Data Visualization and Social Sciences

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First Workshop on Interactions between Mathematics and Social Sciences

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Outline

Motivation: no more boring data

What is Data Visualization?

Some examples

Final comments

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Motivation

No more boring data

- In 2006 Hans Rosling (Prof. of Public Health Science at Karolinska Institute) gave an inspiring talk at **TED** about social and economic developments in the world over the last 50 years, which challenged the views and perceptions of many listeners.

Motivation

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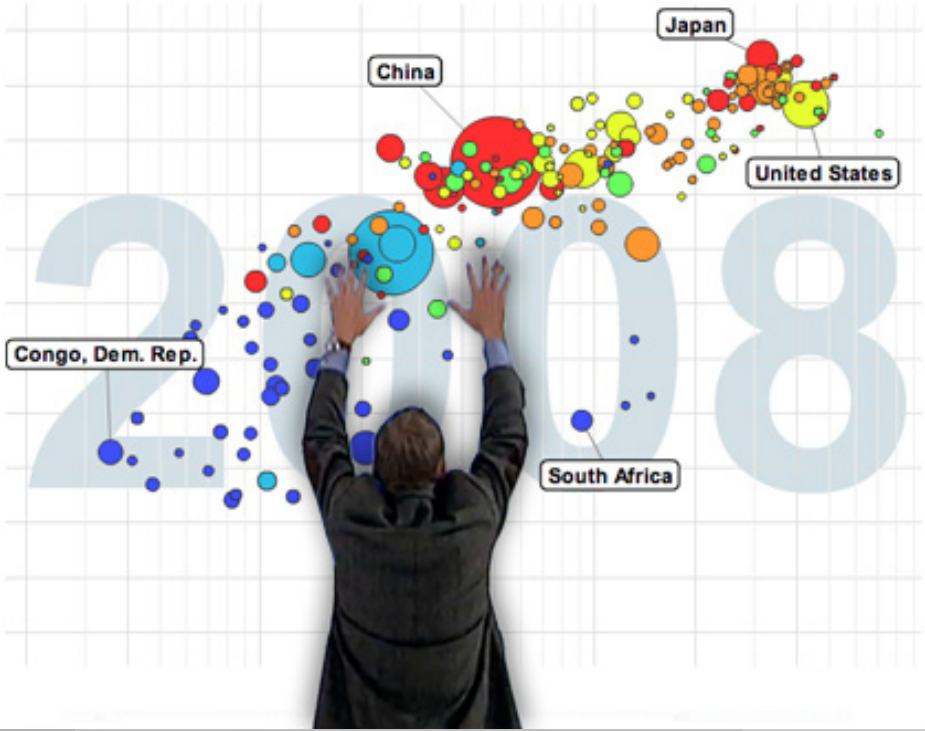
- **"Stats that reshape your world-view"**
  http://www.youtube.com/watch?v=hVimVzgtD6w

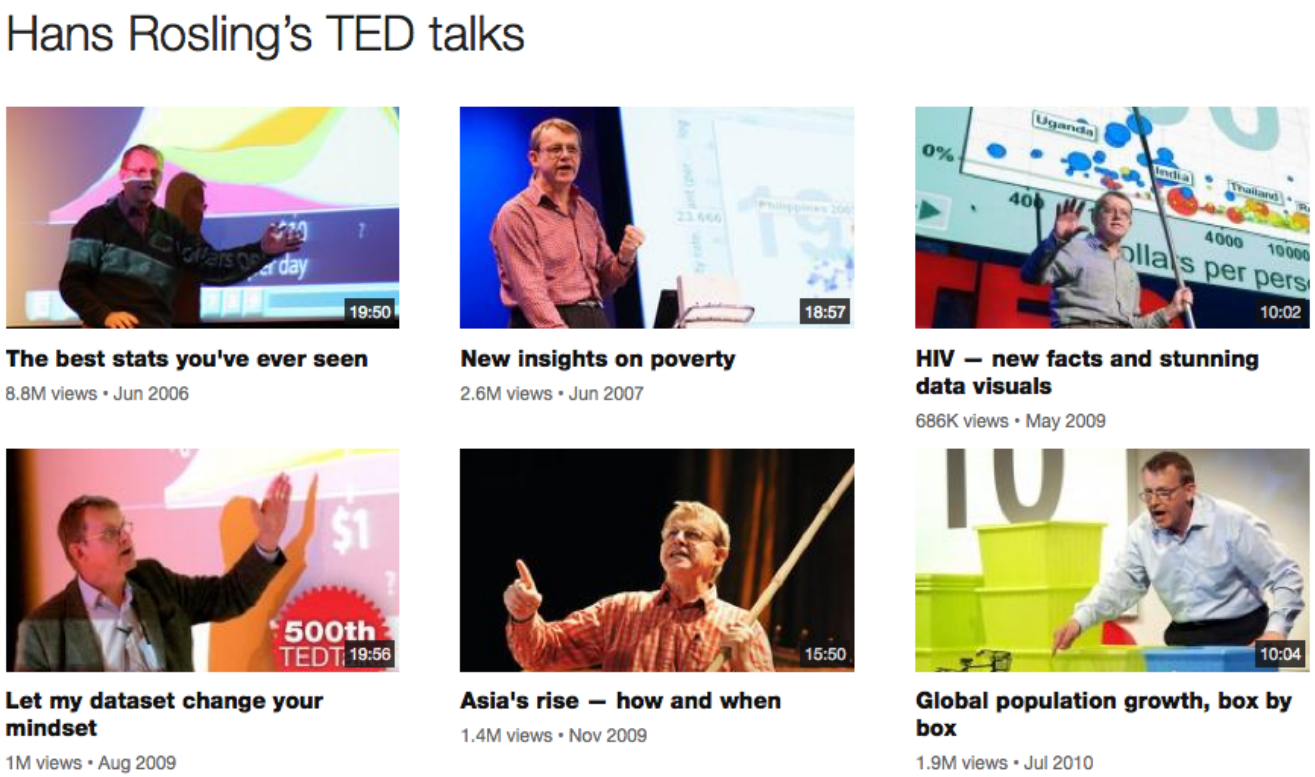


TED
IDEASWORTHSPREADING

Motivation

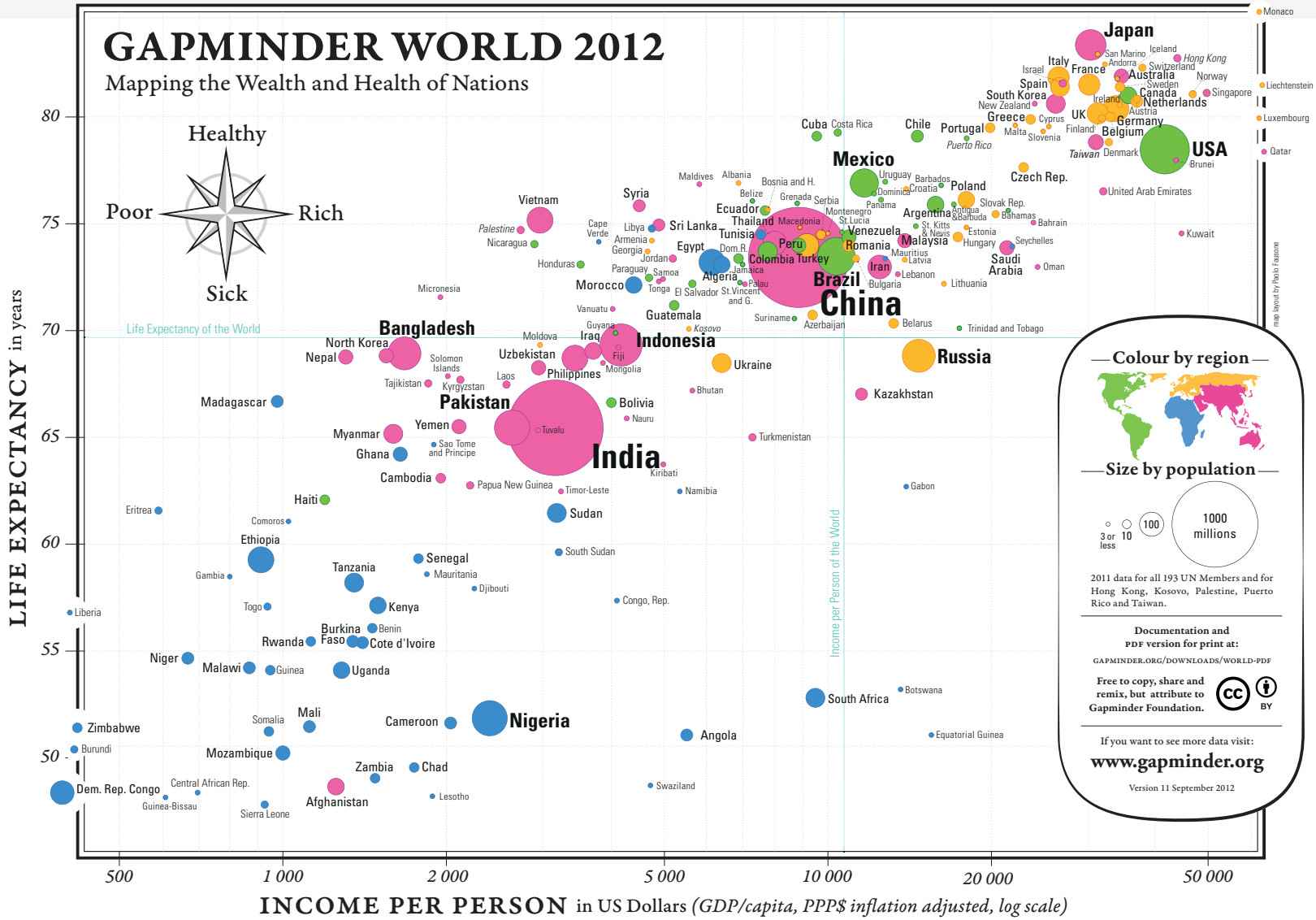
Professor Hans Rosling's TED Talk (2006)

- To visualise his talk, he and his team at `gapminder.org` used a public domain software
- **Gapminder** software was purchased by **Google** and integrated as motion chart into their **Visualization API**



Motivation

Gapminder



Data Science

The Age of Data

- **Data science** is the study of the generalizable extraction of **knowledge from data**
- Includes elements from many fields:
  - signal processing, mathematics, probability models, machine learning, computer programming, data engineering, high performance computing and **visualization**
- **Data science techniques** affect research in many domains, including the biological sciences, medical informatics, health care, social sciences/politics and the humanities. It heavily influences economics, business and finance ("business analytics").

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Data Visualization (DataVis)

What is it?

