Dementia classification based on brain age estimation

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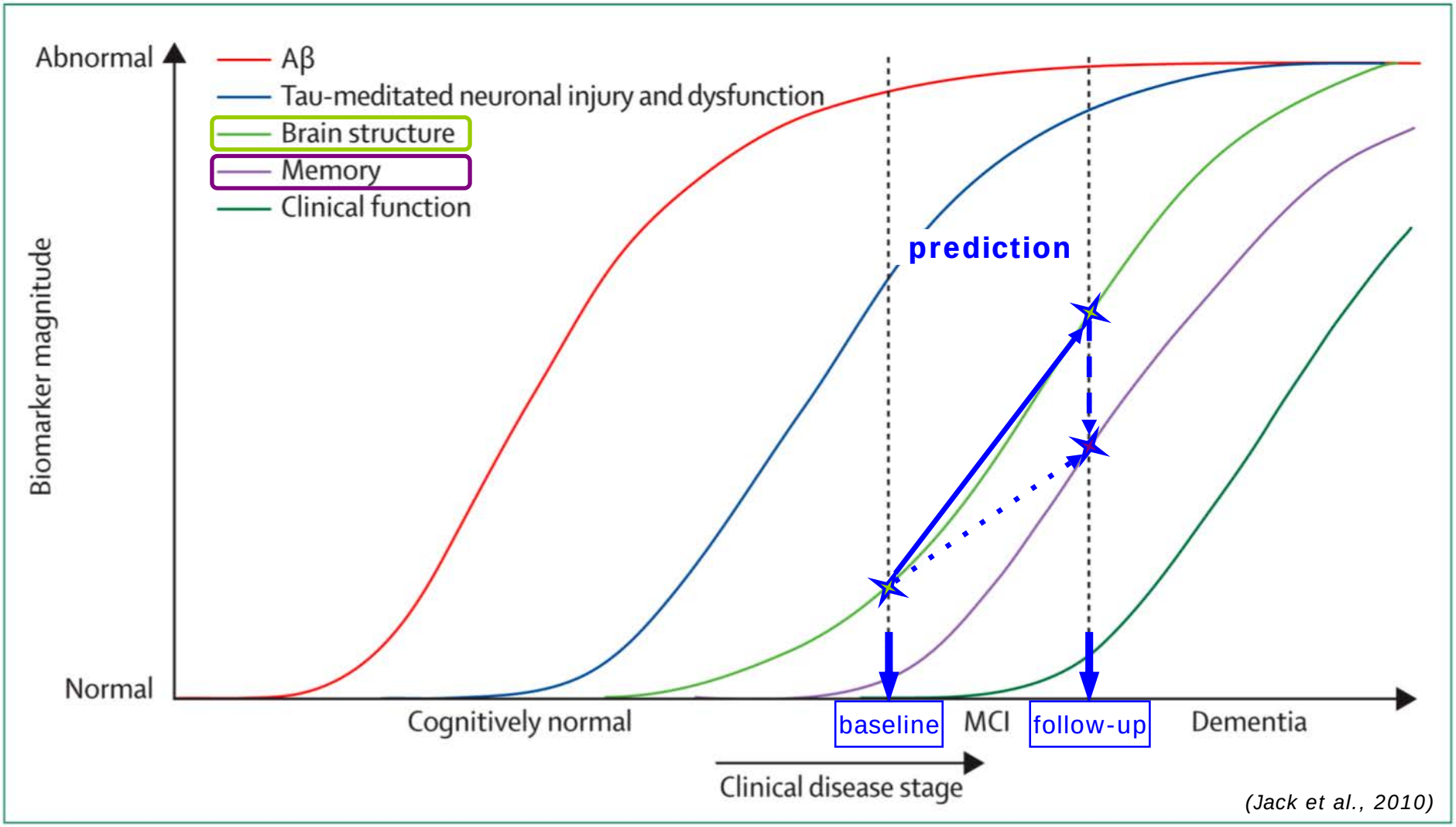
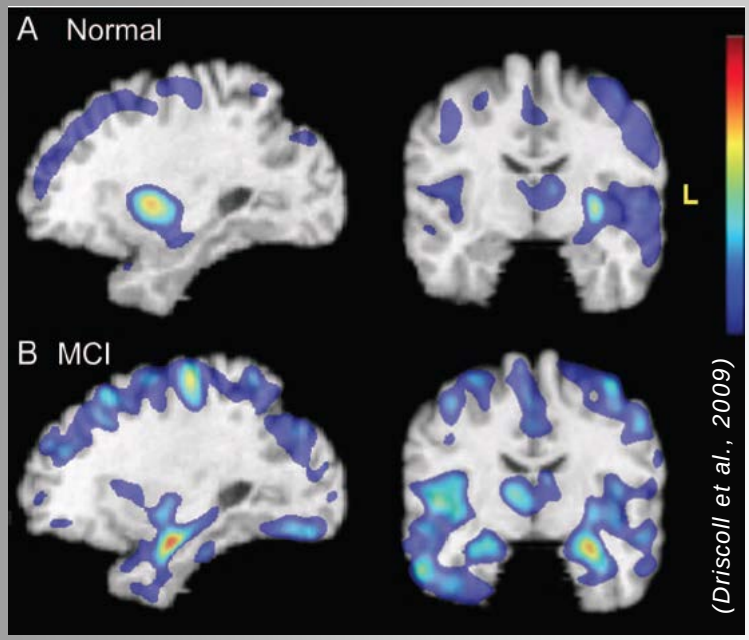
seit 1558

