

# Interactive Statistical Visualization of Medical Data

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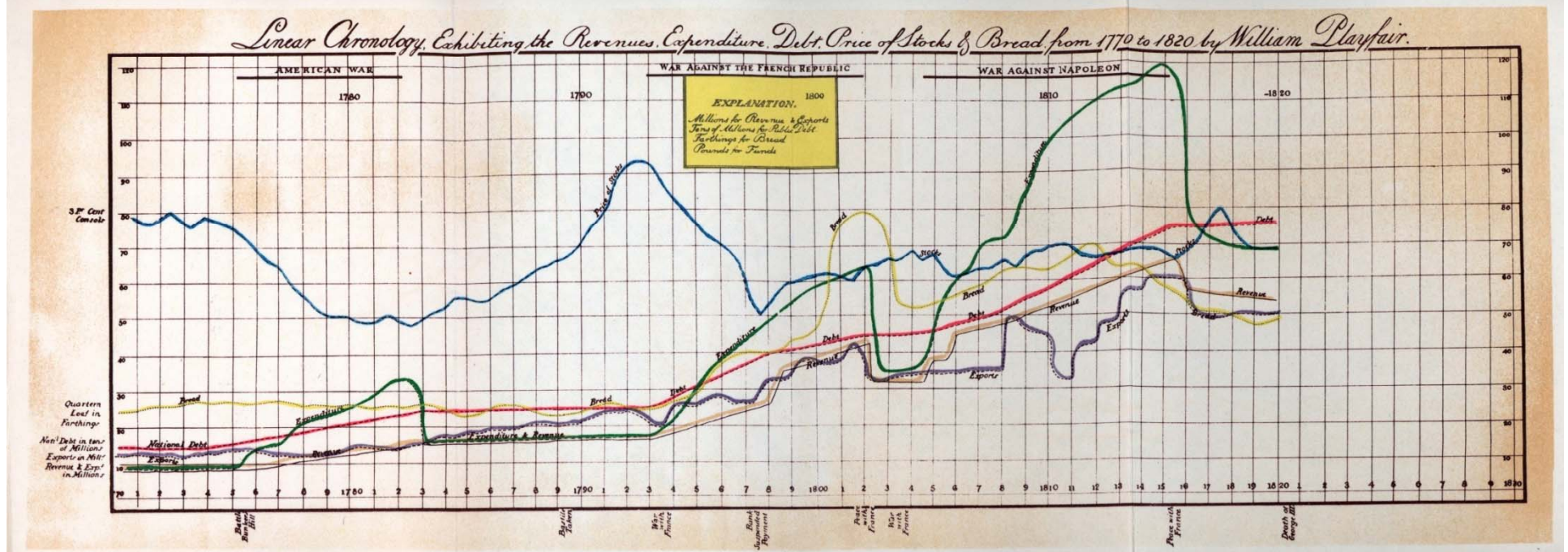


# Contents

- Why Graphics for “Outsiders”?
- Exploratory Graphics for Actigraphy Data
- Carpal Tunnel Syndrome Data
- Micromaps for West Nile Virus and Oral Clefts
- Conclusion

# Historical 250<sup>th</sup> Birthday

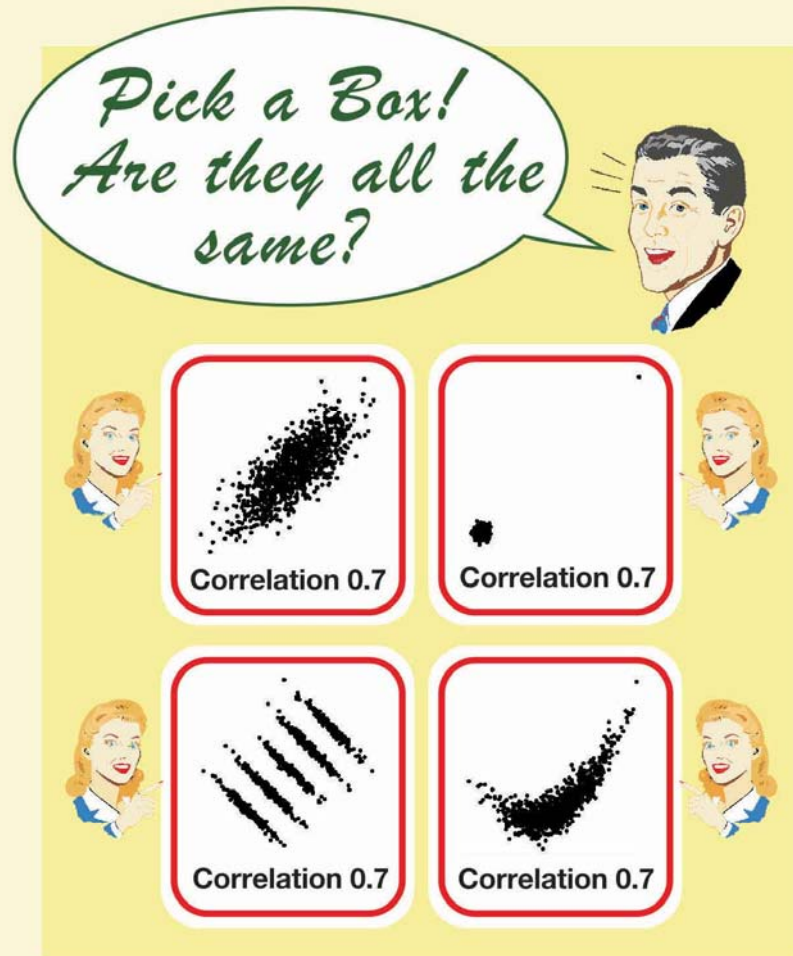
- William Playfair: Born on September 22, 1759
- “Father” and “Inventor” of Statistical Graphics
- Modern plots still look very similar:



## Interview with Andreas Buja\*

- “ ... when I think back about what really may have had the most impact in what I did in the various labs that I worked, it’s graphics! You know whenever I made a striking picture, people actually went “aahh,” “wow,” “that’s great!”, “Why don’t we do more of this?” Pictures really, really speak. ...”

# Inspiration for Statistical Graphics



SECTION ON  
STATISTICAL  
GRAPHICS



AMERICAN  
STATISTICAL  
ASSOCIATION

<http://www.amstat-online.org/sections/graphics/>

American Statistical  
Association  
Statistical Graphics Section  
Poster Series (~2004)

<http://www.public.iastate.edu/~dicook/Stat.Graphics/posters.html>



- **Example:**

- Exploratory Graphics for Functional Actigraphy Data in Sleep Medicine**

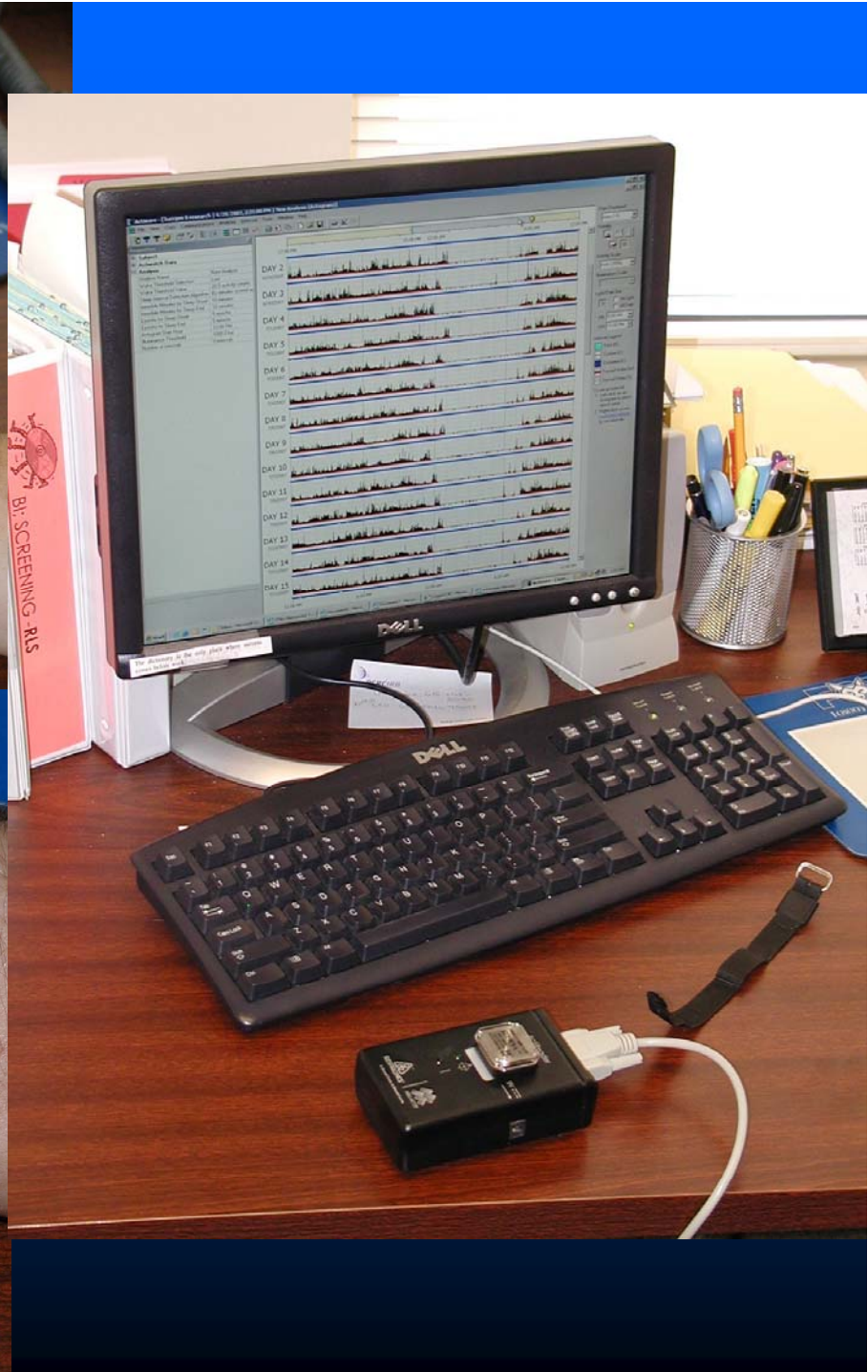
- **Reference:**

- Symanzik, J., Shannon, W. (2008): Exploratory Graphics for Functional Actigraphy Data, American Statistical Association, CD.**

- **Funding Source: NIH R01 HL092347**

## Background (1)

- **Actigraphy**: emerging technology for measuring a patient's activity level continuously over time
- **Actigraph**: watch-like device (attached to the wrist or a leg) that uses an accelerometer to measure (human) movements (every minute or more often)