- **Data visualization** is the use of tools to represent data in the form of charts, maps, plots, animations, or any graphical means that make content easier to understand.
- Instead of presenting information in **numerical tables**, it is a graphical presentation of information, with the goal of providing the viewer with a qualitative understanding of the information contents.
- Graphic representations of data are popular because:
  - they open up the way we think about complex data,
  - reveal hidden patterns/structures in the data, and
  - highlight connections among elements.
  - check assumptions or support hypotheses from the data

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Characteristics of Data

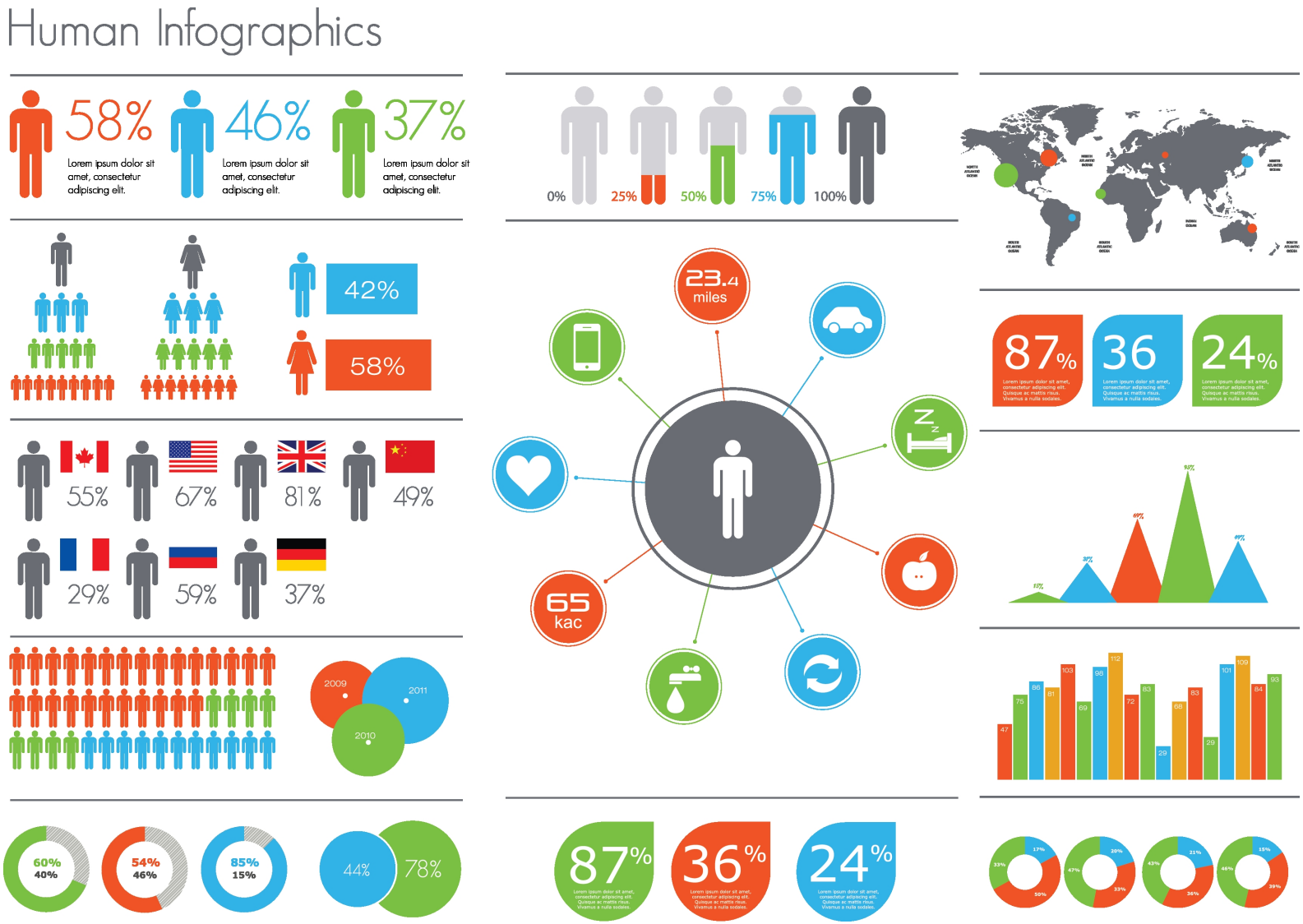
- Numeric, symbolic (or mix)
- Scalar, vector, or complex structure
- Various units
- Discrete or continuous
- Spatial, quantity, category, temporal, relational, structural
- Dense or sparse
- Ordered or non-ordered
- Disjoint or overlapping
- Binary, enumerated, multilevel
- Independent or dependent
- Multidimensional
- ...

Data Visualization (DataVis)

Descriptive Graphs

Data Visualization (DataVis)

Infographics



Data Visualization (DataVis)

Why ?

- **Why visualize social science research?**
  - Social Science research seeks to understand, explain, and predict human behavior by observing, reflecting, and/or measuring social phenomena.
  - Social Sciences are gradually becoming a more quantitative scientific field

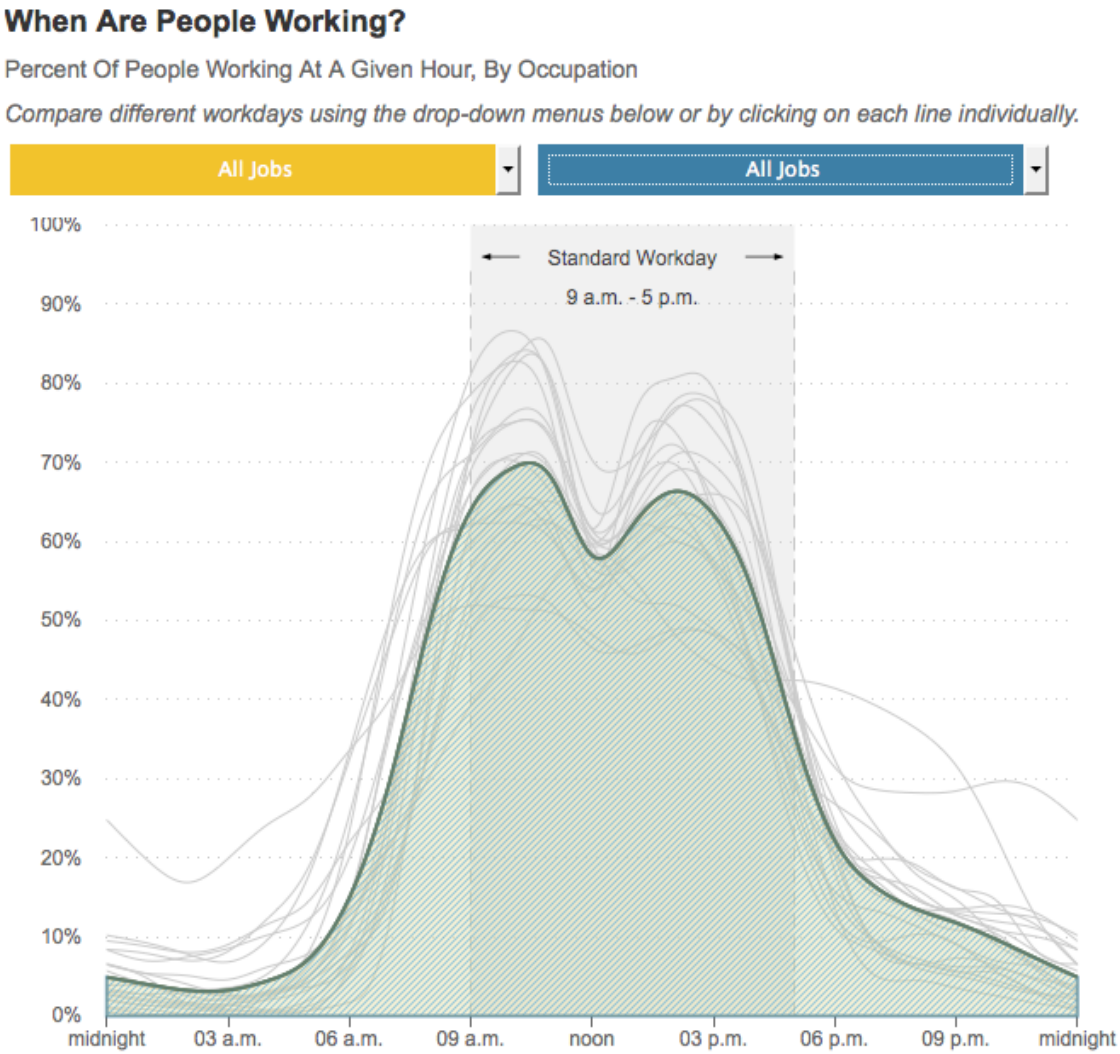
Data Visualization (DataVis)

Why ?

- **Why visualize social science research?**
  - Social Science research seeks to understand, explain, and predict human behavior by observing, reflecting, and/or measuring social phenomena.
  - Social Sciences are gradually becoming a more quantitative scientific field
  - Indeed, most of the top influencial news agencies and Public Institutions (The Guardian, New York Times, Washington Post, OECD,...) have their own DataVis Sections
    http://datajournalismhandbook.org

Some examples

Who's In The Office? The American Workday In One Graph (www.npr.org)



