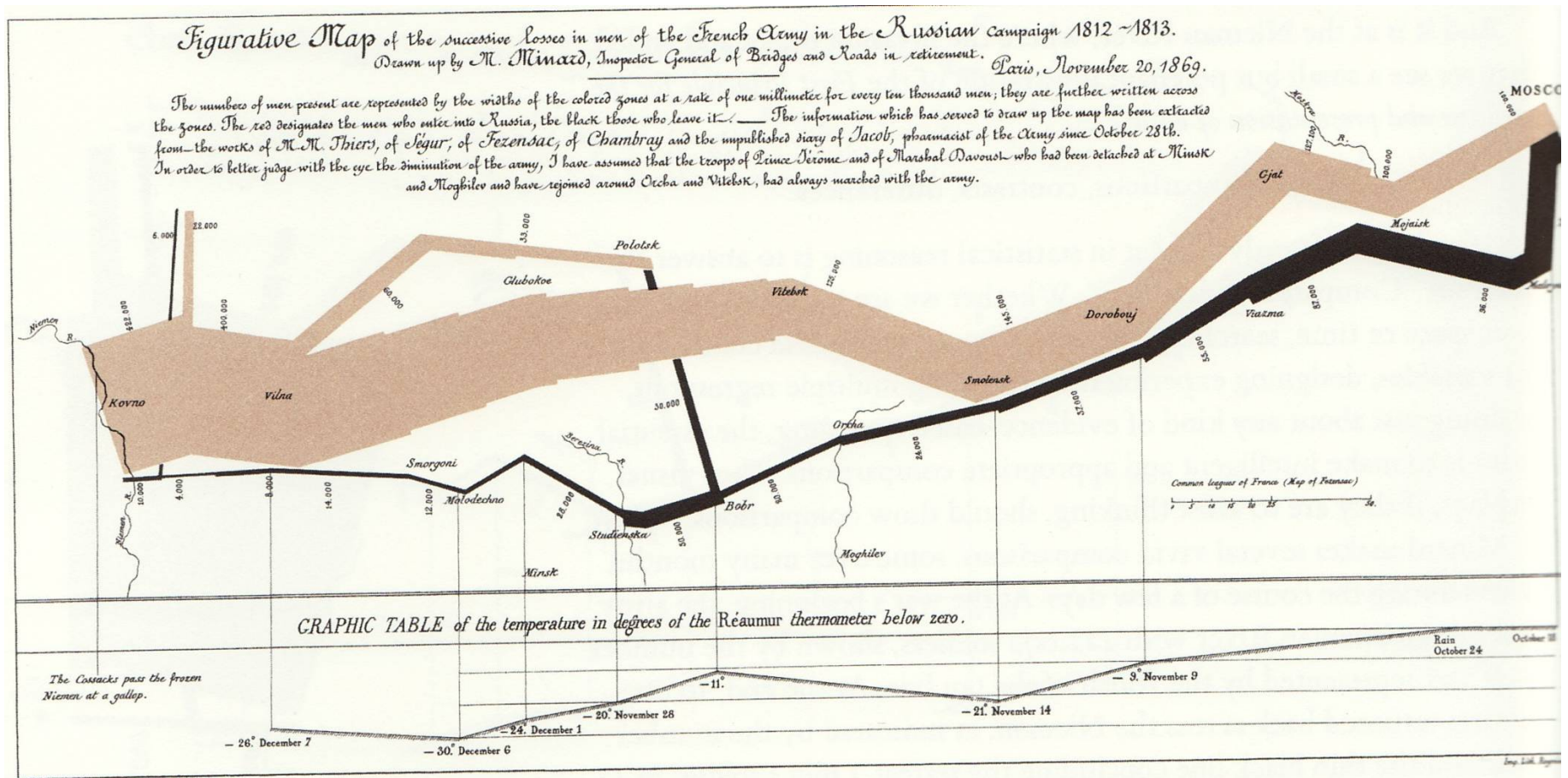


The Visual Display of Quantitative Information  
Envisioning Information  
Visual Explanations

