An Object-Oriented Approach in R for the Visualization of Functional Actigraphy Data

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- Visualization of Functional Data
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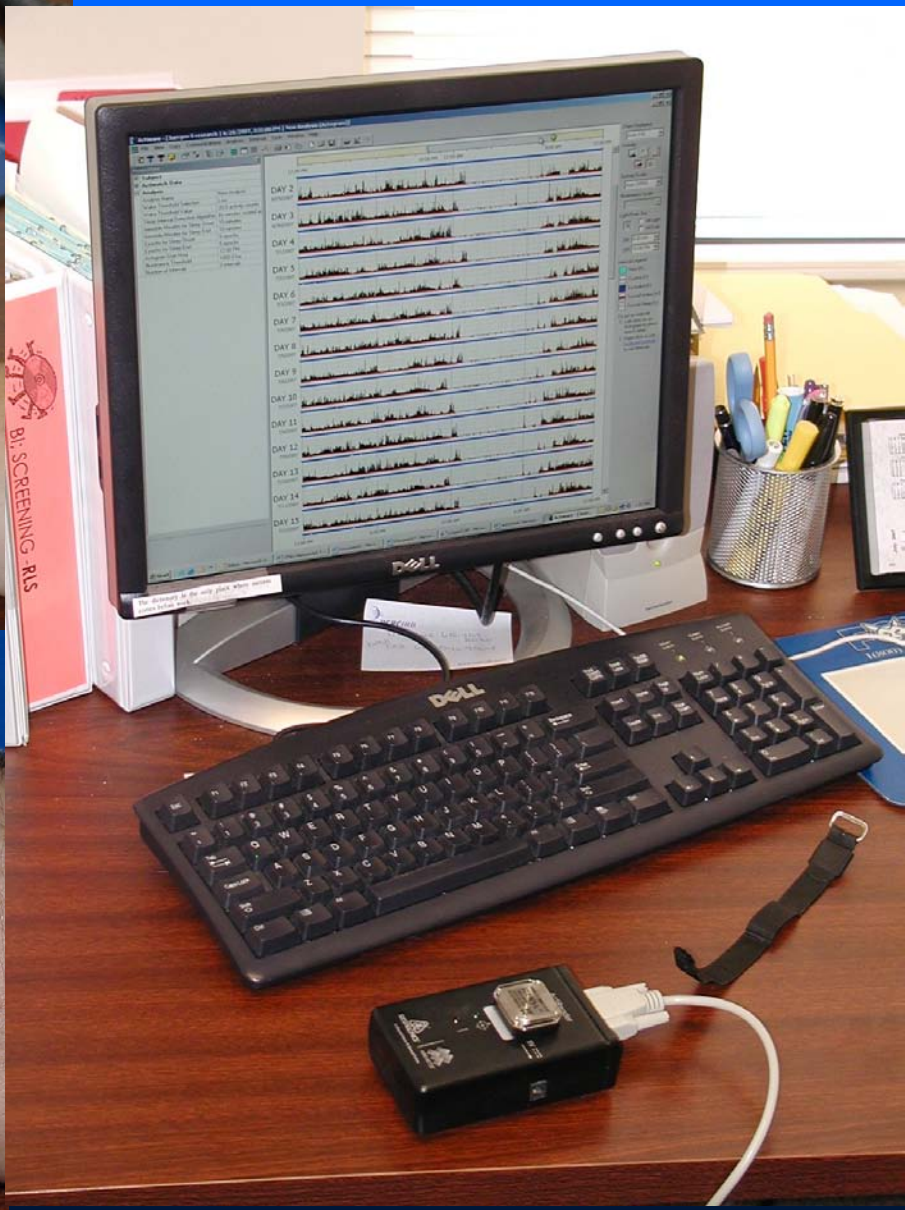
Background (1)

- 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 measures (human) movements (every minute or more often)


• Respiratory
• Accessibility
• Rehab
• Bronchodilators
• PMR


BI: SCREENING - RLS
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
DAY 7
DAY 8
DAY 9
DAY 10
DAY 11
DAY 12
DAY 13
DAY 14
DAY 15
DELL

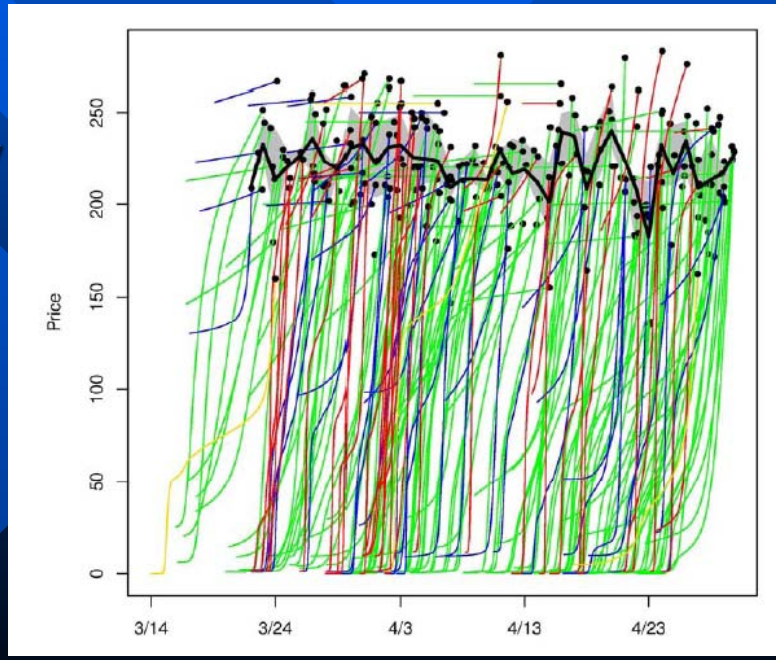

Actiwatch

Background (2)

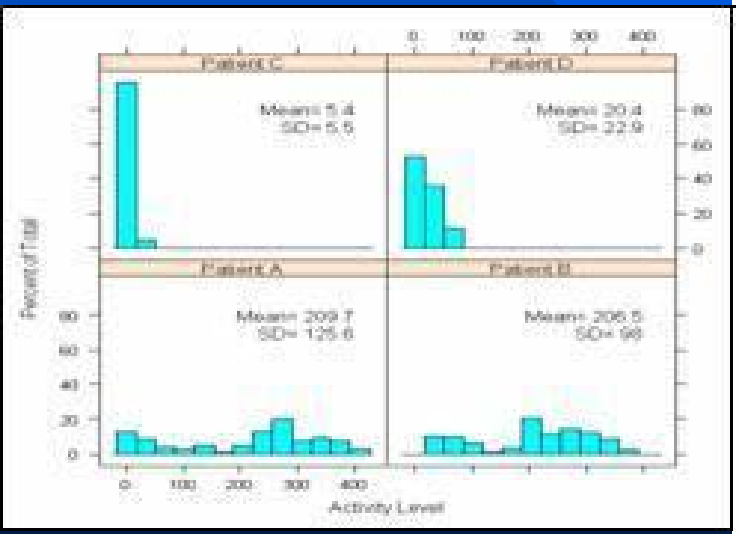
- Analysis of Human Actigraphy Data: Useful for detecting sleep, for assessing insomnia and restless leg syndrome, for tracking recovery after heart attacks, and as an assessment tool for overall status of HIV patients
- Actigraphy Data can be best described as functional data

