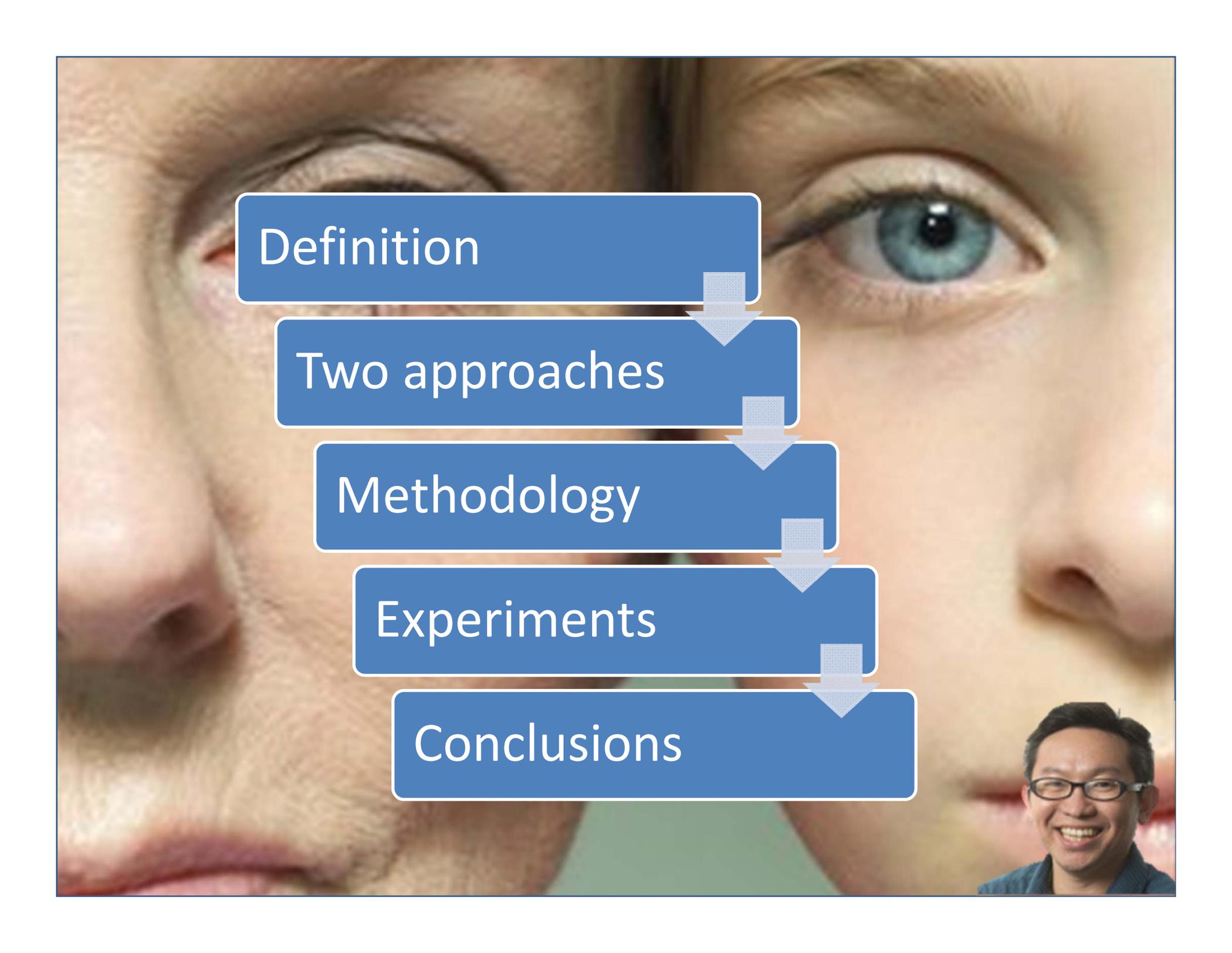


# Multimodal ageing (and habituation)





Definition

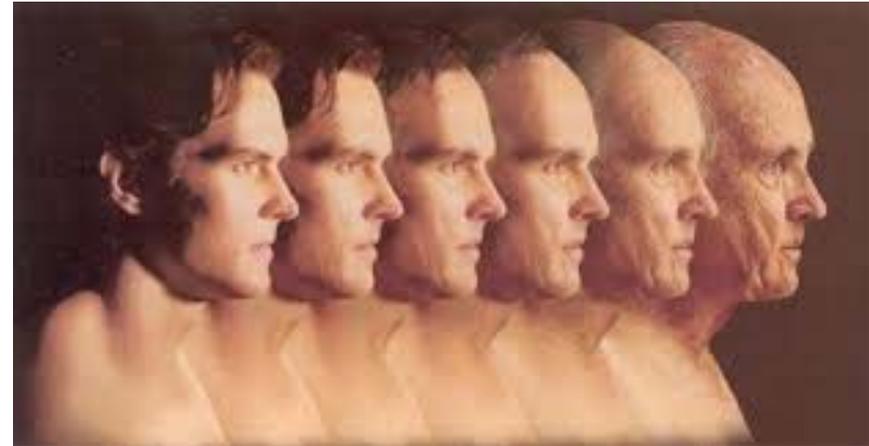
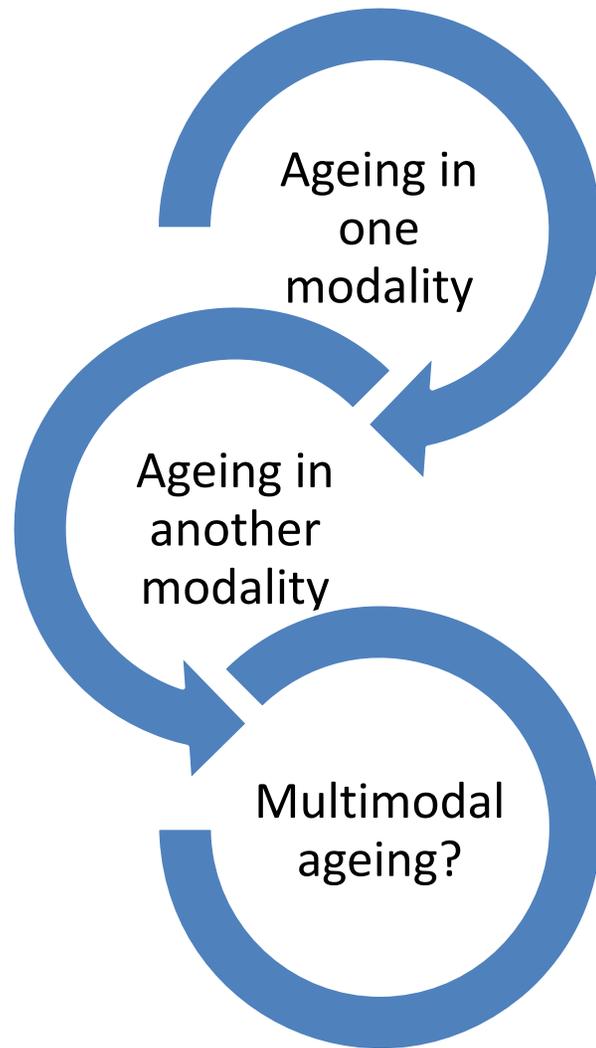
Two approaches

Methodology

Experiments

Conclusions

# Multimodal Ageing



“Ageing is the accumulation of changes in a person over time”

Irreversible process?

# Performance change over time

Low frequency

Ageing

Gradual change

Environment

Drastic change

Behavioral

High frequency

Compound changes

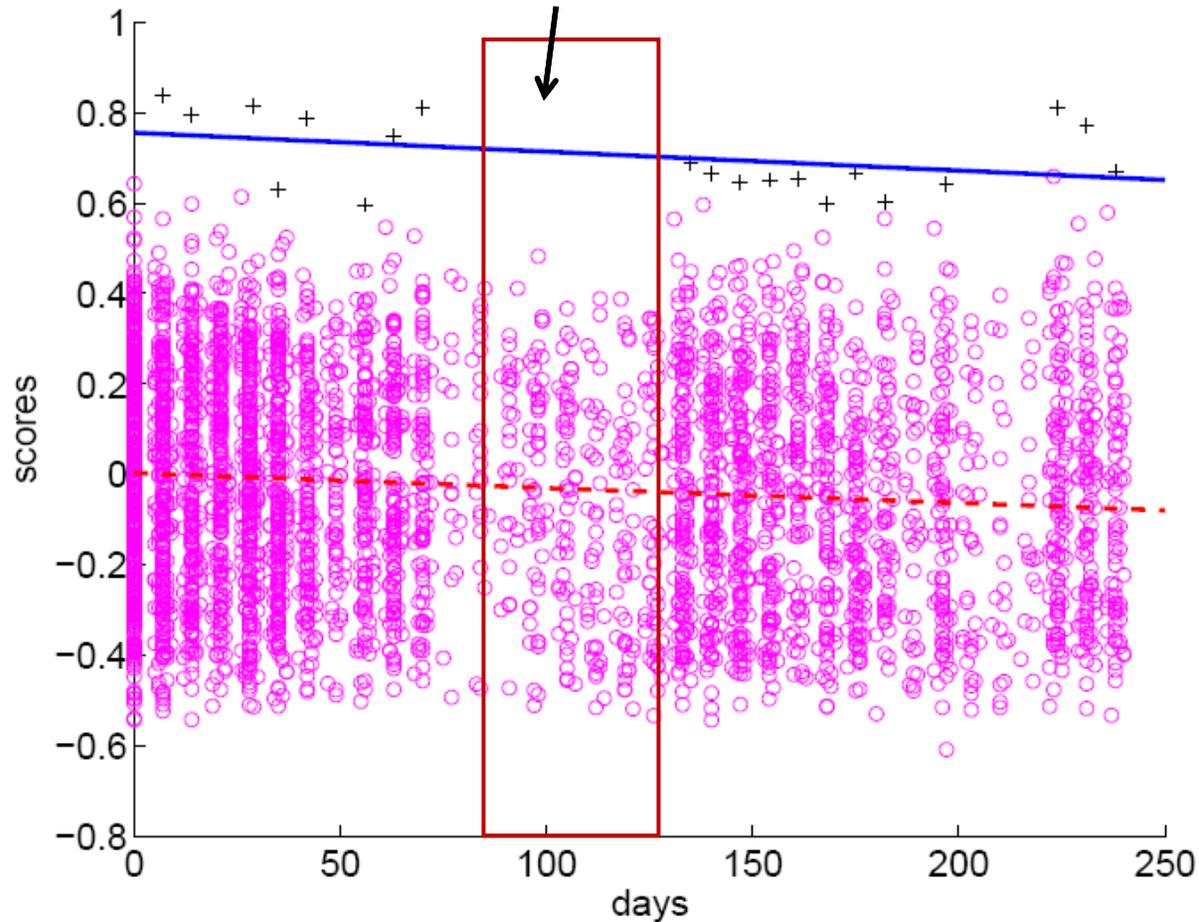
Unobservable (unless controlled for)