Edward Tufte

# The Fundamental Principles of Analytical Design

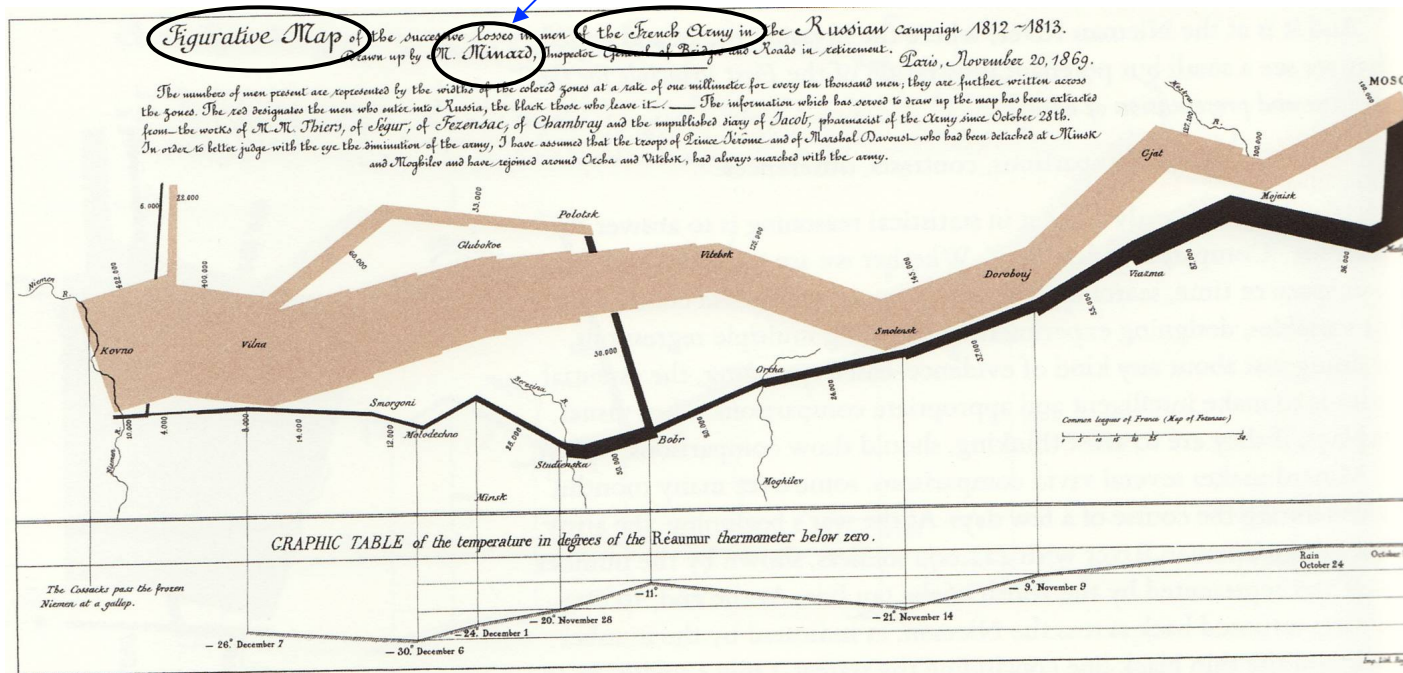


# The Story

- Charles Joseph Minard (1869) described the successive losses of lives in the French army during the invasion of Russia in 1812
- The best statistical graphics ever
  - Vivid historical content
  - Brilliant design

