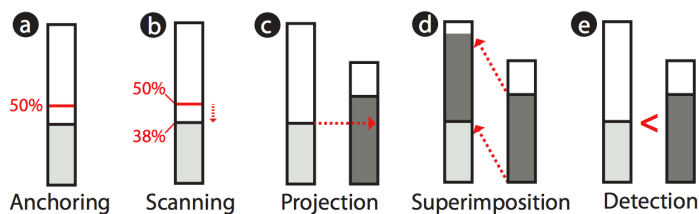
Think about annotations (text or visual) that are useful in presenting or analyzing visualizations.

Are any of these amenable to automated generation?

With 1 or 2 people near you, talk about what types of annotations you would support and how your algorithm would generate them.

# Facilitating chart reading

Elementary processes in graphical perception



[Simkin and Hastie 1987]



# Facilitating chart reading



Graphical Overlays [Kong and Agrawala 2012]

# AI-generated stories

Artificial intelligence based on human narrative cognition

- Conceptual dependency theory (Schank 1969)
- Case based reasoning (Schank 1982)

STORY: Transportation Committee Hearing on FHV Caps TOLD AS: Structured Story

**Wealth Advisors, Ltd.**

Dear Kaitlin,

Good news about your retirement investments. Since last quarter, your retirement account has grown. Your balance increased 2.7% to \$43,898 at the end of September. You're also up 3.2% for the year. You're still on track for retirement. We're watching your portfolio and by our calculations, you're on track to reach your goal of \$300,000 for retirement in 30 years. To assist you in staying on track, we have digital

**April Inventory Loss Report**

Store: 311, Arbor Beach

**Arbor Beach Bakery Misses Monthly Inventory Goals**

Across departments, the bakery in the Arbor Beach Store has the greatest opportunity for improvement in the approaching summer months. Four of the five bakery groups fell short of inventory targets, while every group within the bakery saw an increase in Inventory Loss compared to last year. As a result, the bakery's overall Inventory Loss level grew 6% year-over-year.

[Narrative & Stories]

# Annotated visualizations with news

The New York Times Business Day Technology

Search All NYTimes.com Go Orange Savings Account

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION ARTS STYLE TRAVEL JOBS REAL ESTATE

AUTOS

Search Technology Go **Inside Technology** **Bits Blog** **Personal Tech**

Internet Start-Ups Business Computing Companies Digital Cameras Cellphones ALL PRODUCTS

### Apple Passes Microsoft as No. 1 in Tech

By MOJIB HELFT and ASHLEY VINCE  
Published: May 26, 2010

SAN FRANCISCO — Wall Street has called the end of an era and the beginning of the next one: The most important technology product no longer sits on your desk but rather fits in your hand.

The moment came Wednesday when Apple, the maker of iPods, iPhones and iPads, shot past Microsoft, the computer software giant, to become the world's most valuable technology company.

This changing of the guard caps one of the most stunning turnarounds in business history for Apple, which had been given up for dead only a decade earlier, and its co-founder and visionary chief executive, Steven P. Jobs.

The rapidly rising value attached to Apple by investors also heralds an important cultural shift: Consumer tastes have overtaken the needs of business as the leading force shaping technology.

Microsoft, with its Windows and Office software franchises, has dominated the relationship most people had with their computers for almost two decades, and that was reflected in its stock market capitalization. But the click-clack of the keyboard has coded ground to the swipe of a finger across a smartphone's touch screen.