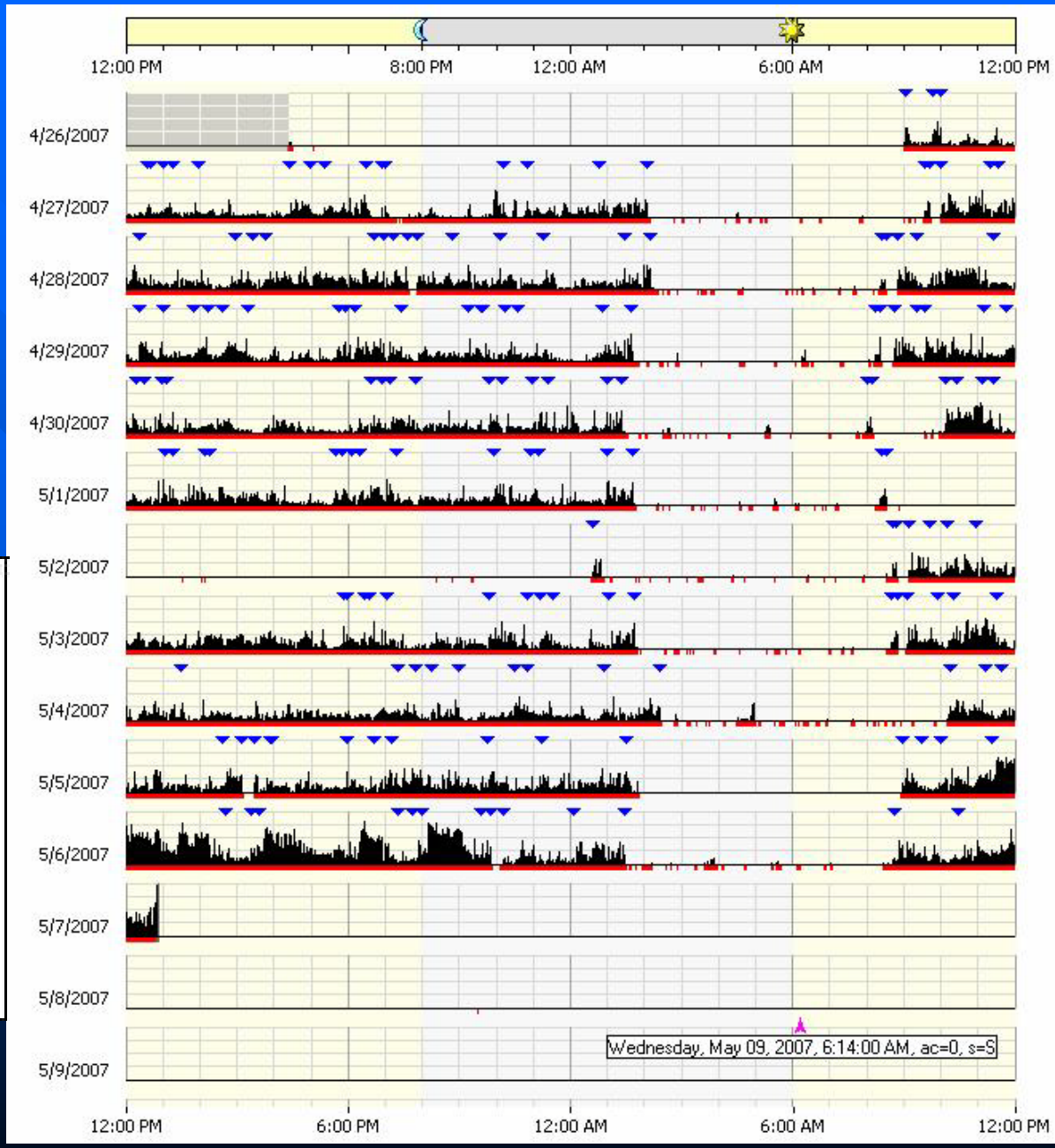
Visualization of Functional Data

- 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).



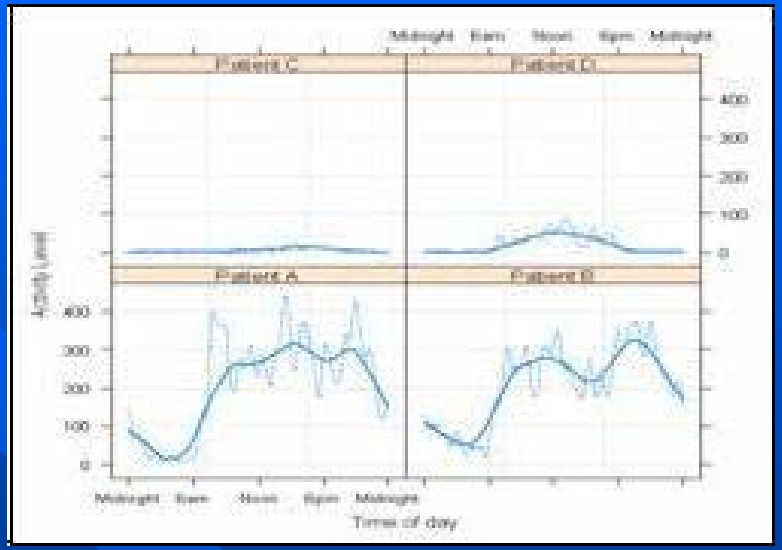
Current Visualization of Actigraphy Data





New Visualization of Actigraphy Data

- Plots:
  - Raw data
  - Smoothed data
  - Averages etc.
  - Velocity (First Derivative)
  - Acceleration (Second Derivative)
  - Cumulative Sums
  - Sorted Cumulative Sums



- Interaction:
  - Linking & Brushing
  - Zooming & Focusing

Object-Oriented Approach

- "**Object-oriented programming** (**OOP**) is a programming paradigm that uses "objects" – data structures consisting of datafields and methods together with their interactions – to design applications and computer programs. […]

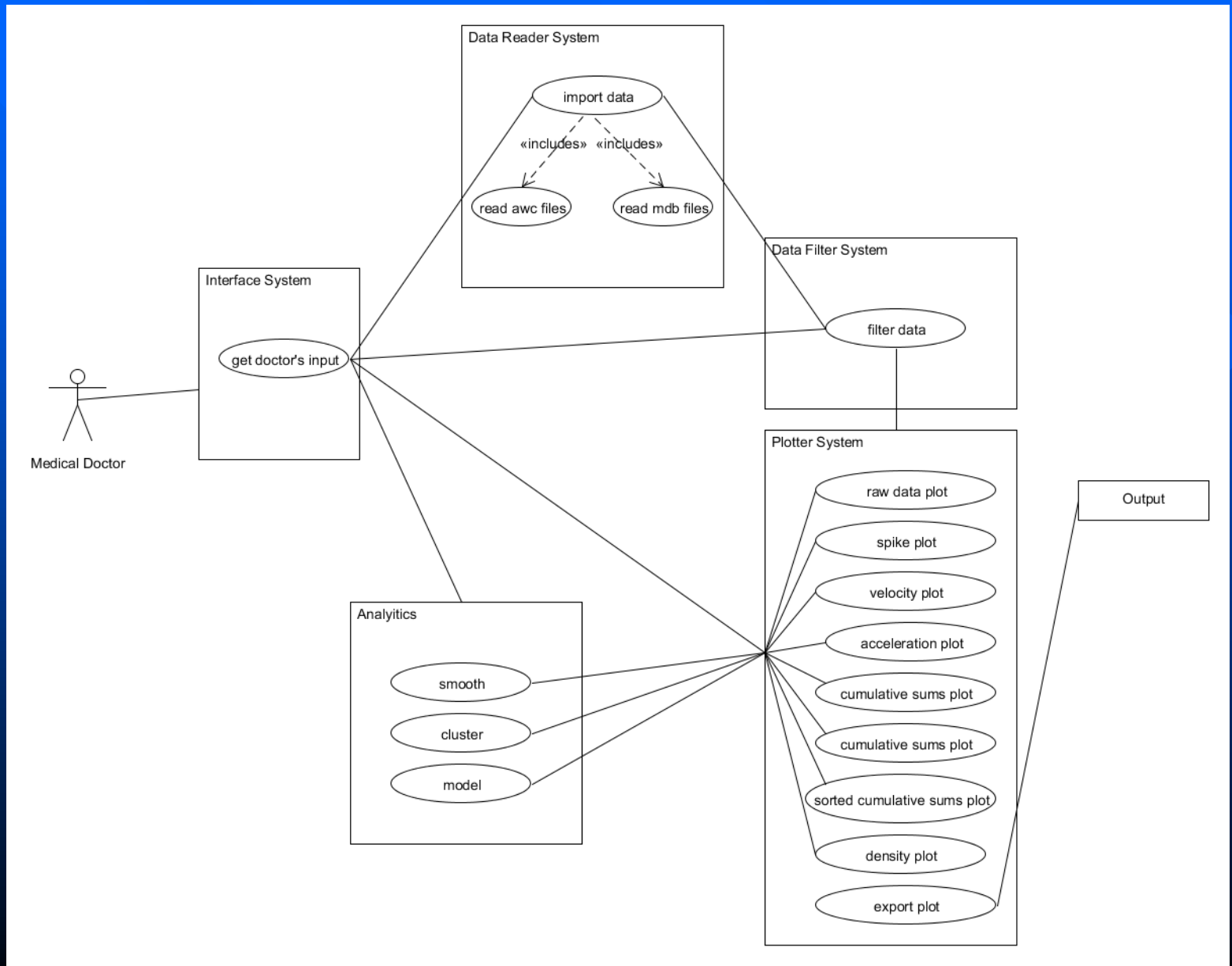
  An object is a discrete bundle of functions and procedures, often relating to a particular real-world concept such as a bank account holder or hockey player. Other pieces of software can access the object only by calling its functions and procedures that have been allowed to be called by outsiders. […]"