Observable

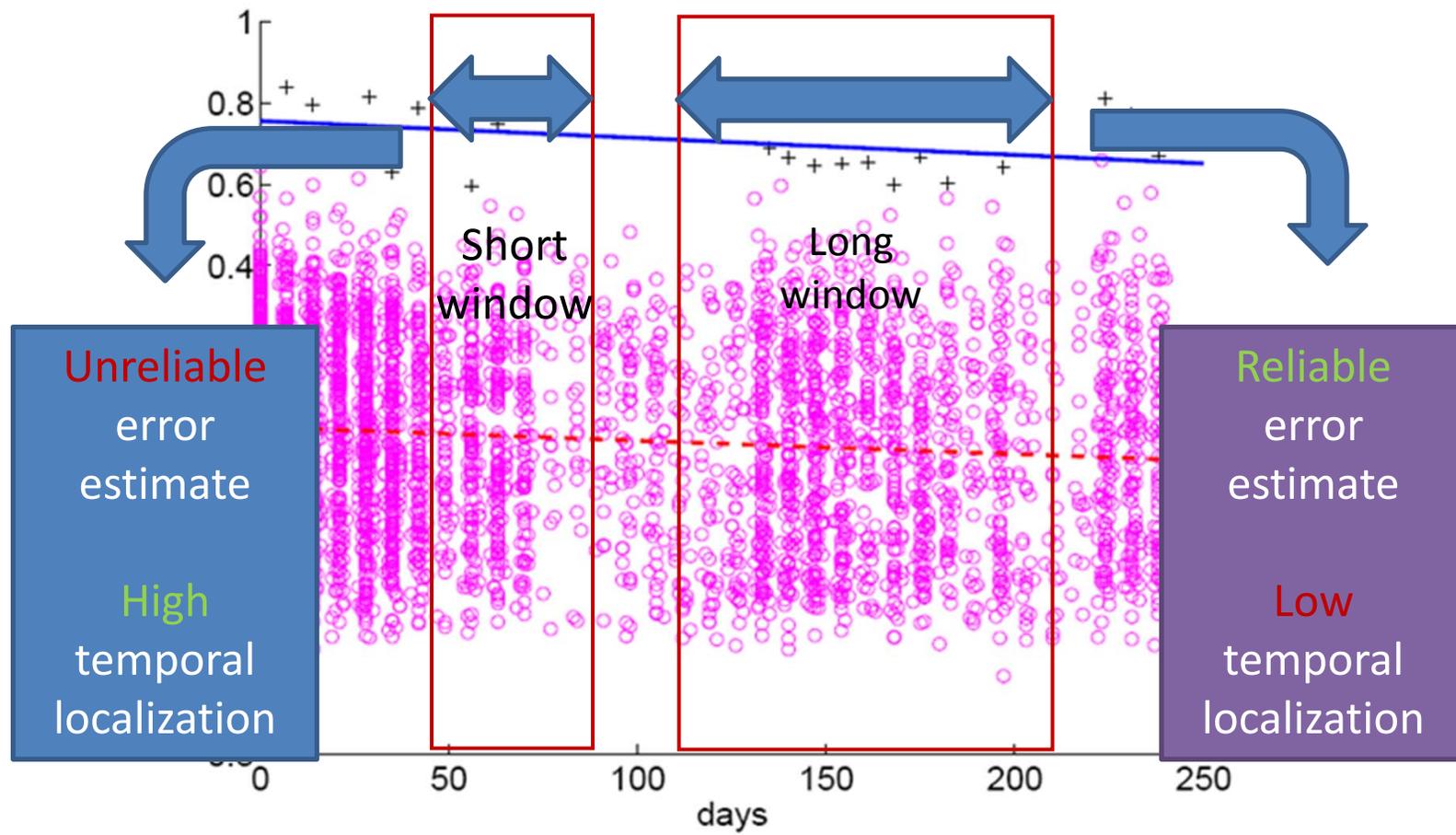
M  
E  
N  
U

# The windowing approach

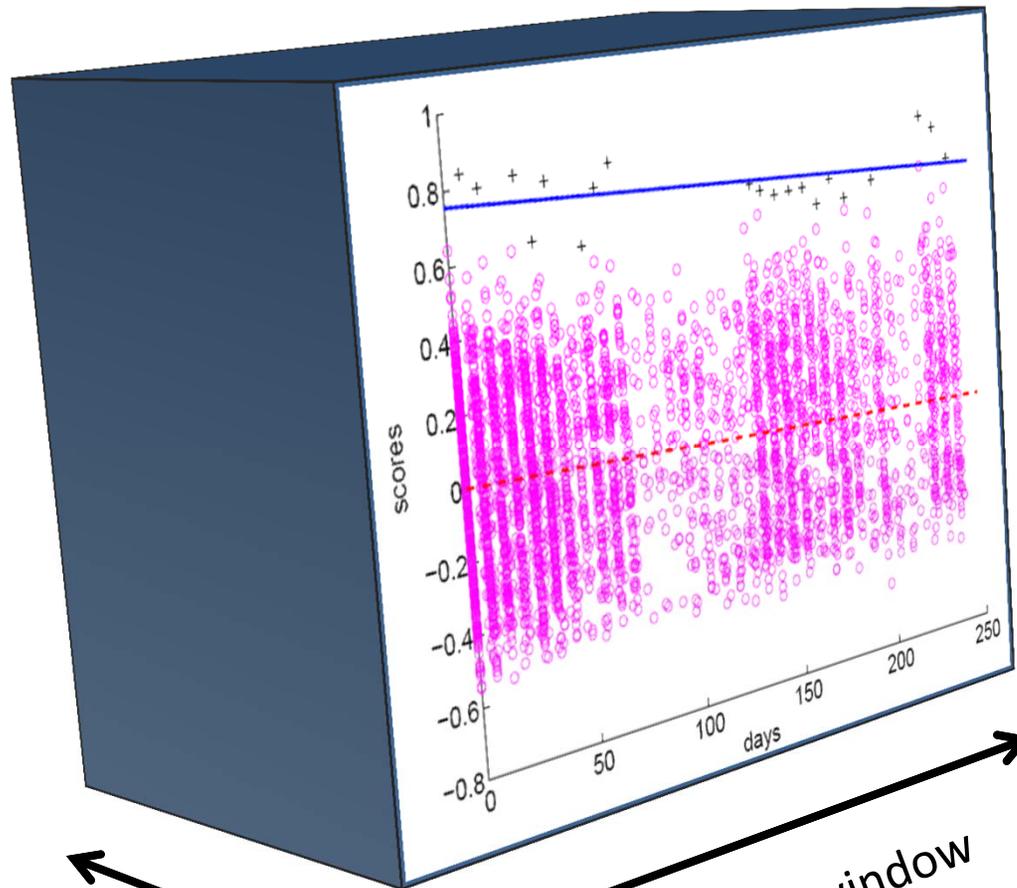
No or few genuine scores observed!



# Dilemma: Reliable error or finer temporal resolution?



# The windowing approach

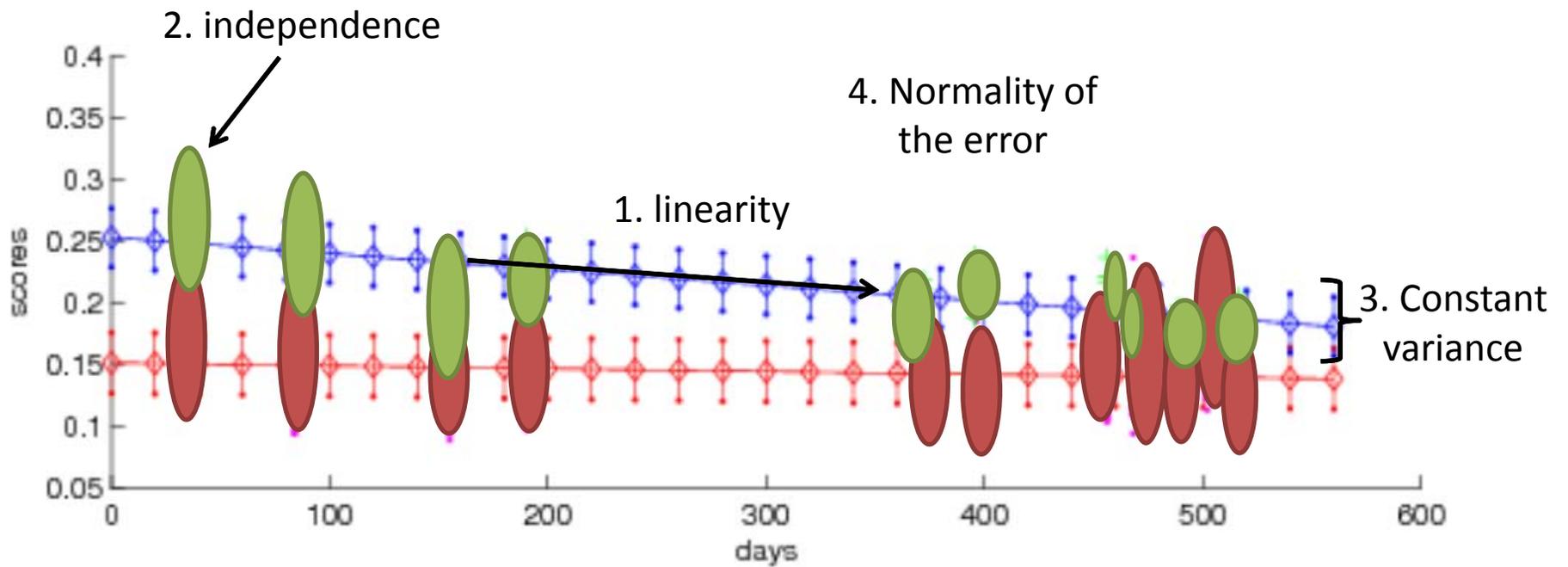


Cannot model  
subject-specific  
performance

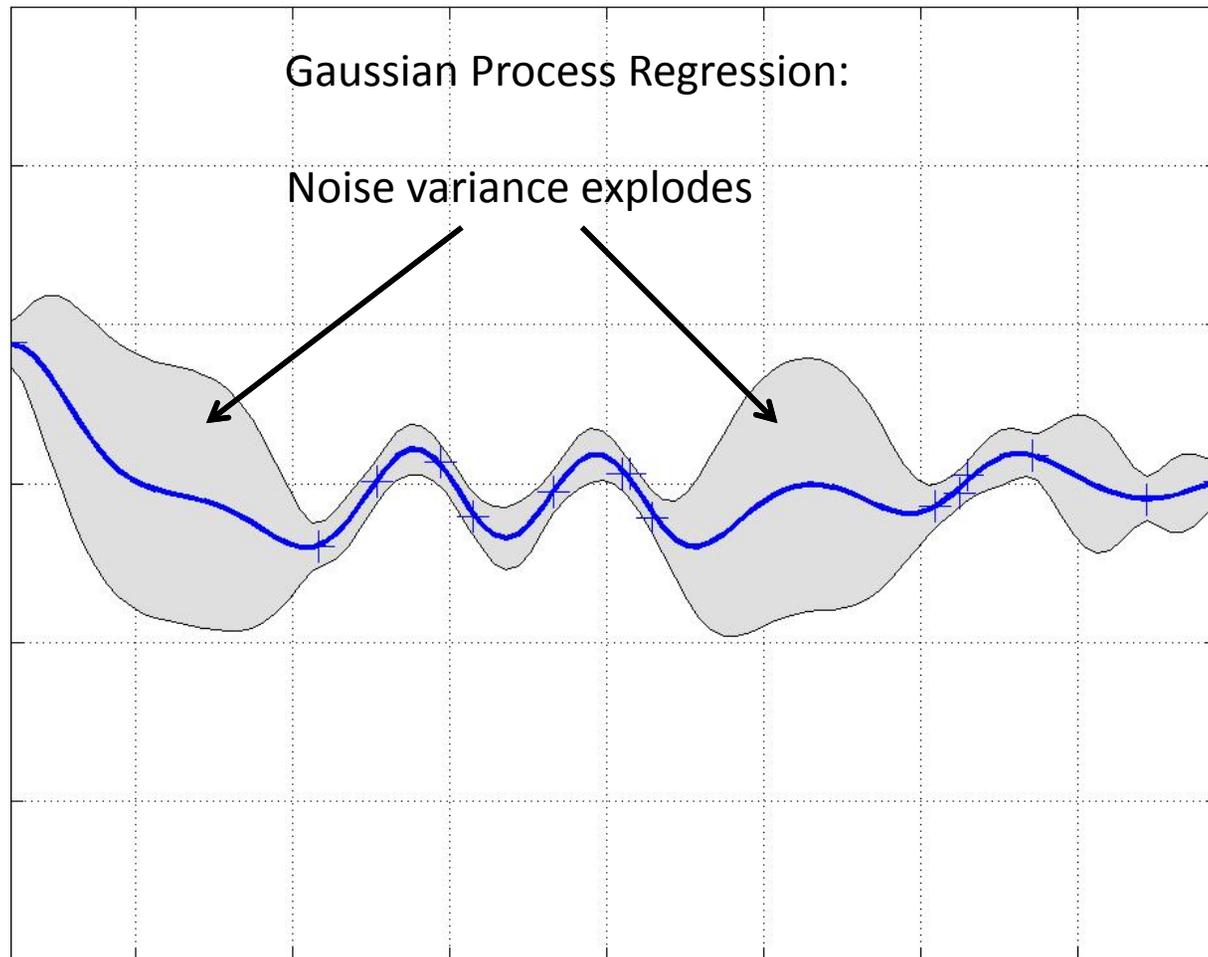
Stack the scores due  
to all templates  
together

Scan the window  
through time

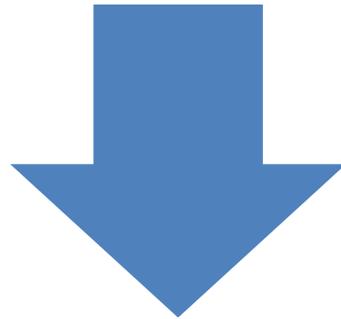
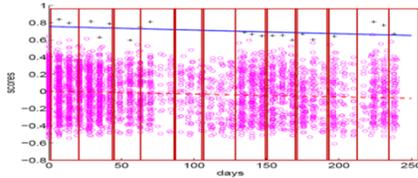
# The regression approach



# Choice of regression matters



# windowing



Cannot model subject-specific performance



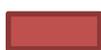
Dilemma between reliable error estimate & fine temporal resolution



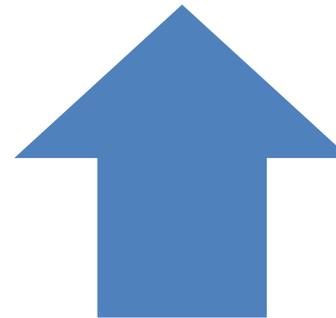
Subject-specific performance



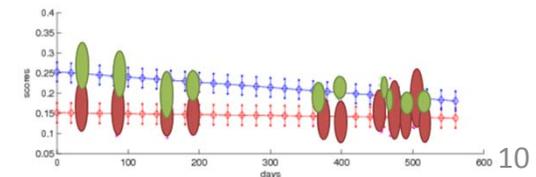
Parametric error model (sensitive to *minute* changes)