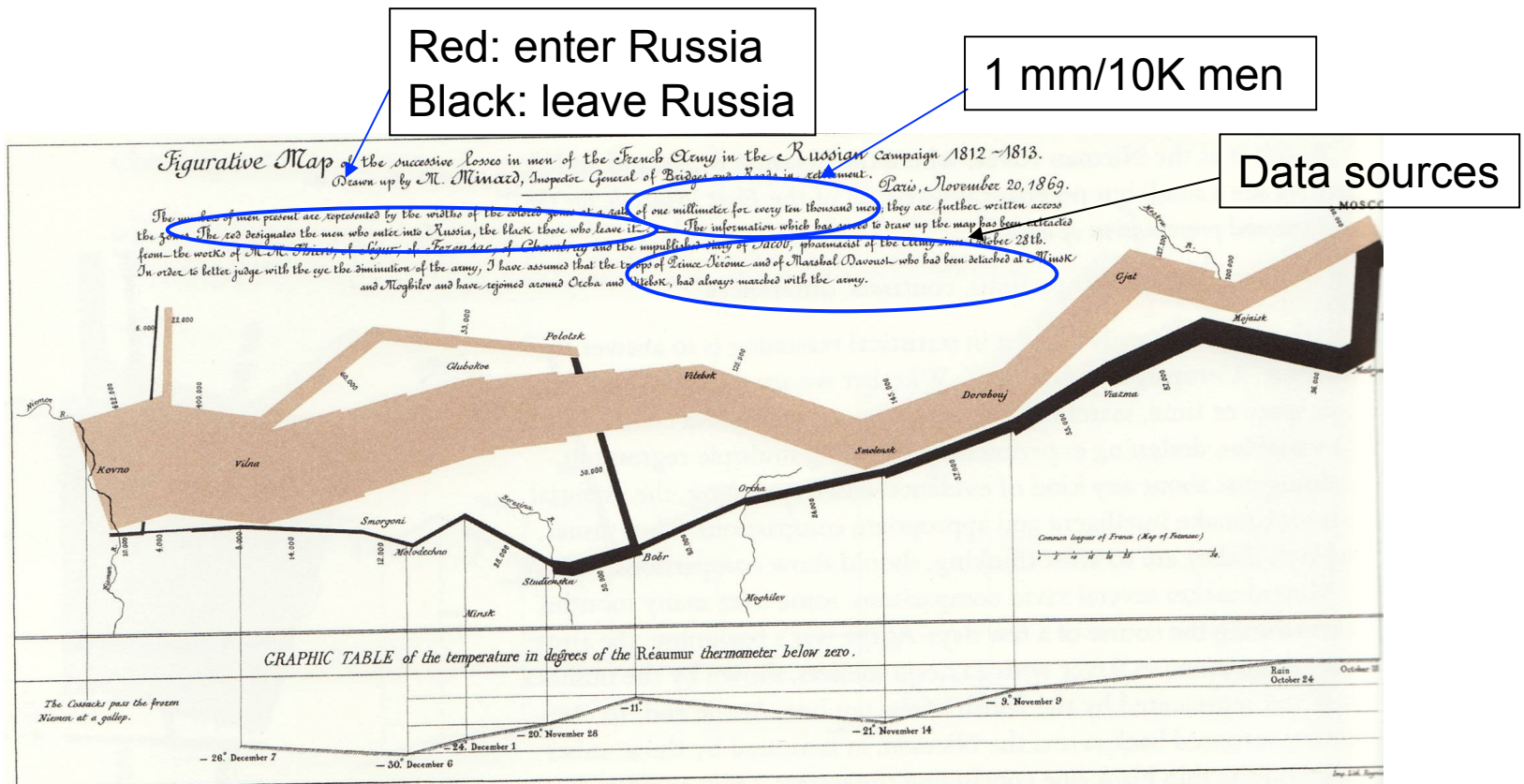
# Let's look at it closely

- First, a title announces the design method (figurative map), the subject (French army), and the author (Minard)