- From http://en.wikipedia.org/wiki/Object-oriented_programming

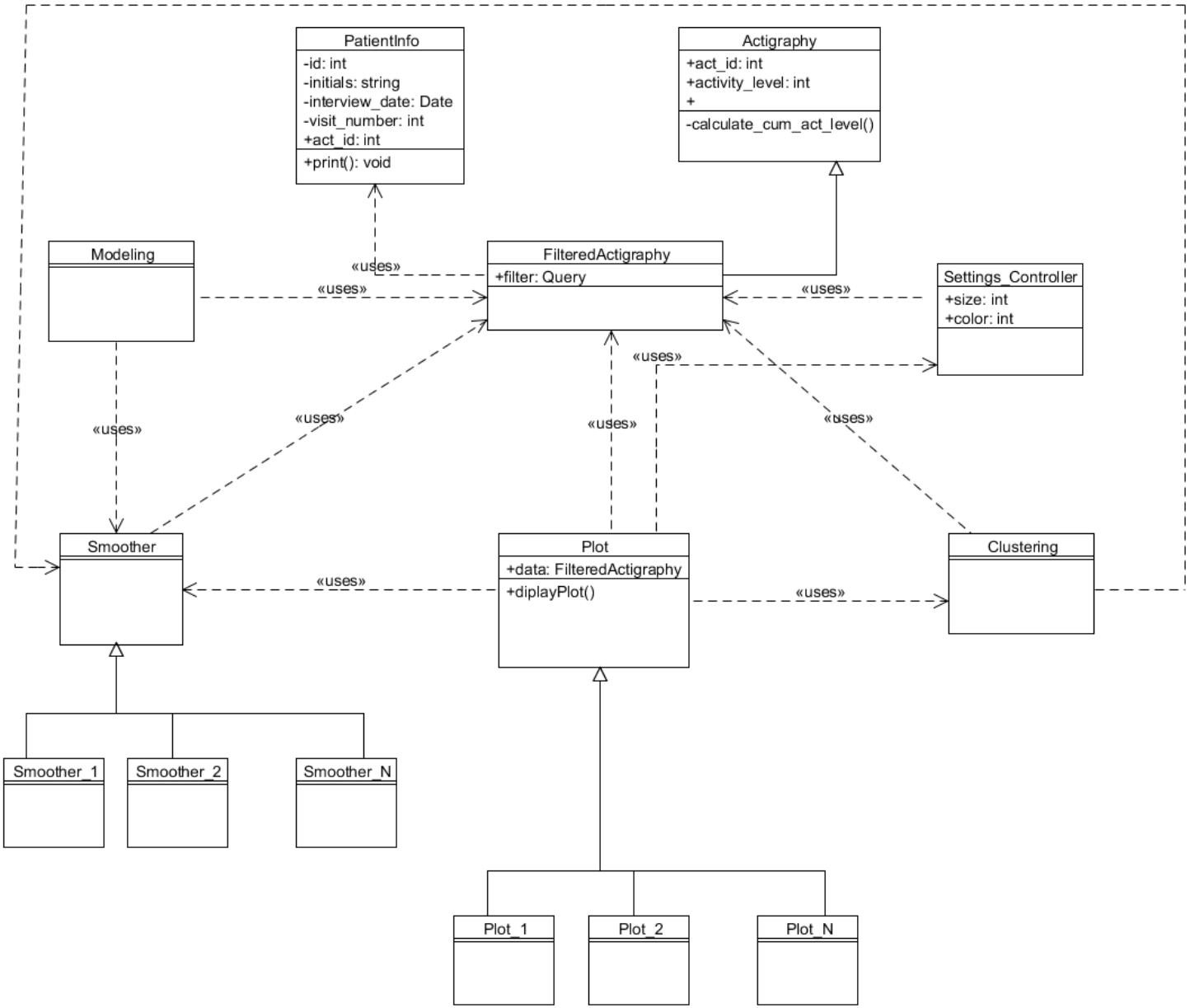
Object-Oriented Programming in R

- S3 System (via *UseMethod* function):
  - Available for a long time
  - Many restrictions
  - Widely used
- S4 System (via R package *methods*):
  - More sophisticated
  - Less computationally efficient
  - Less widely used
- Directly via R package *R.oo*:
  - Extends S3
  - Developed since 2002
  - Easy to use, more user friendly
  - Reference variables
  - Widely used

OOP for AVAD Software (Use Case Diagram)



OOP for AVAD Software (Class Diagram)



User Interfaces for AVAD Software

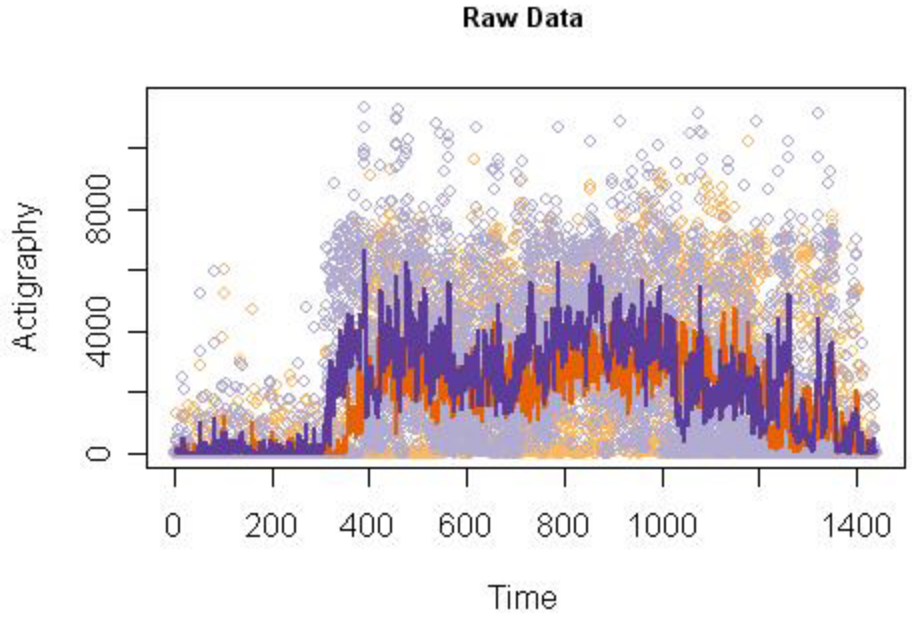
- Main users in the medical field
- Easy-to-use interfaces needed (users unlikely to learn R)
- Approaches via
  - Web interface (everyone knows how to operate a Web browser)
  - Rmcdr interface from within Excel (data collected with Excel)