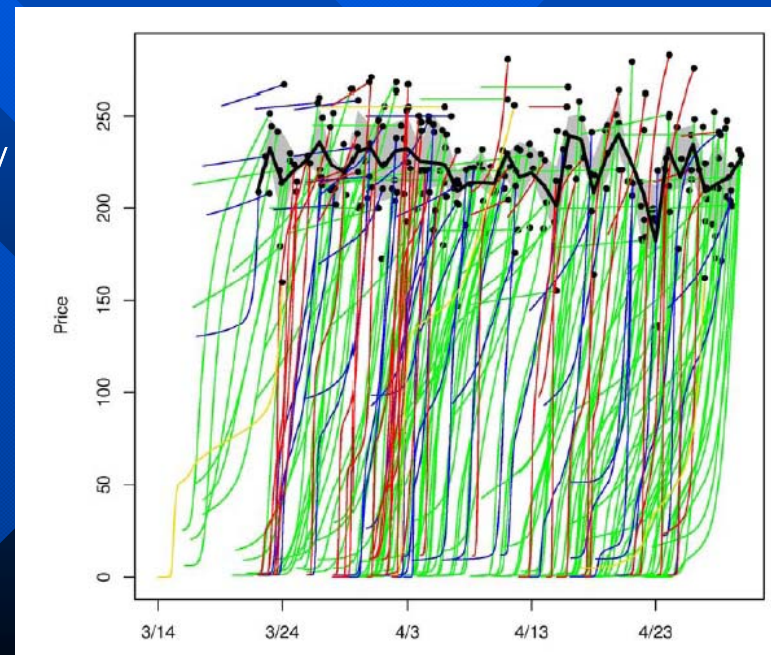


## Background (2)

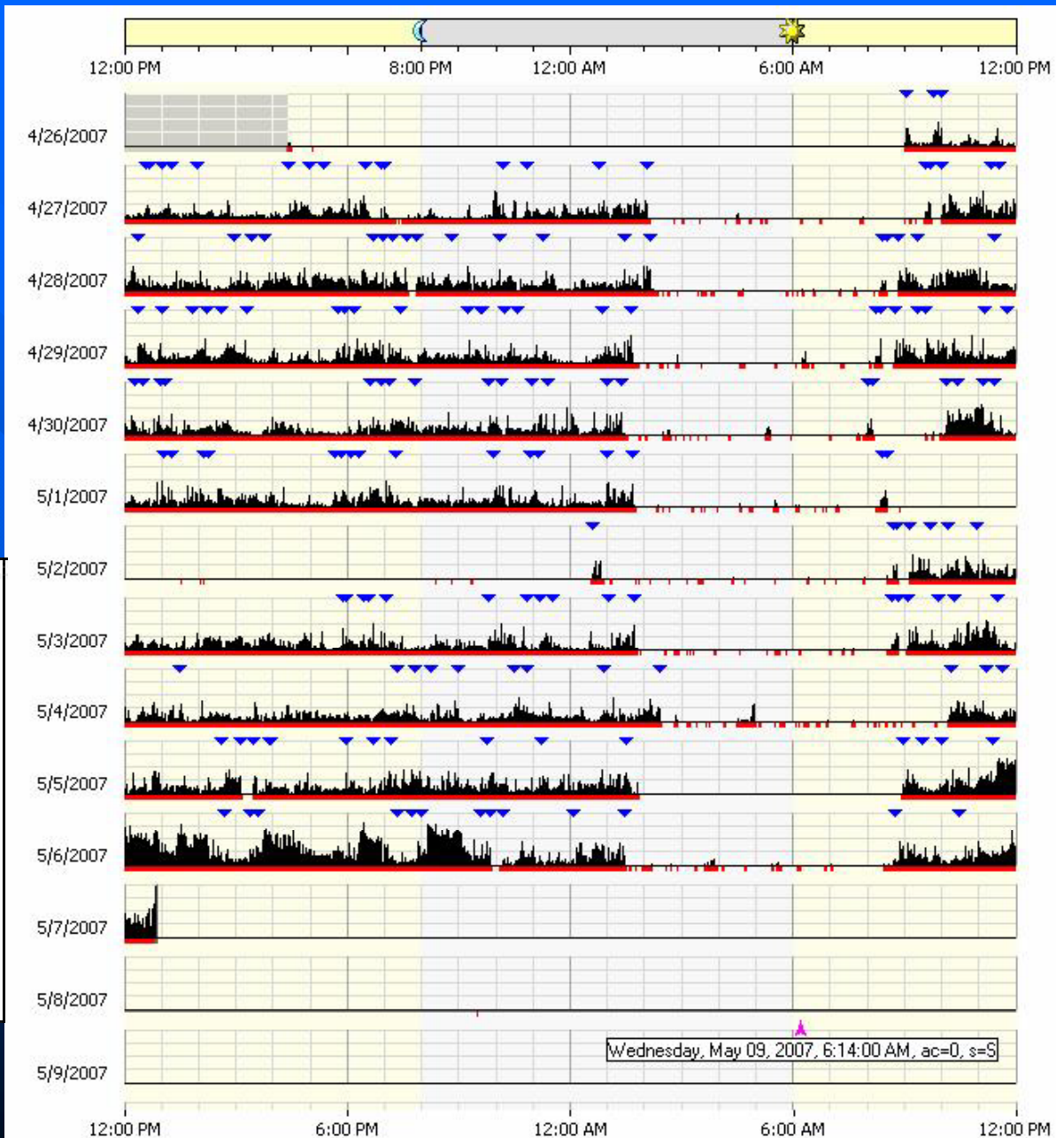
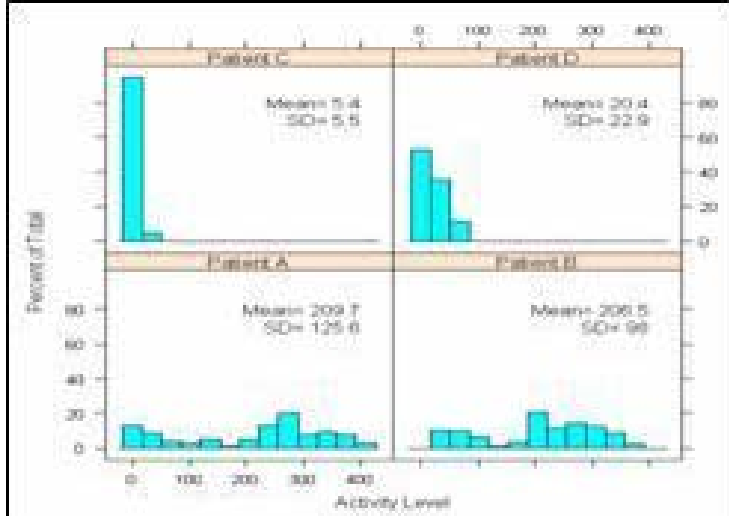
- **Analysis of Human Actigraphy Data:**  
Useful for detecting sleep, for assessing insomnia and restless leg syndrome, for tracking recovery after heart attacks, and as an assessment tool for overall status of HIV patients
- Actigraphy Data can be best described as functional data

# Visualization of Functional Data

- Very limited ! A rare example is:  
Jank, W., Shmueli, G., Plaisant, C., Shneiderman, B.  
(2008): Visualizing Functional Data with an Application to  
eBay's Online Auctions, In: Chen, C., Härdle, W., Unwin,  
A. (Eds.), Handbook of Data Visualization, Springer,  
Berlin/Heidelberg, 873-898.
- Figure from  
<http://www.smith.umd.edu/faculty/wjank/DIV-Berlin2006.pdf>  
(page 30).

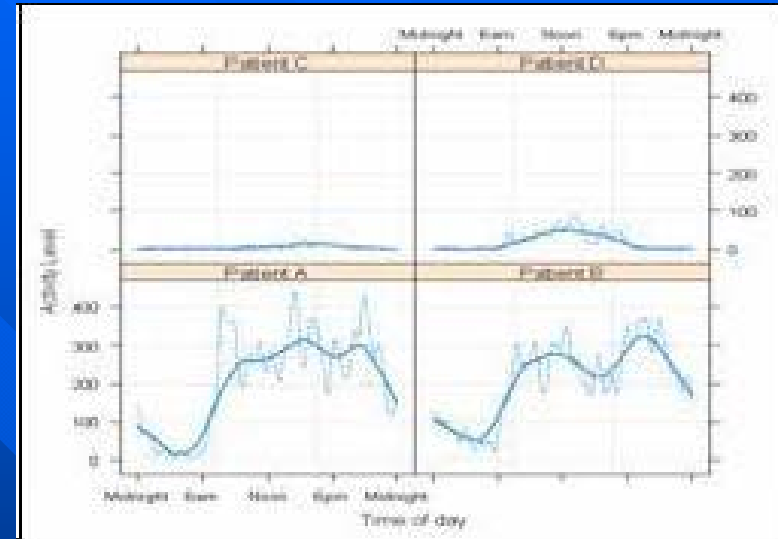


# Current Visualization of Actigraphy Data



# Suggested Future Visualization of Actigraphy Data (1)

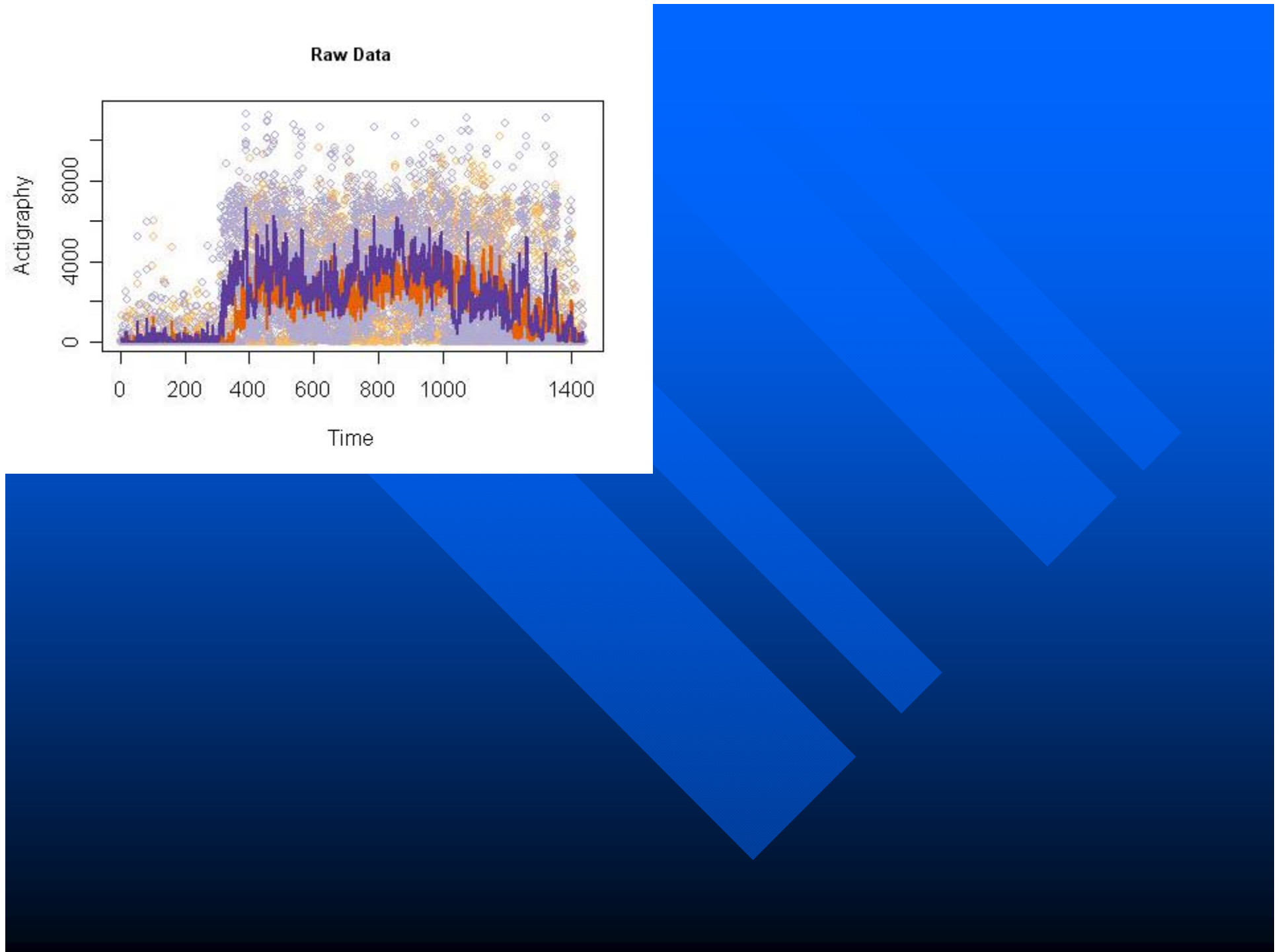
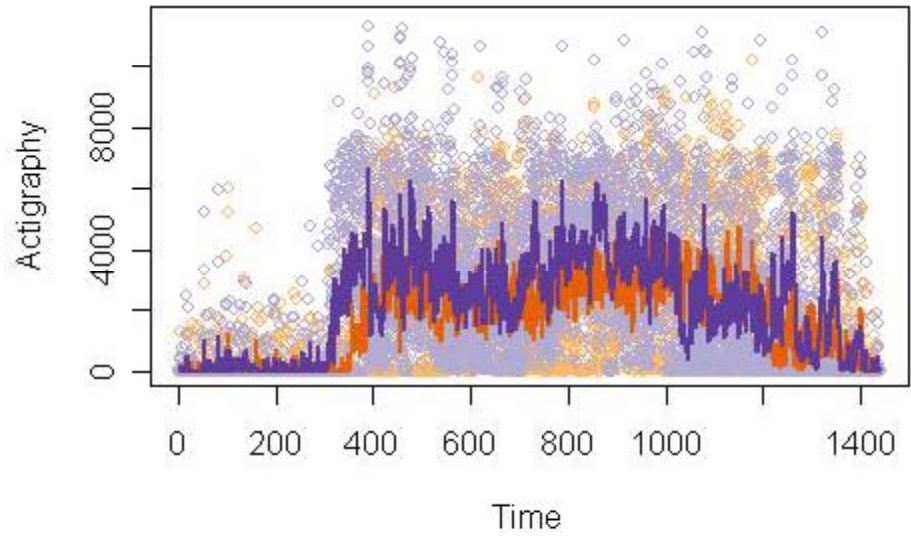
- Displays for
  - Raw data
  - Smoothed data
  - Averages etc.
  - Velocity (First Derivative)
  - Acceleration (Second Derivative)
  - Brushing & Linking
  - Cumulative Sums
- Example: 1 Subject
  - Orange: 5 Days at Baseline
  - Purple: 5 Days after 6 Months