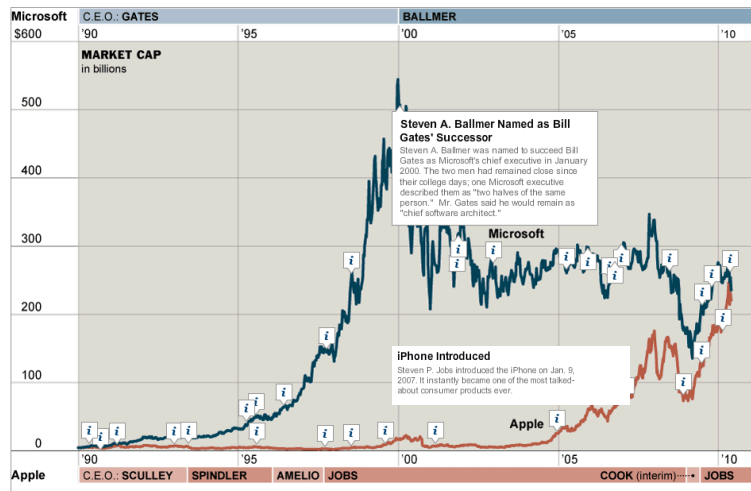
Microsoft C.E.O.: GATES BALLMER  
Apple C.E.O.: SCULLY SPINDLER AMELIO JOBS COOK (interim) JOBS

MARKET CAP in billions

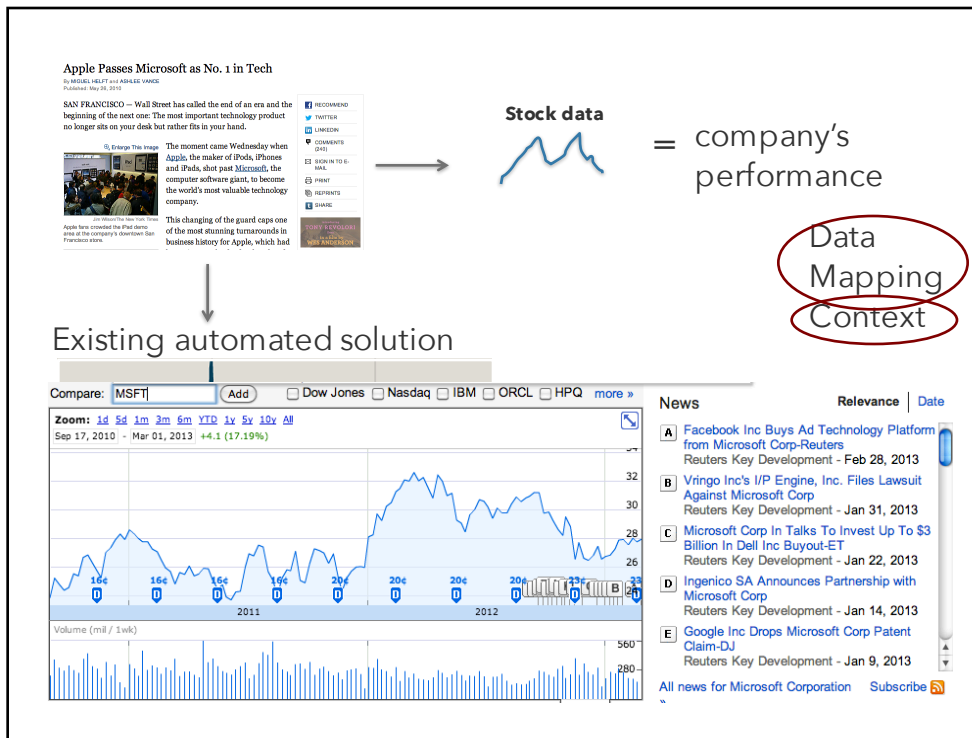
Microsoft C.E.O.: GATES BALLMER  
Apple C.E.O.: SCULLY SPINDLER AMELIO JOBS COOK (interim) JOBS

Produced by Joshua Brustein and Daniele Belopotosky/The New York Times

# Annotations tell the story

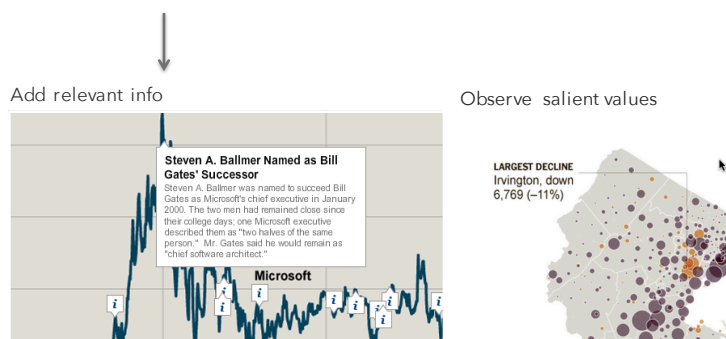


Produced by Joshua Brustein and Daniele Belopotosky/The New York Times



Can we identify criteria designers use to add context?