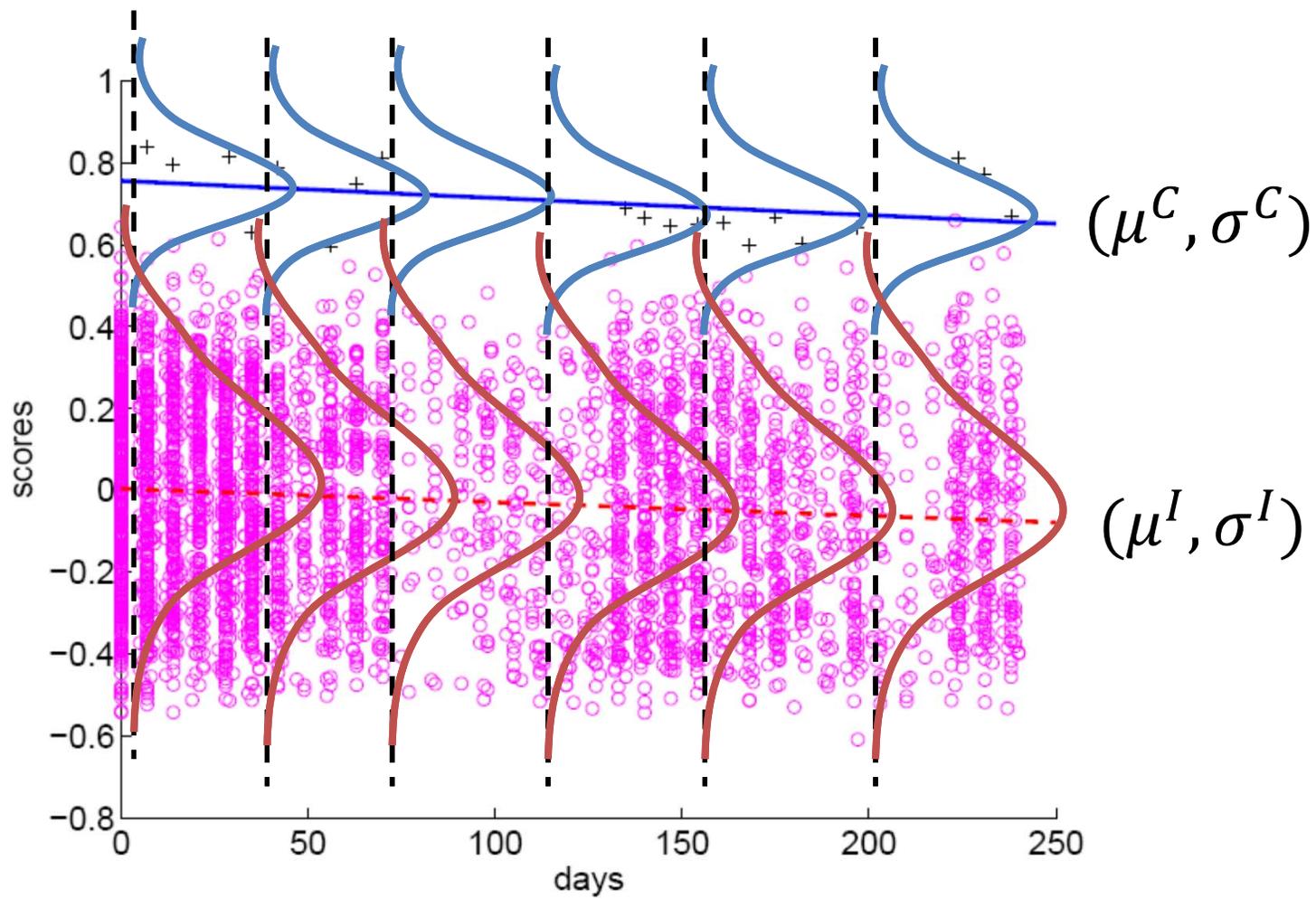


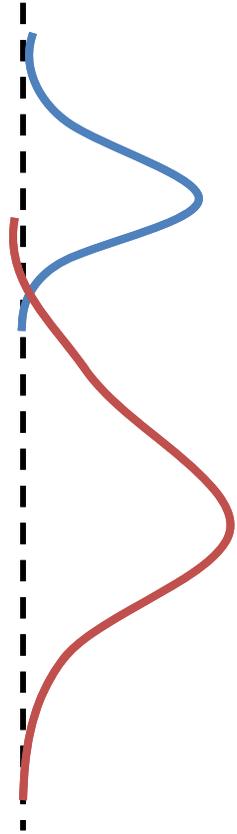
Rely on the smoothness assumption



# regression





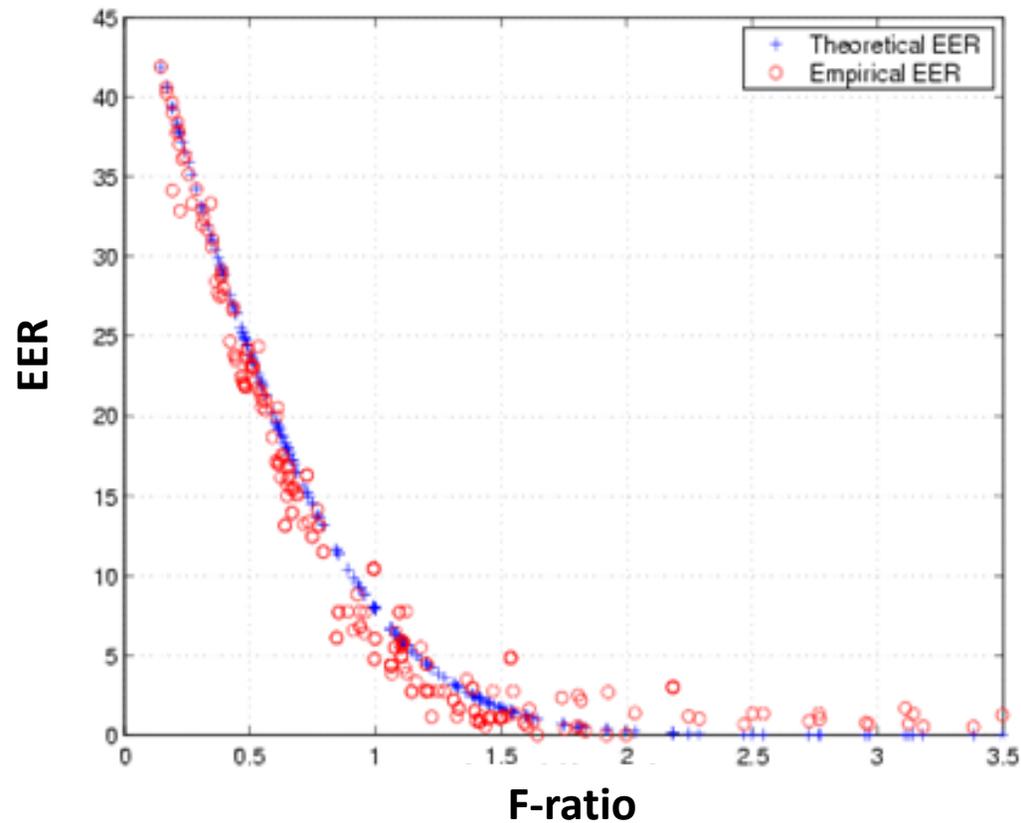
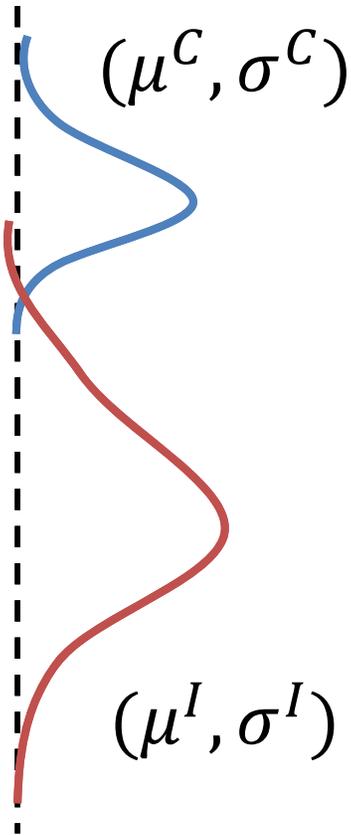


$$\text{F-ratio} = \frac{\mu^C - \mu^I}{\sigma^C + \sigma^I}$$

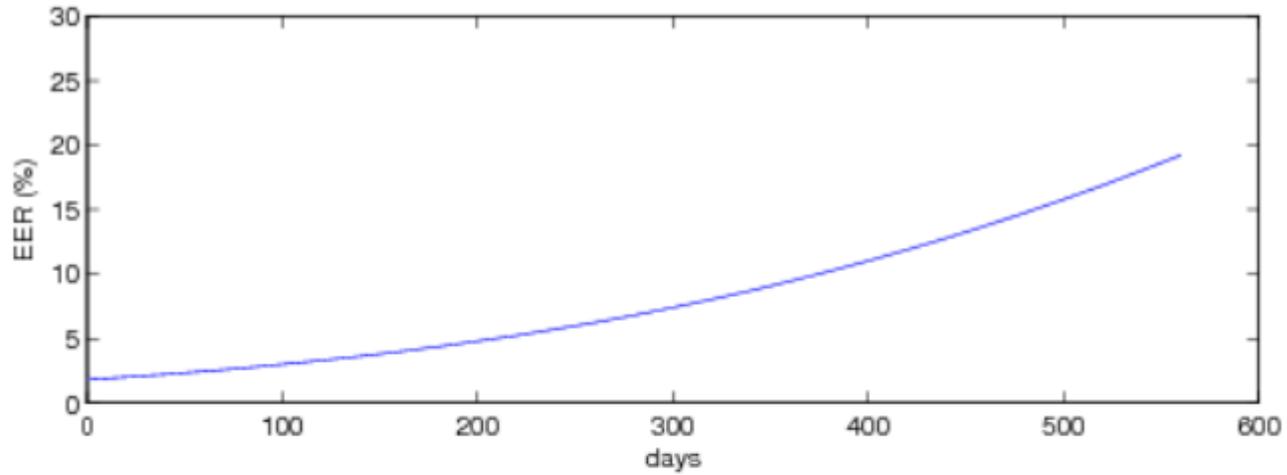


$$\text{EER} = \frac{1}{2} - \frac{1}{2} \text{erf} \left( \frac{\text{F-ratio}}{\sqrt{2}} \right)$$

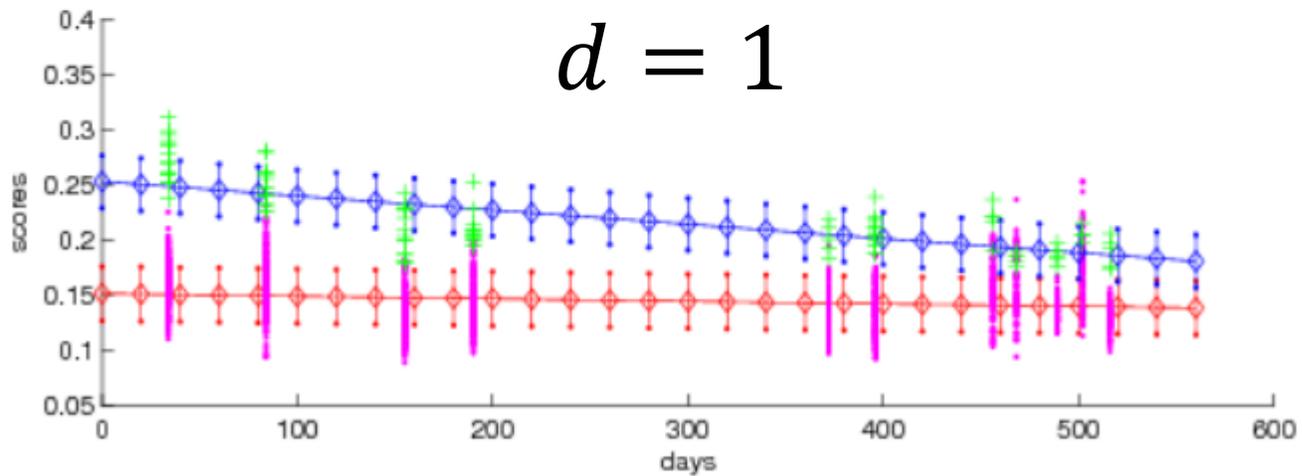
$$\text{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z \exp[-x^2] dx$$