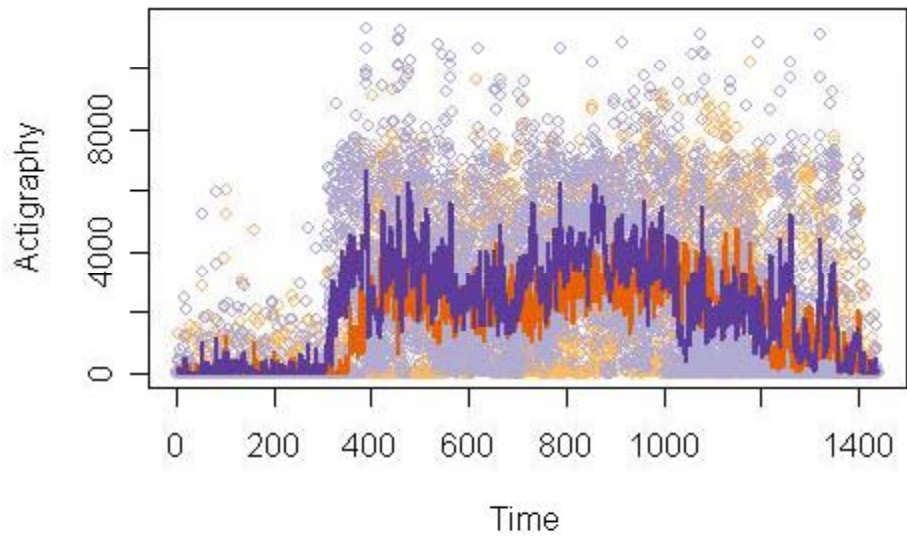
# Live Demo

-  AVAD Software (Web Interface to R)
- Prototype Developer: Abbass Sharif

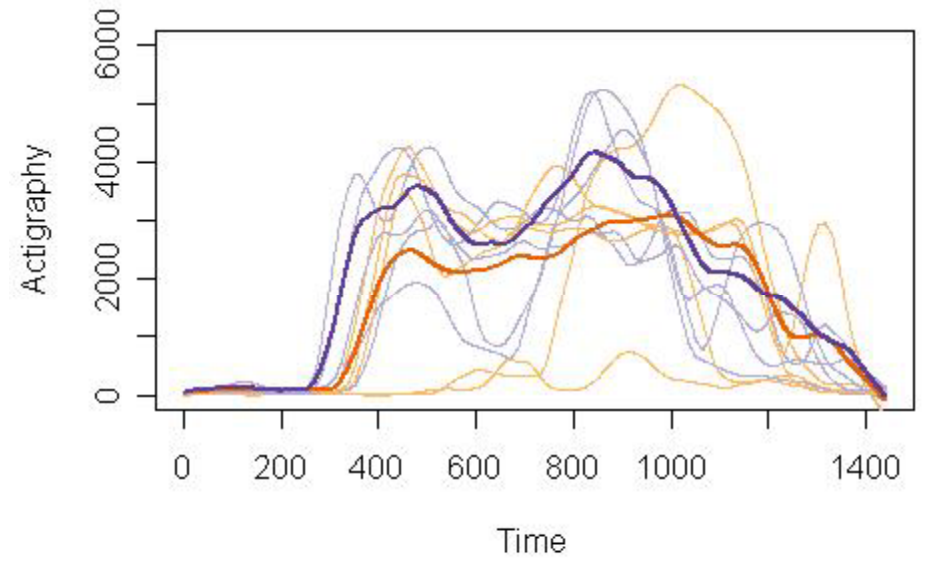
Raw Data



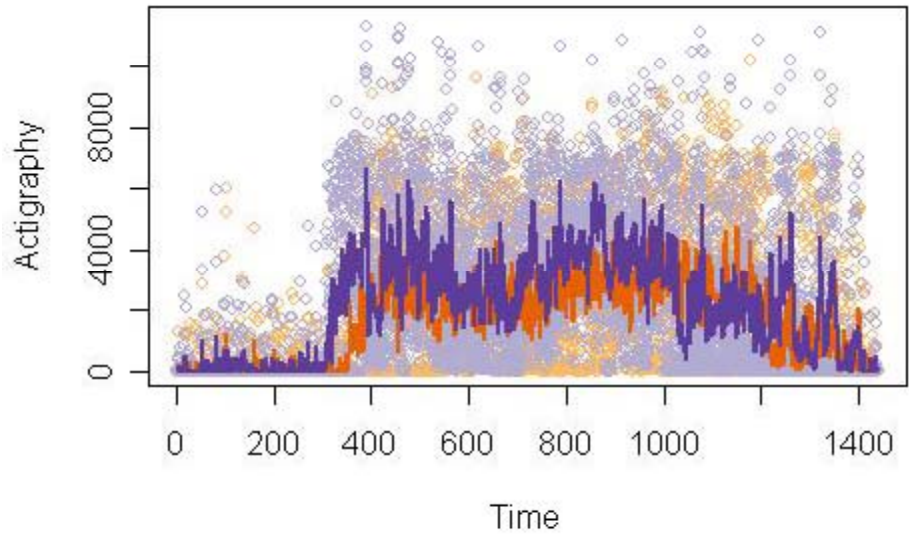
**Raw Data**



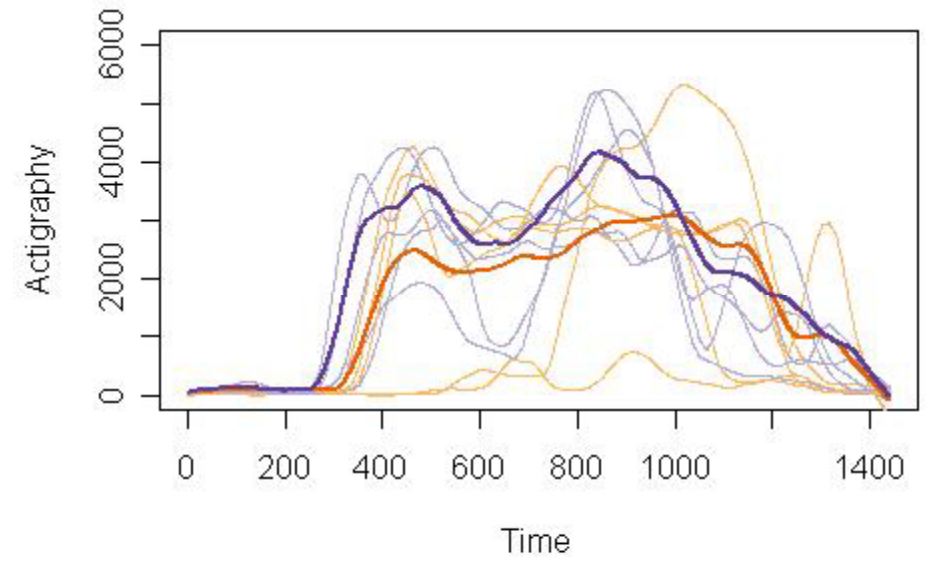
**Smoothed Daily Data**



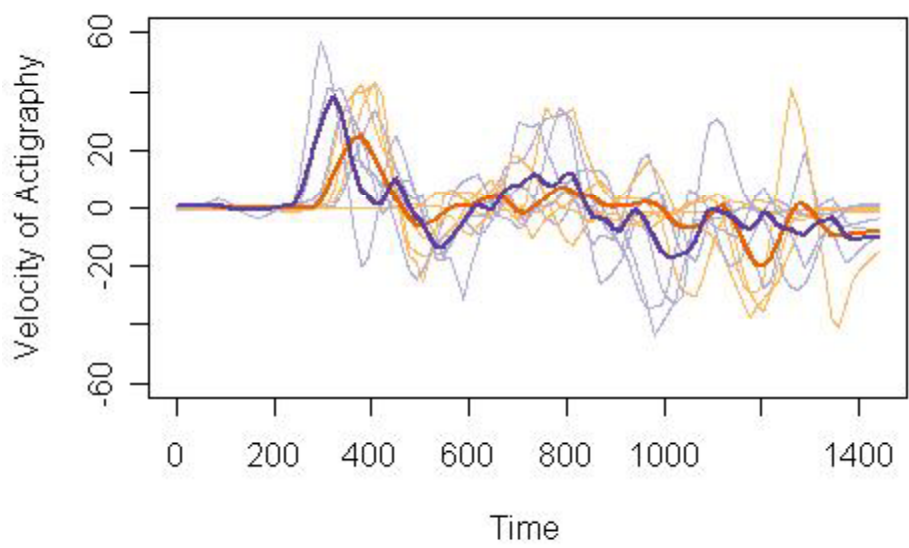
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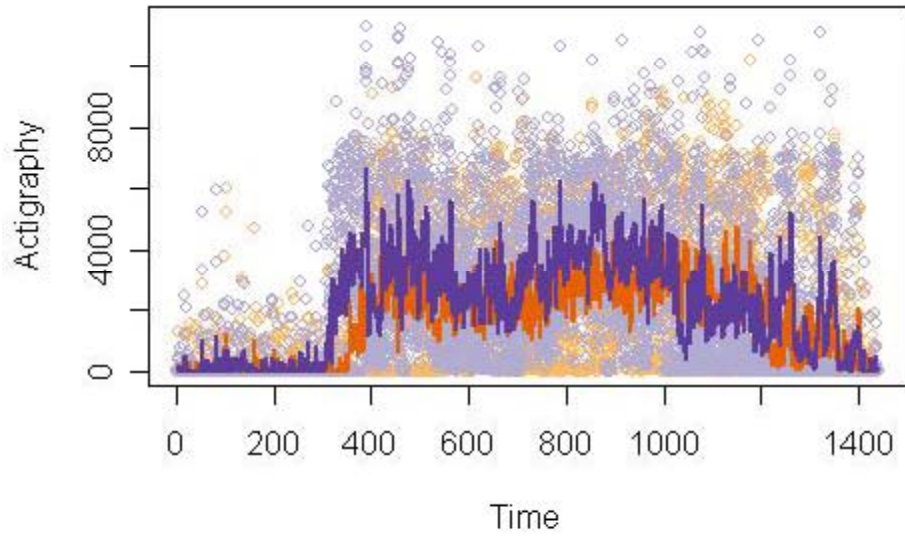
**Smoothed Daily Data**



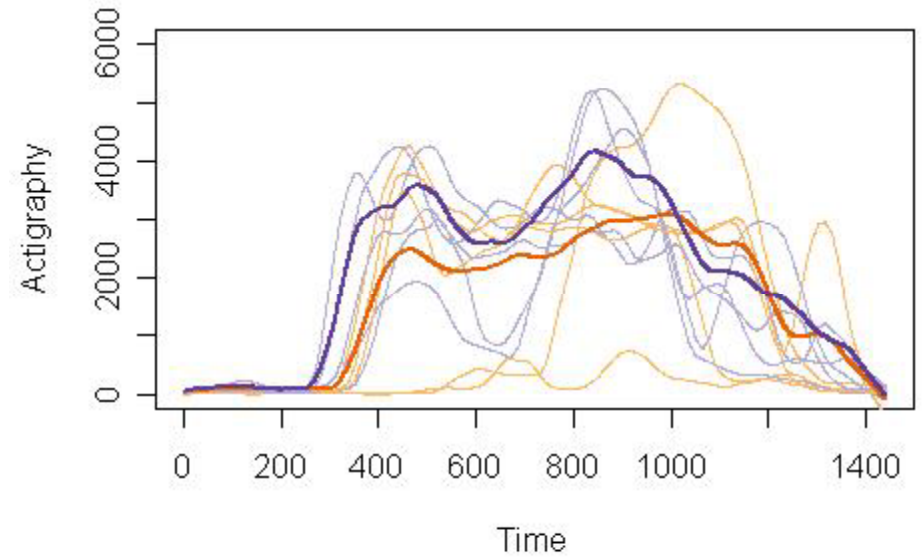
**Velocity (First Derivative) of Smoothed Daily Data**



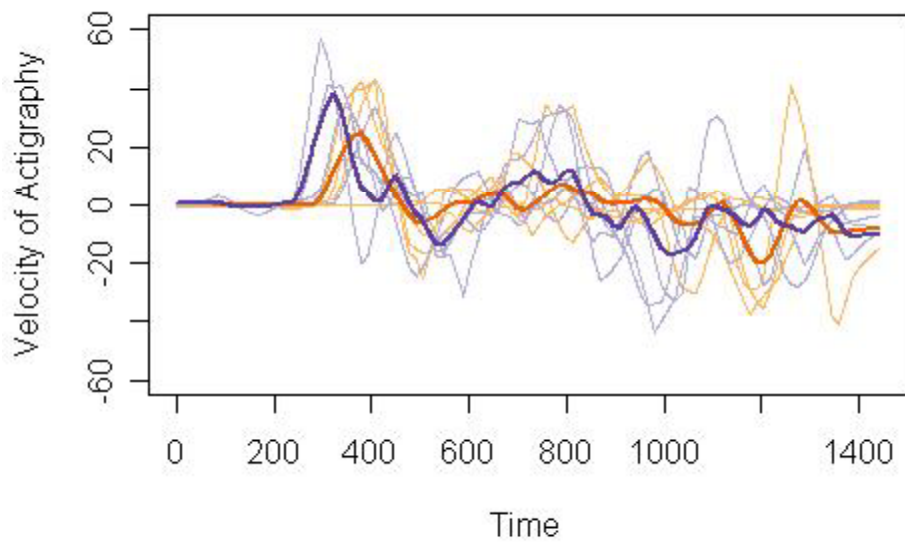
**Raw Data**



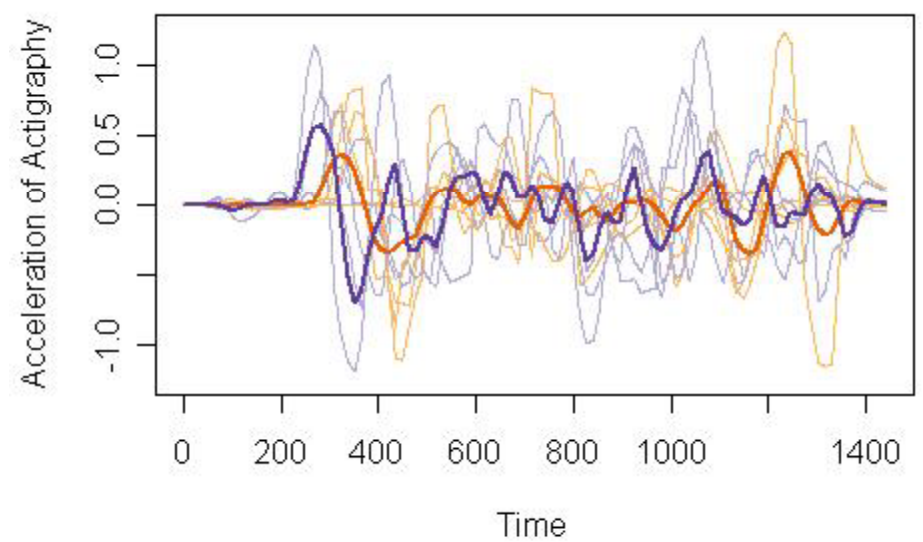
**Smoothed Daily Data**



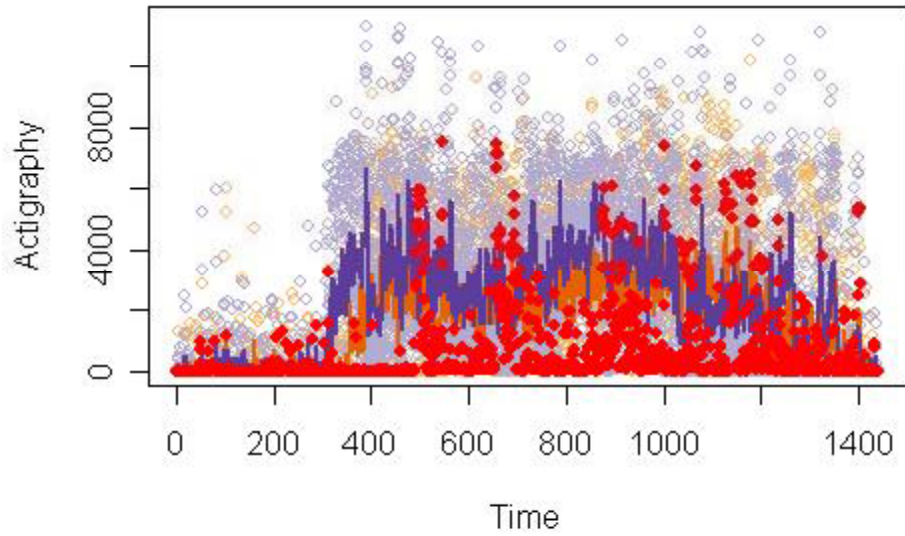
**Velocity (First Derivative) of Smoothed Daily Data**