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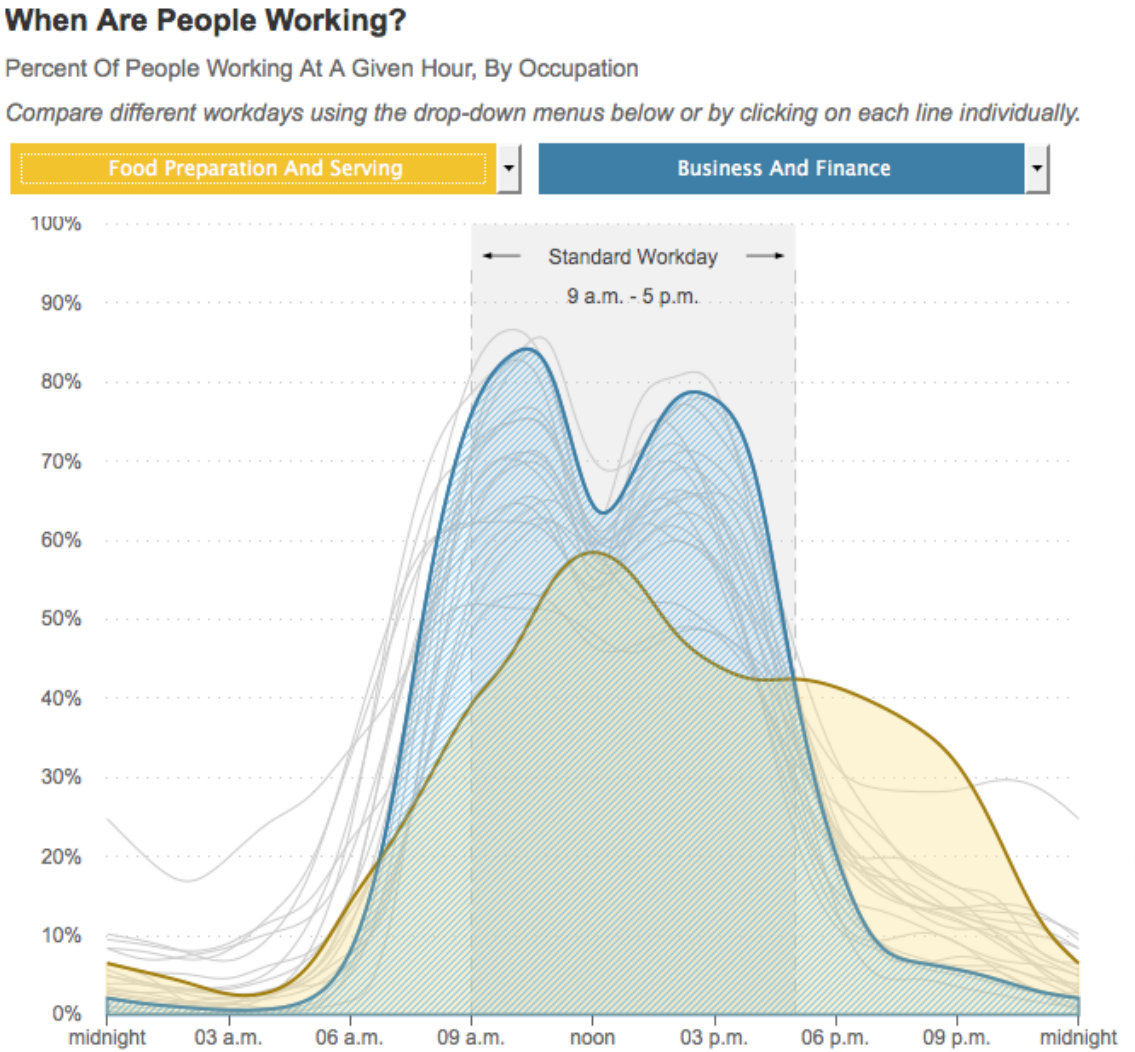

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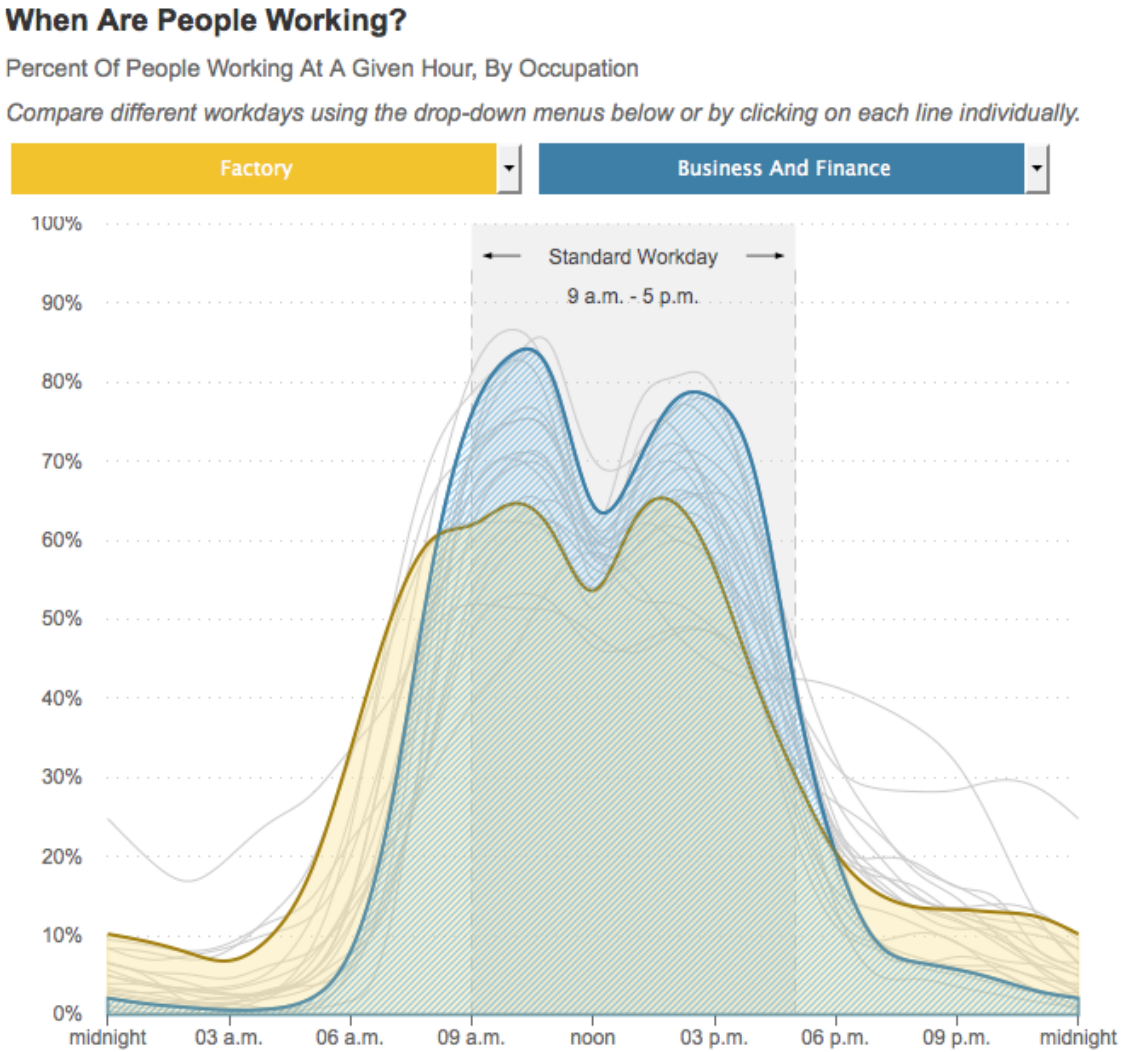

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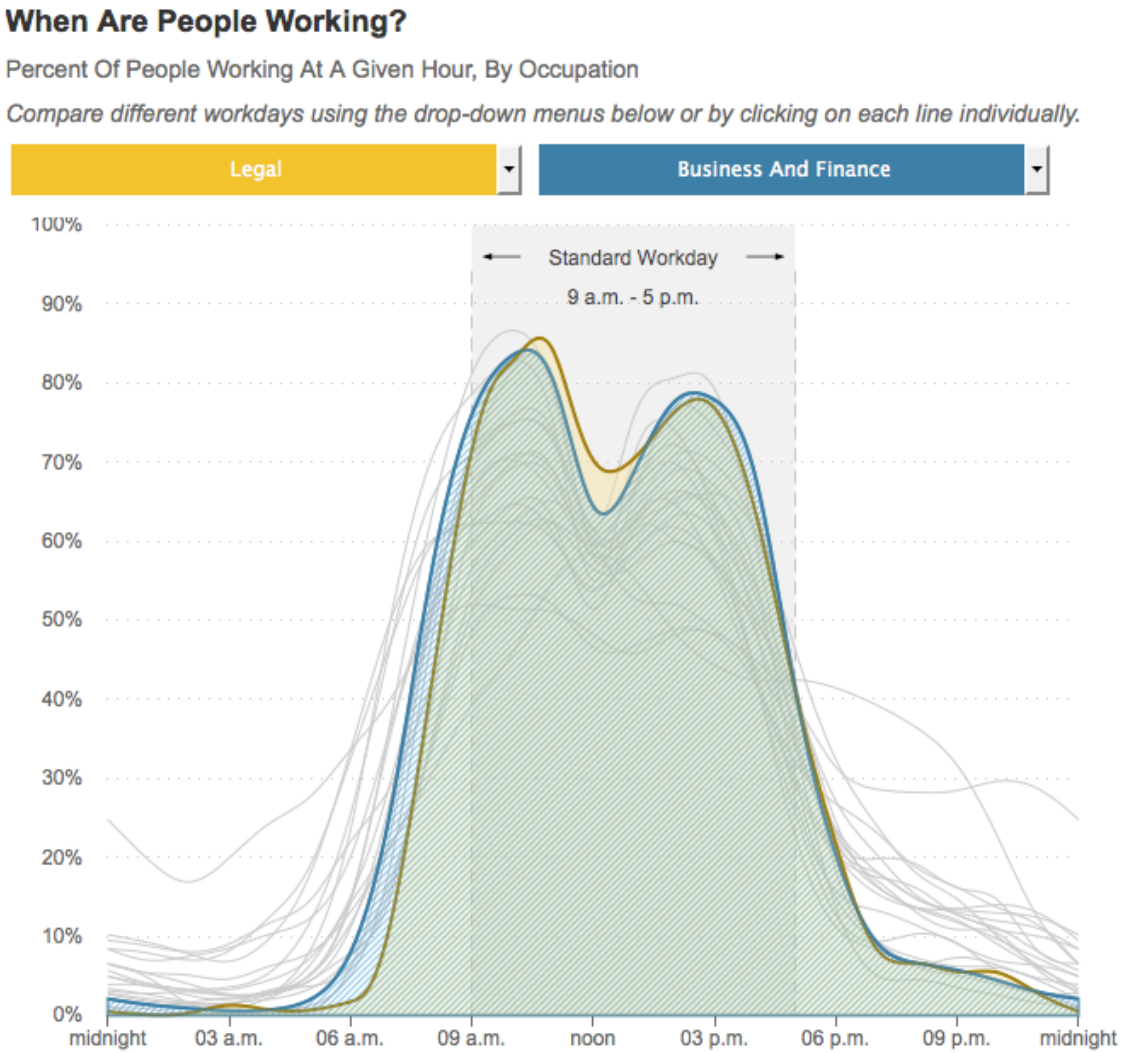
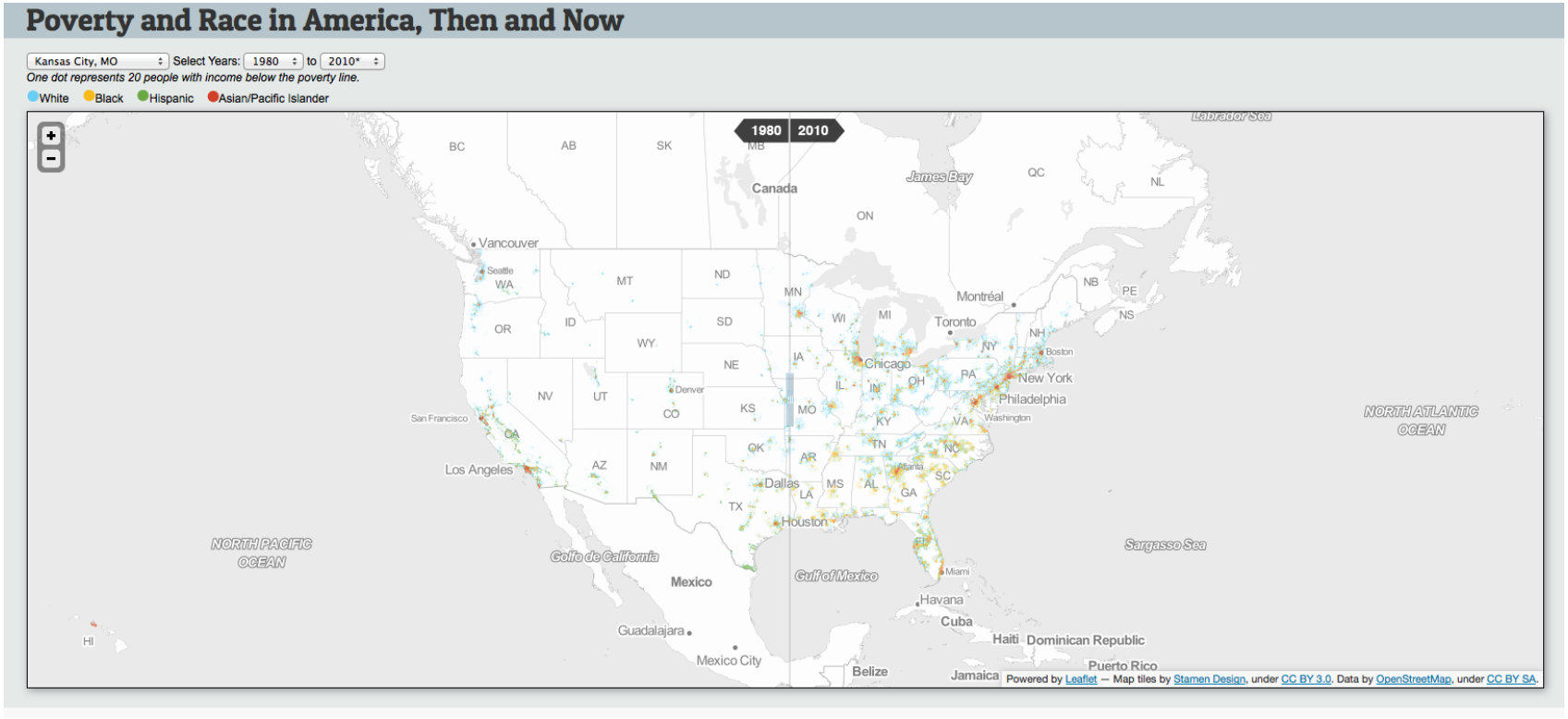