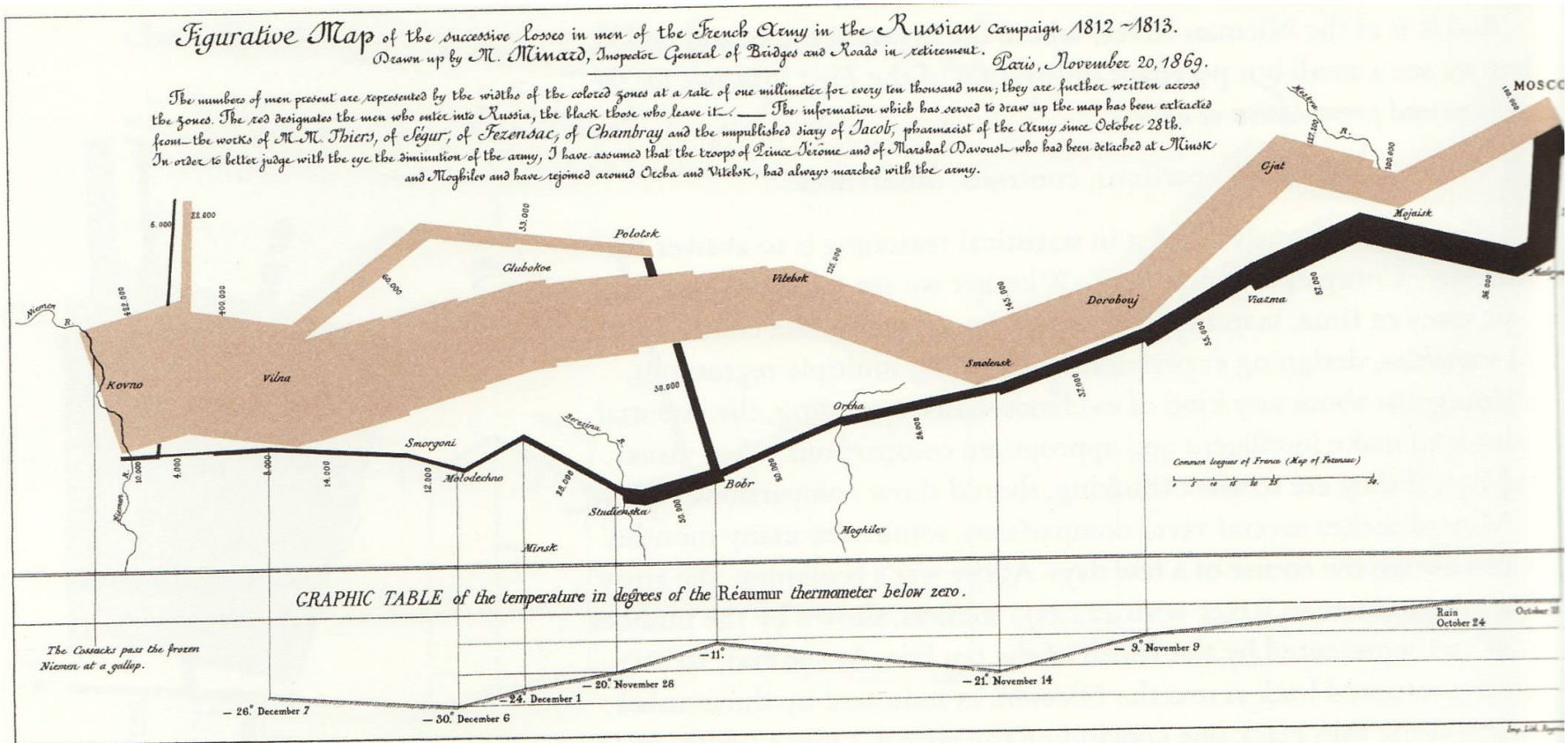


# And ...

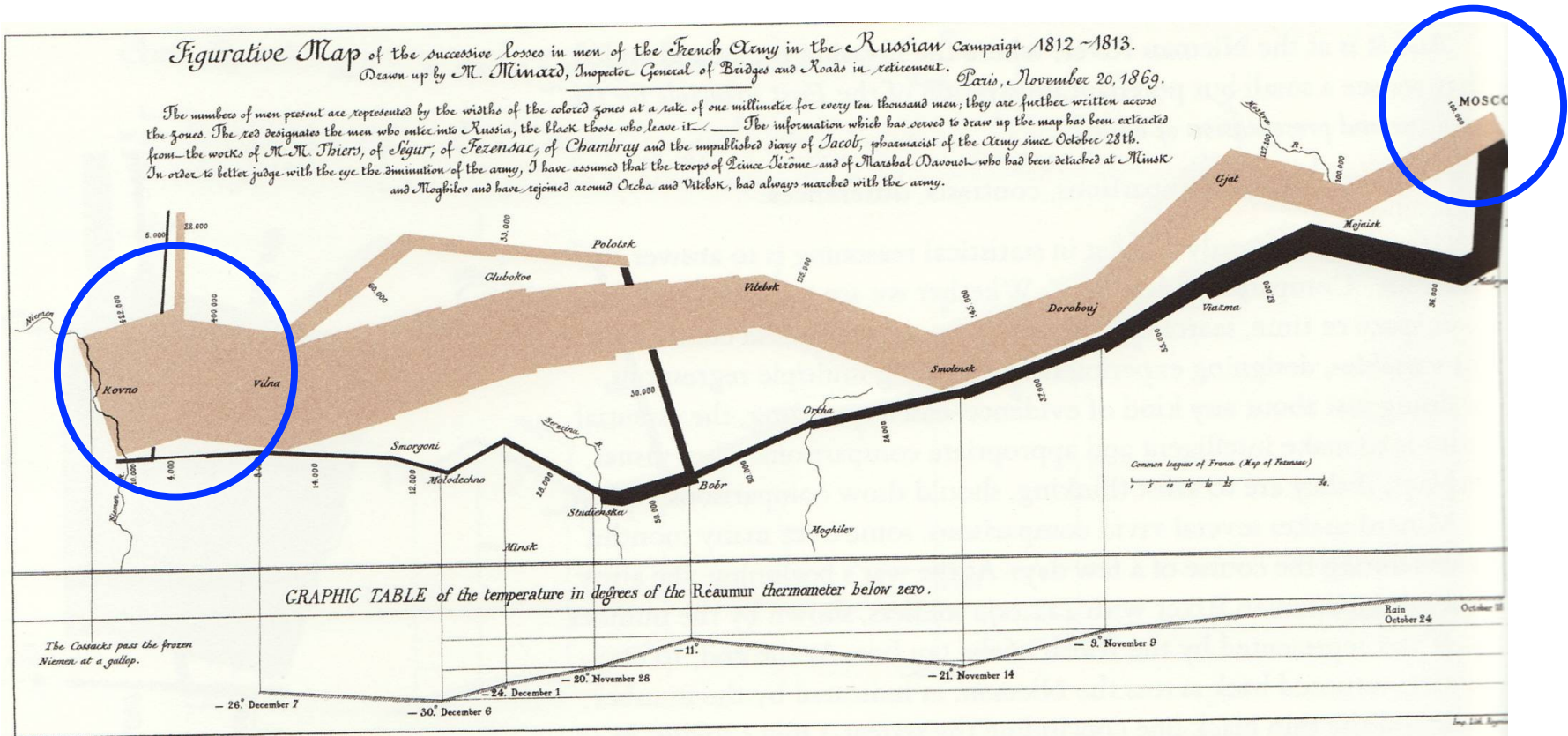
- The color code, the scales of