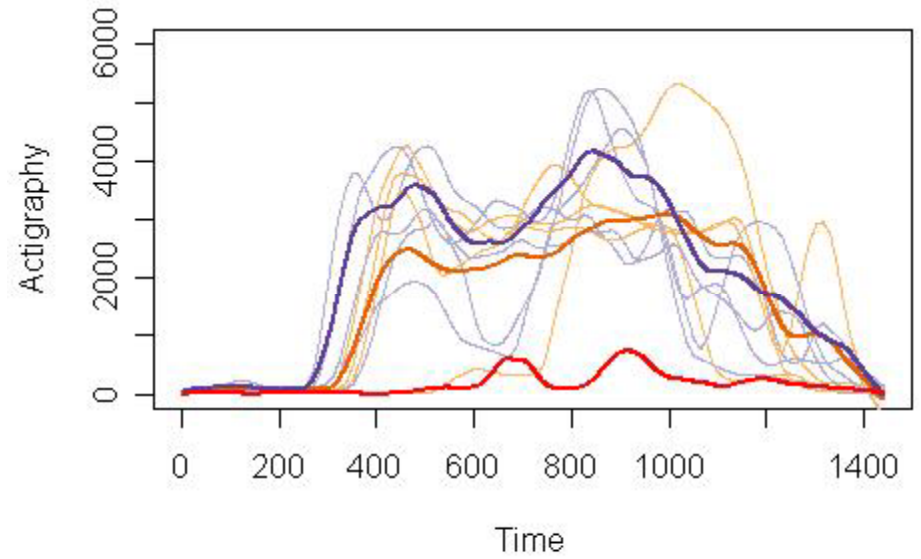
**Acceleration (Second Derivative) of Smoothed Daily Data**



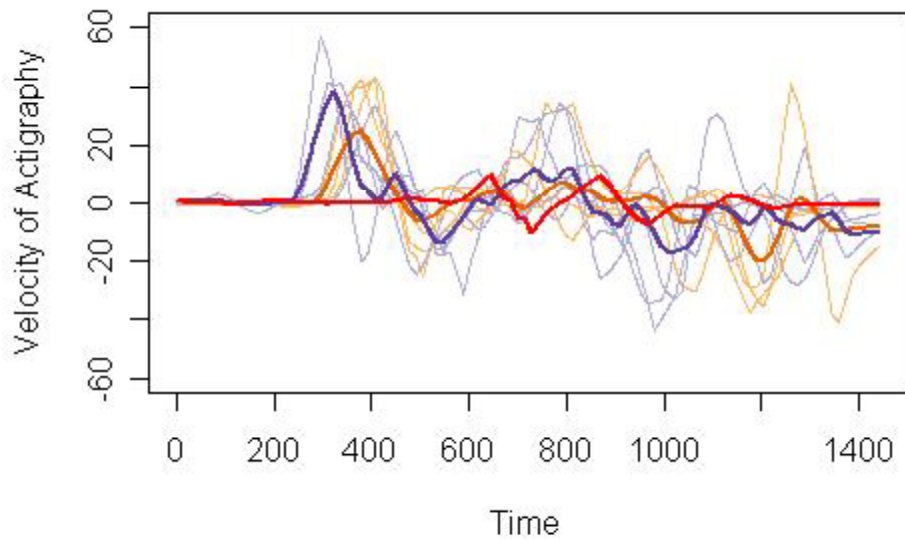
**Raw Data (Base Day 3 Brushed)**



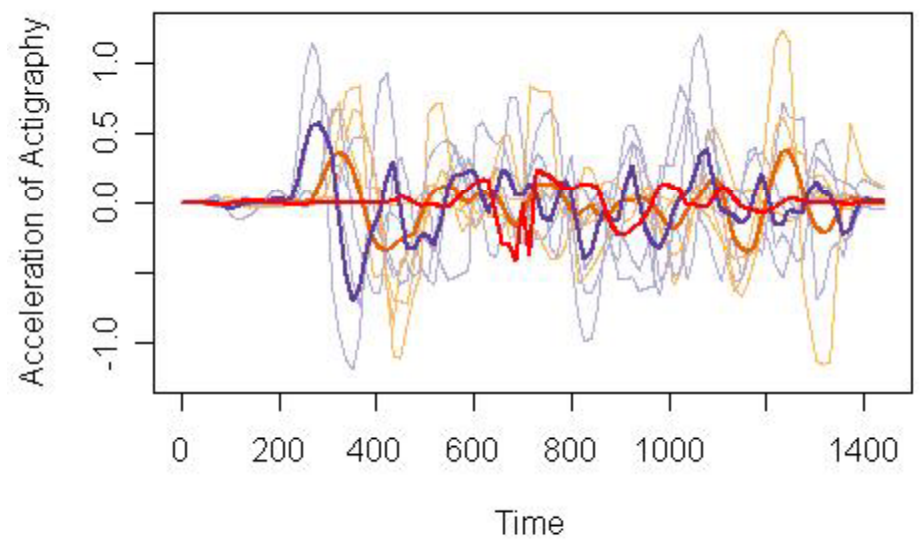
**Smoothed Daily Data (Base Day 3 Brushed)**



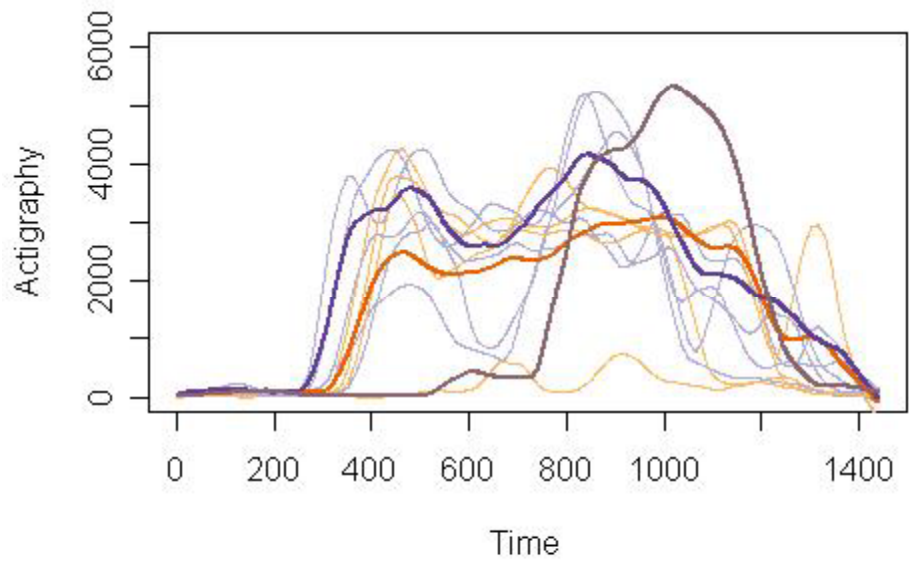
**Velocity (First Derivative) of Smoothed Daily Data (Base Day 3 Brushed)**



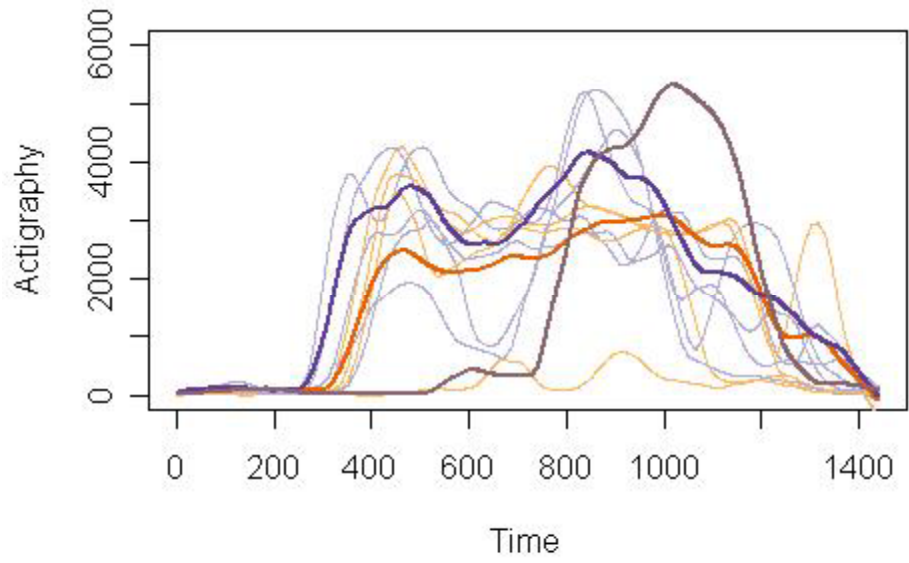
**Acceleration (Second Derivative) of Smoothed Daily Data (Base Day 3 Brushed)**



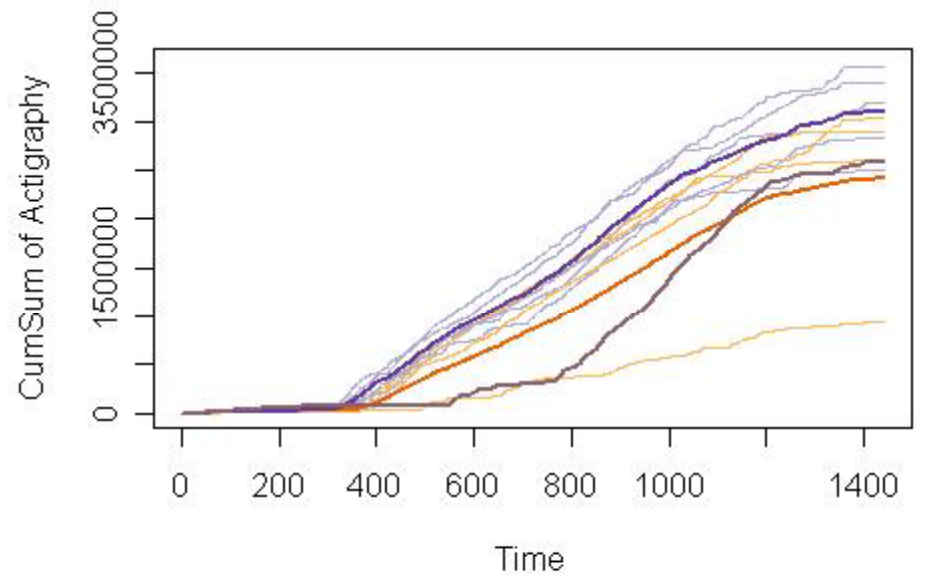
Smoothed Daily Data (Base Day 2 Brushed)



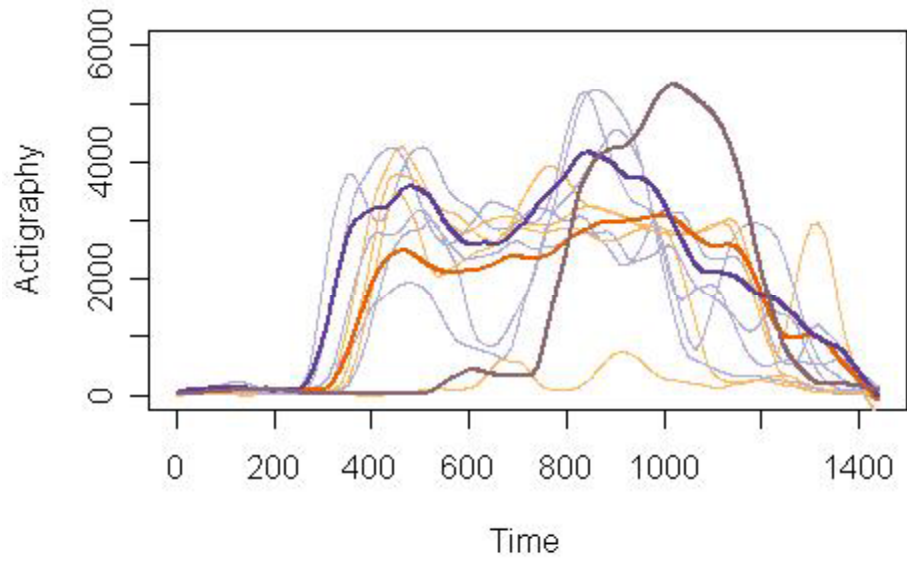
Smoothed Daily Data (Base Day 2 Brushed)



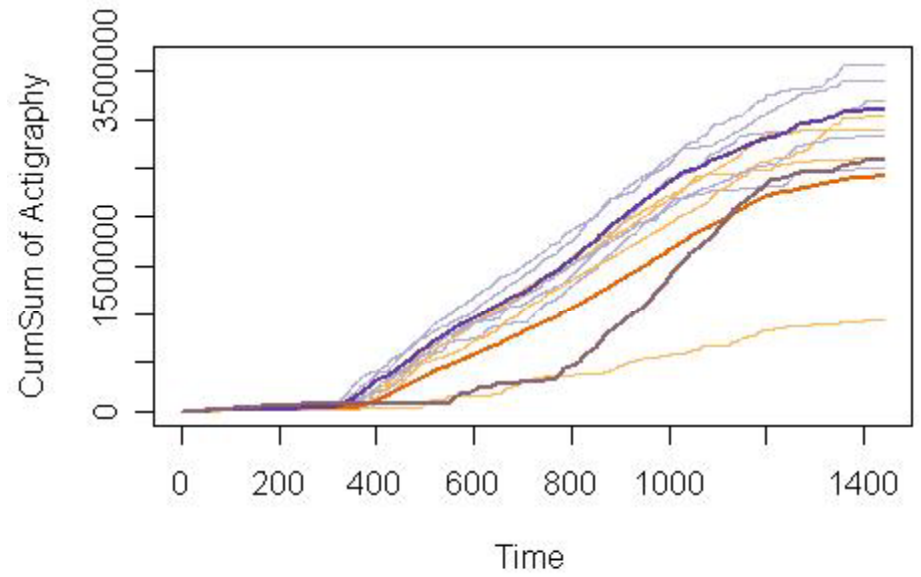
Cumulative Sums (Base Day 2 Brushed)