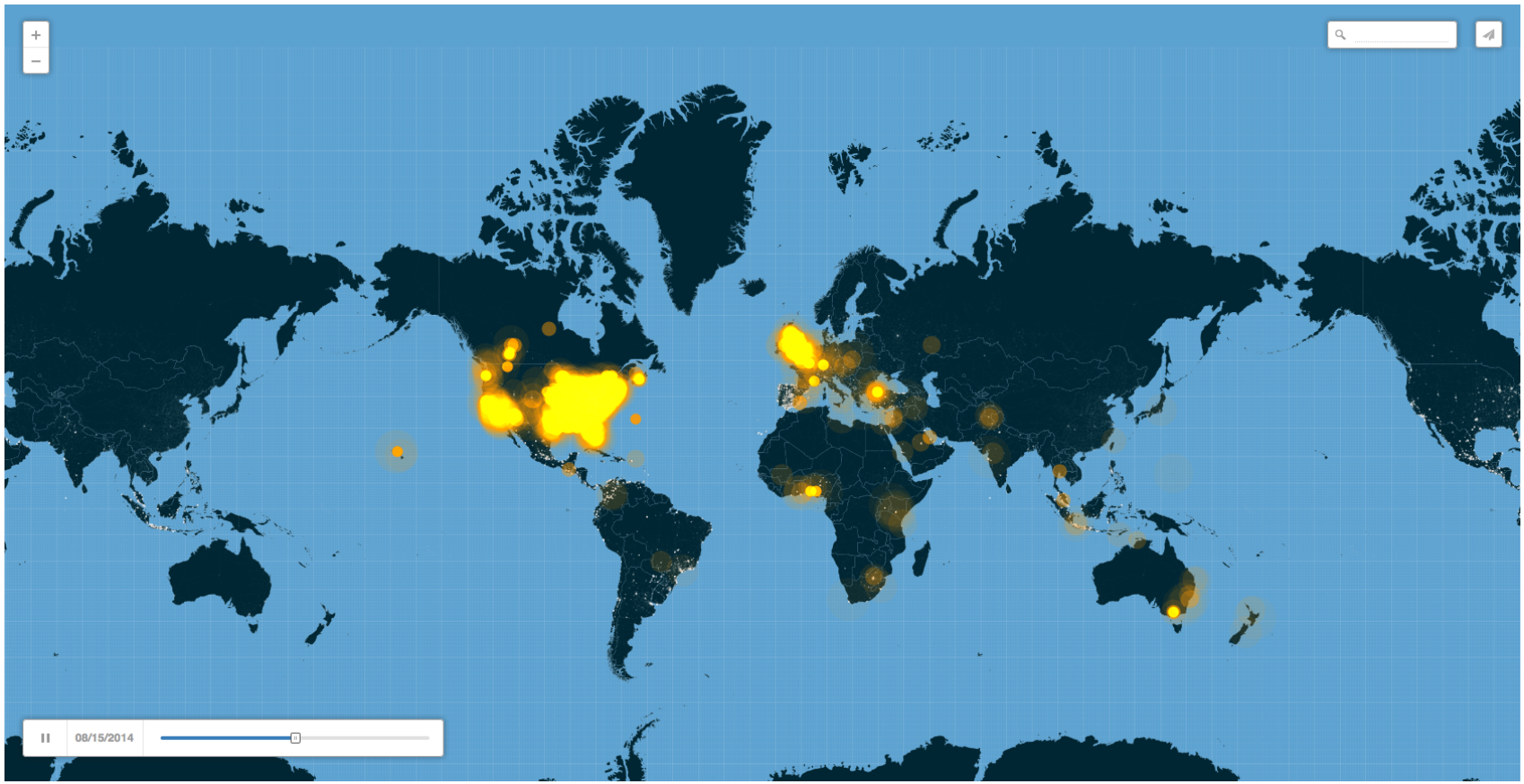
Some examples

Metro trends: Poverty and Race in America, Then and Now



Some examples

cartoDB: How news of #Ferguson spread across Twitter



Data Visualization (DataVis)

Social Networks Analysis

- Visual representations of social networks are important to understand network data
- It facilitates qualitative interpretation of network data
- **Network maps** are widely used for visualizing social network structures, trading relations between countries, migration rates, groups, individuals etc ...
- Help to study patterns of relationships that connect members of a social system at all scales.
- It is a powerful method for conveying complex information

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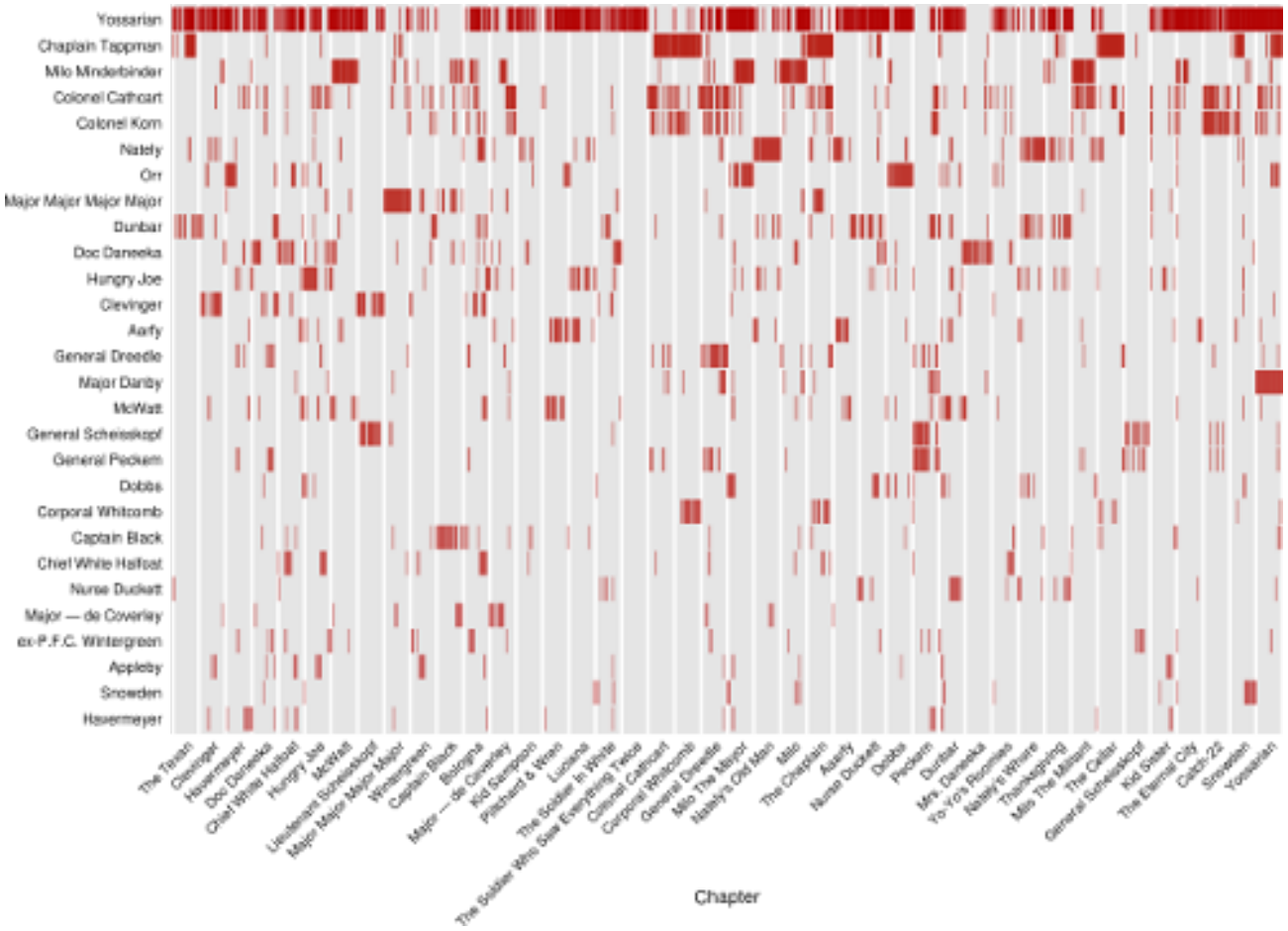
- It is a powerful method for conveying complex information
- **Example:** *Les Misérables*
  - Network representation of character co-occurrence in the chapters of Victor Hugo's classic novel.
  - The original data set is from **The Stanford GraphBase: A Platform for Combinatorial Computing** (by Donald Knuth)