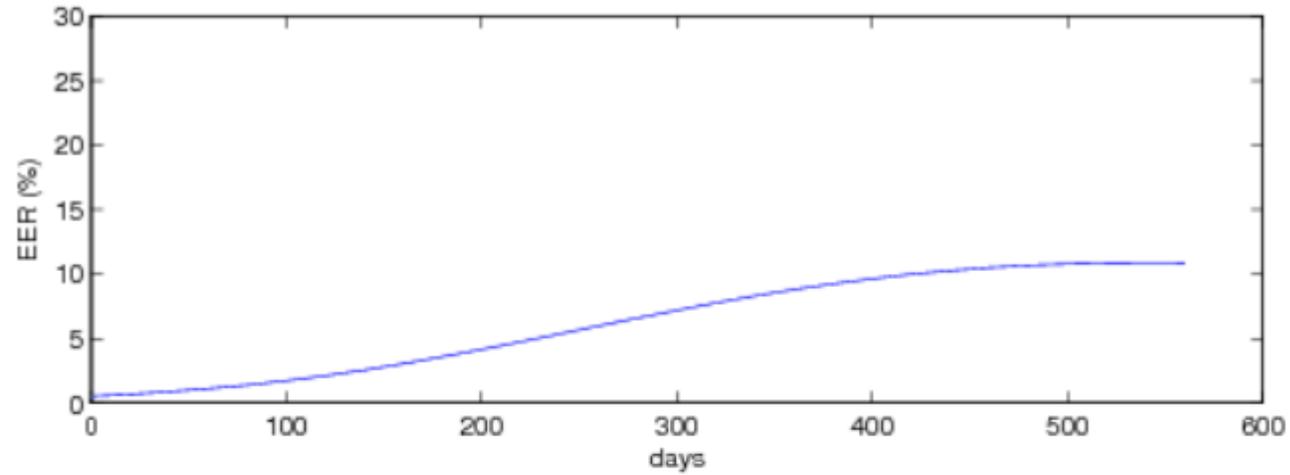
# Polynomial regression



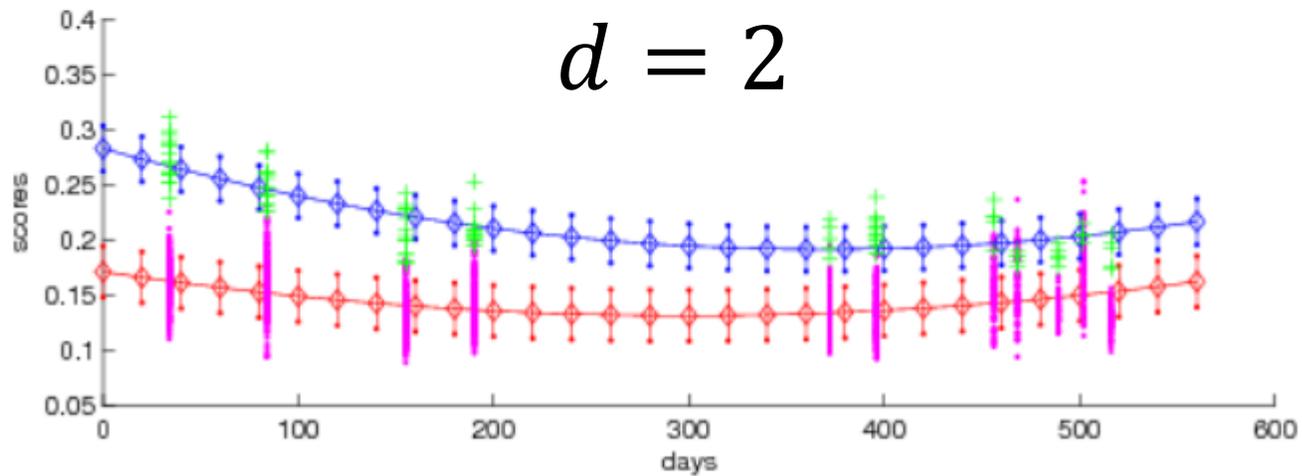
$d = 1$



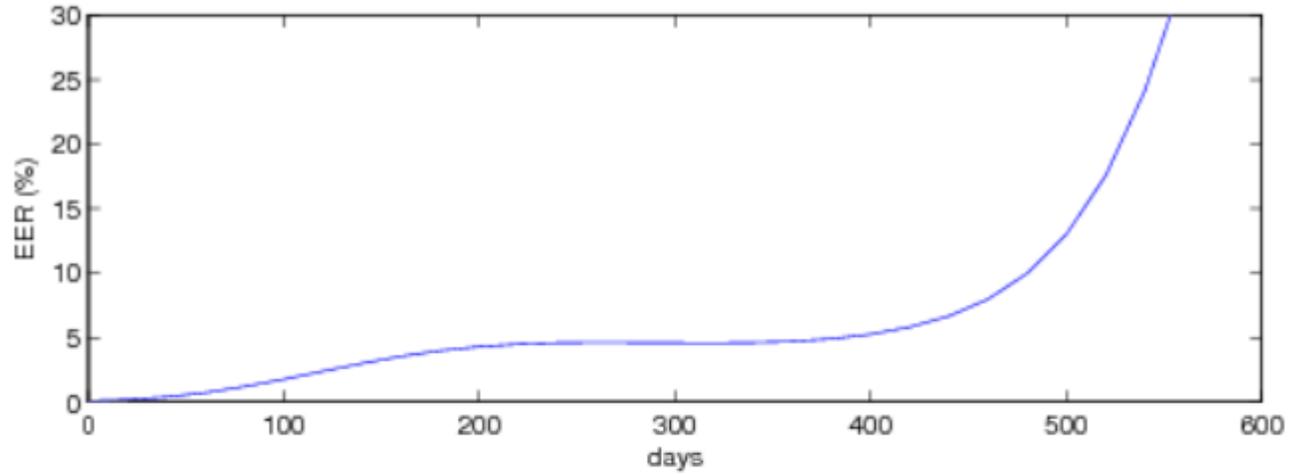
# Polynomial regression



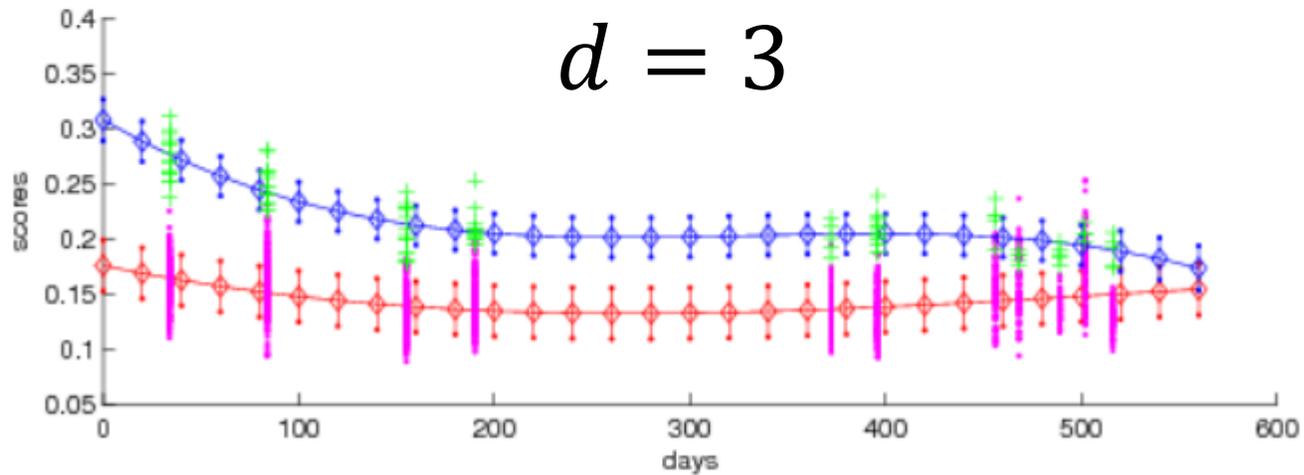
$d = 2$



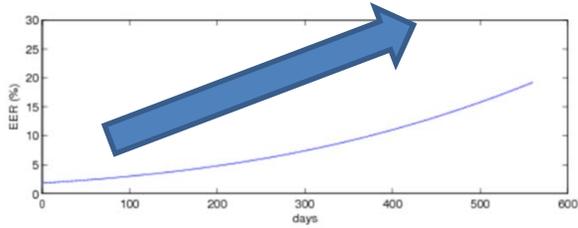
# Polynomial regression



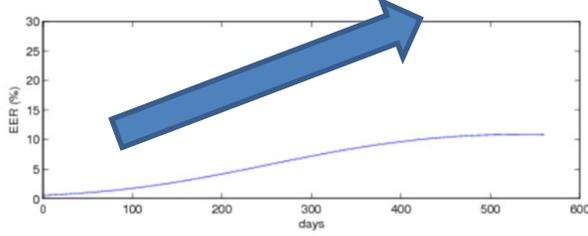
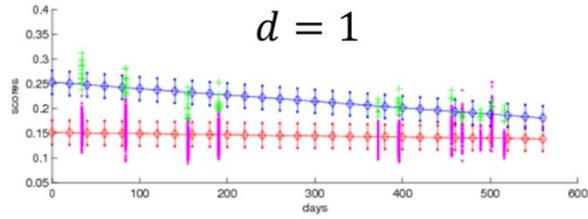
$d = 3$



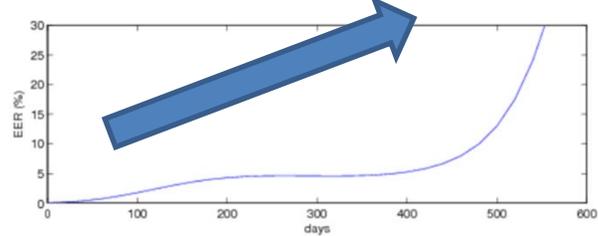
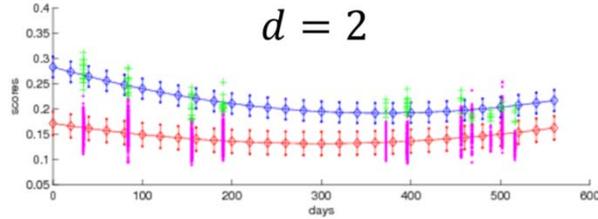
# Detecting trends



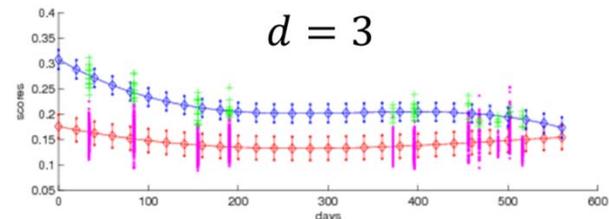
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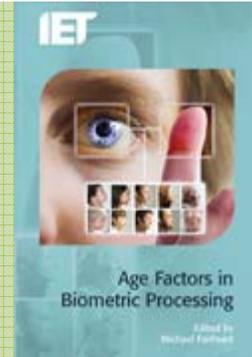


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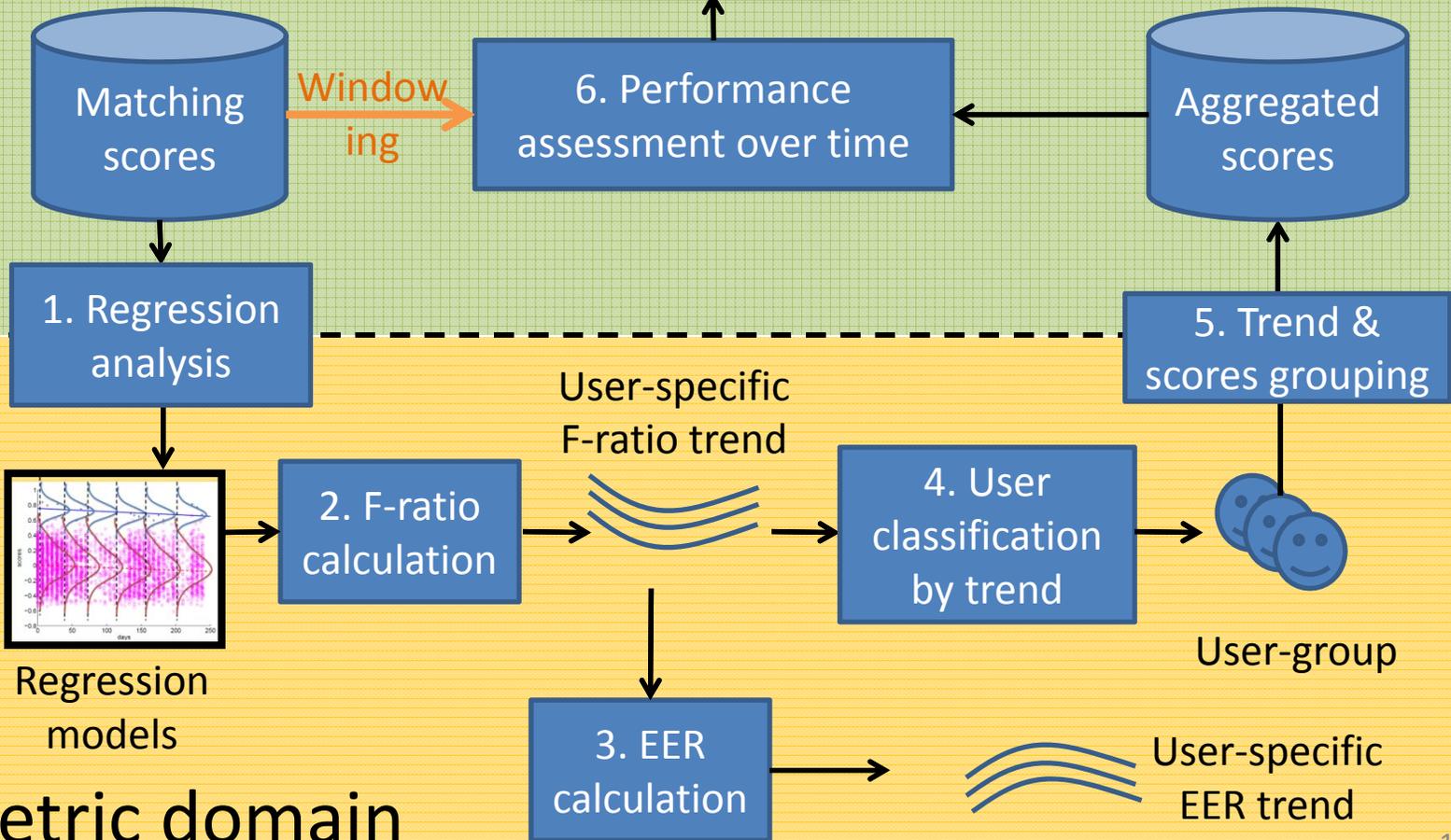
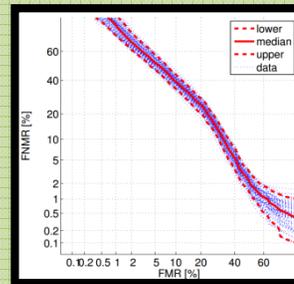