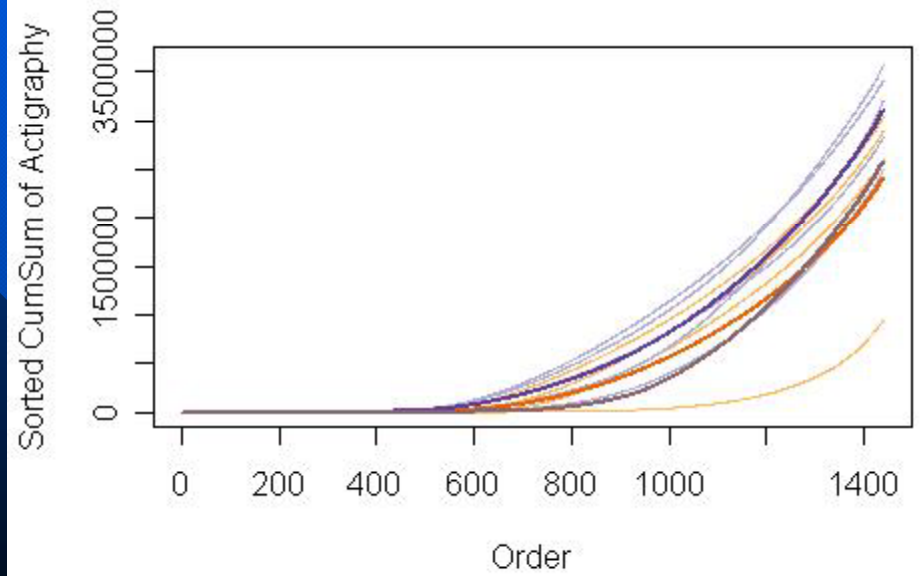
**Smoothed Daily Data (Base Day 2 Brushed)**



**Cumulative Sums (Base Day 2 Brushed)**



**Sorted Cumulative Sums (Base Day 2 Brushed)**



## Conclusions

Visualization of Actigraphy Data provides

- Potential for application in various medical fields
- Additional insights into actigraphy data
- Ease to compare baseline and past-treatment data
  - » of a single patient
  - » of multiple patients
  - » to identify outliers
  - » to compare averages

- **Example:**

- Agreement in Carpal Tunnel Syndrome (CTS) Studies**

- **References:**

- Dale, A.M., Strickland, J., Symanzik, J., Franzblau, A., Evanoff, B. (2008): Reliability of Hand Diagrams for the Epidemiologic Case Definition of Carpal Tunnel Syndrome, Journal of Occupational Rehabilitation, 18(3):233-248.**

- Symanzik, J. (2010): Interactive and Dynamic Statistical Graphics, In: Lovric, M (Ed.), International Encyclopedia of Statistical Science, Springer, Forthcoming.**

- **Funding Source: CDC R01 OH008017-01**

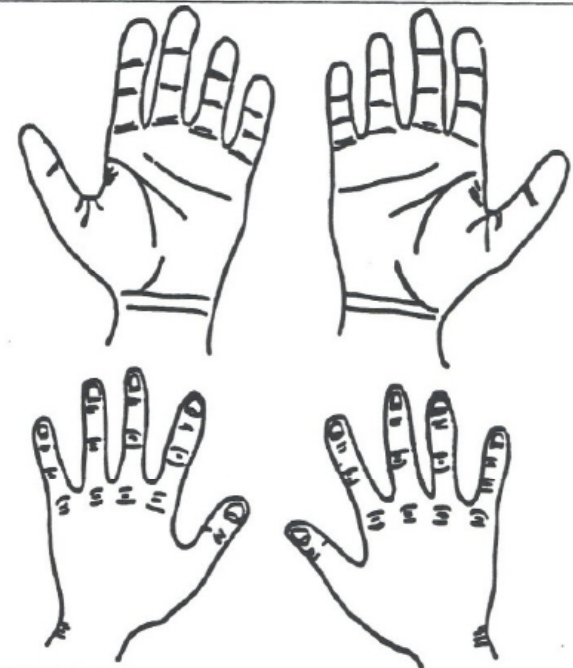
# Study Background

- Subjects have to indicate where they experience what kind of “pain” on their fingers/hands
- Background:
  - 393 Subjects
  - 494 Hand Diagrams
- Expert raters assign values from 0 (unlikely) to 3 (classic), describing severity of CTS
- Interested in rating agreement among 3 expert raters


	RIGHT WRIST	LEFT WRIST	RIGHT HAND	LEFT HAND	RIGHT FINGERS	LEFT FINGERS
Burning/ Pain	○	○	○	○	○	○
Tightness/ Stiffness	○	○	○	○	○	○
Soreness/ Cramping/ Aching	○	○	○	○	○	○
Numbness/ Tingling	○	○	○	○	○	○

Please show on the diagram to the right where you have experienced numbness, tingling, burning, or pain by shading in the problem area.

If you have not experienced these symptoms, please skip to the next question.



# Live Demo

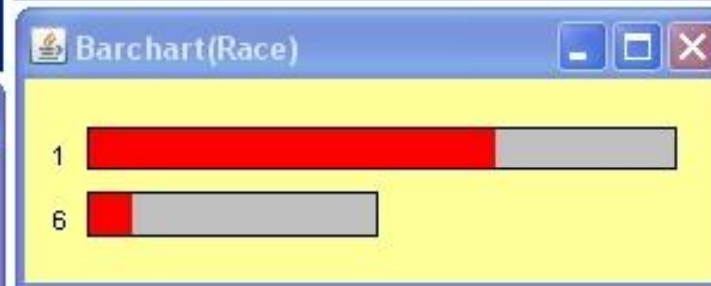
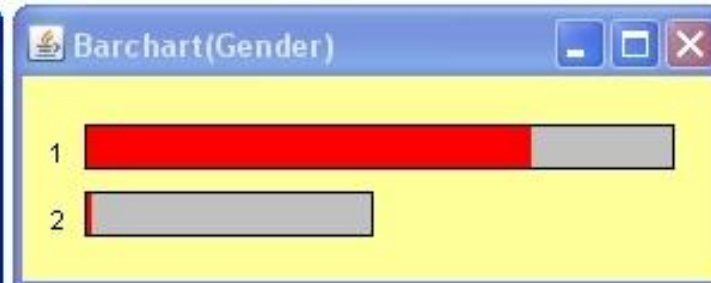
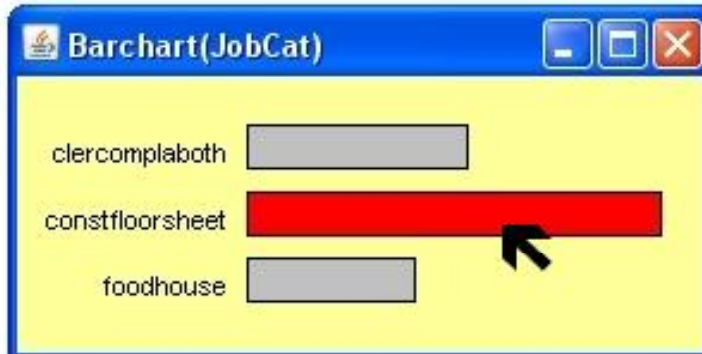
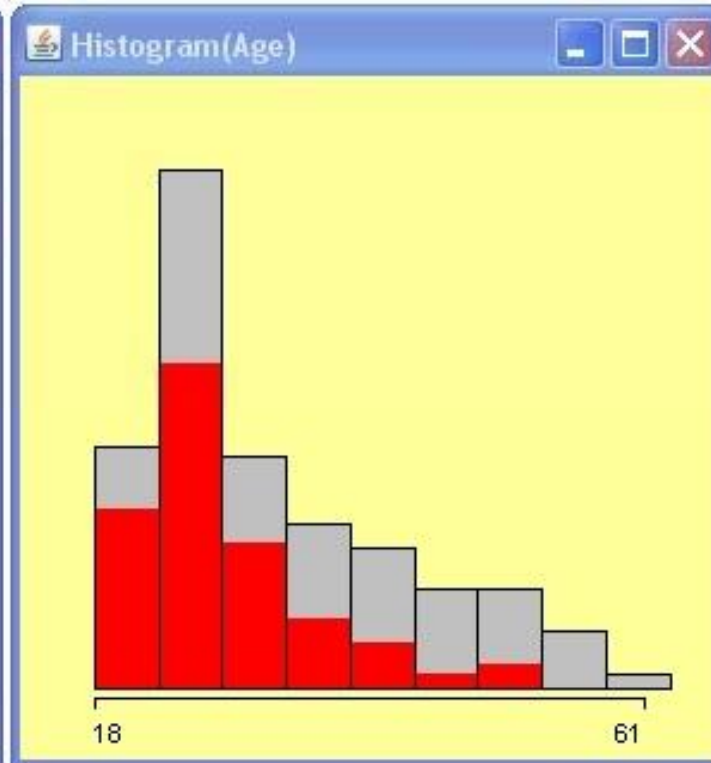
-  Mondrian
- <http://www.rosuda.org/Mondrian/>
- Visualization of categorical and geographic data
- Main Developer: Martin Theus

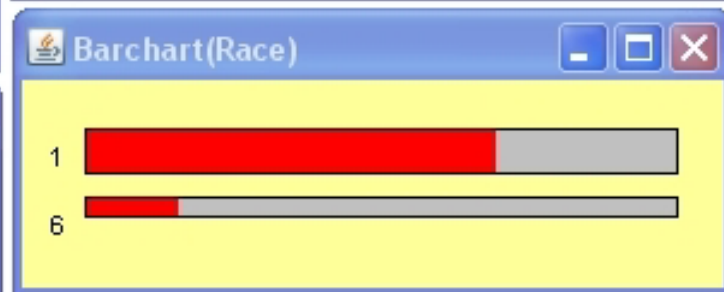
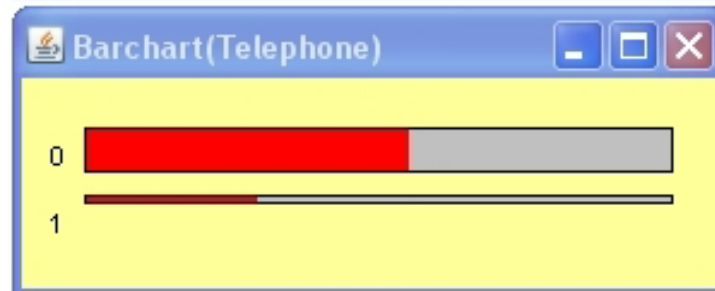
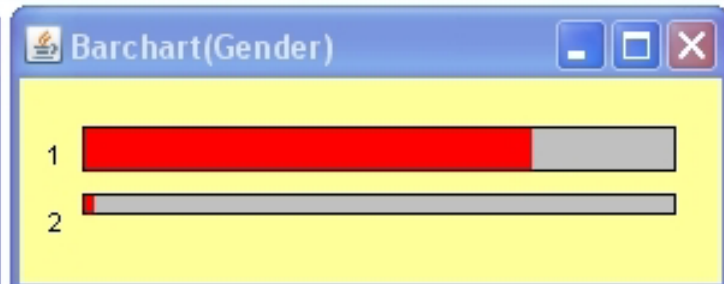
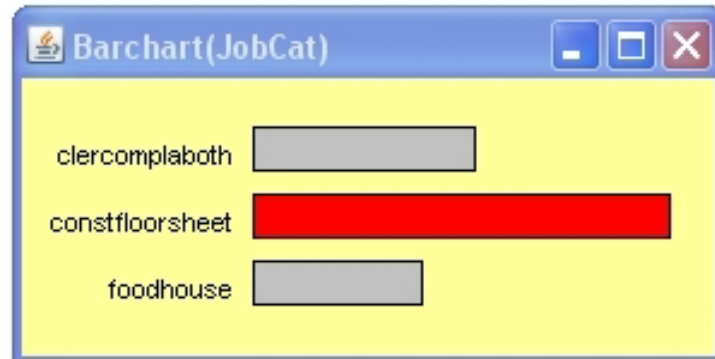
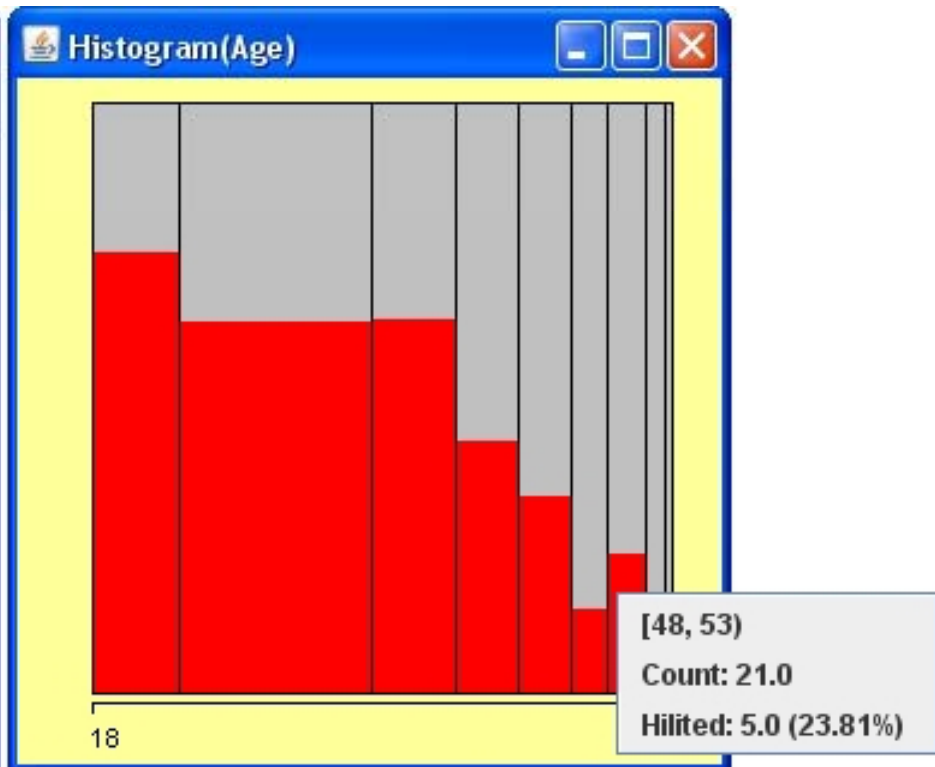
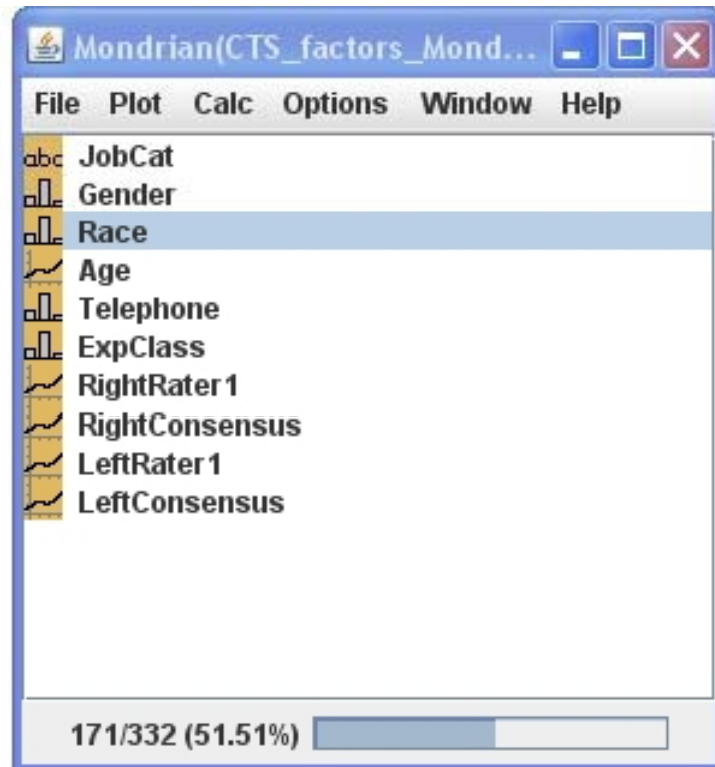
Mondrian(CTS\_factors\_Mond...)