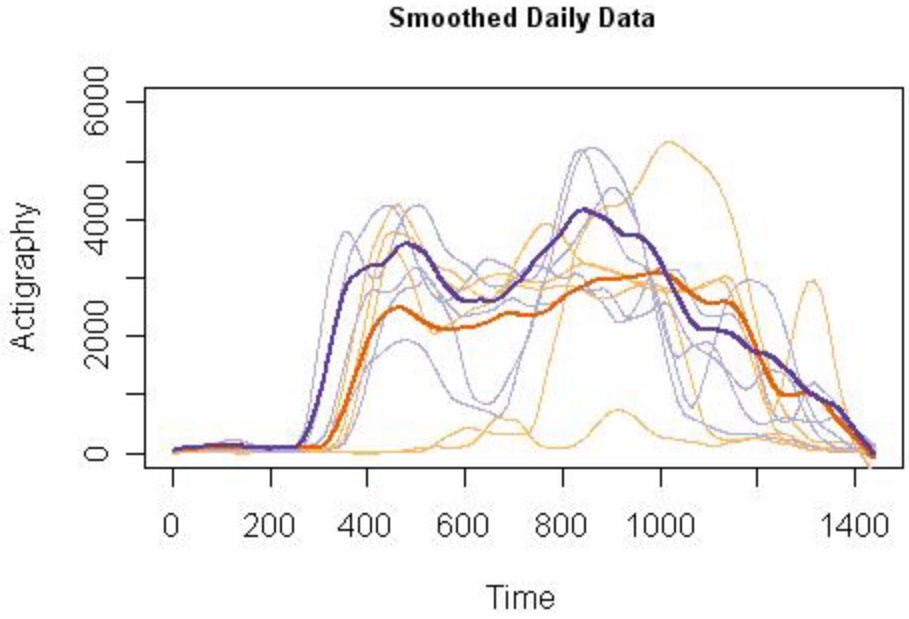
Live Demos (1)

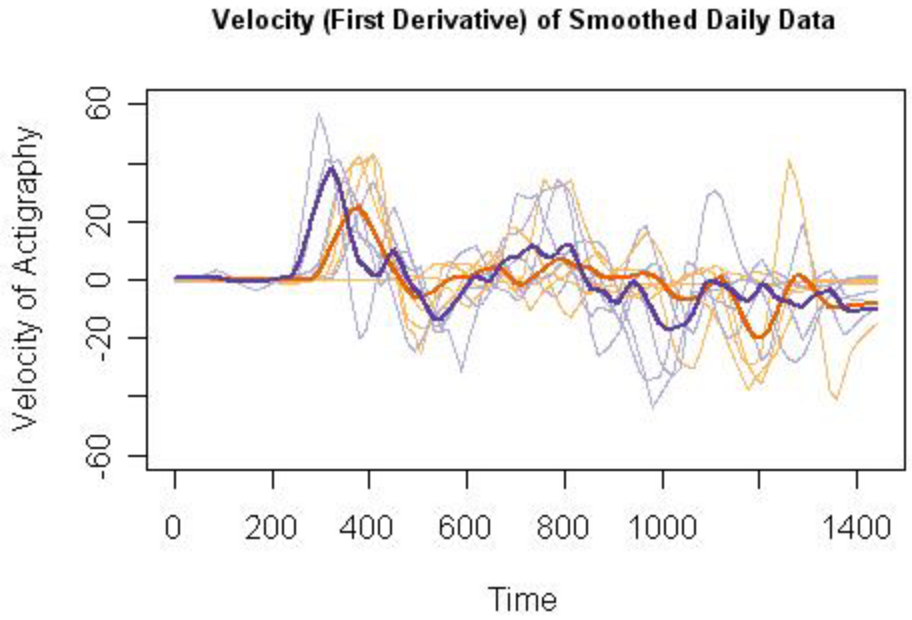
-  AVAD Software (Web Interface to R)

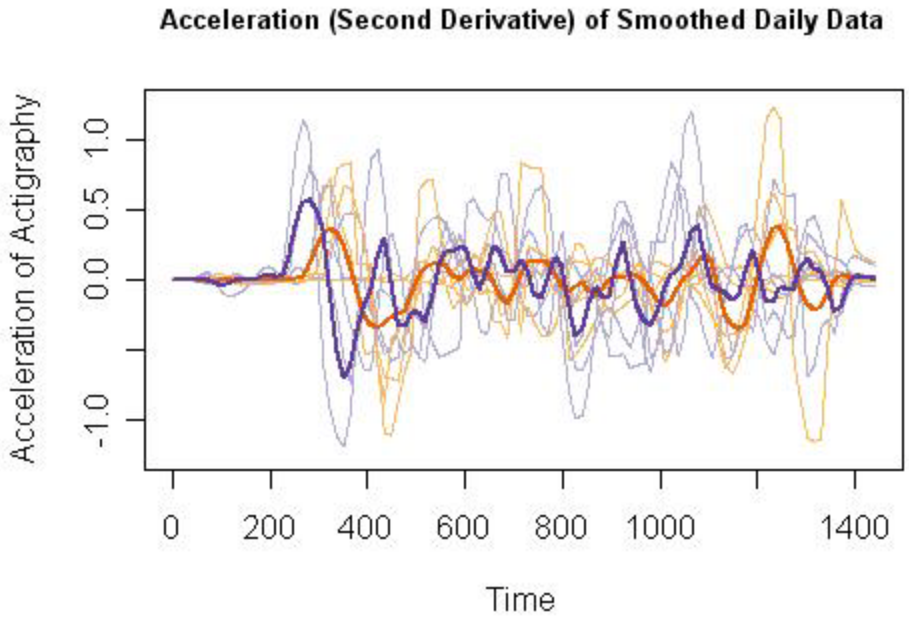
- Based on R package Rpad
- Operational up to R 2.9.2

- Example: 1 Subject
  - Orange: 5 Days at Baseline
  - Purple: 5 Days after 6 Months


Raw Data
Actigraphy
0
4000
8000
0
200
400
600
800
1000
1400
Time


Smoothed Daily Data
Actigraphy
0
2000
4000
6000
0
200
400
600
800
1000
1400
Time


Velocity (First Derivative) of Smoothed Daily Data
Velocity of Actigraphy
-60
-20
0
20
60
0
200
400
600
800
1000
1400
Time


Acceleration (Second Derivative) of Smoothed Daily Data
Acceleration of Actigraphy
-1.0
0.0
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1.0
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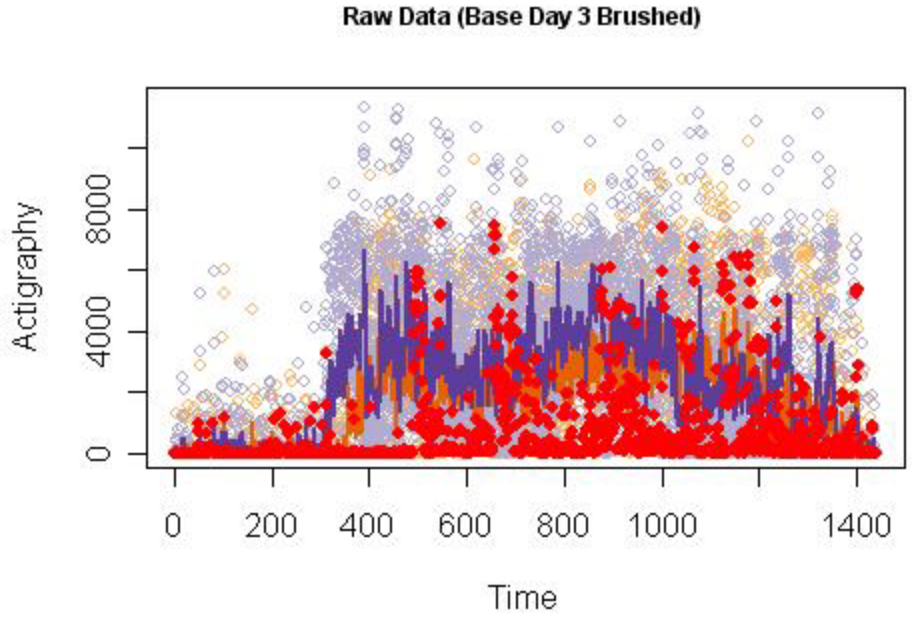
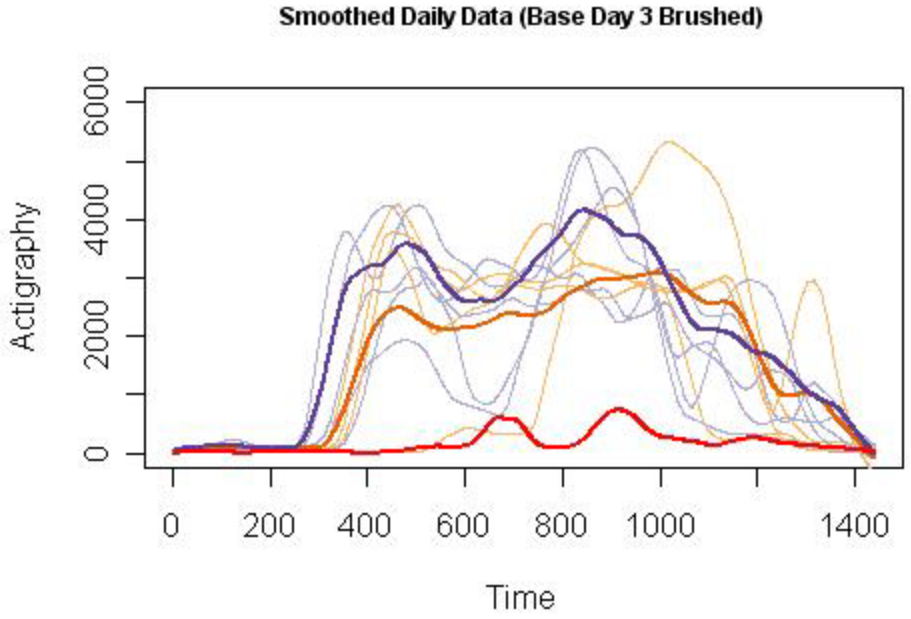
200
400
600
800
1000
1400
Time