    * Inspired by Jeff Clark's Novel Views: Les Miserables series

Social Networks Analysis

Example: Les Misérables

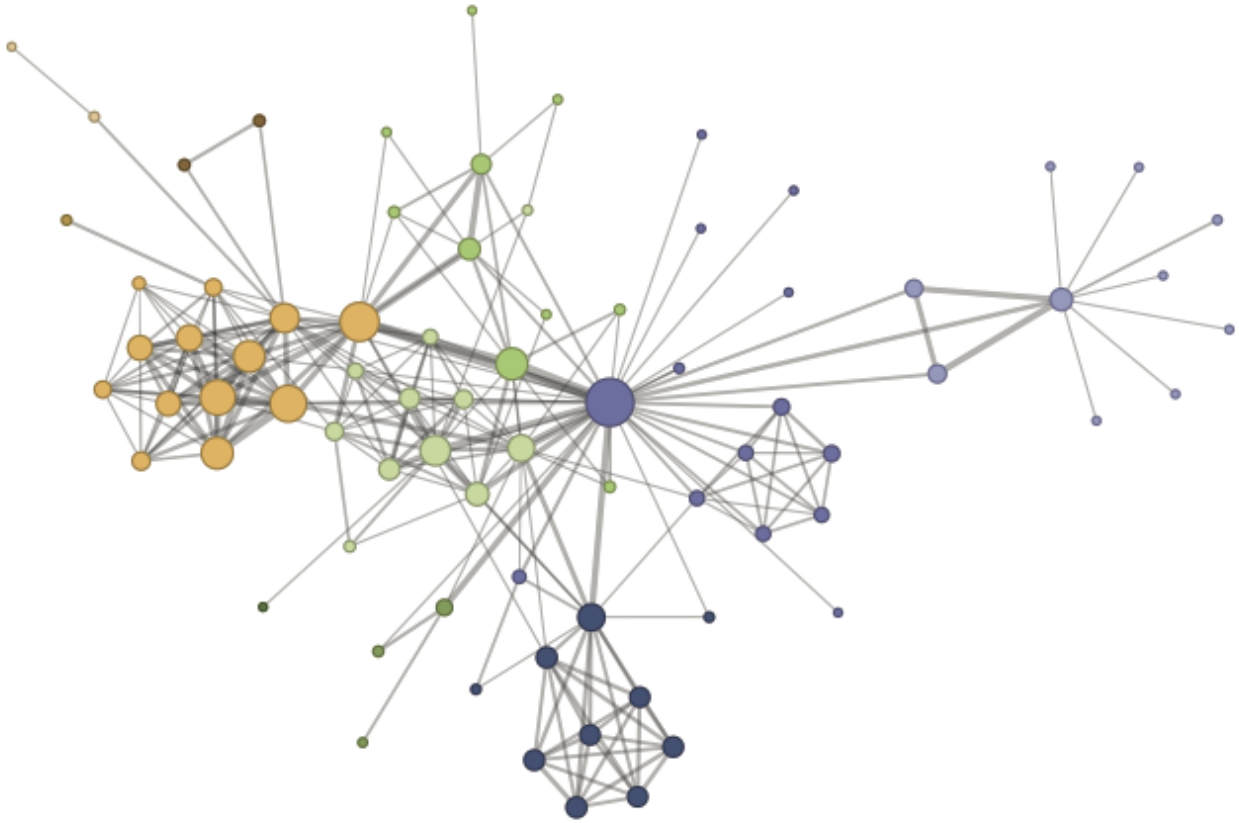
- This plot essentially represents a time series of when different characters were mentioned in the book.



Social Networks Analysis

Example: Les Misérables

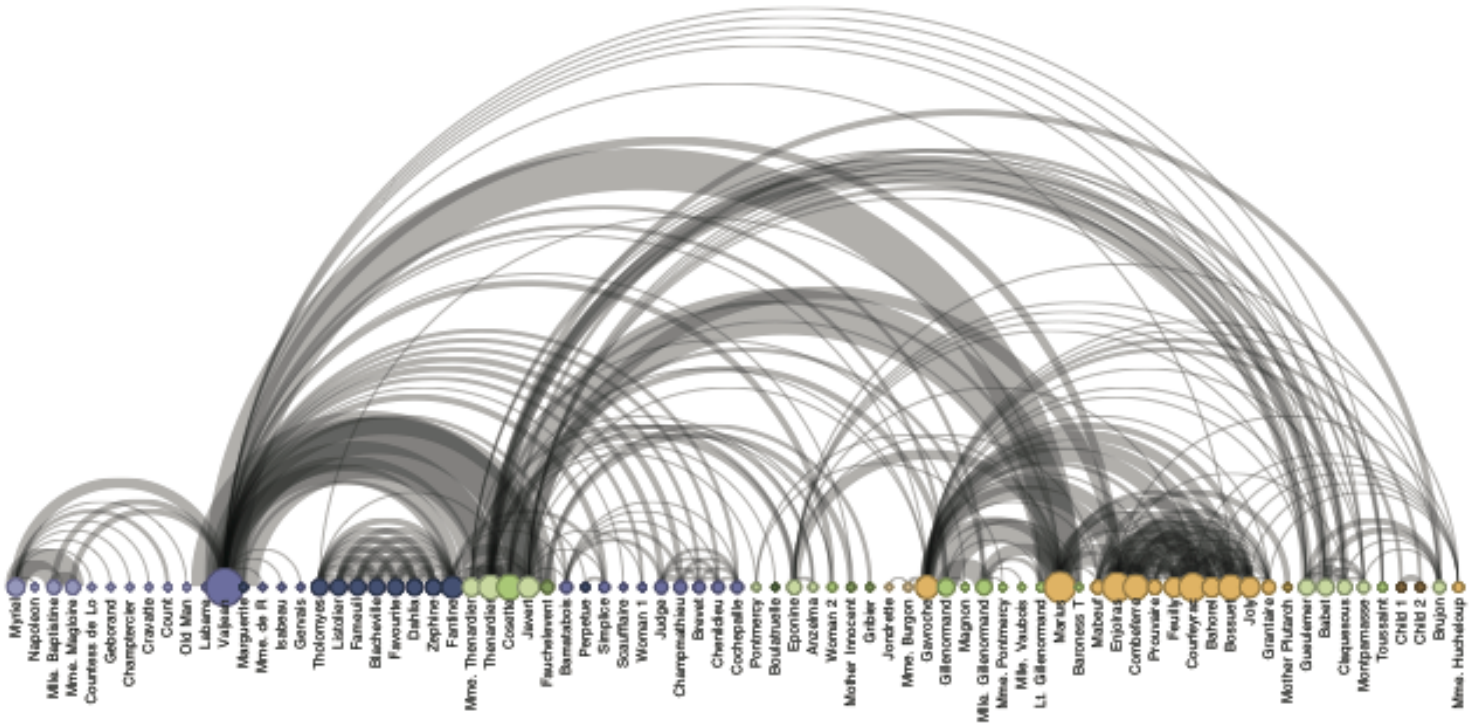
- Co-ocurrence of characters with node colors depicting **cluster memberships** computed by a **community-detection algorithm**



Social Networks Analysis

Example: Les Misérables

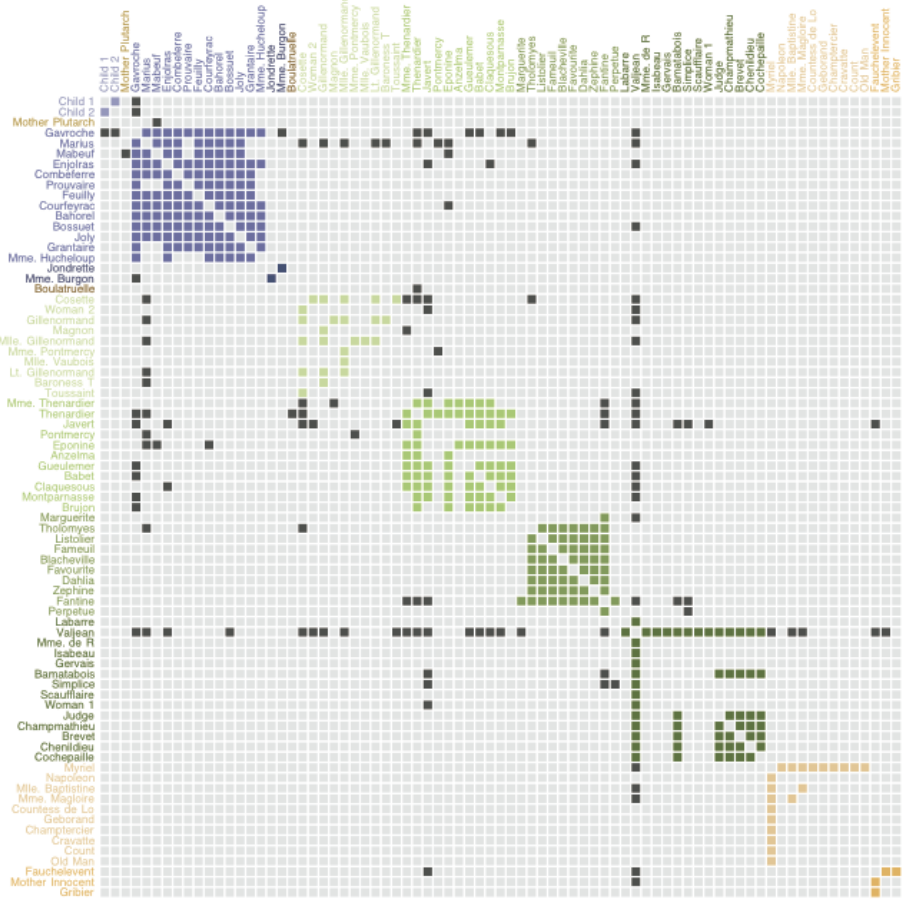
- Co-ocurrence of characters with **Arc-diagrams**