$d = 3$

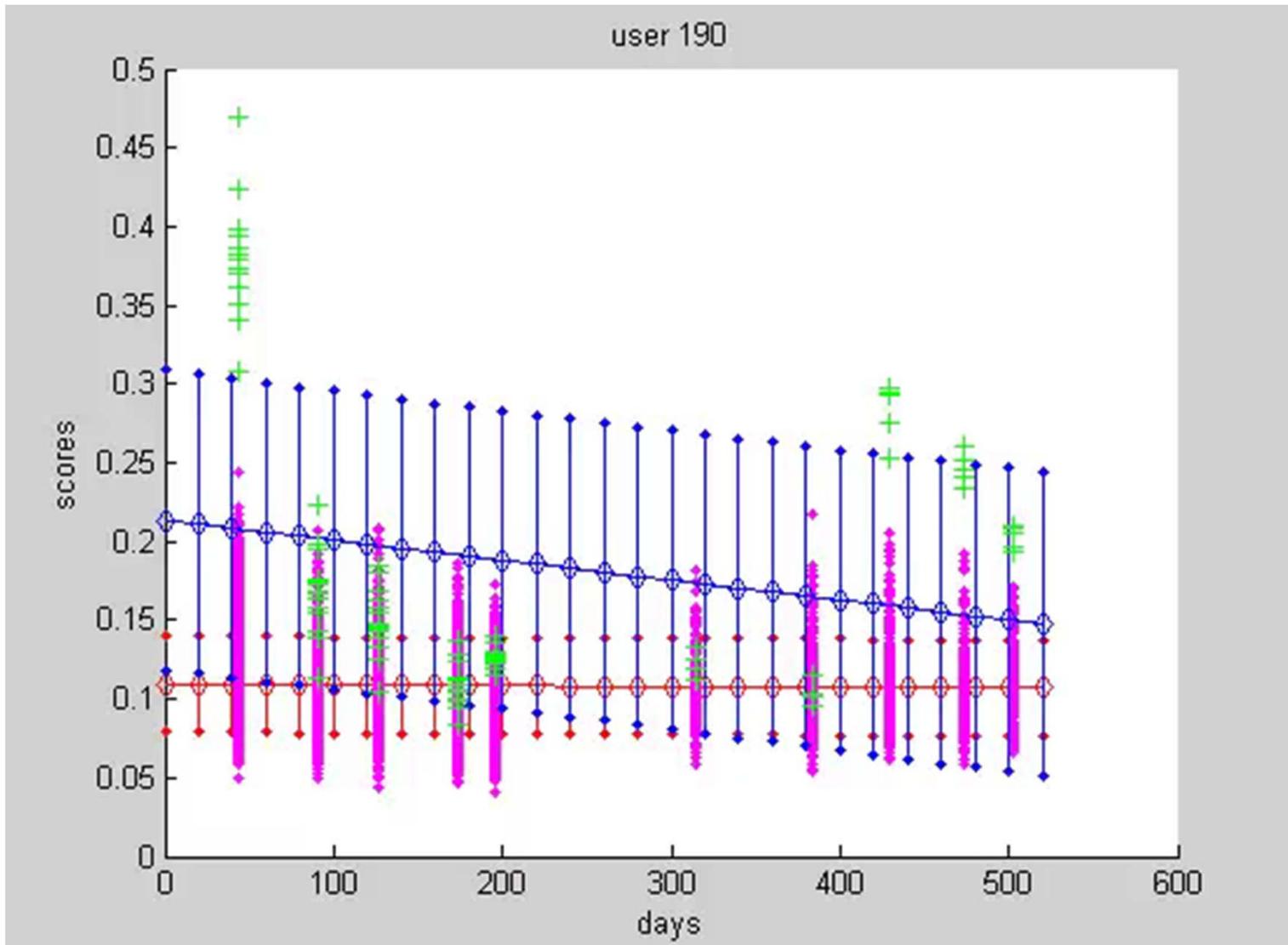




# Score domain



# Parametric domain



Dataset

Protocols

Classifiers

Results

## Mobio Dataset

Population size

- 150 subjects (6 locations)

Samples per subject

- 192 videos

Device

- Nokia device



Days covered

- 500-600 days

Setting

- Office environment (unconstrained)

20

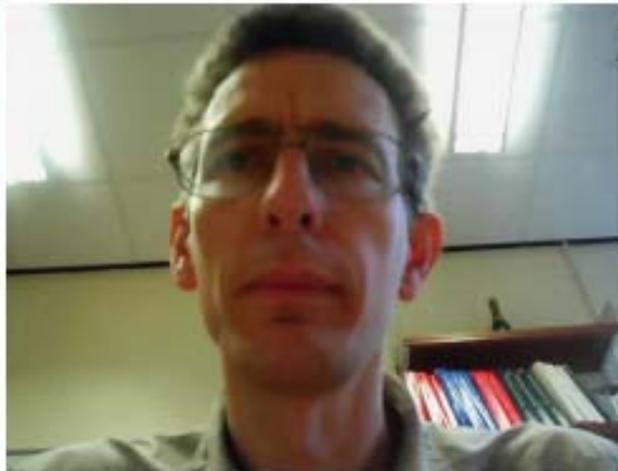
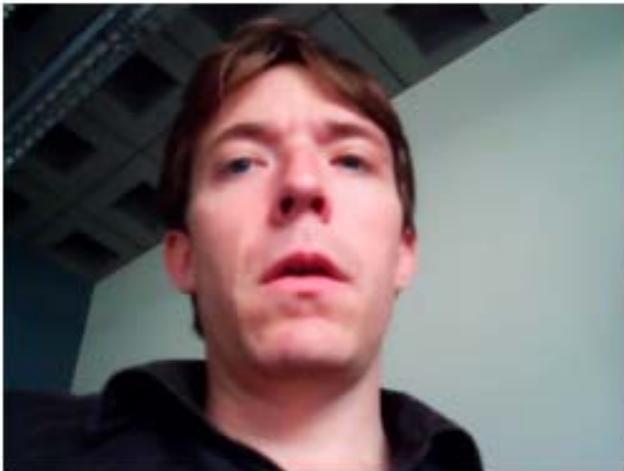
P. Tresadern, et al, **Mobile Biometrics: Combined Face and Voice Verification for a Mobile Platform**, Pervasive Computing, IEEE 12, no. 1 (2013): 79-87.

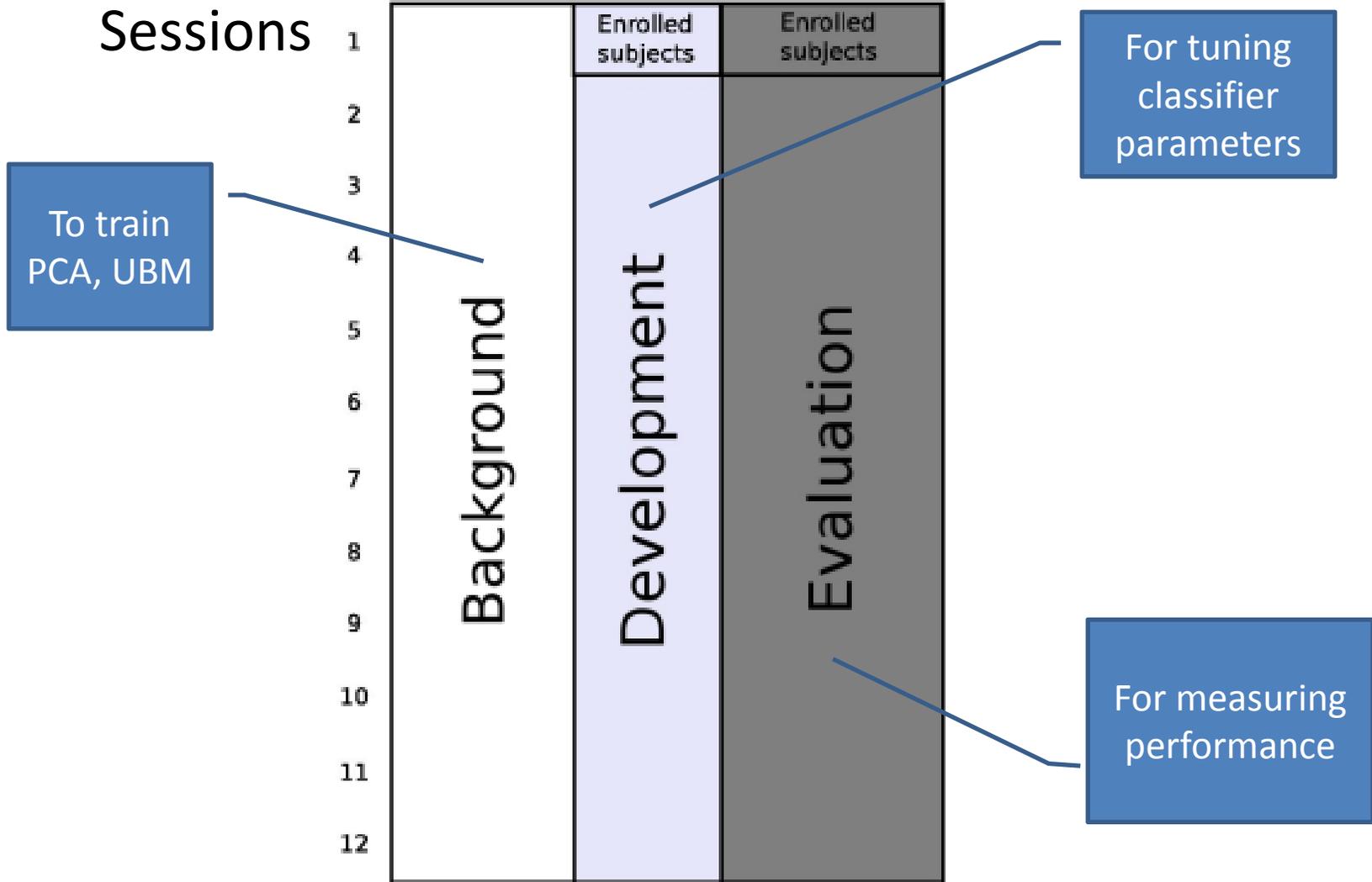
Dataset

Protocols

Classifiers

Results



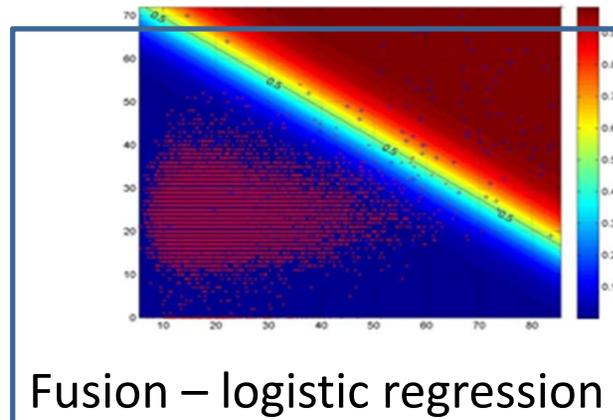
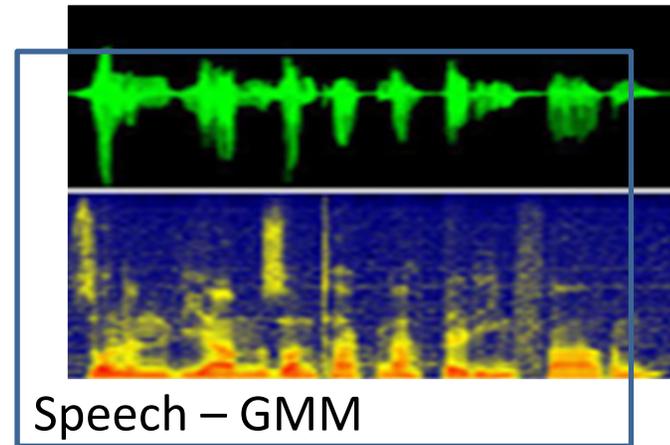
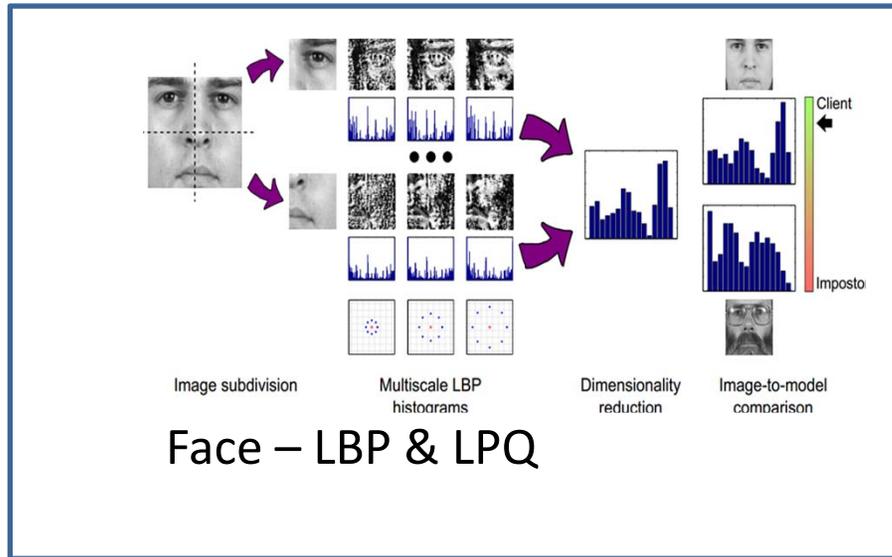