Raw Data (Base Day 3 Brushed)
Actigraphy
0
4000
8000
0
200
400
600
800
1000
1400
Time


Smoothed Daily Data (Base Day 3 Brushed)
Actigraphy
0
2000
4000
6000
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200
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600
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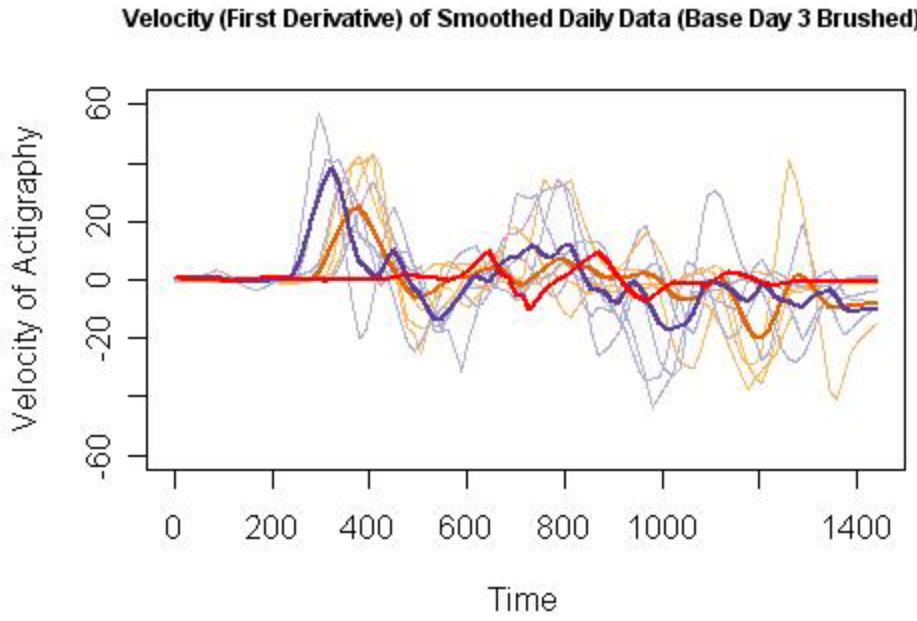
1400
Time


Velocity (First Derivative) of Smoothed Daily Data (Base Day 3 Brushed)
Velocity of Actigraphy
-60
-20
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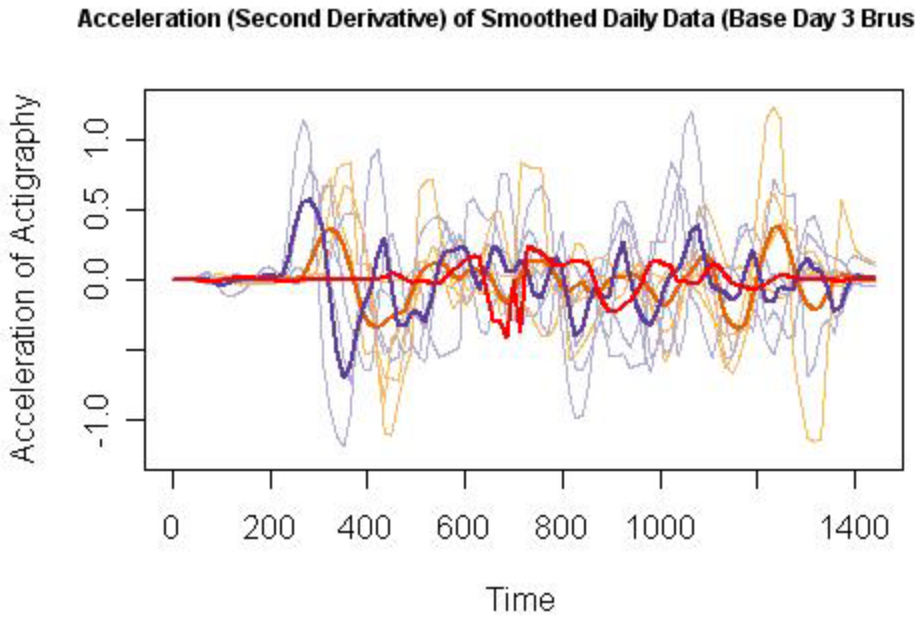
Time


Acceleration (Second Derivative) of Smoothed Daily Data (Base Day 3 Brushed)
Acceleration of Actigraphy
-1.0
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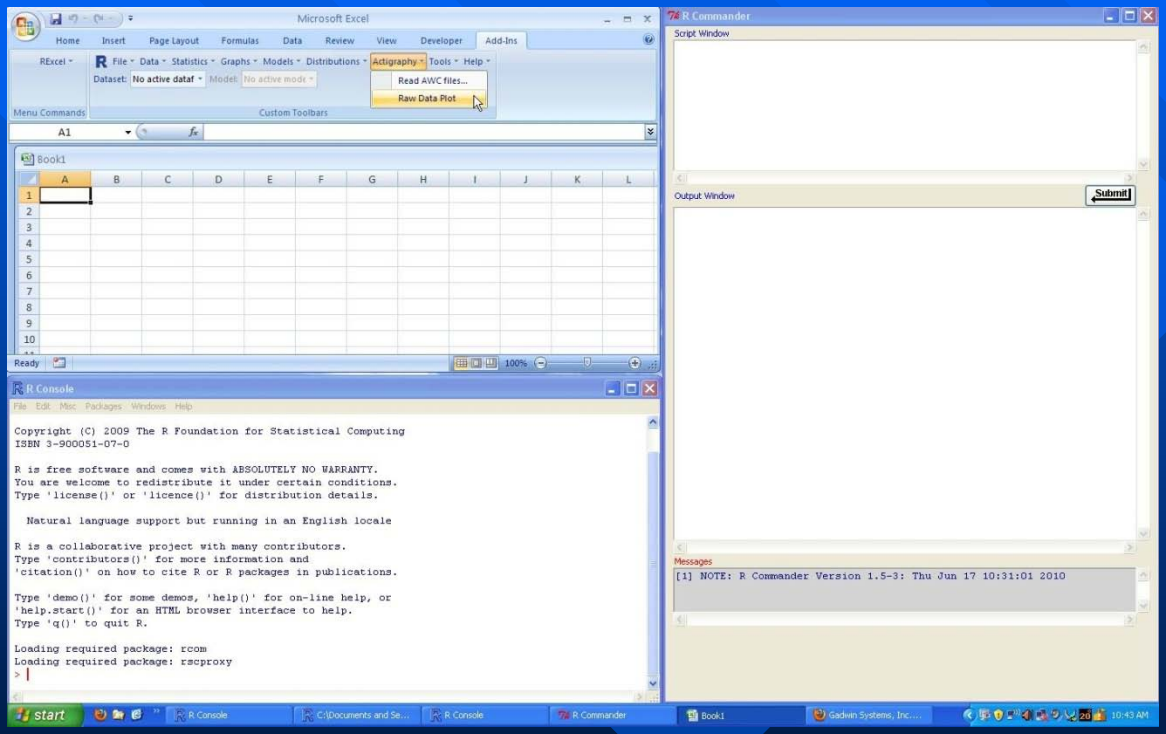
Time