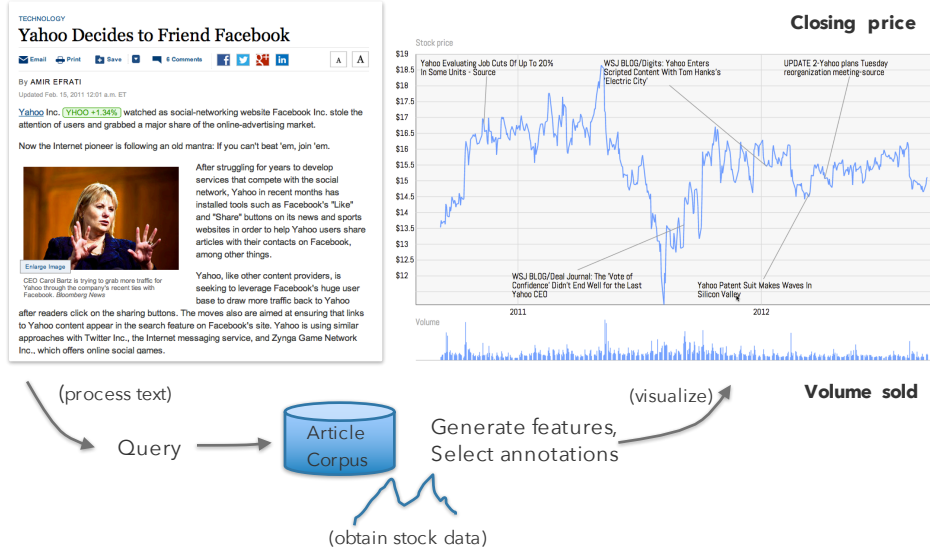
Examined annotation content, placement (*function*) in 136 news visualizations



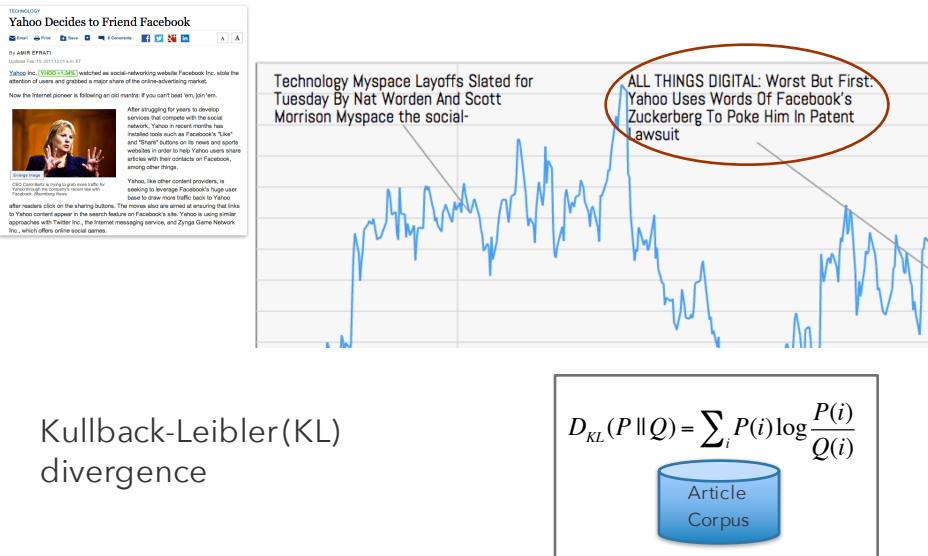
[Hullman et al. 2013]