Social Networks Analysis

Example: Les Misérables

- **Adjacency matrix** where each value in row i and column j corresponds to the link from node i to node j



Social Networks Analysis

Practical applications

- Applications include:
  - Data aggregation and mining, network propagation modelling
  - Behavior analysis
  - In business it support activities such as customer interaction, marketing, and business intelligence
  - National Security: Determine crime networks and leaders within the network

Social Networks Analysis

Sentiment analysis in Twitter

- Twitter data has been used to predict and explain a variety of real-world phenomena, including opinion polls, elections, the spread of contagious diseases, and the stock market.
- Twitter messages in aggregate contain useful information that can be exploited with statistical methods.
- The hypothesis is that we can obtain high accuracy on classifying sentiment in Twitter messages using machine learning techniques.
- **Sentiment** is defined to be a personal positive or negative feeling
- There are different approaches. **E.g.:** Bayesian Models, Maximun Entropy Classifiers, ...
- and tools such as **Sentiment Viz** (NC State University, CS Department)

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Search term:

mathematics

Emotions are represented as a psychology model by Russell (1980)

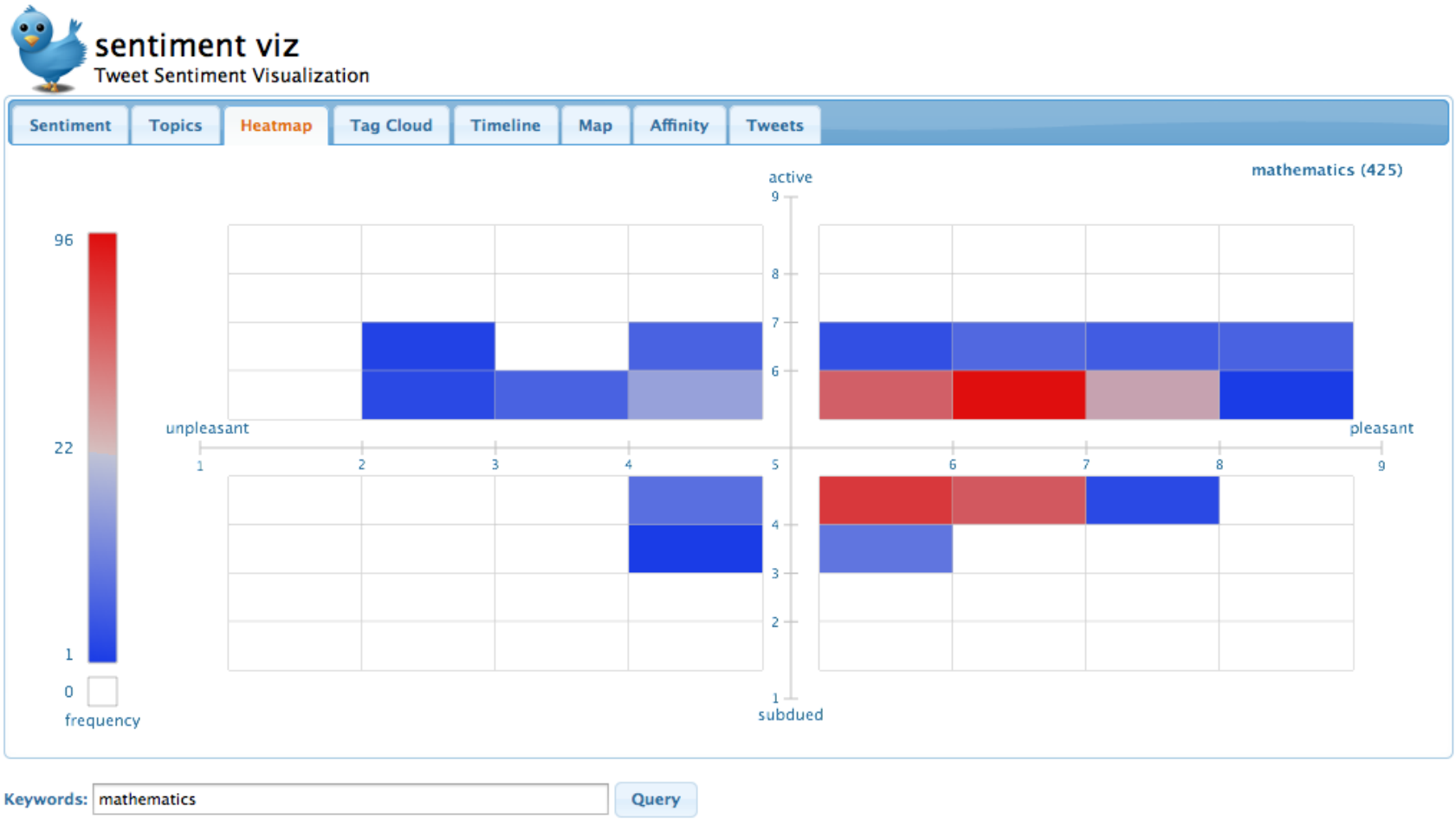
Search term:

mathematics

Clustering emotions

Search term:

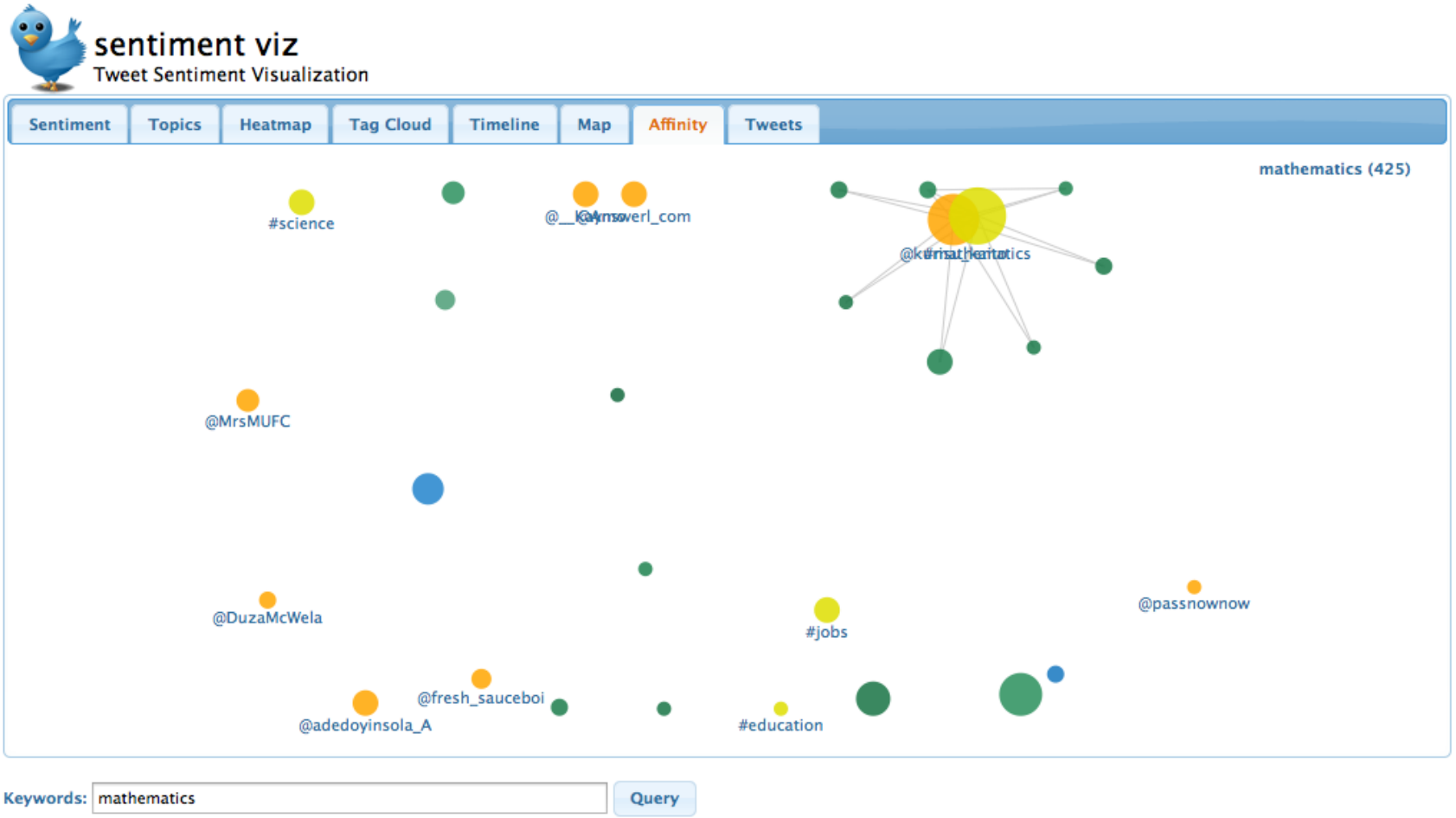
mathematics



Frequency of emotions on a 8×8 grid of emotion regions

Search term:

mathematics



Relathionships of affinities between Tweets

Politics in the US

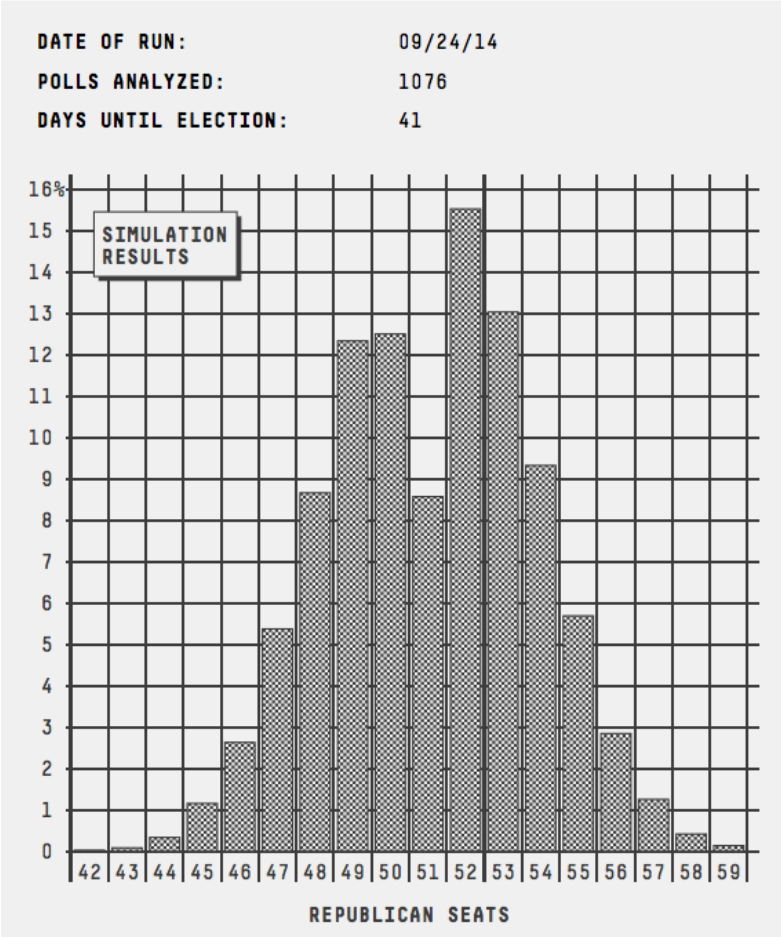
FiveThirtyEight election forecasting model

- **Nate Silver** (and american statistician) created www.FiveThirtyEight.com and predicted in 2008 presidential elections in the U.S. the winner of **49 of the 50 states**, the next year he correctly predicted the winner of **all 35** U.S. Senate races.
- **FiveThirtyEight's election forecasting model** combines hundreds of opinion polls with historical and demographic information to calculate odds for each Senate race.
- They estimate the probability that each party will win control of the Senate.
  - Based on a **probabilistic model** and **historical evidence** (empirical data)
  - ... and **simulating outcomes** to estimate probabilities
  - The forecast is updated regularly

Politics in the US

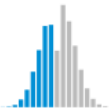
FiveThirtyEight election forecasting model

The Model's Output

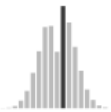


What It Means

Republicans have a **56.9%** chance of winning a majority.