Live Demos (2)

- Rcmdr Interface to R (through Excel)



- Utilizing Rcmdr GUI and package
- Functional on all recent R versions

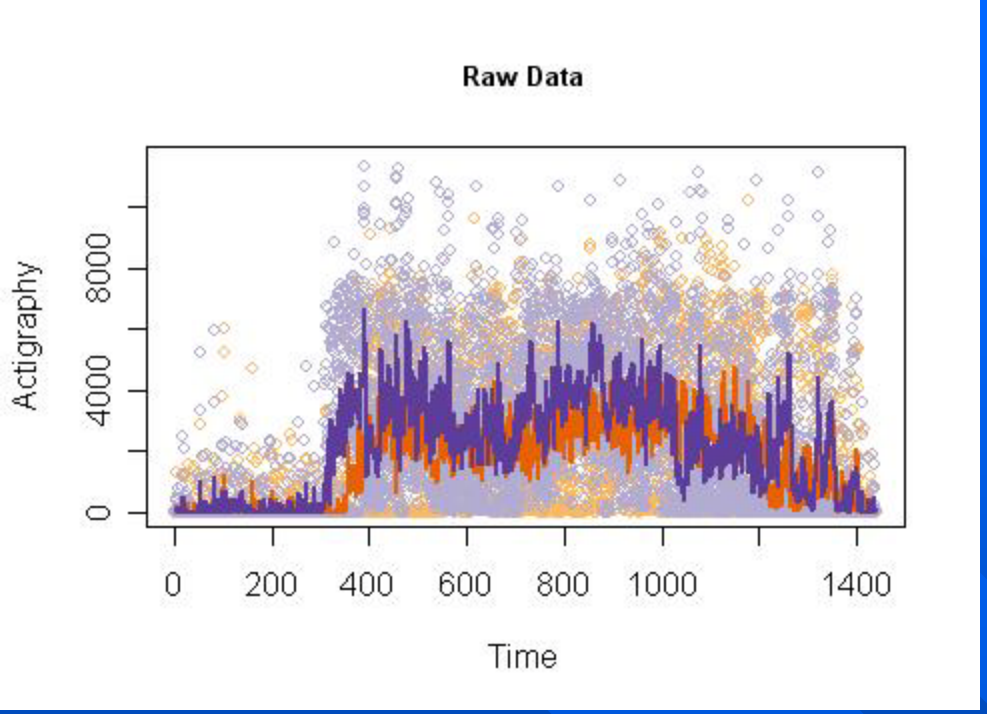
Conclusions

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

Questions ???