Dataset

Protocol

Classifiers

Results

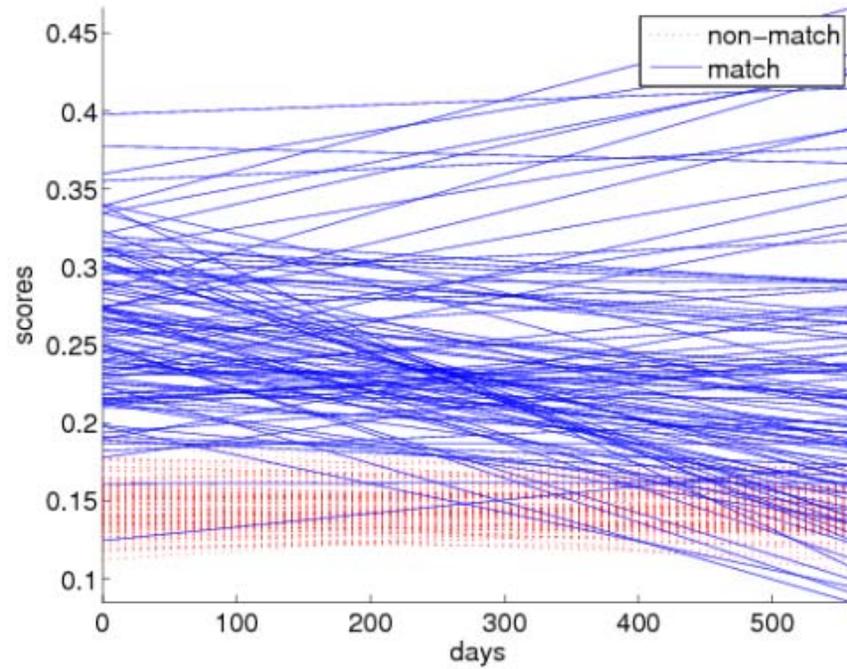


Dataset

Protocol

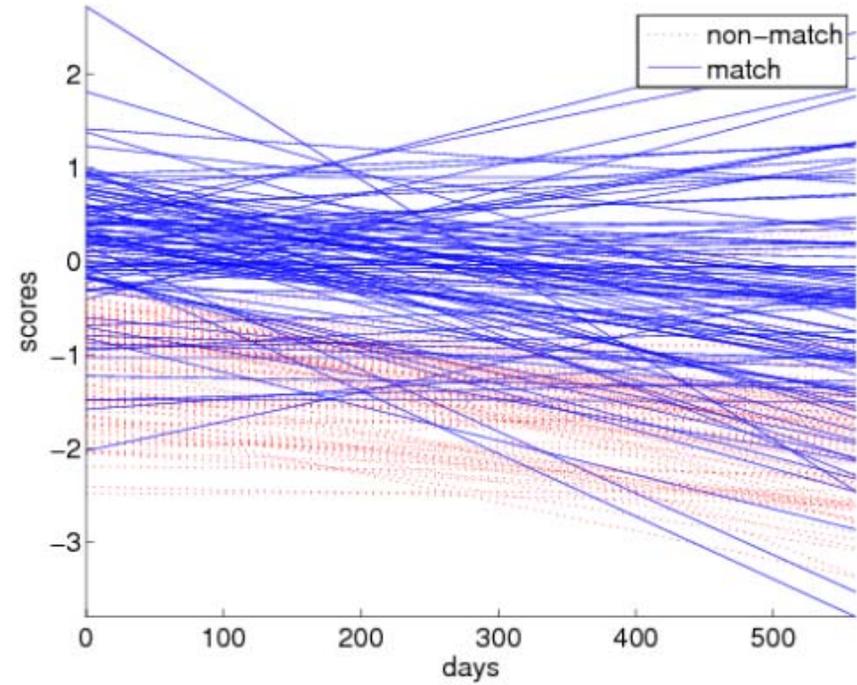
Classifiers

Results



Face1: MLBP

(Similar for Face2: MLPQ)



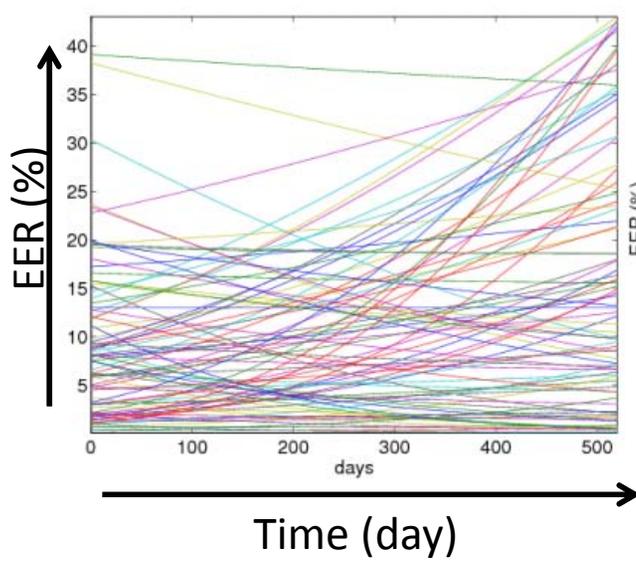
Speech (GMM)

Dataset

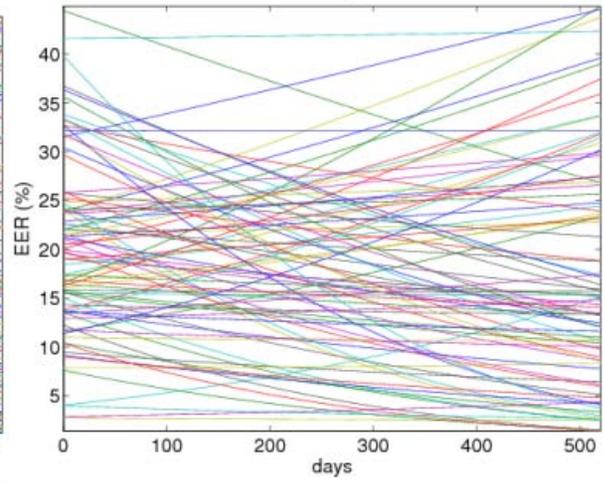
Protocol

Classifiers

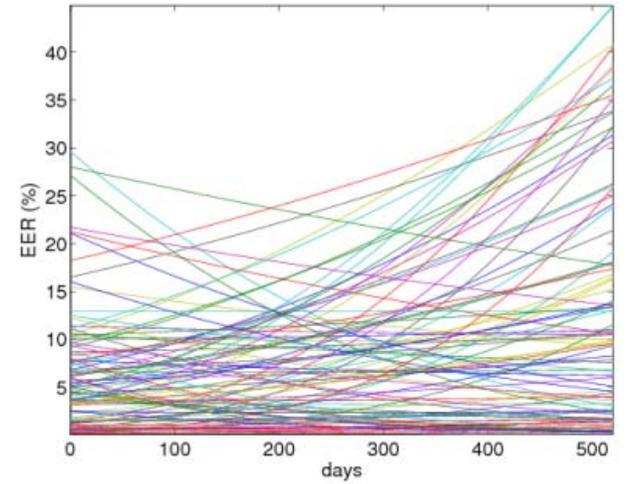
Results



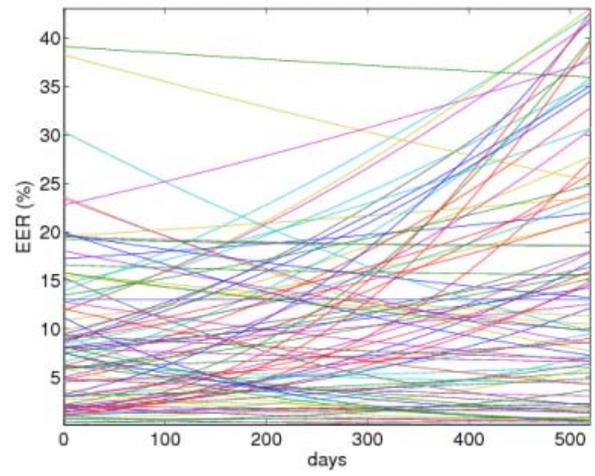
Face1

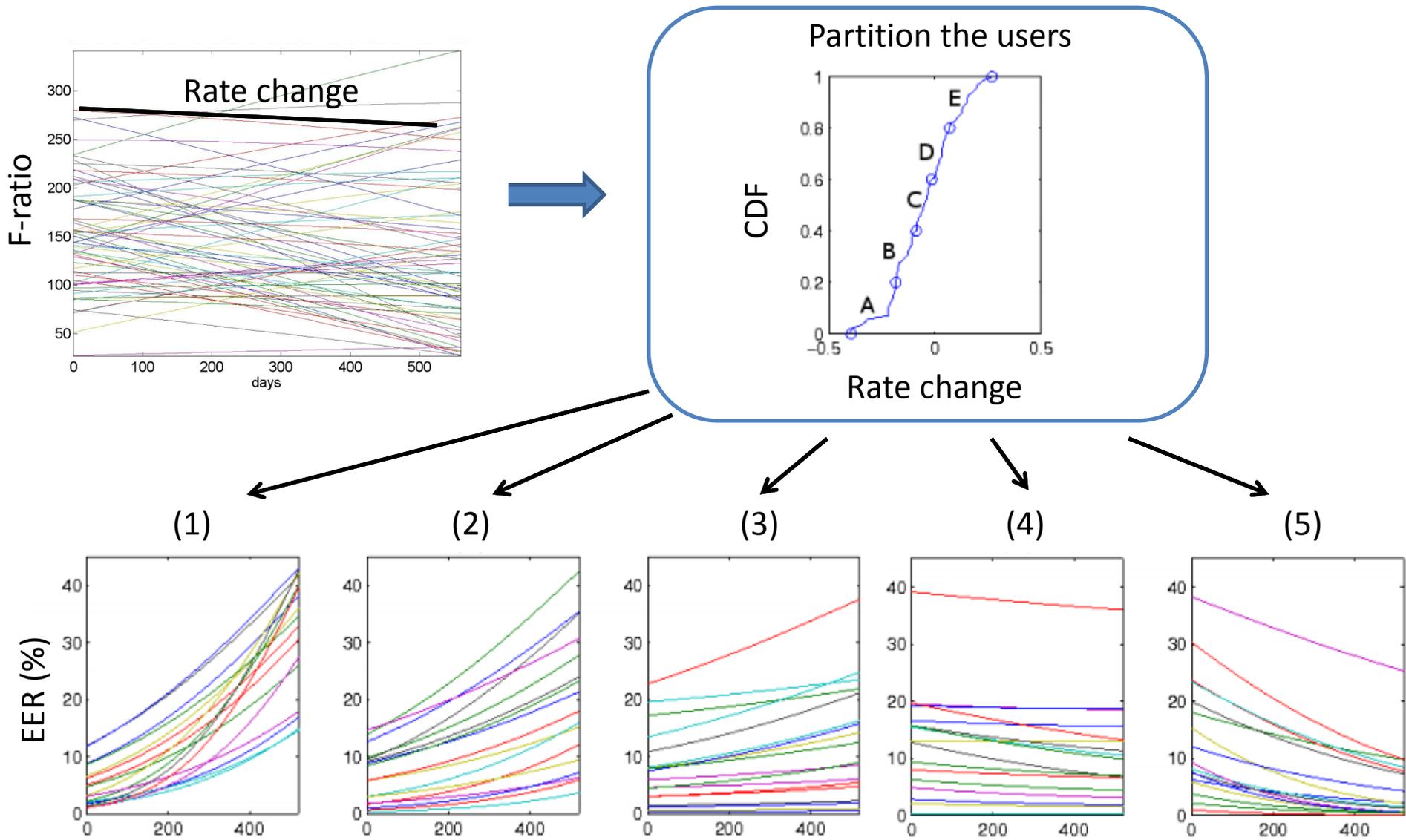


Speech



Face1+Face2+Speech





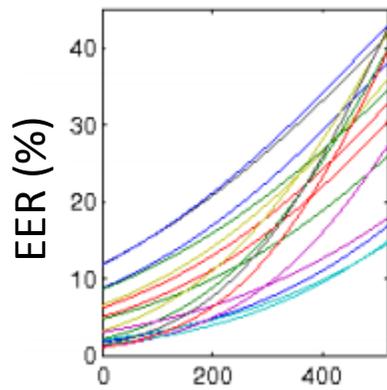
Dataset

Protocol

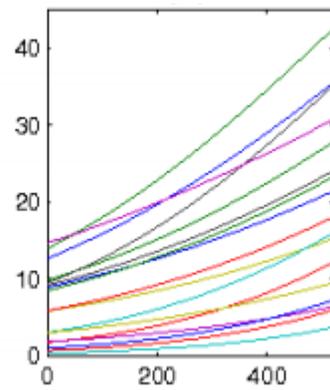
Classifiers

Results

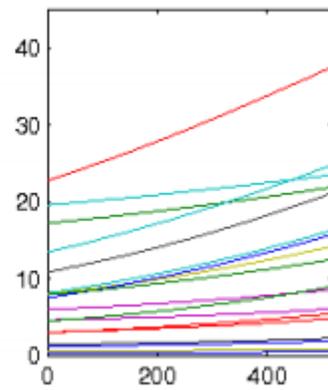
(1)