measurement, and data sources



# Then the history begins

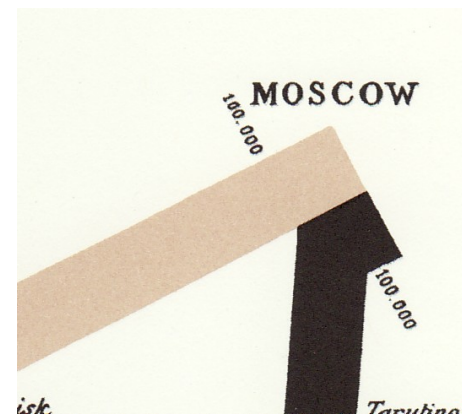
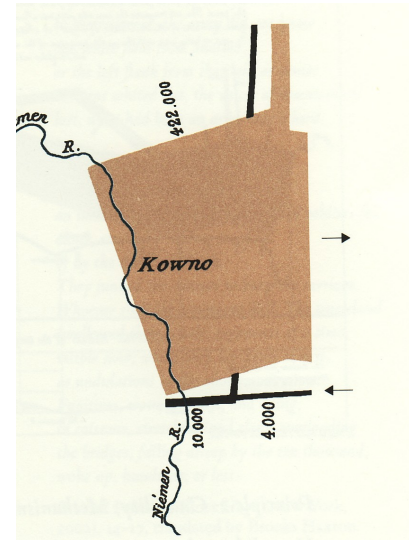