# Contextifier system

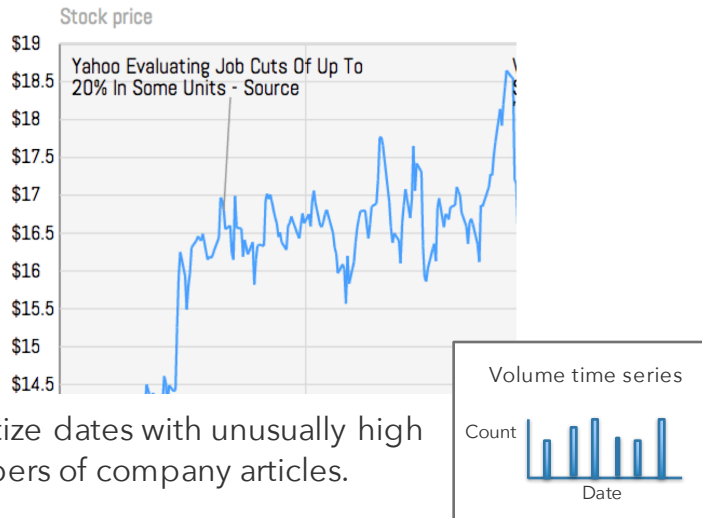
Input: news article about a company



# Relevancy feature

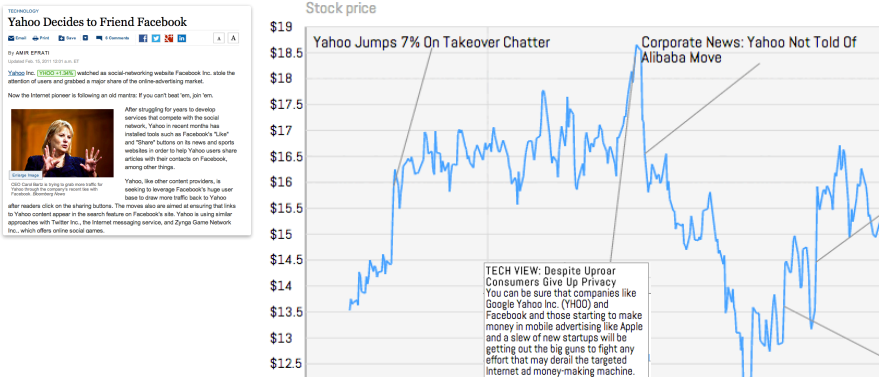


# Article volume



Prioritize dates with unusually high numbers of company articles.

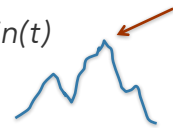
# Visual saliency



Visual saliency proxy via simple analyses on stock series.

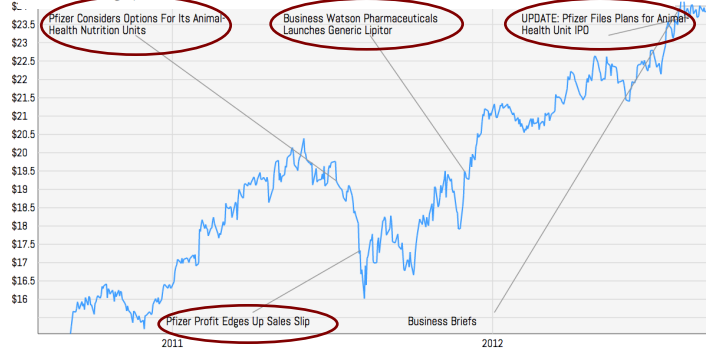
$$\max(t), \min(t)$$

$$t_i - t_{i-1}$$



## Animal Health Experts Warn Horse Owners About Early Danger Signs of Widespread Mosquito-Borne Diseases; Eastern Equine Encephalitis and West Nile Virus rising Experts Urging Vaccination