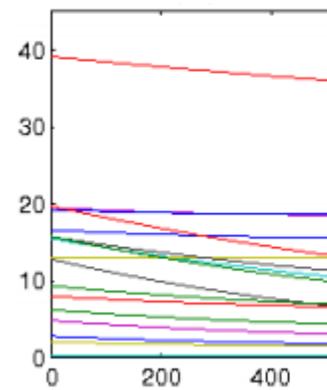
(2)



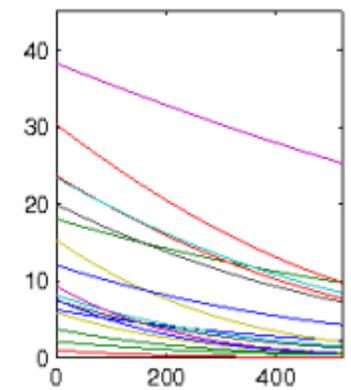
(3)



(4)



(5)

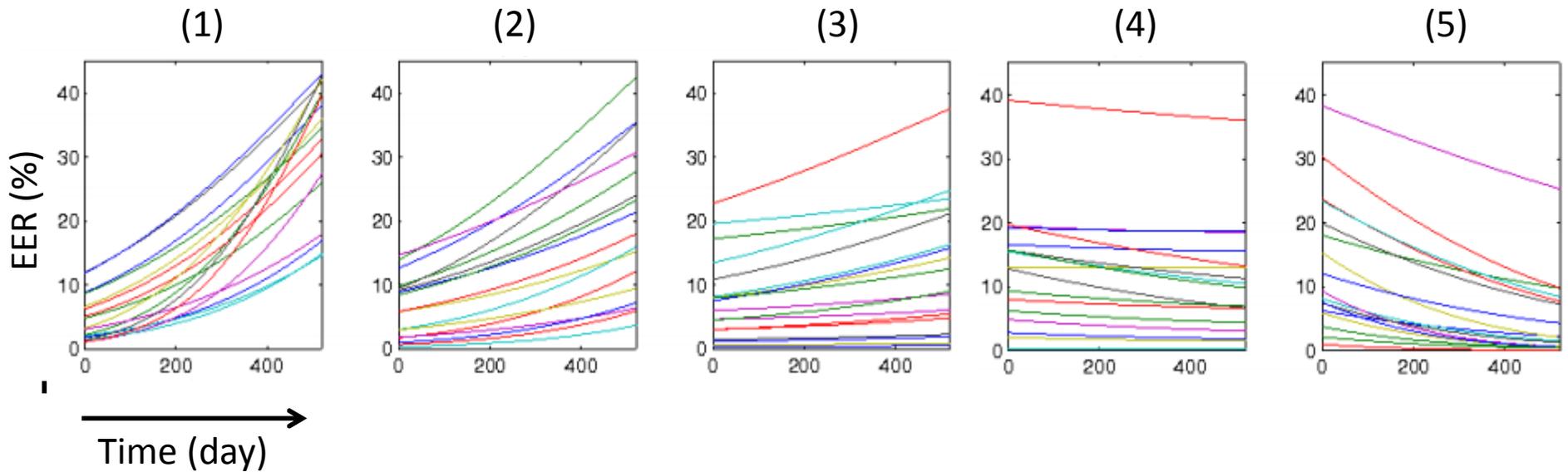


Dataset

Protocol

Classifiers

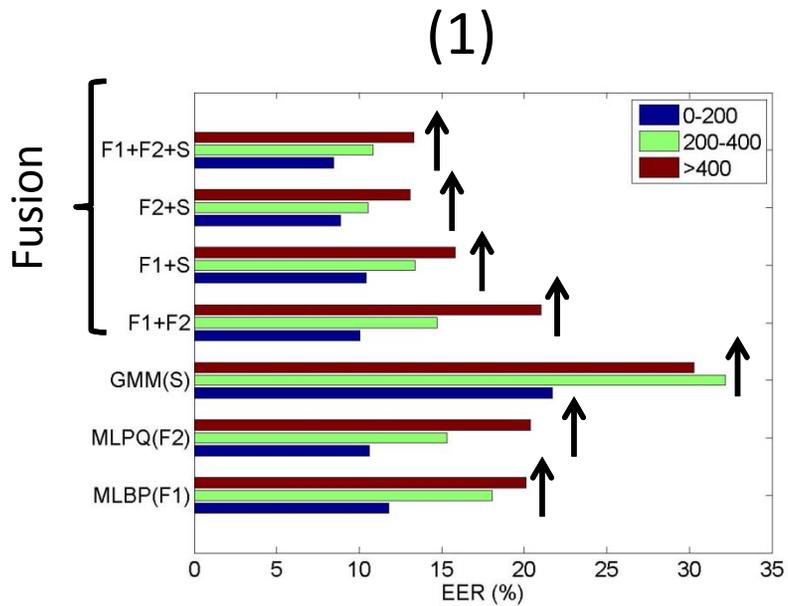
Results



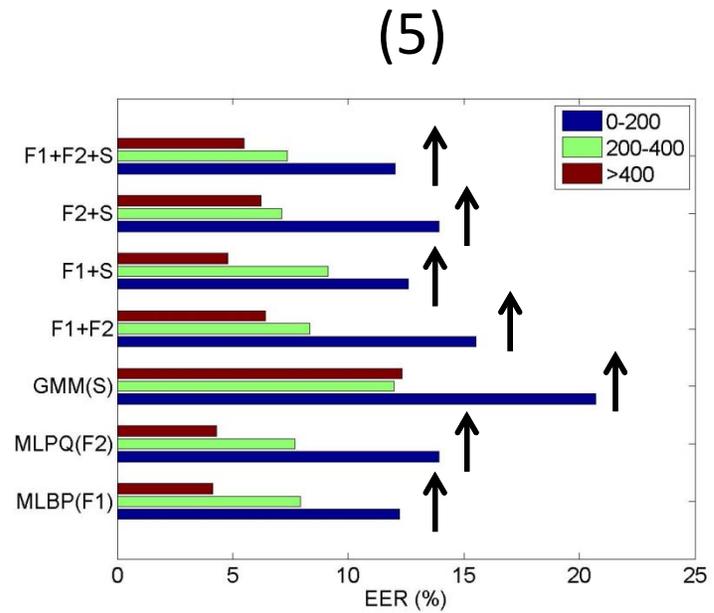
Getting worse

Stable

Getting better



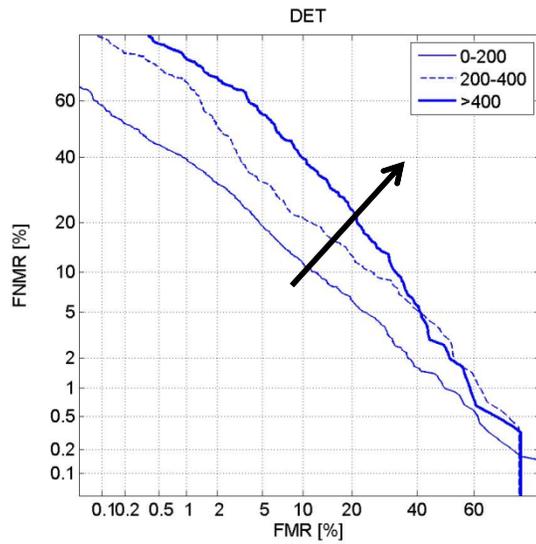
Getting worse



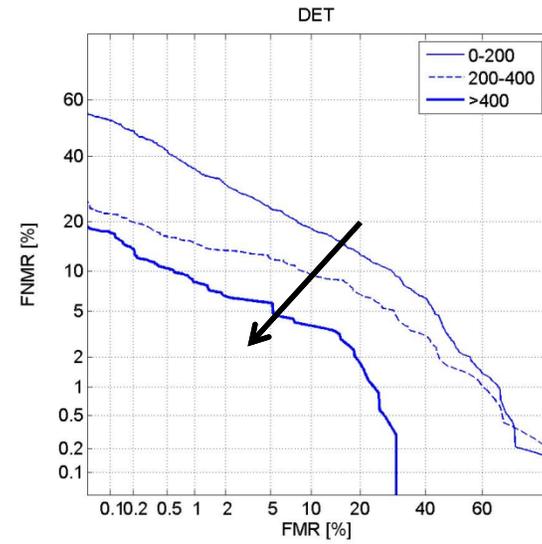
Getting better

Face (MLPQ)

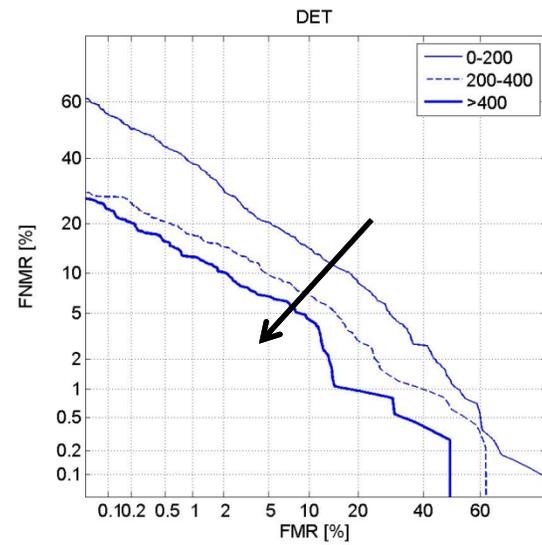
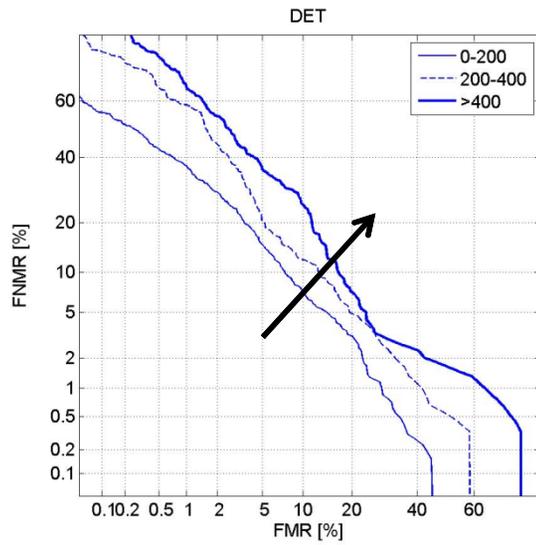
Partition 1 (getting worse)



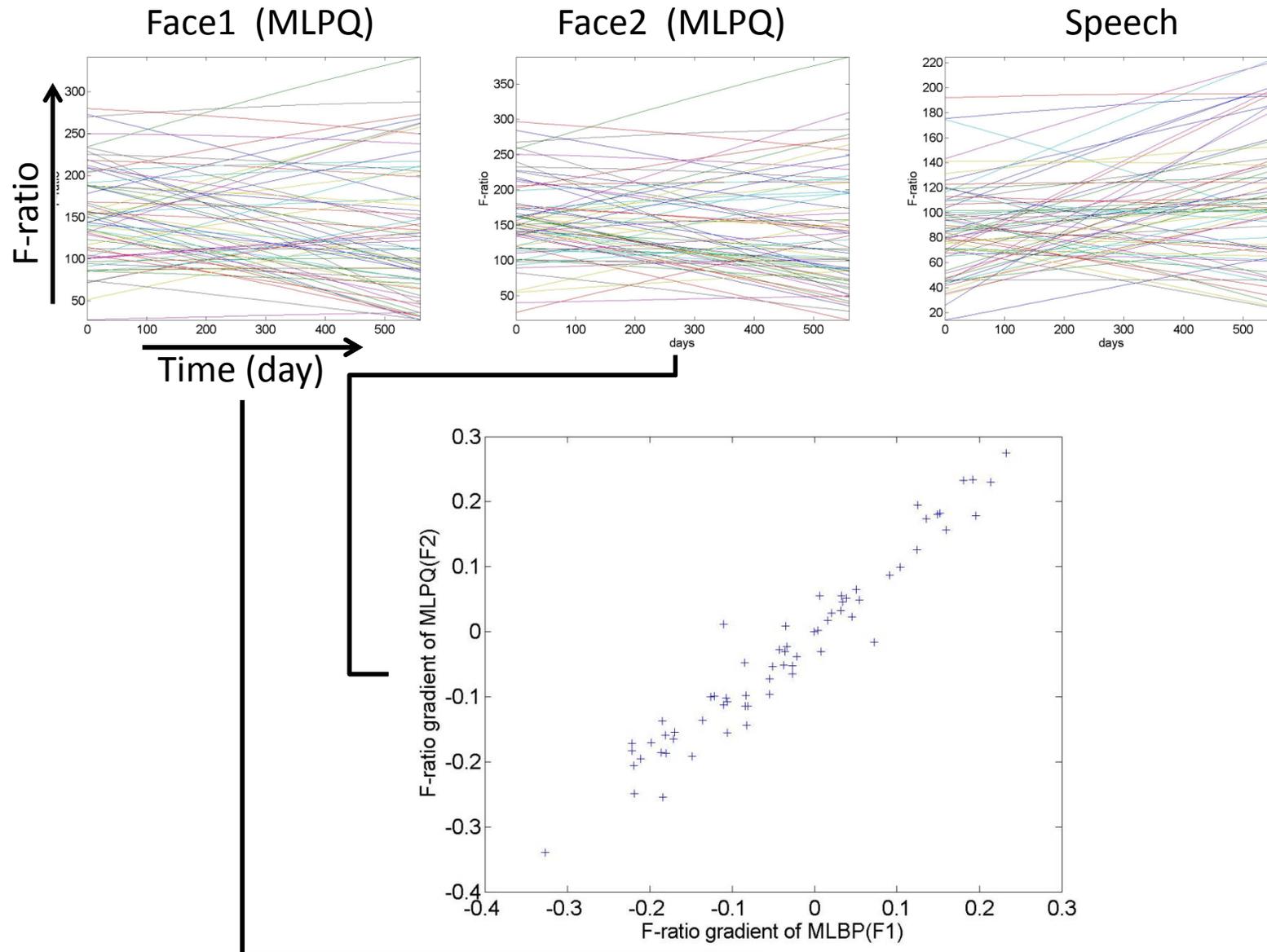
Partition 5 (getting better)