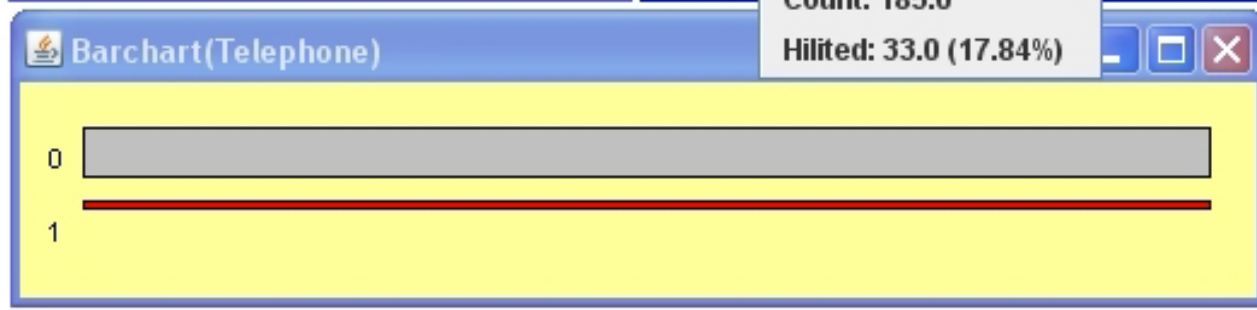
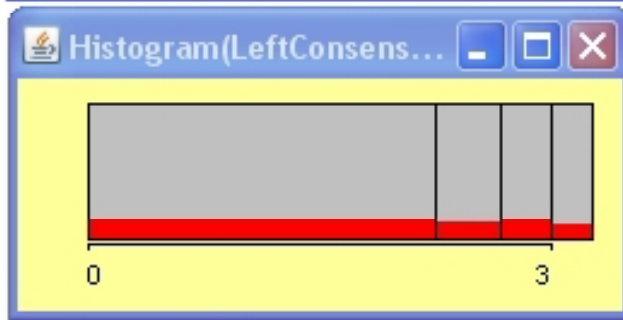
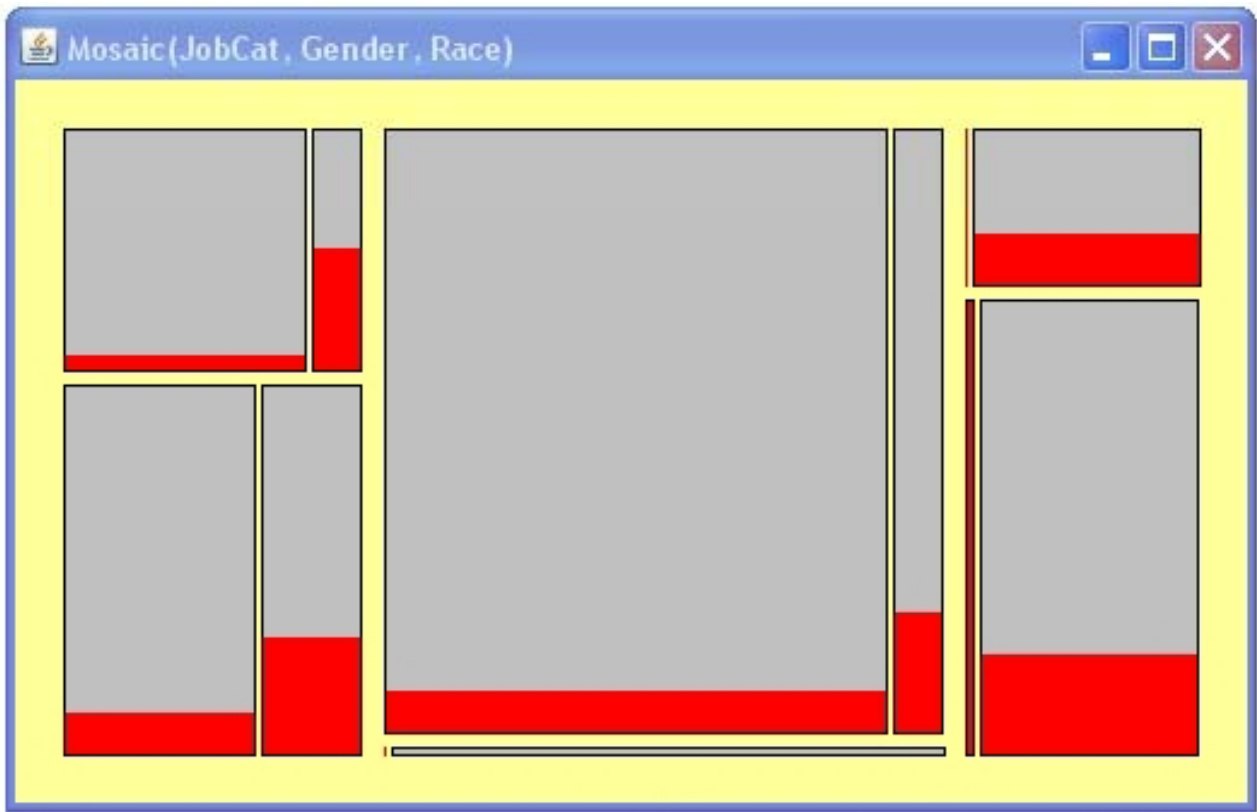
File Plot Calc Options Window Help

- abc JobCat
- Gender
- Race
- Age
- Telephone
- ExpClass
- RightRater1
- RightConsensus
- LeftRater1
- LeftConsensus

171/332 (51.51%)





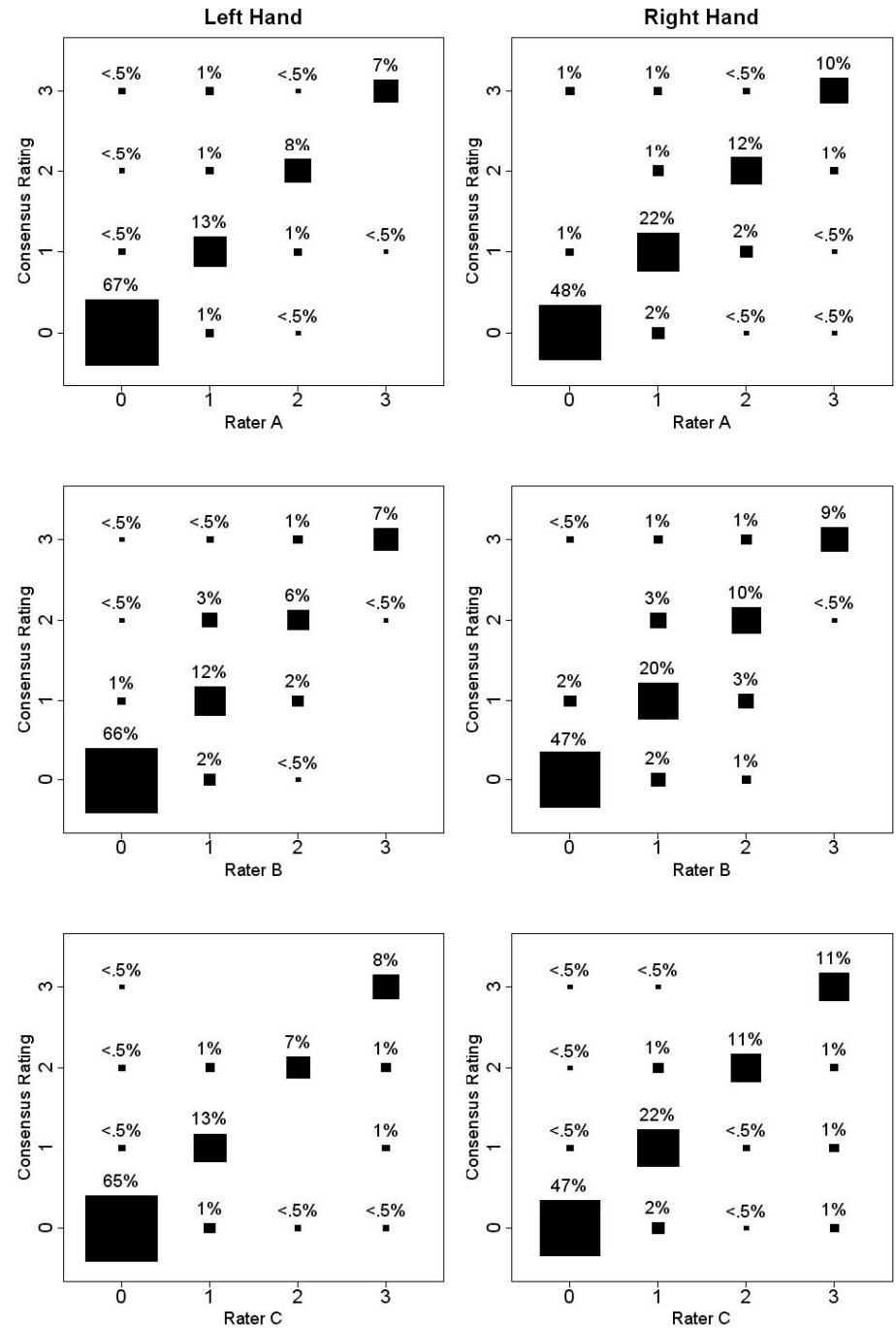


# Numerical Results (1)

- Weighted “kappa” represents agreement between three experts, based on difference between how much agreement is present compared to how much agreement would be expected by chance alone (possible range is -1.0 to 1.0)
- Interpretation:
  - $< 0$  : Less than chance agreement
  - 0.01 – 0.20: Slight agreement
  - 0.21 – 0.40: Fair agreement
  - 0.41 – 0.60: Moderate agreement
  - 0.61 – 0.80: Substantial agreement
  - 0.81 – 0.99: Almost perfect agreement
- Observed Results:
  - Left Hand Diagrams: 0.88 (95% CI: 0.83, 0.91)
  - Right Hand Diagrams: 0.83 (95% CI: 0.78, 0.87)

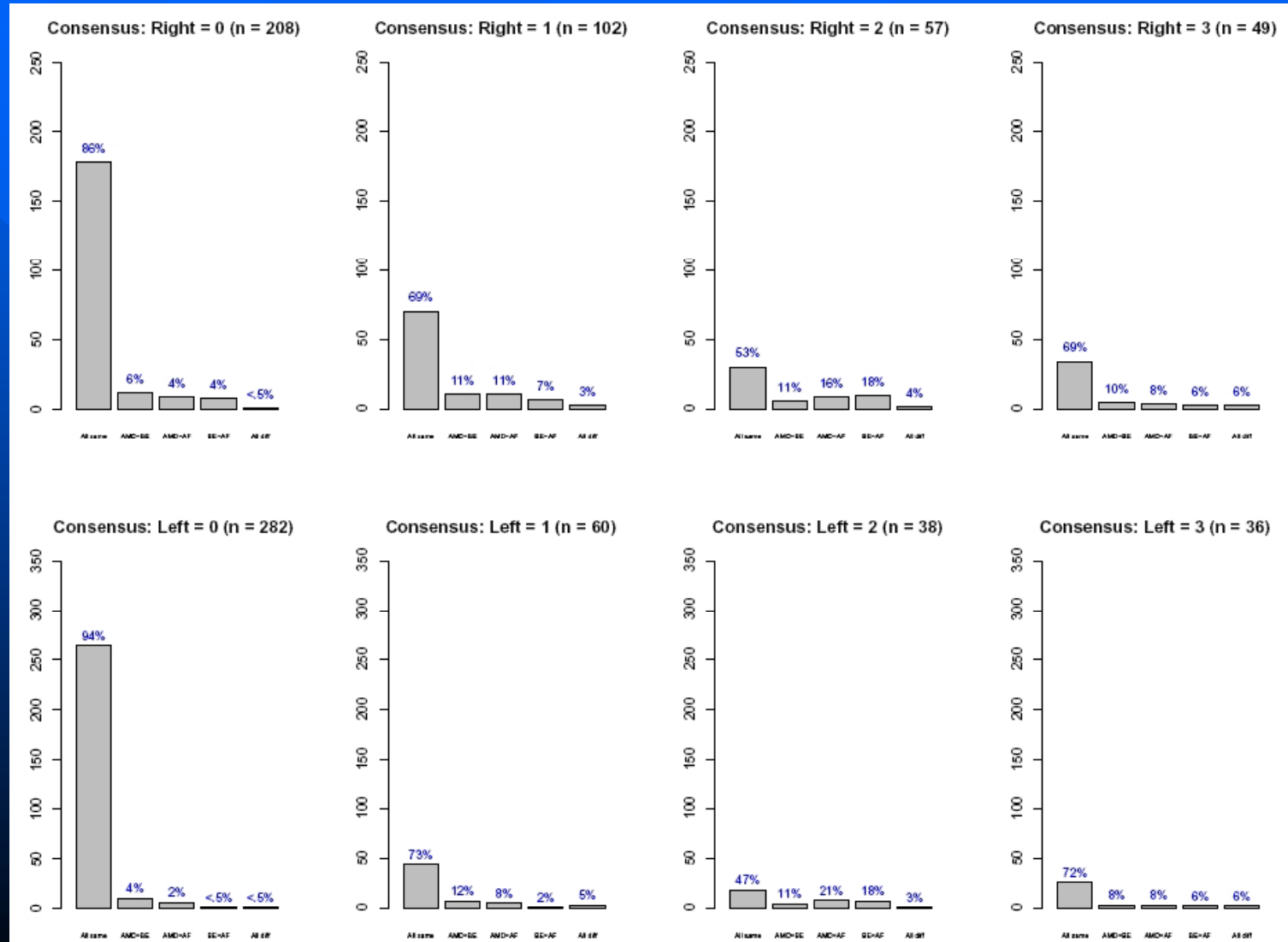
# Graphical Results (1)