Dynamic biomarkers of the Alzheimer's pathological cascade

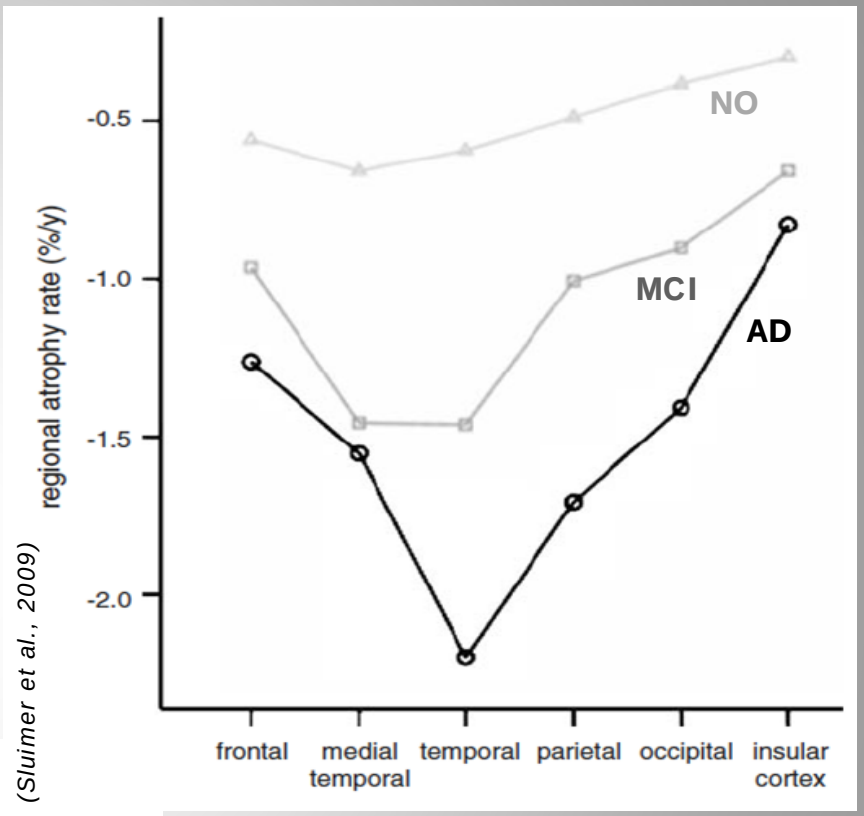


(Jack et al., 2010)