Backup Slides


Raw Data
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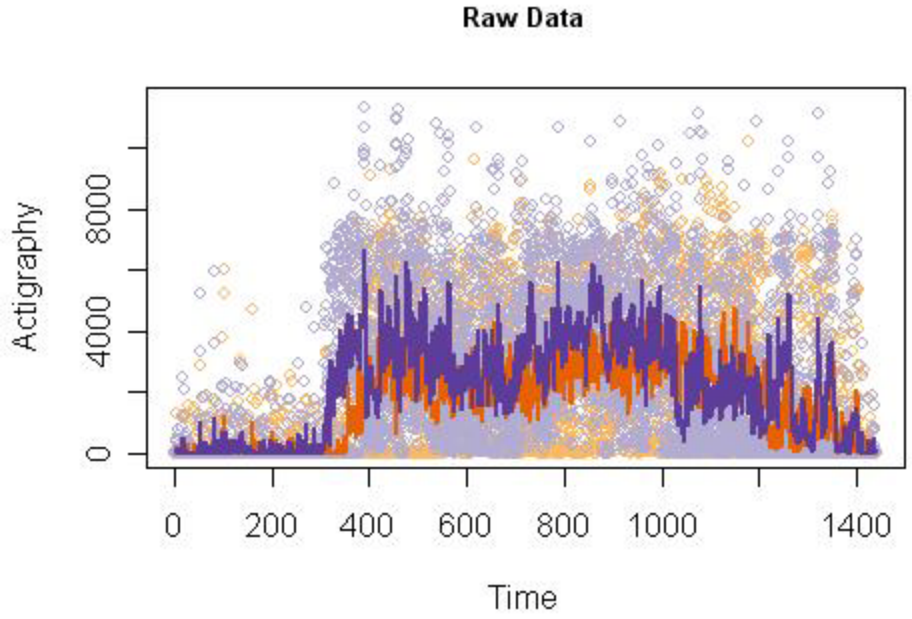
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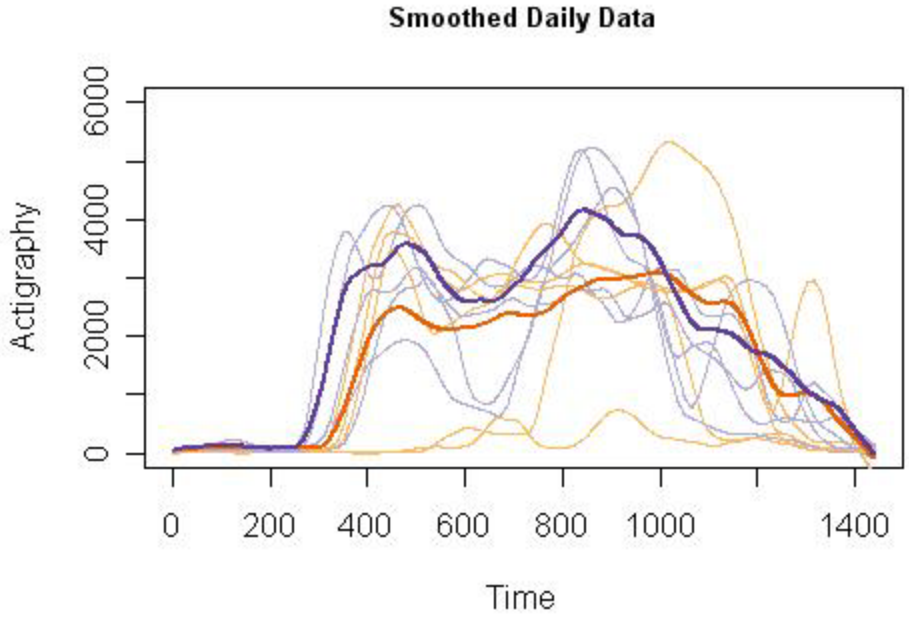
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Actigraphy
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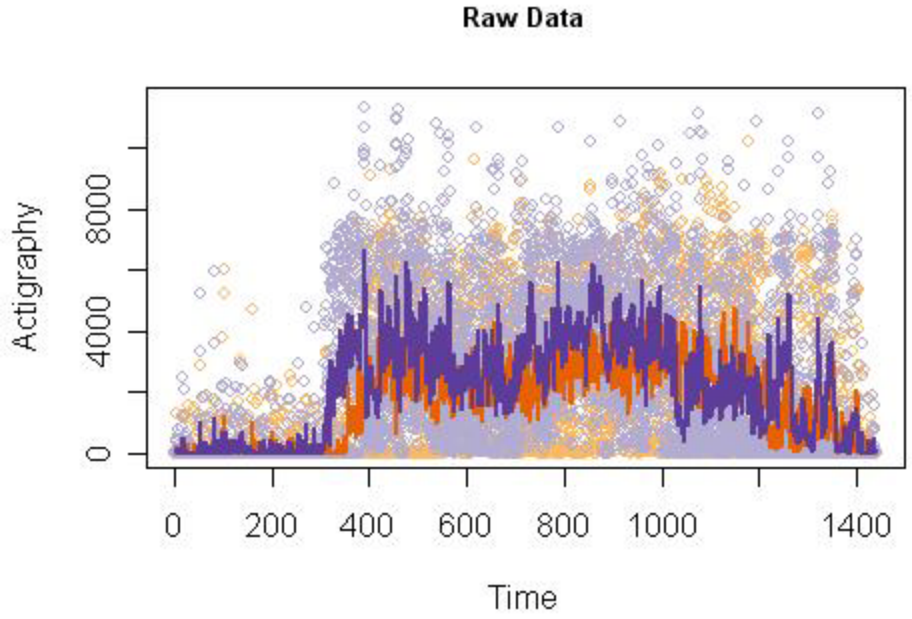
Time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Actigraphy
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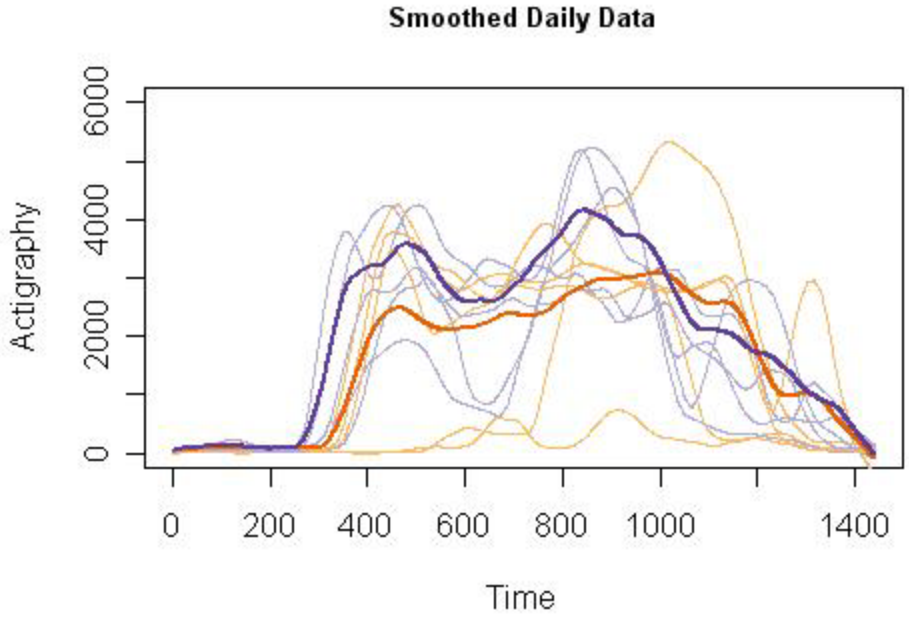
Time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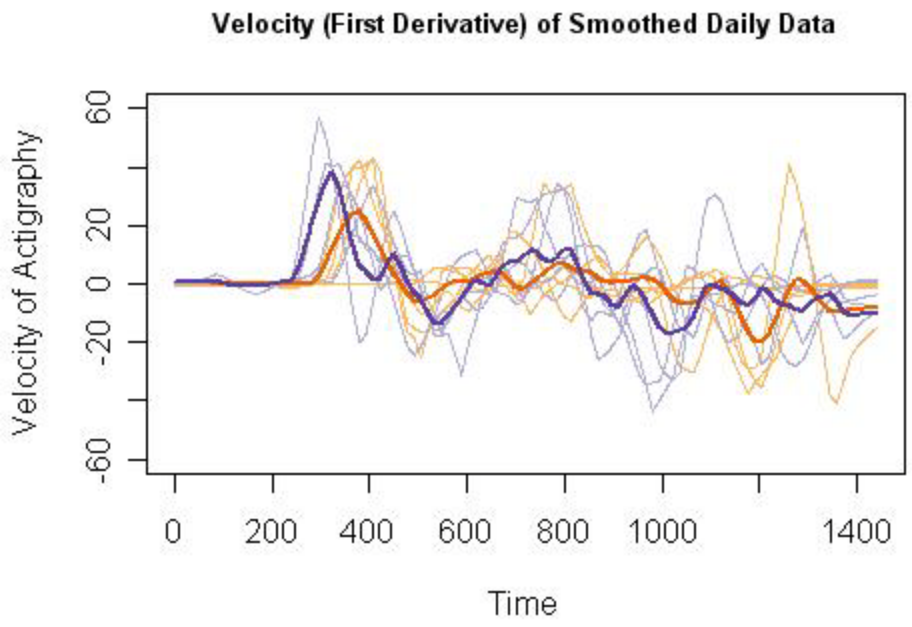
Time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Velocity of Actigraphy
-60
-20
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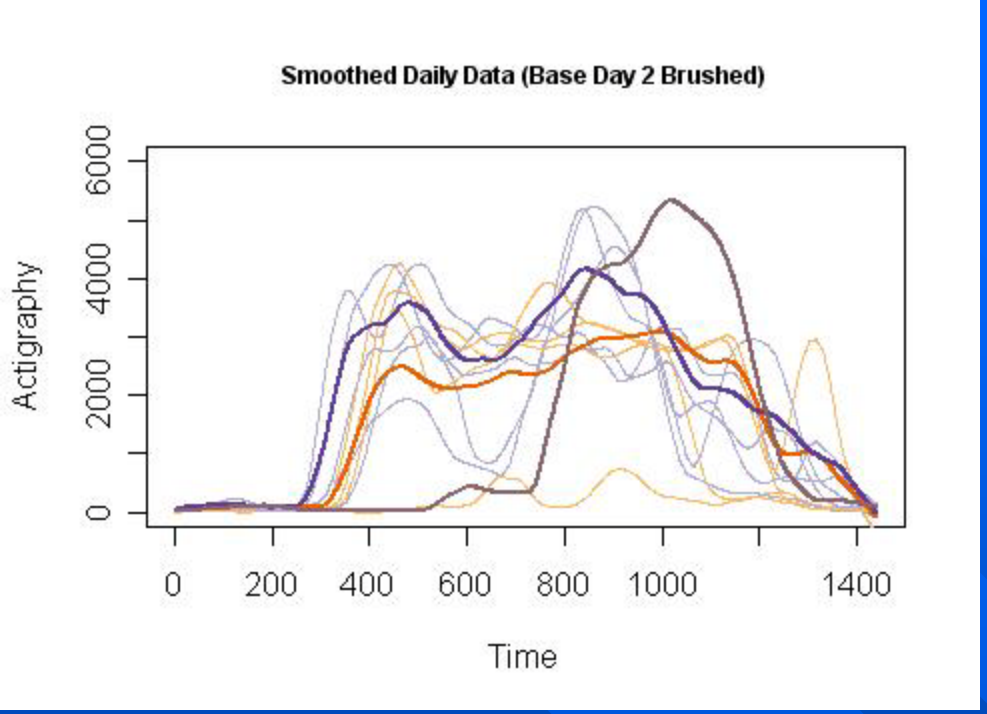
Time


Smoothed Daily Data (Base Day 2 Brushed)
Actigraphy
0
2000
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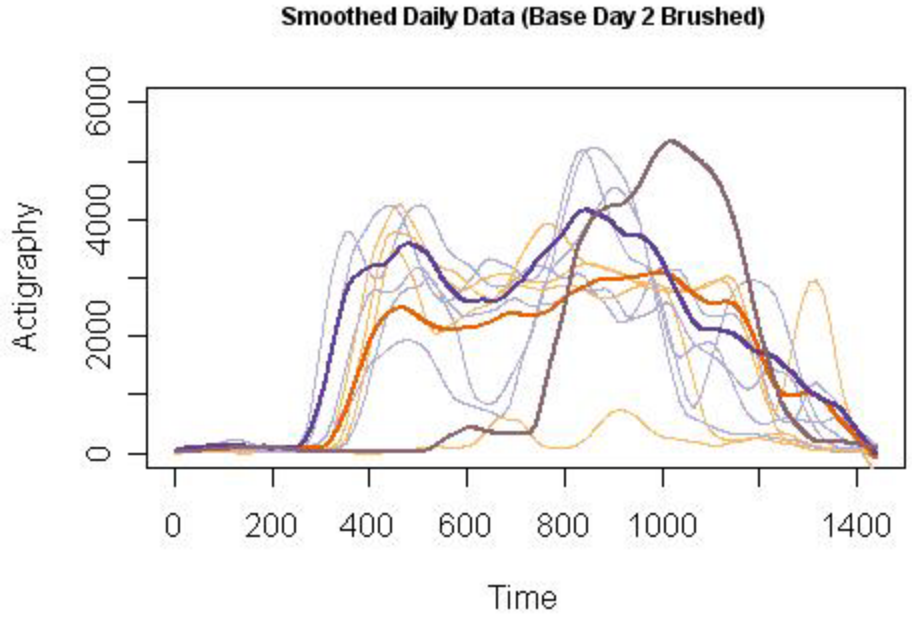
0
200
400
600
800
1000
1400
Time