Democrats have a **43.1%** chance of keeping the majority.



There is a **15.5%** chance Republicans will control **52** seats and Democrats will control **48** seats.

Politics in the US

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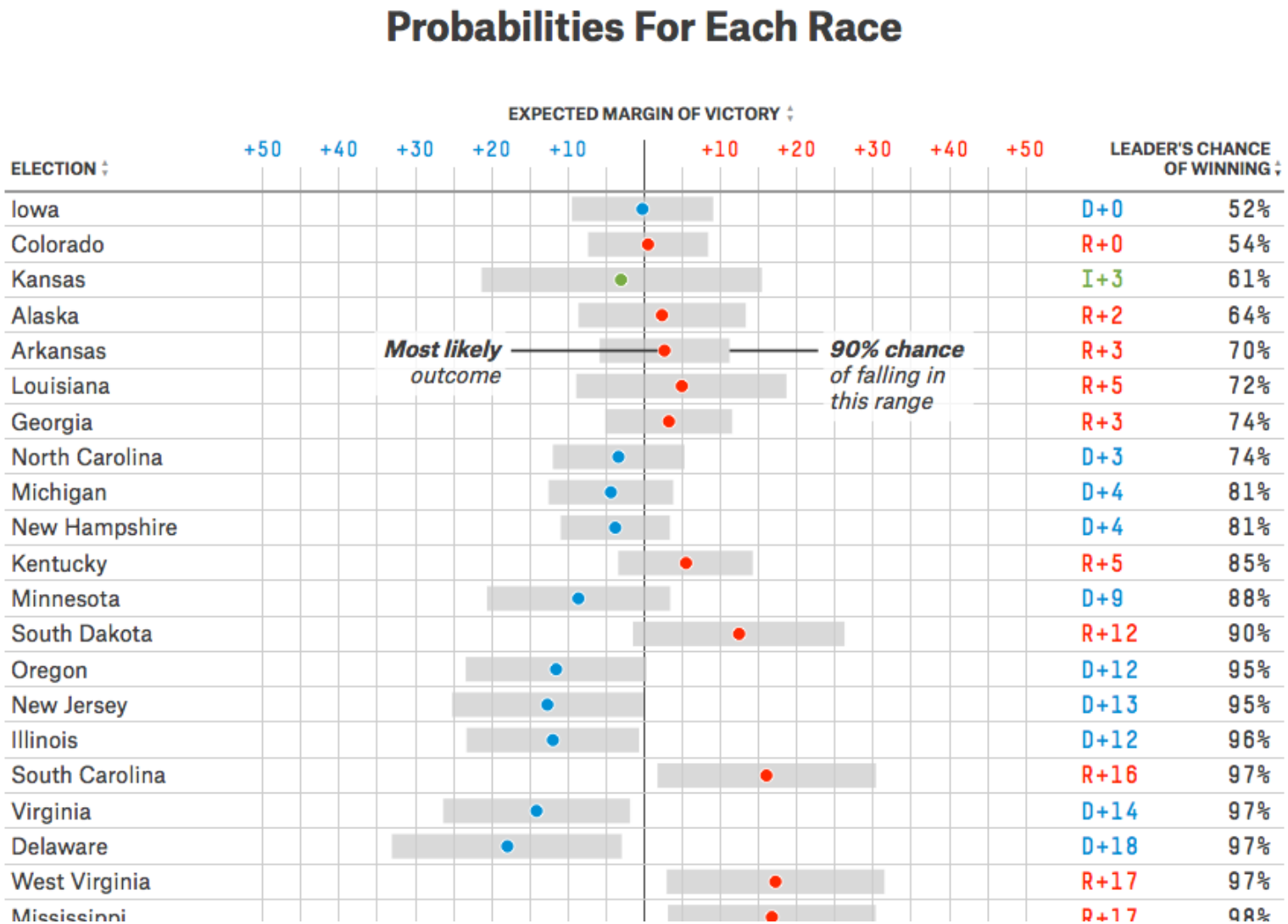
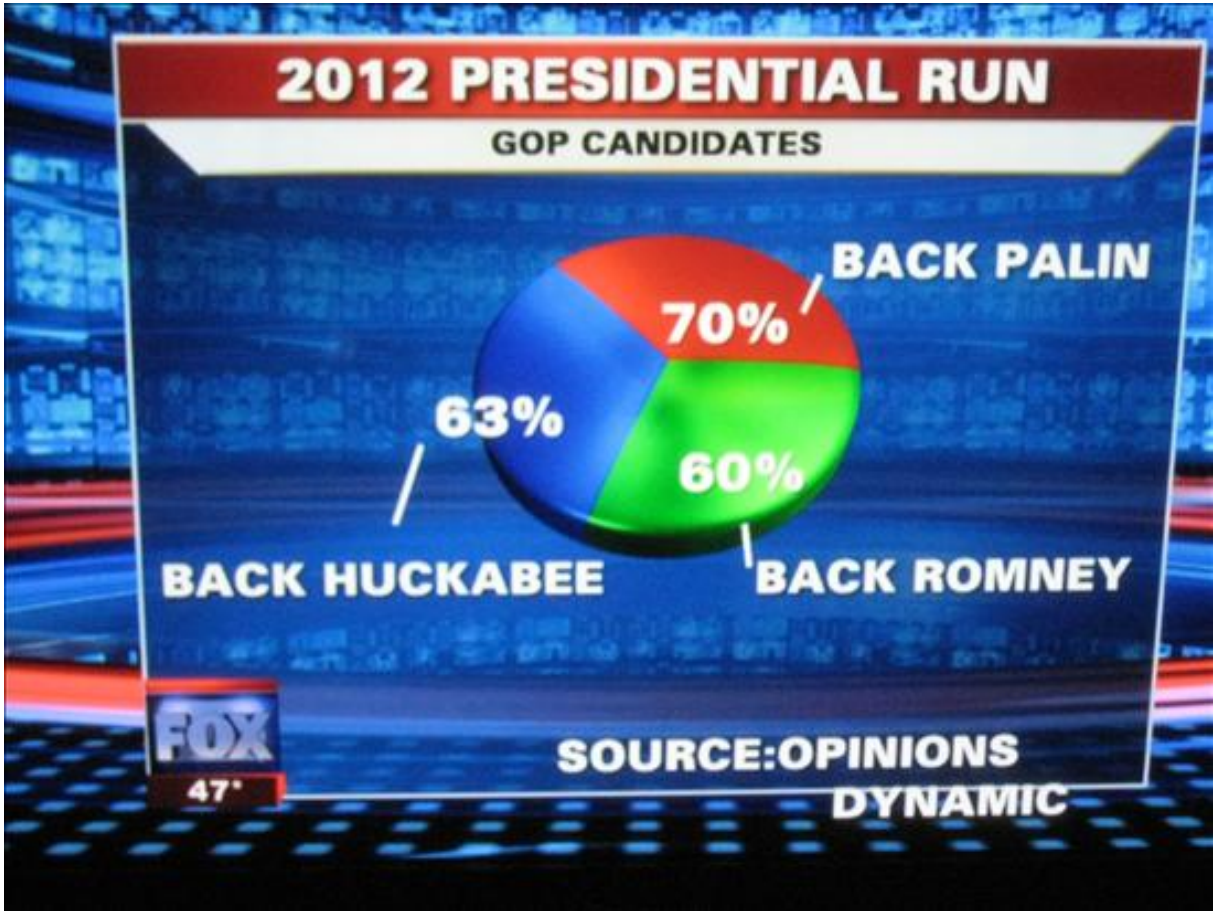


Final comments

- More and more **Open Data** $\Rightarrow$ **Open Science** for publishing results of scientific activities available for analyze and reuse
- **DataVis** takes advantage of recent developments in
  - Computer Science and Computer Graphics,
  - Statistical methods,
  - Methods of information visualization, visual design
  - Social Networks (graph visualization, network maps, ...)
  - Geographic Information Systems (GIS)
- However, there is a risk related to possible misuse of graphical data displays (by mistakes or intentionally)