- Comparison of Rating Consensus Scores of 3 Raters, Compared to the Raters' Individual Scores



# Graphical Results (2)

## Detailed Comparison of Raters' Individual Scores



- **Example:**

## **Micromaps for Oral Clefts and West Nile Virus**

- **References:**

**Symanzik, J., Gebreab, S., Gillies, R. Wilson, J. (2003): Visualizing the Spread of West Nile Virus, 2003 Proceedings, American Statistical Association, Alexandria, Virginia, CD .**

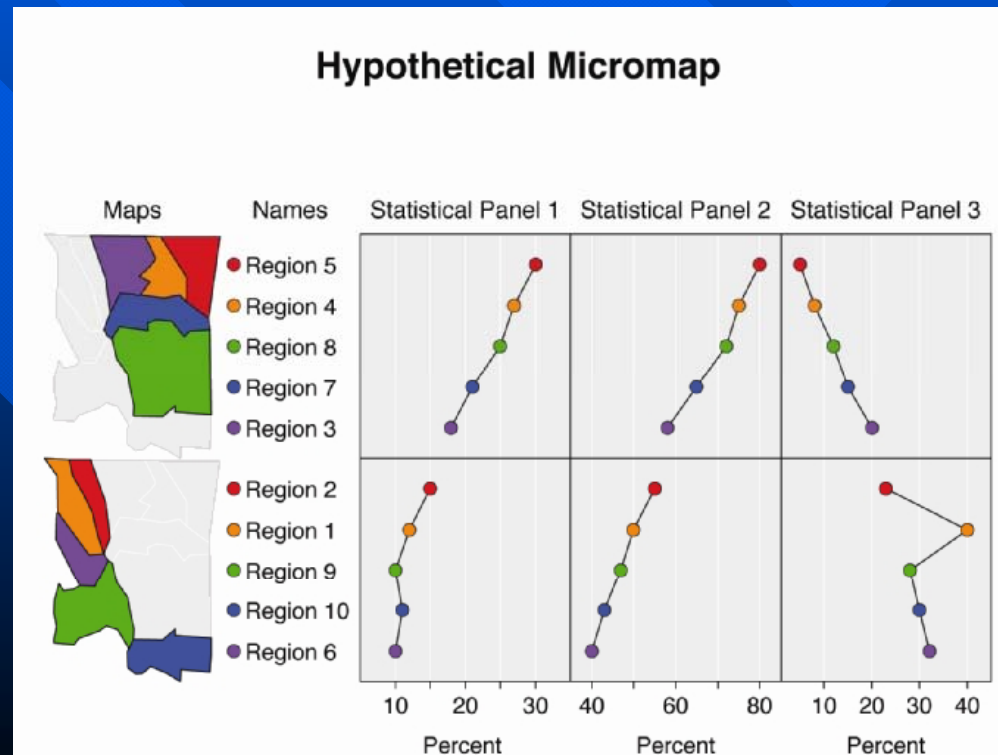
**Gebreab, S. Y., Gillies, R. R., Munger, R. G., Symanzik, J. (2008): Visualization and Interpretation of Birth Defects Data Using Linked Micromap Plots, *Birth Defects Research (Part A): Clinical and Molecular Teratology*, Vol. 82, 110-119.**

**Symanzik, J., Carr, D. B. (2008): Interactive Linked Micromap Plots for the Display of Geographically Referenced Statistical Data, In: Chen, C., Härdle, W., Unwin, A. (Eds.), *Handbook of Data Visualization*, Springer, Berlin/Heidelberg, 267-294.**

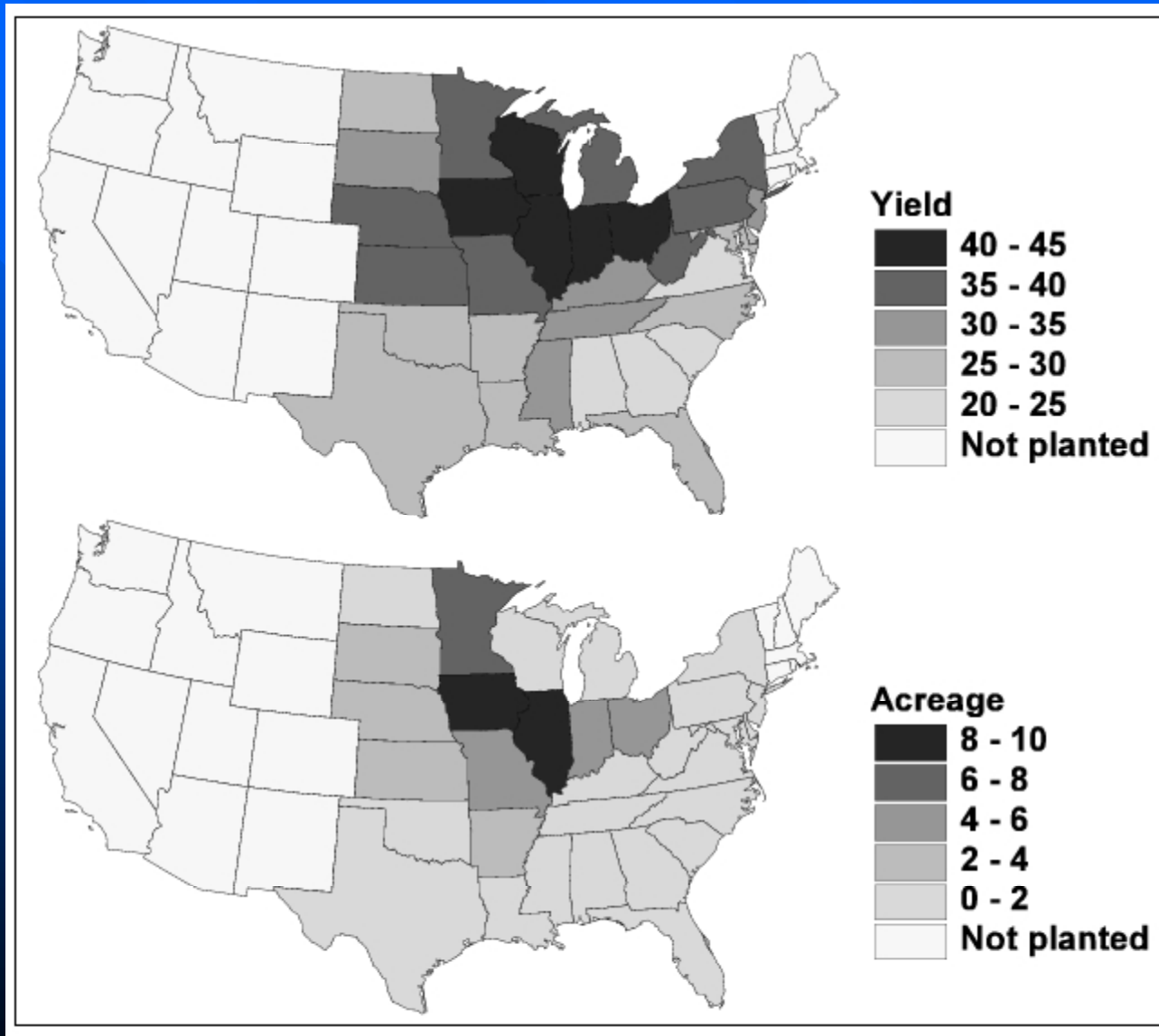
- **Funding Sources: NIDCR 1-R01 HD39061 and others**

# Micromaps

- Link of row-labeled univariate (or multivariate) statistical summaries to corresponding geographical region
- Focus on statistical display and not on maps
- Useful for
  - environmental data
  - agricultural data
  - medical data
  - economical data