Smoothed Daily Data (Base Day 2 Brushed)
Actigraphy
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800
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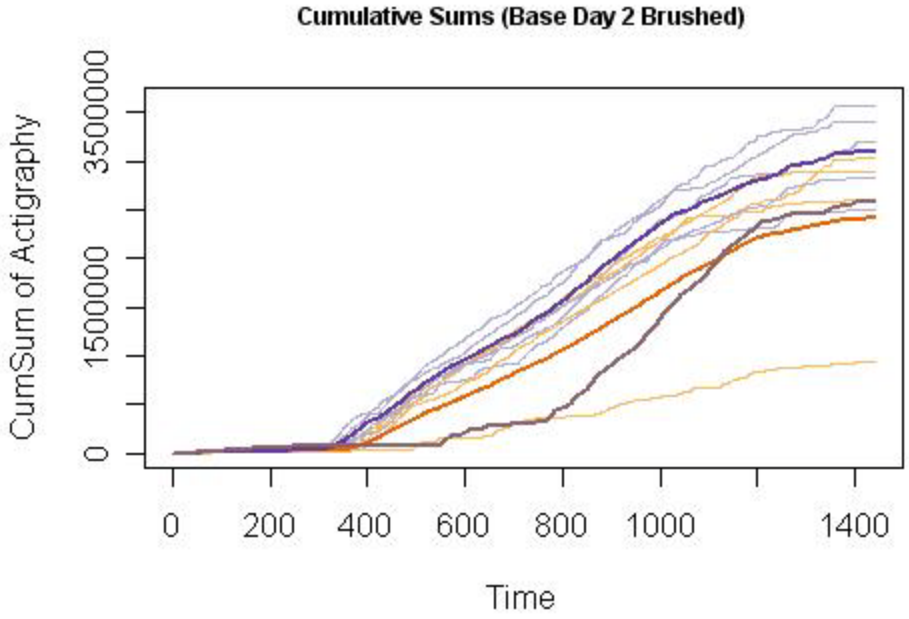
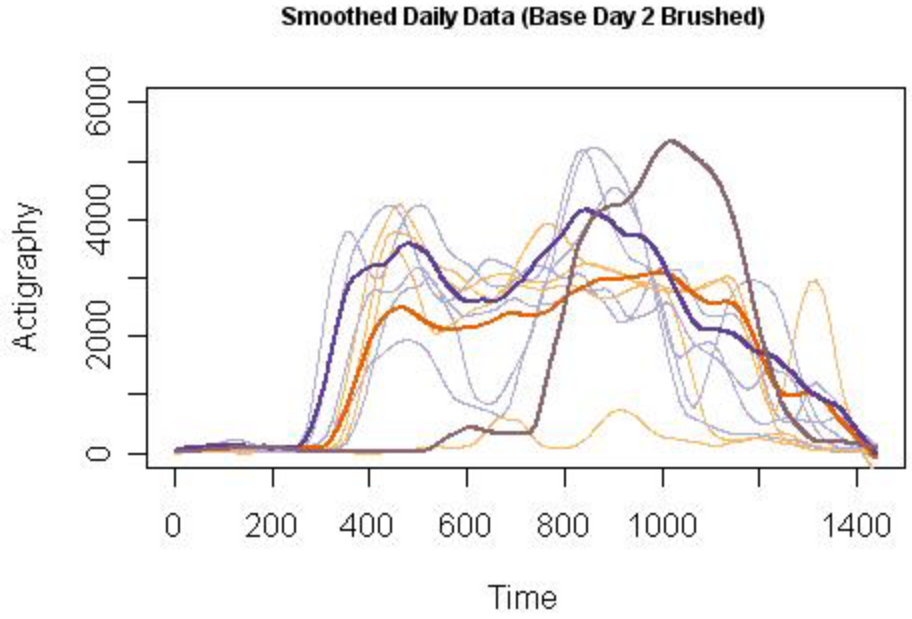
1400
Time


Cumulative Sums (Base Day 2 Brushed)
CumSum of Actigraphy
0
1500000
3500000
0
200
400
600
800
1000
1400
Time


Smoothed Daily Data (Base Day 2 Brushed)
Actigraphy
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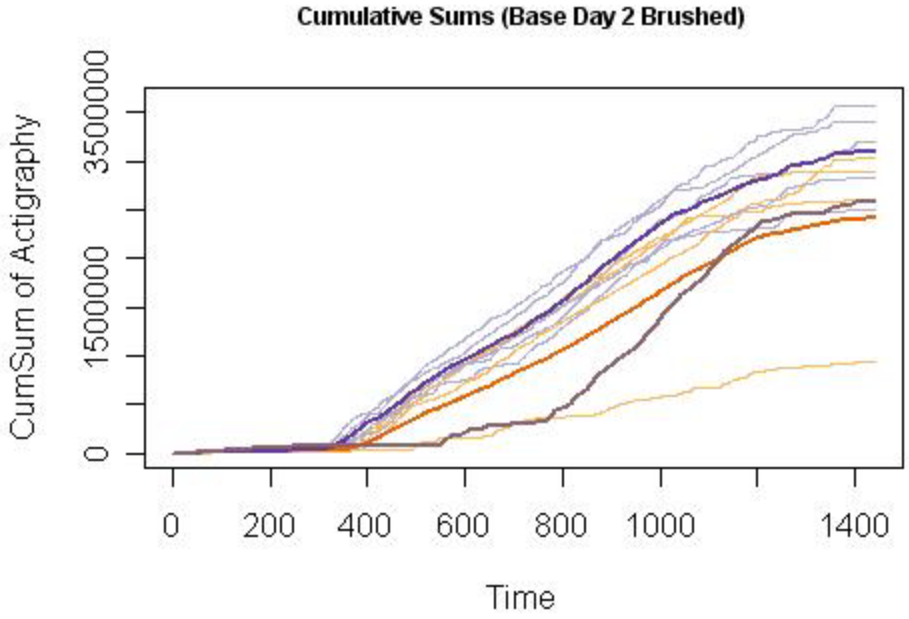
Time


Cumulative Sums (Base Day 2 Brushed)
CumSum of Actigraphy
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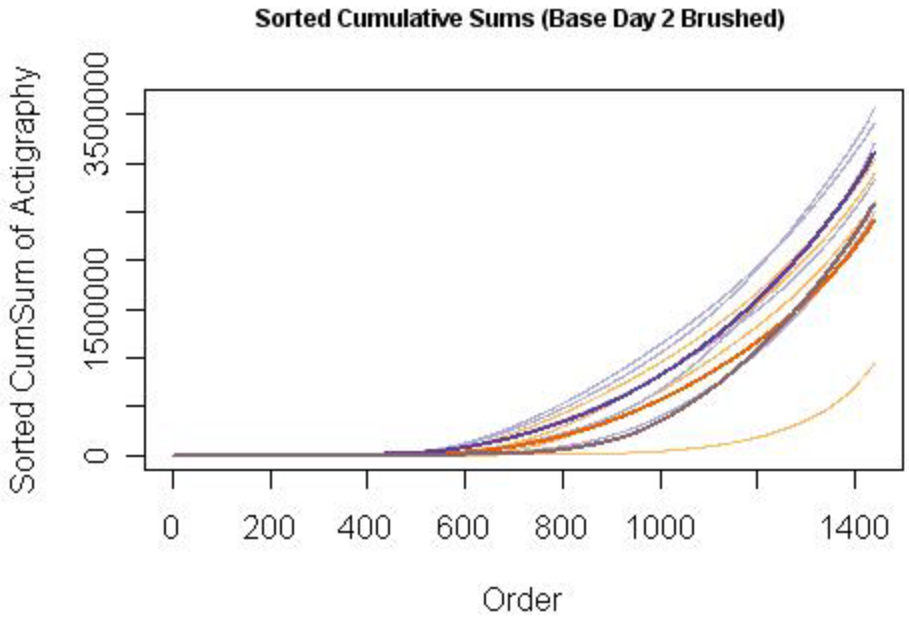
Time


Sorted Cumulative Sums (Base Day 2 Brushed)
Sorted CumSum of Actigraphy
0
1500000
3500000
0
200
400
600
800
1000
1400
Order