# June 1812



# The Nieman River

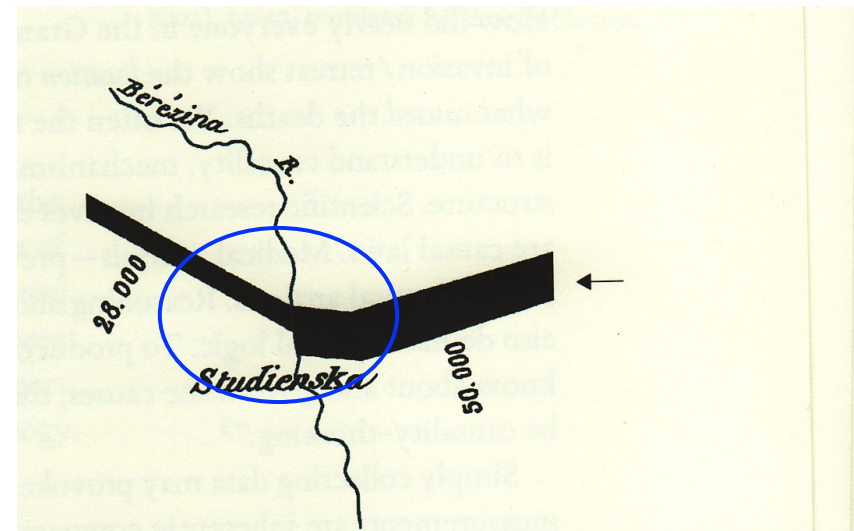
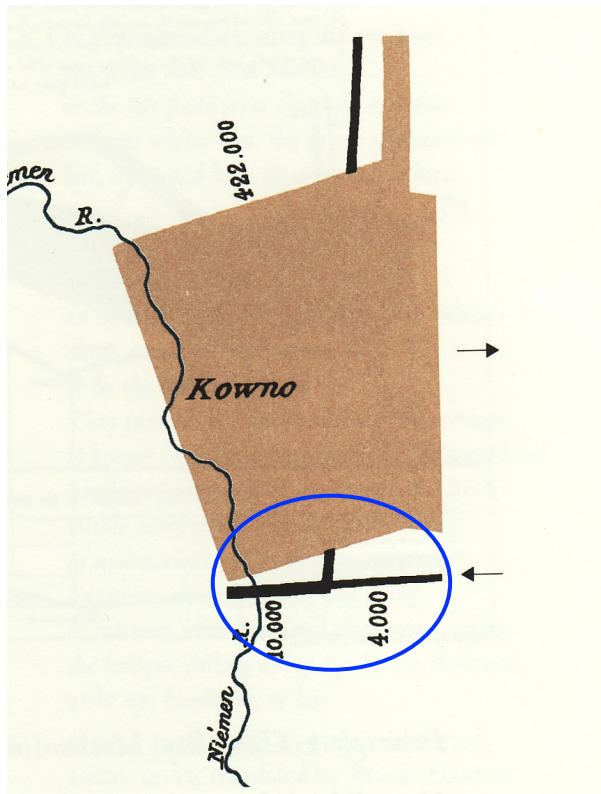
- On the Polish-Russian border near the Nieman River, the Grand Army had 422,000 men
- When the army arrived at Moscow in September, only 100,000 survived





# Principle 1: Comparison

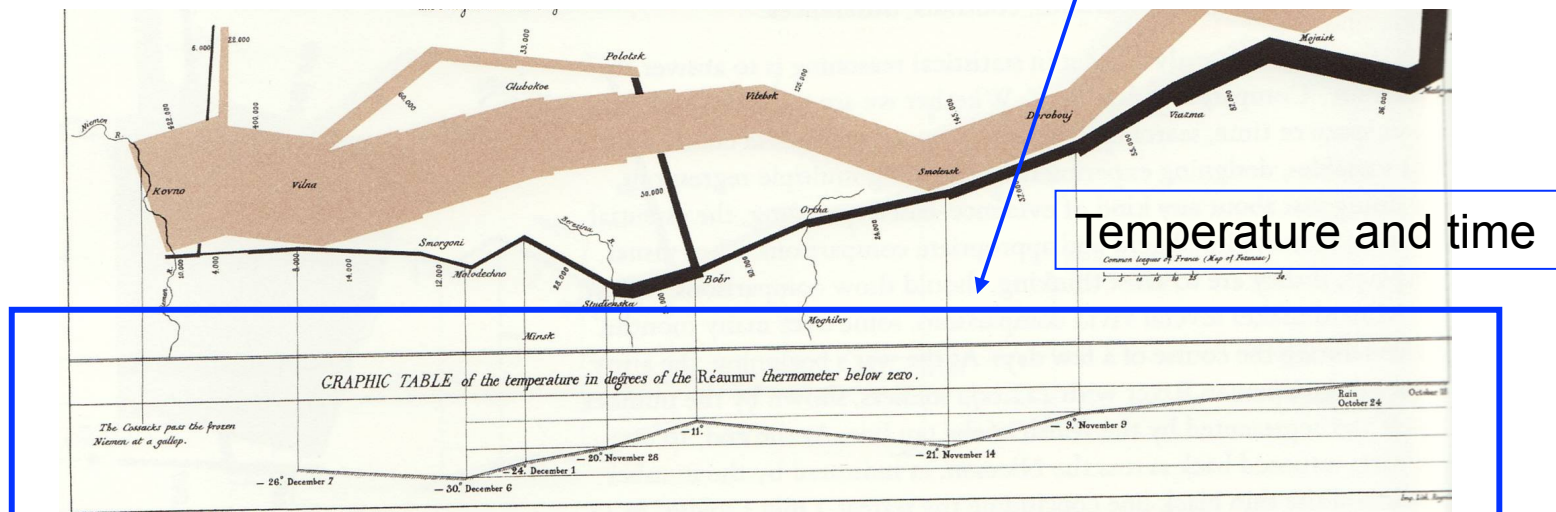
- Show comparisons, contrasts, differences