Final comments



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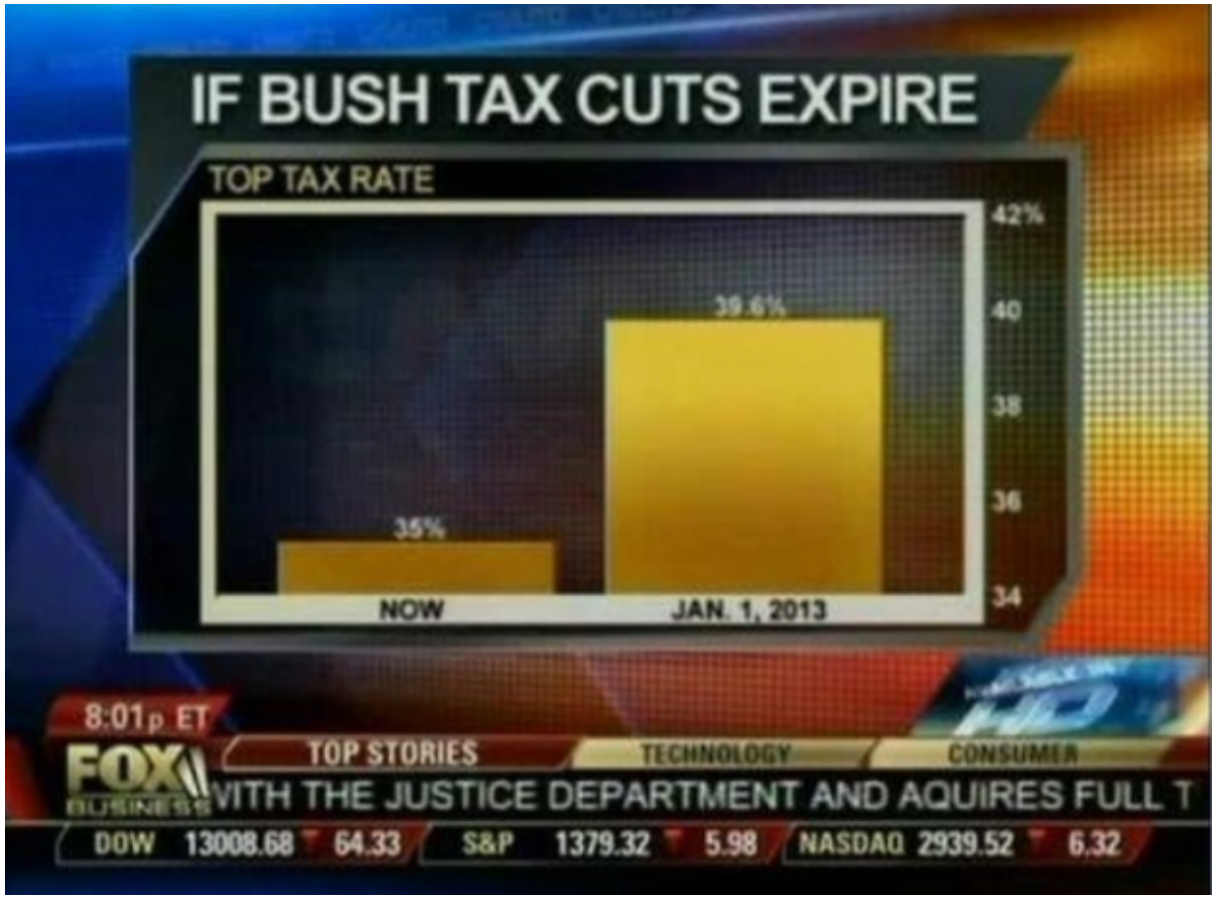

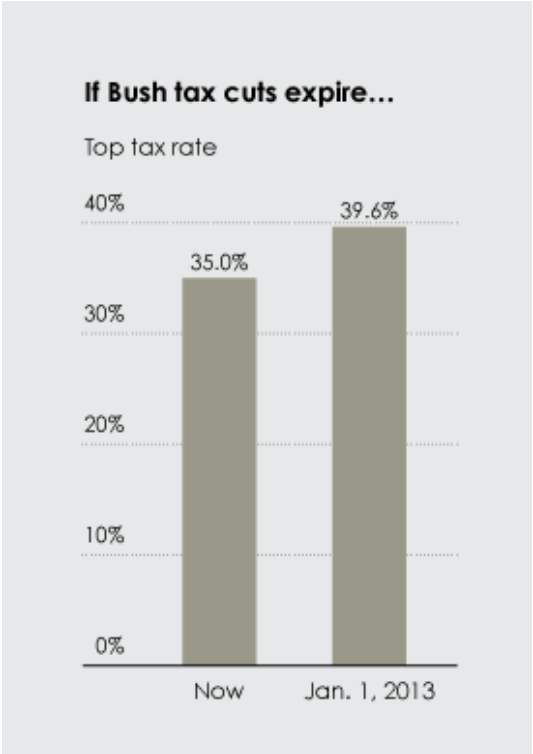

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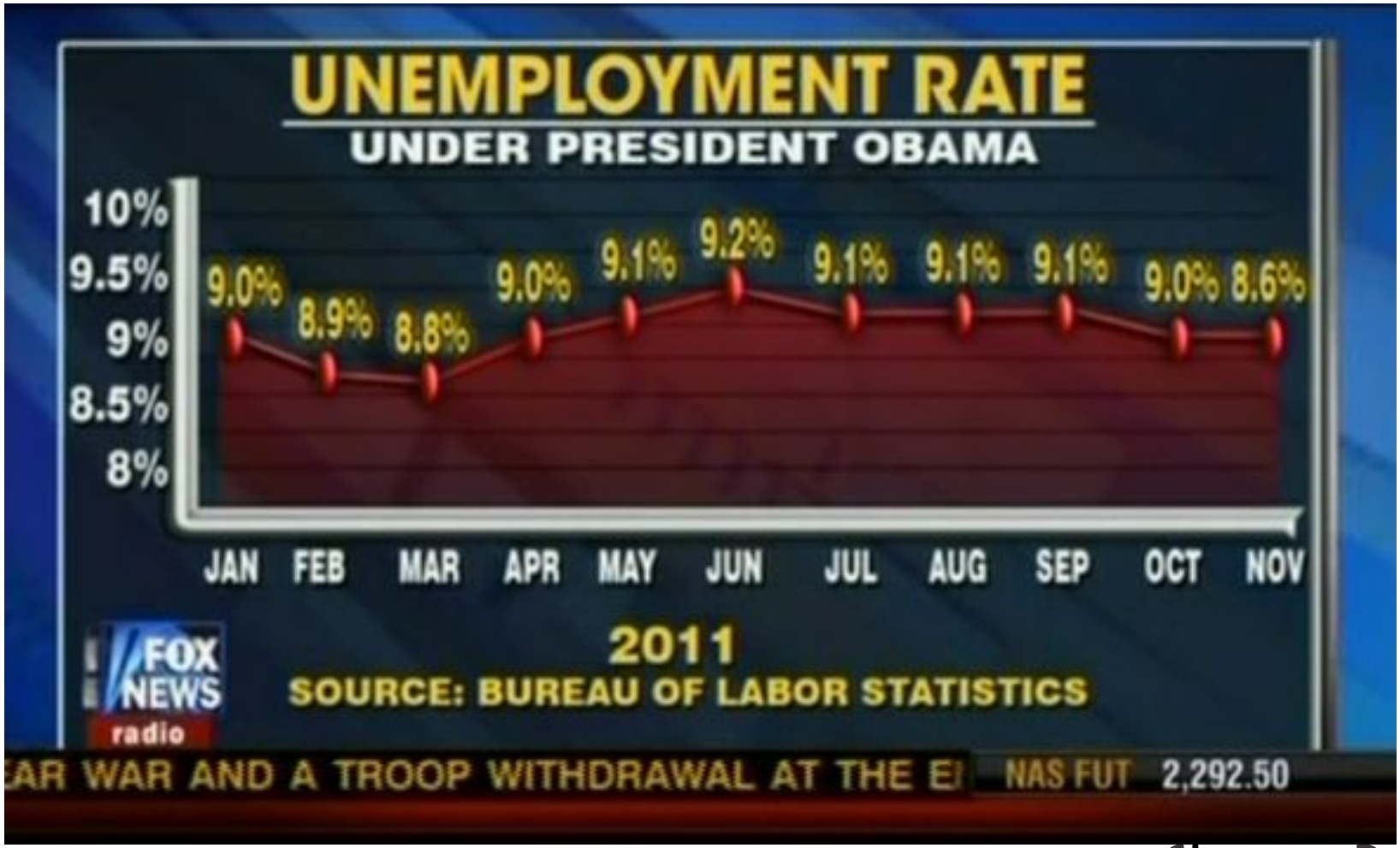

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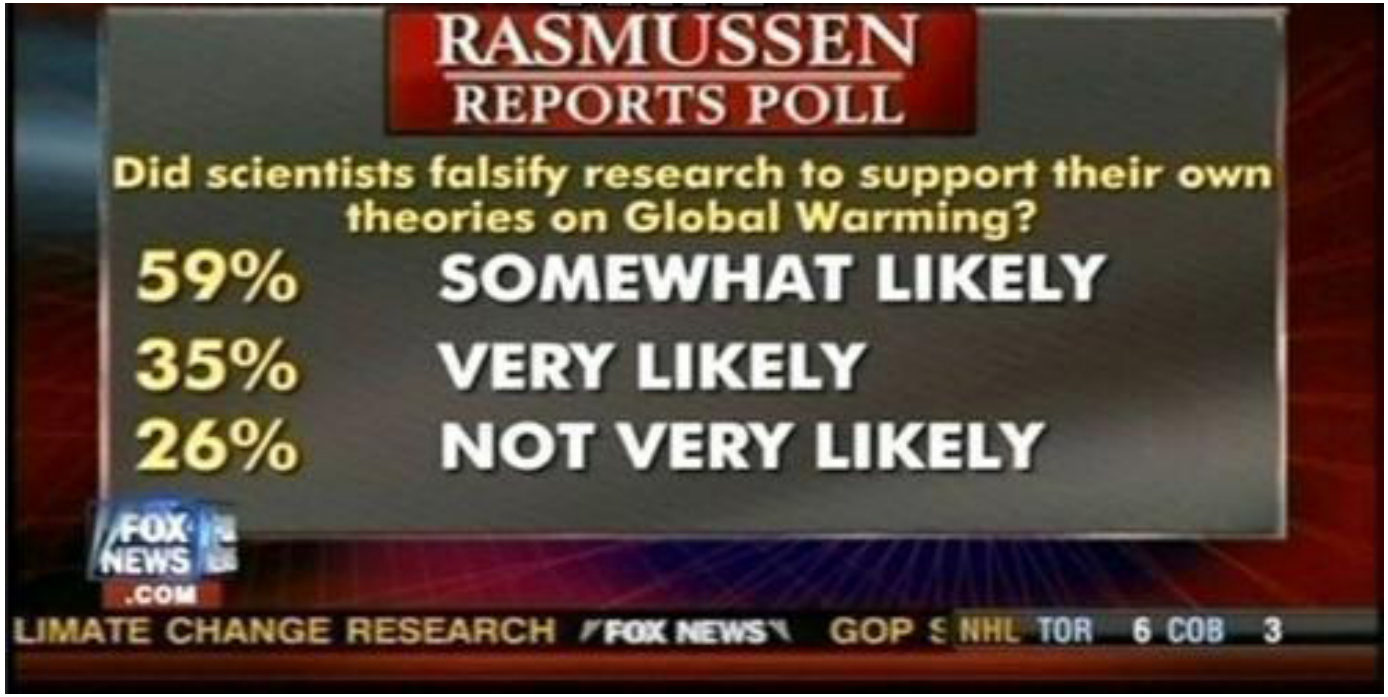

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