NEW YORK Sept. 7 /PRNewswire/ -- Animal health experts warn that fatal cases of Eastern Equine Encephalitis and West Nile are being reported in numerous states even in areas where activity has been low for several years. This follows a rise in the early warning signs of mosquito-borne diseases that include Eastern Equine Encephalitis West Nile and Western Equine Encephalitis. This doesn't bode well for either horses or humans. To help prevent the spread of additional cases Pfizer Animal Health and other health organizations are strongly encouraging horse owners and veterinarians to follow the American Association of Equine Practitioners (AAEP) guidelines for vaccinations against mosquito-borne diseases. "If horses aren't vaccinated this situation could become much worse" says Kevin Hankins DVM MBA Equine Veterinary Services at Pfizer Animal Health. Though annual vaccinations should happen in early spring the AAEP also recommends boosters after five or six months. Pfizer Animal Health offers a trusted line of vaccines including WEST NILE-INNOVATOR to help protect against West Nile virus. All Pfizer Animal Health equine vaccines are backed by an Immunization Support Guarantee. Pfizer Animal Health will support reasonable diagnostic and treatment costs up to \$5,000 if a horse properly vaccinated by a veterinarian with one of its antigens contracts the corresponding equine disease (EEE WEE WNV Venezuelan Equine Encephalitis (VEE) Tetanus or Influenza).

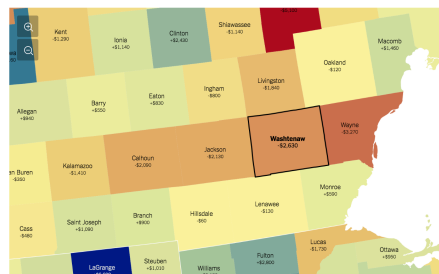


Combine terms in an objective function

## Personalization

### The Best and Worst Places to Grow Up: How Your Area Compares

Children who grow up in some places go on to earn much more than they would if they grew up elsewhere. MAY 4, 2015 | RELATED ARTICLE



Consider Washtenaw County, Mich., our best guess for where you might be reading this article. (Feel free to change to another place by selecting a new county on the map or using the search boxes throughout this page.)

It's among the worst counties in the U.S. in helping poor children up the income ladder. It ranks 201st out of 2,478 counties, better than only about 8 percent of counties. Compared with the rest of the country, it is also bad for rich boys and rich girls.

Here are the estimates for how much 20 years of childhood in Washtenaw County adds or takes away from a child's income (compared with an average county), along with the national percentile ranking for each.

#### What a Childhood in Washtenaw County Does to Future Income

For poor kids				For average-income kids				For rich kids				For kids in the top 1%			
GROUP	INCOME CHG.	NAT. PCT.		GROUP	INCOME CHG.	NAT. PCT.		GROUP	INCOME CHG.	NAT. PCT.		GROUP	INCOME CHG.	NAT. PCT.	
All kids	-\$2,620	8%		All kids	-\$3,780	<1%		All kids	-\$4,620	<1%		All kids	-\$4,880	<1%	
Boys	-\$2,700	6%		Boys	-\$5,180	<1%		Boys	-\$7,900	<1%		Boys	-\$8,970	<1%	
Girls	-\$2,500	13%		Girls	-\$1,900	8%		Girls	-\$1,440	12%		Girls	-\$830	19%	

Washtenaw County is very bad for income mobility for children in poor families. It is better than only about 8 percent of counties.

**Location matters** – enormously. If you're poor and live in the Detroit area, it's better to be in Sanilac County than in Wayne County or Genesee County. Not only that, the younger you are when you move to Sanilac, the better you will do on average. Children who move at earlier ages are less likely to become single parents, more likely to go to college and more likely to earn more.

[Aisch, Bloch, Cox, and Quealy 2015]

## Summary

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Narrative visualizations blend communication /  
exploratory techniques

Messaging, metaphor, sequencing, and other suggestive  
strategies have a powerful impact on interpretation

Semiotics, narrative theory, causal reasoning are critical

Automated systems possible by formalizing features