Surviving Troops: 50,000 -> 28,000

# Principle 2: Causality, Mechanism, Structure, Explanation

- Why nearly everyone in the Grand Army died?
  - The map only shows the locations of bad news, not the cause
  - Minard depicted a possible cause



# Principle 3: Multivariate Analysis

- Minard's Map depicted the war by 6 variables: size of army, 2D location, direction of army movement, temperature, and dates.
- Nearly all interesting worlds we seek to understand are multivariate in nature
- The only thing that is truly two dimensional is our display screen
  - Need to escape flatland

# Principle 4: Integration of Evidence

- Minard's Map contains words, numbers, images, and diagrams, all integrated together
  - The number of troops, invasion flow-lines in 2D space, temperatures and dates, and description by words
- Use transparency overlays
- *What matters is the evidence, not a particular mode of evidence*

# Principle 5: Documentation

*What is the display about?* Losses in men of the French Army in the Russian Campaign 1812-1813

*Who did the work?* Drawn up by M. Minard

*Who's that?* Inspector General of Bridges and Roads in retirement.

*Where and when was the work done?* Paris, November 20, 1869.

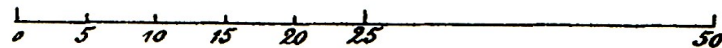
*What are the data sources?* The information which has served to draw up the map has been extracted from the works of M. M. Thiers, of Ségur, of Fezensac, of Chambray and the unpublished diary of Jacob, the adjutant-general of the Army since October 28th.

*Any assumptions?* In order to better judge with the eye the diminution of the army, I have assumed that the troops of Prince Jérôme and of Marshal Davoust who had been detached at Minsk and Moghilev and have rejoined at Orcha and Vitebsk, had always marched with the army.

*What are the scales of measurement?*

*for invasion and retreat flow-lines: one millimeter for every ten thousand men*

*for the underlying map: Common leagues of France (Map of Fezensac)*



The French "lieue" is of variable length, approximately 2.5 miles or 4 kilometers (historically varying by up to 10% between regions).

*for the temperature: degrees of the Réaumur thermometer below zero*

*Who published and printed the work?* Autog. par Regnier, 8. Pas. S<sup>te</sup> Marie S<sup>t</sup> G<sup>ain</sup> à Paris. Imp. Lith. Regnier et C<sup>o</sup>.

## Principle 6: Content Counts Most of All

- What matters the most: A good knowledge of the content and a deep caring about the substance
- The first question to ask: what are the content-reasoning tasks that this display is supposed to help with?

## Principle 6: Content Counts Most of All

- What matters the most: A good knowledge of the content and a deep caring about the substance
- The most effective way to improve a presentation is to get better content!!

# Recap of the principles

- Show comparisons
- Show causality
- Show multivariate data
- Integrating relevant evidence
- Documentation
- Contents count most of all



# The General Principle

The principles of analytical design are derived from the principles of analytical thinking