Face 1 +  
Face 2 +  
Speech

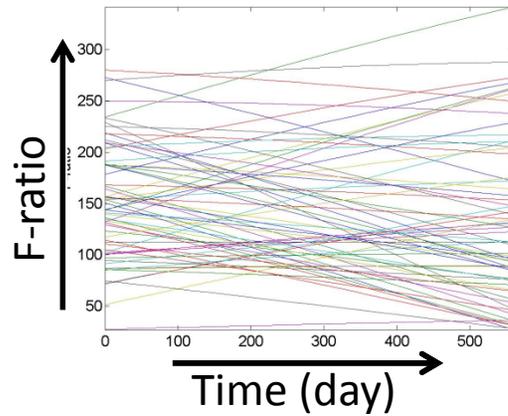


# Modality correlation in ageing?

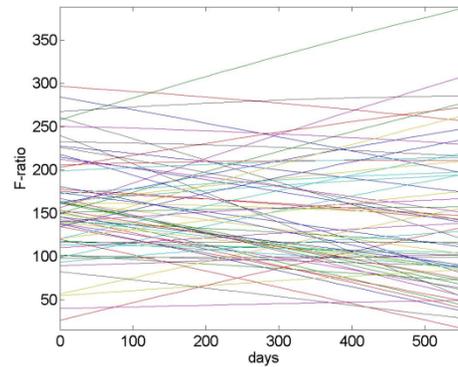


# Modality correlation in ageing?

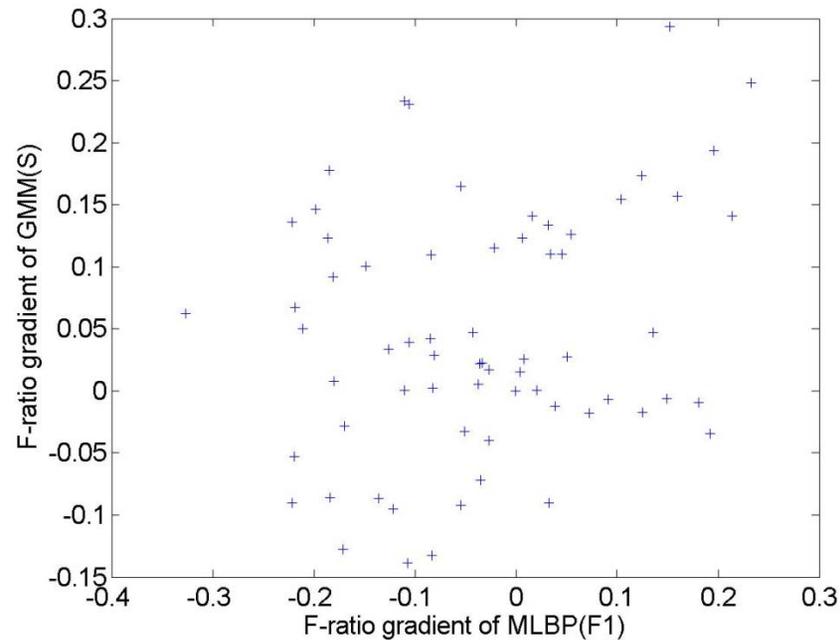
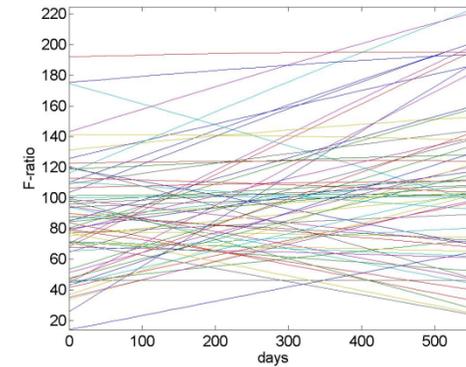
Face1 (MLPQ)



Face2 (MLPQ)



Speech



# Conclusions

## Ageing

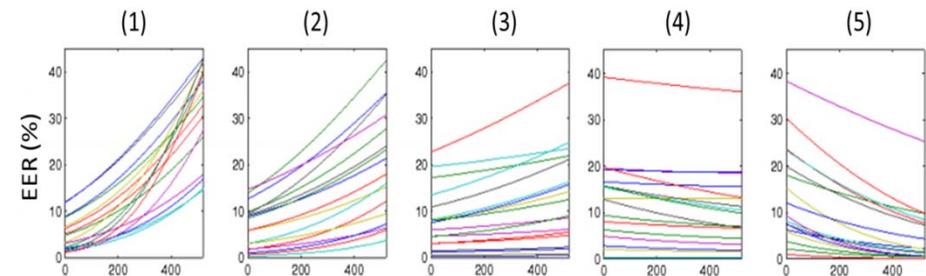
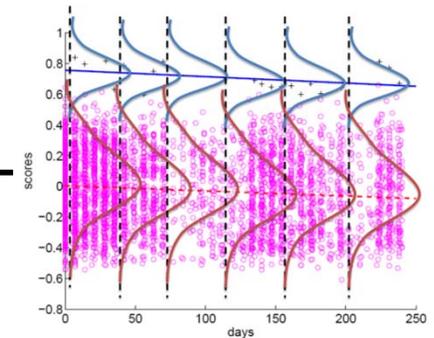
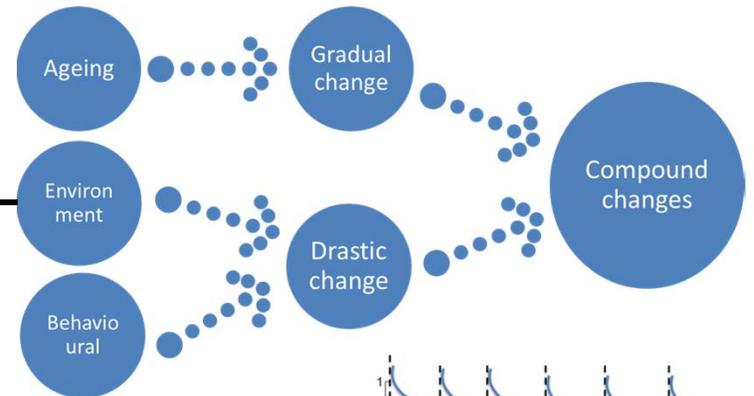
- Complex issue

## Contribution

- A framework to detect ageing

## Findings

- Ageing and habituation
- Subject-dependency



# Questions?

Email to [n.poh@surrey.ac.uk](mailto:n.poh@surrey.ac.uk)

Thanks to the MOBIO project and partners  
Chan Chi Ho, Medha Pandit, Josef Kittler  
IBPC conference and special session

## Ageing

- Complex issue

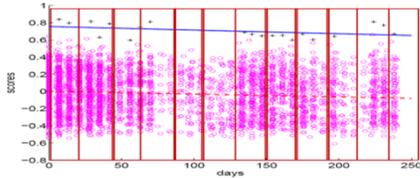
## Contribution

- A tool to detect ageing

## Findings

- Ageing and habituation
- Subject-dependency

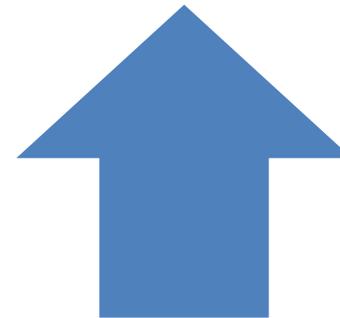
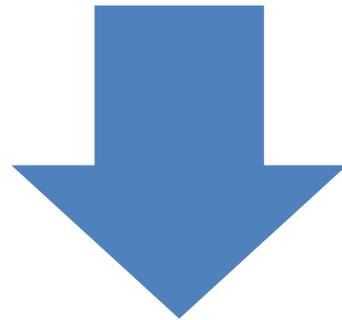
# windowing



Cannot model subject-specific performance



Vulnerable to sparse observations & discontinuities

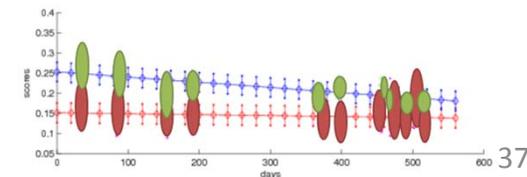


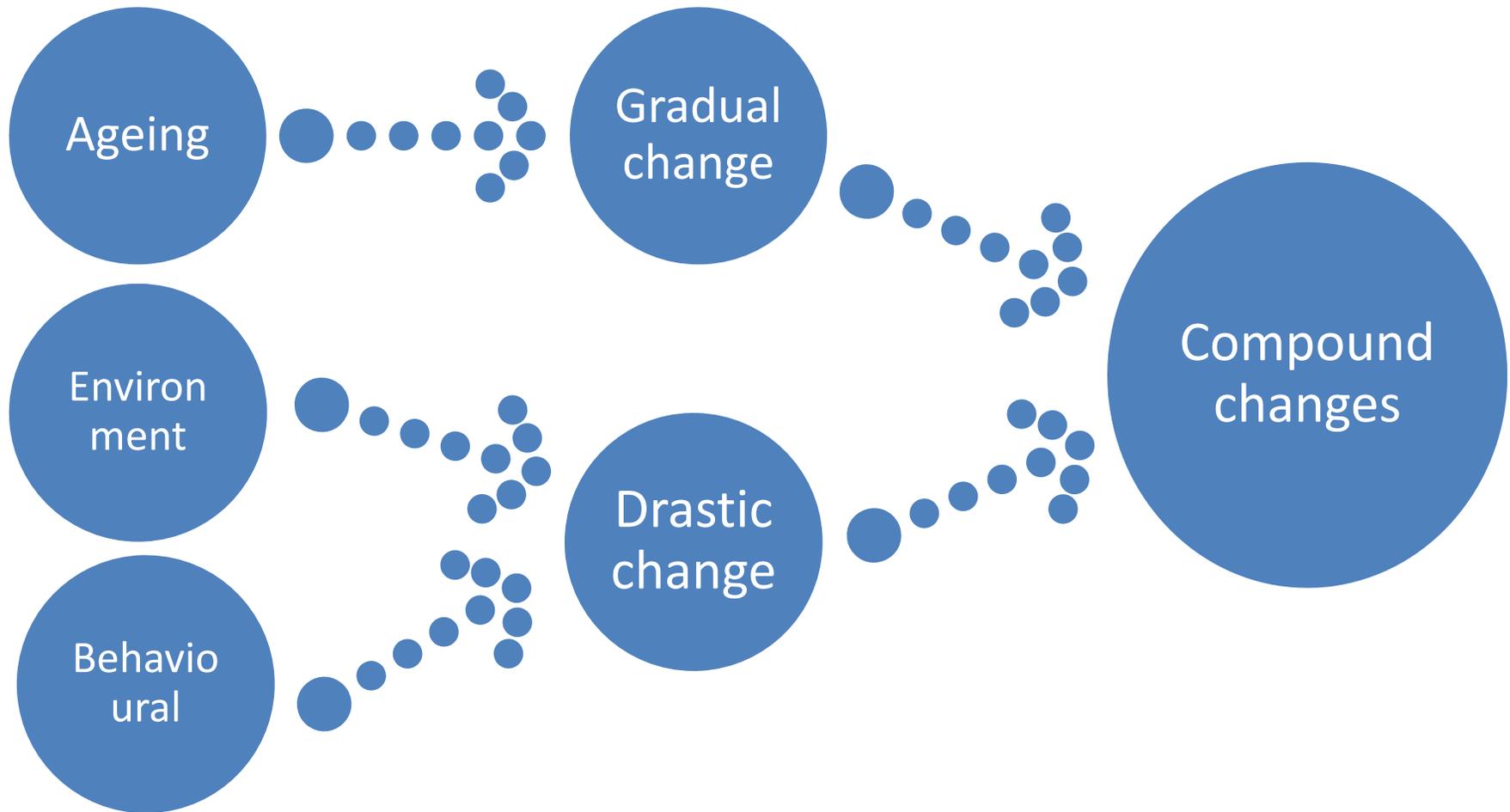
 Rely on smoothness assumptions

 Subject-specific performance

 Parametric error model (sensitive to *minute* changes)

# regression





# Ageing