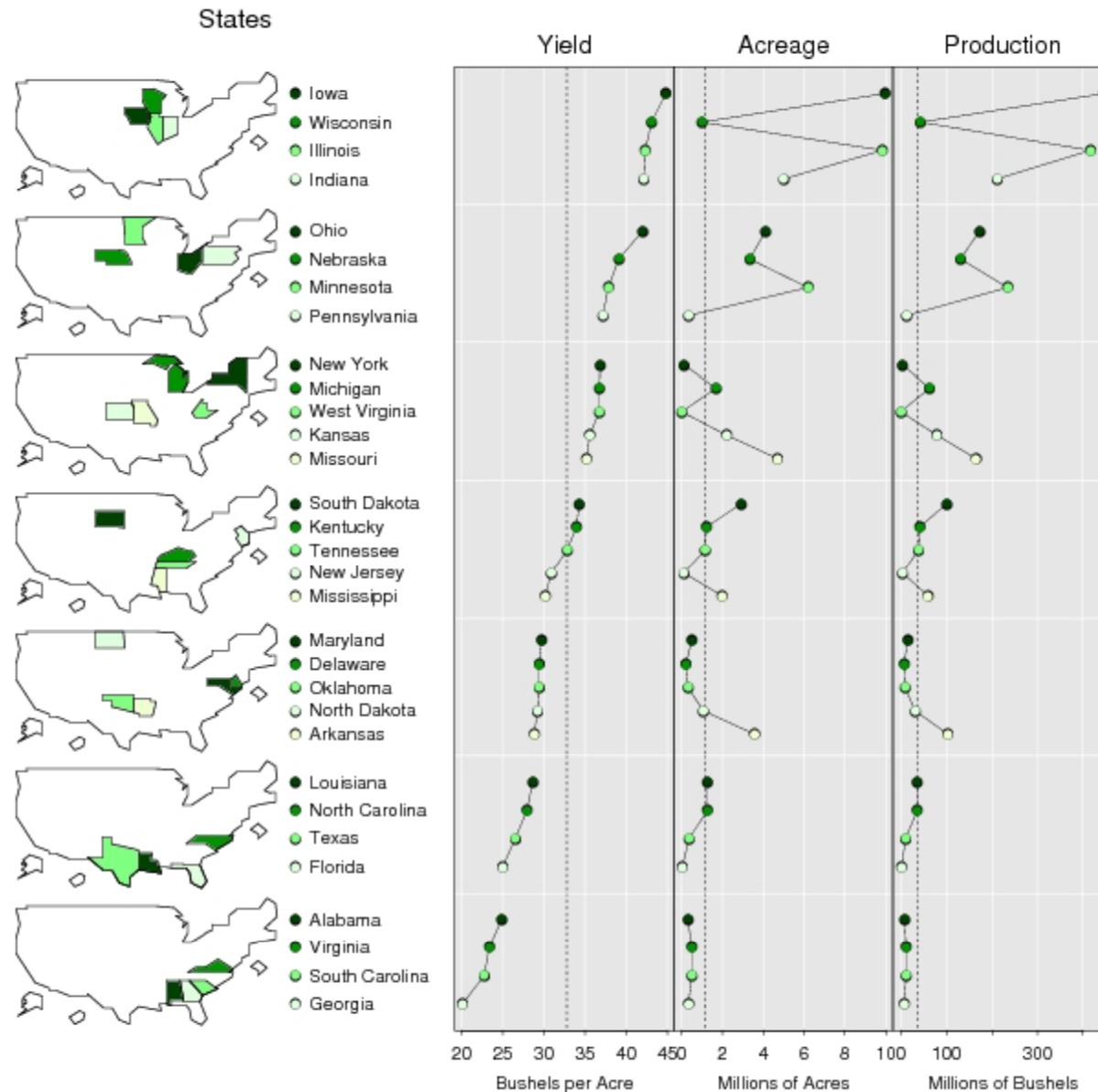


# Choropleth Maps vs Micromaps (1)



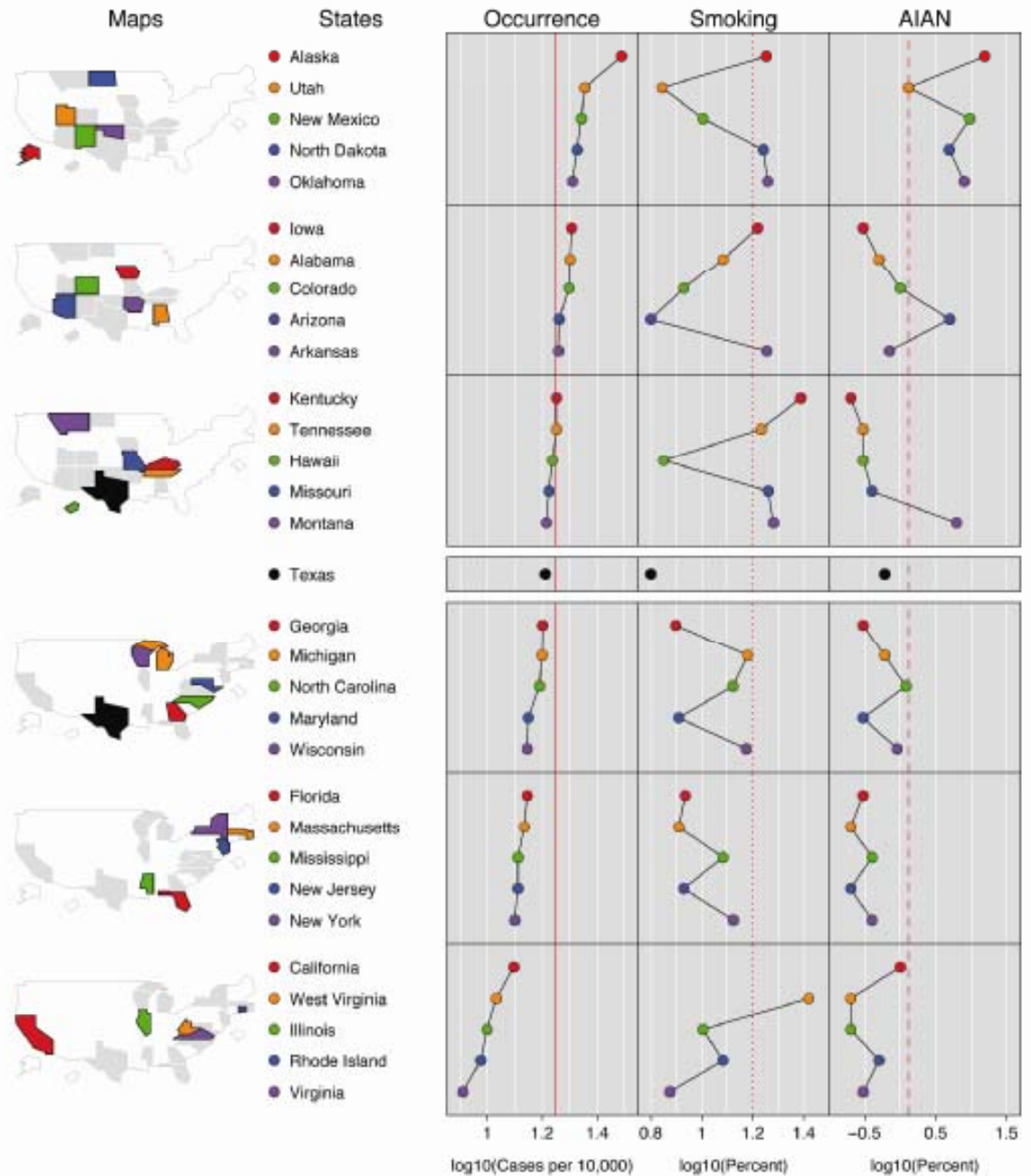
# Choropleth Maps vs Micromaps (2)

Soybean Statistics by State, 1997 Census of Agriculture



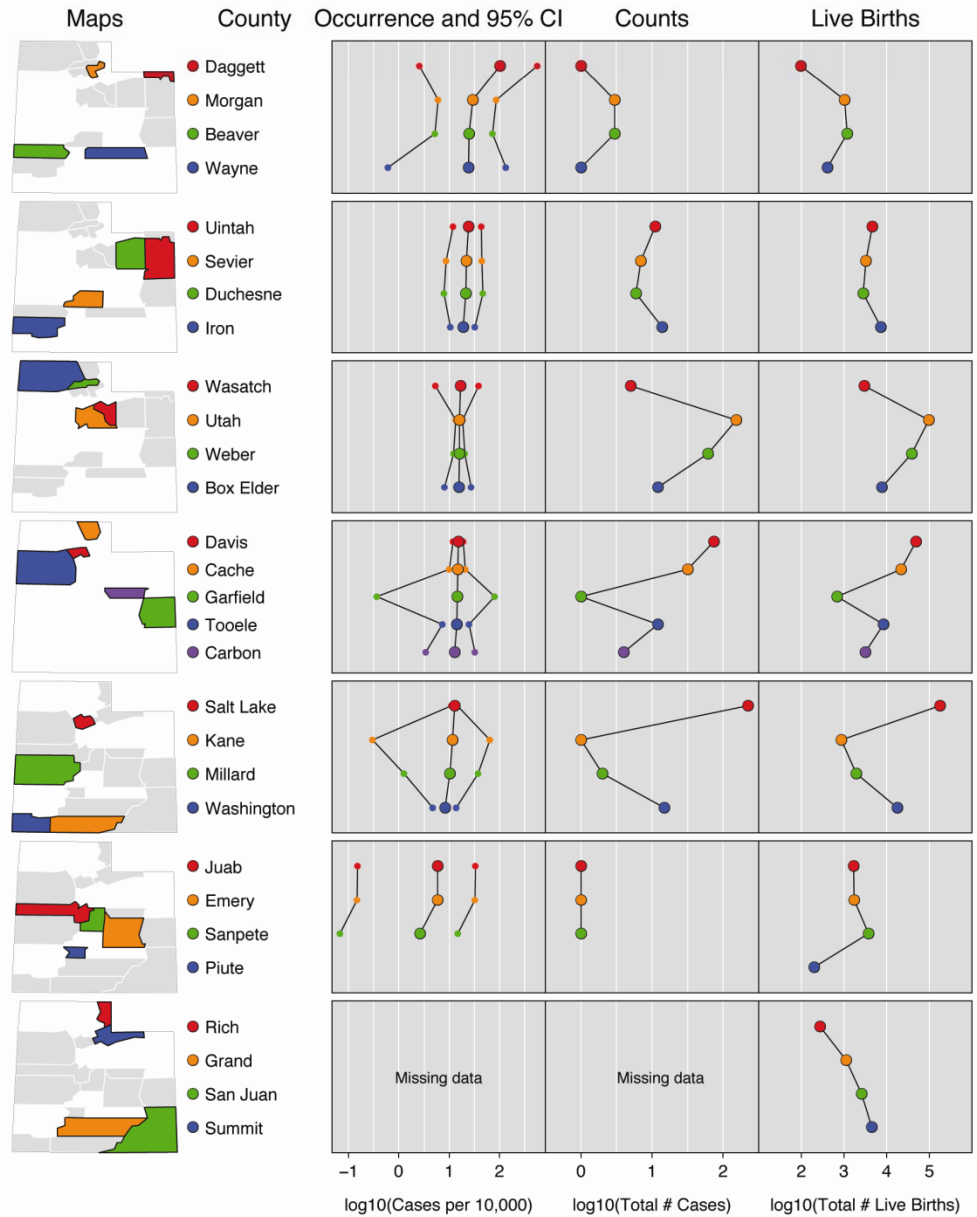
# Oral Cleft Micromap Example: USA

## Oral Cleft Occurrence by State 1998–2002



# Oral Cleft Micromap Example: Utah

## Oral Cleft Occurrence by County for the State of Utah 1995–2004

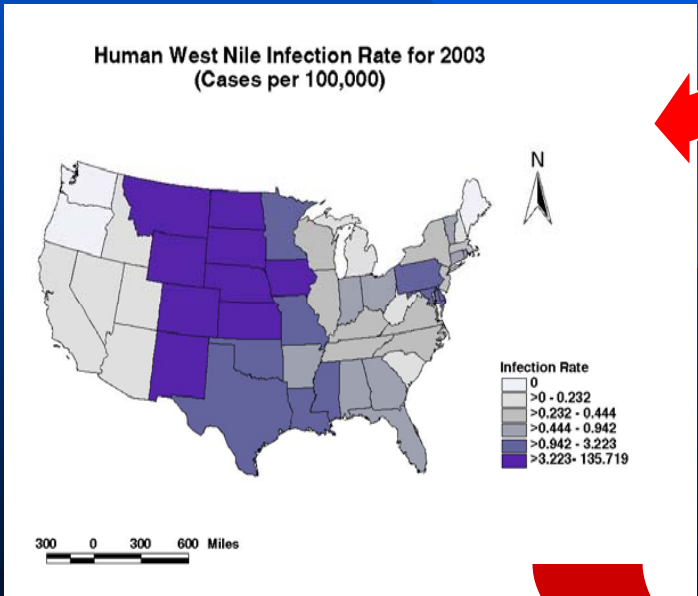
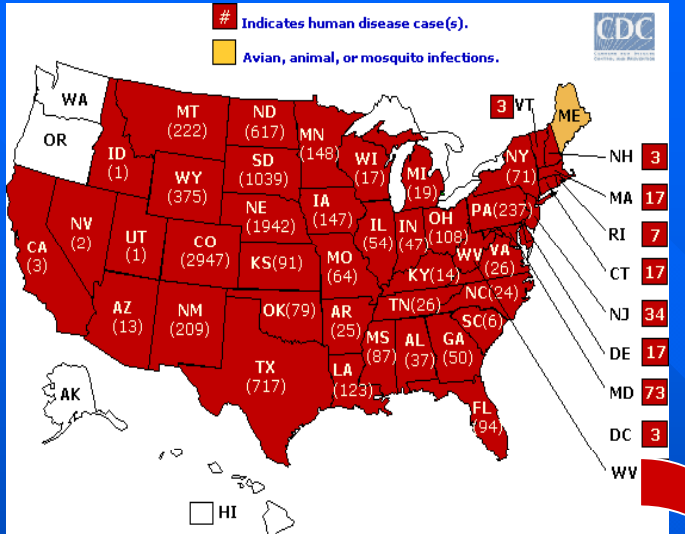


## West Nile Virus (WNV) ???

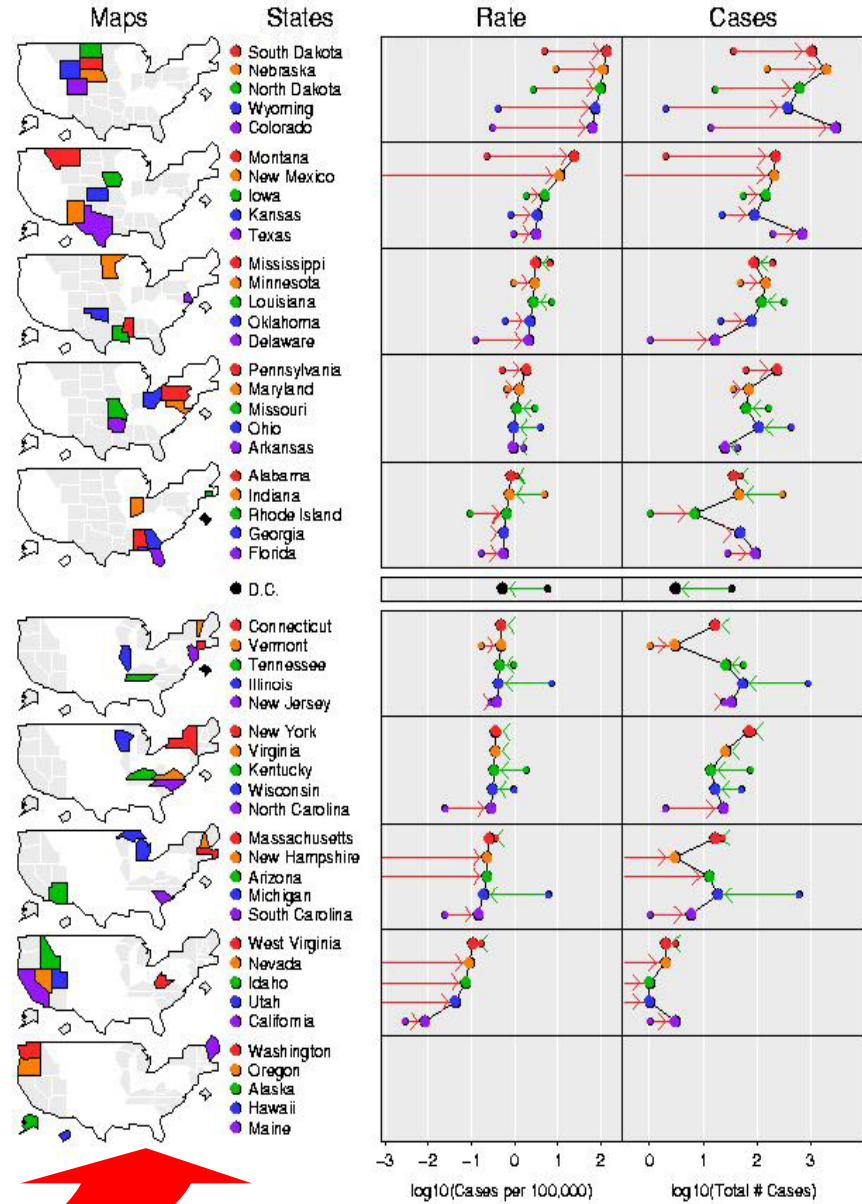
- Introduced to the US in 1999
- Spread across North America in 5 years
- Initial event - Culex mosquito transmits virus within avian populations
- Bridging Aedes albopictus transmits virus from birds to animals and humans



# From 2003 CDC



## West Nile Virus 2003 Lab-Positive Human Cases



WEST NILE VIRUS MICROMAPS - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address <http://webcat.gis.usu.edu:8080/index.html>

Search Web Mail My Yahoo! Games Yahoo! Personals LAUNCH Sign In

**Left Column Data**

Area: US - state level

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Rate

Year: 2002

Sex: Both Sexes

**Right Column Data (optional)**

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Count

Year: 2002

Sex: Both Sexes

Draw Clear

Overview

Options ?

State	Rank	Latest Annual Infection Rate Year 2002	Rank	Total Infections Per Year Year 2002
		Cases per 100,000		Count
	1=Lowest		1=Lowest	
Nebraska	51		43	
Louisiana	50		48	
Illinois	49		51	
Mississippi	48		45	
Michigan	47		50	
District of Columbia	46		30	
South Dakota	45		32	
Indiana	44		47	
Ohio	43		49	
Missouri	42		44	
North Dakota	41		22	
Iowa	40		38	
Kentucky	39		41	
Arkansas	38		33	
Alabama	37		36	
Tennessee	36		39	
Minnesota	35		35	
Wisconsin	34		37	
Texas	33		46	
Kansas	32		25	
Maryland	31		31	
Oklahoma	30		24	

Micromaps for sorted column

United States Internet

Start WEST NILE VIRUS ... 11:48 AM

■ <http://webcat.gis.usu.edu:8080/index.html>

## Overall Conclusions

- Visual approach effective to see unexpected structure in data
- Not every graphic will make it into a paper, but many of those that do not make it will provide useful insights for the researchers:
  - Graphics often help to create new hypotheses
  - Graphics useful to verify results
- Combination of different graphical techniques (static, interactive, various plots) most effective
- Graphics can be used for almost all types of data

*Questions ???*