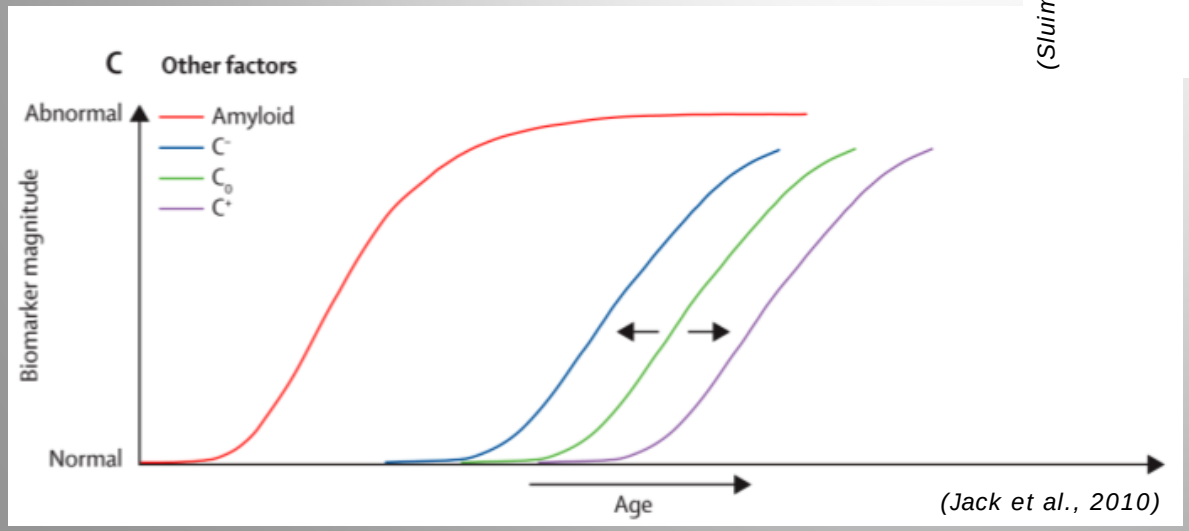
Advanced atrophy in MCI & Alzheimer's disease



➔ complex & **characteristic** atrophy patterns over time



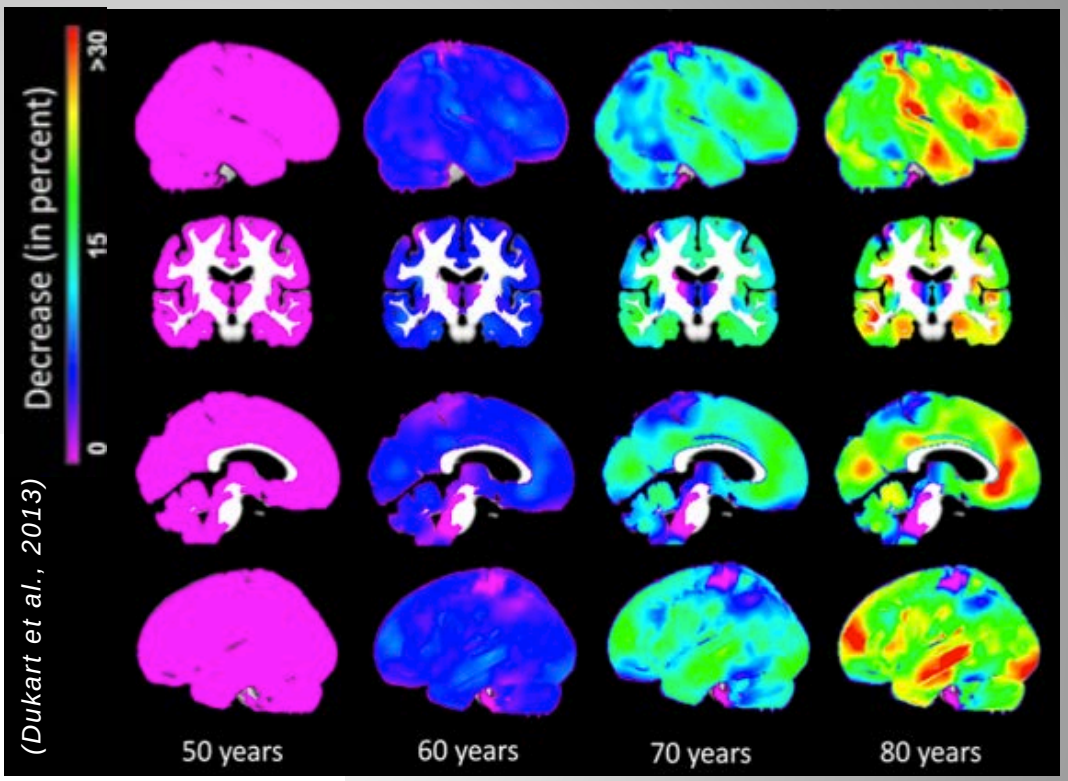
➔ with **intra**individual variability



➔ with **inter**individual variability within the disease course

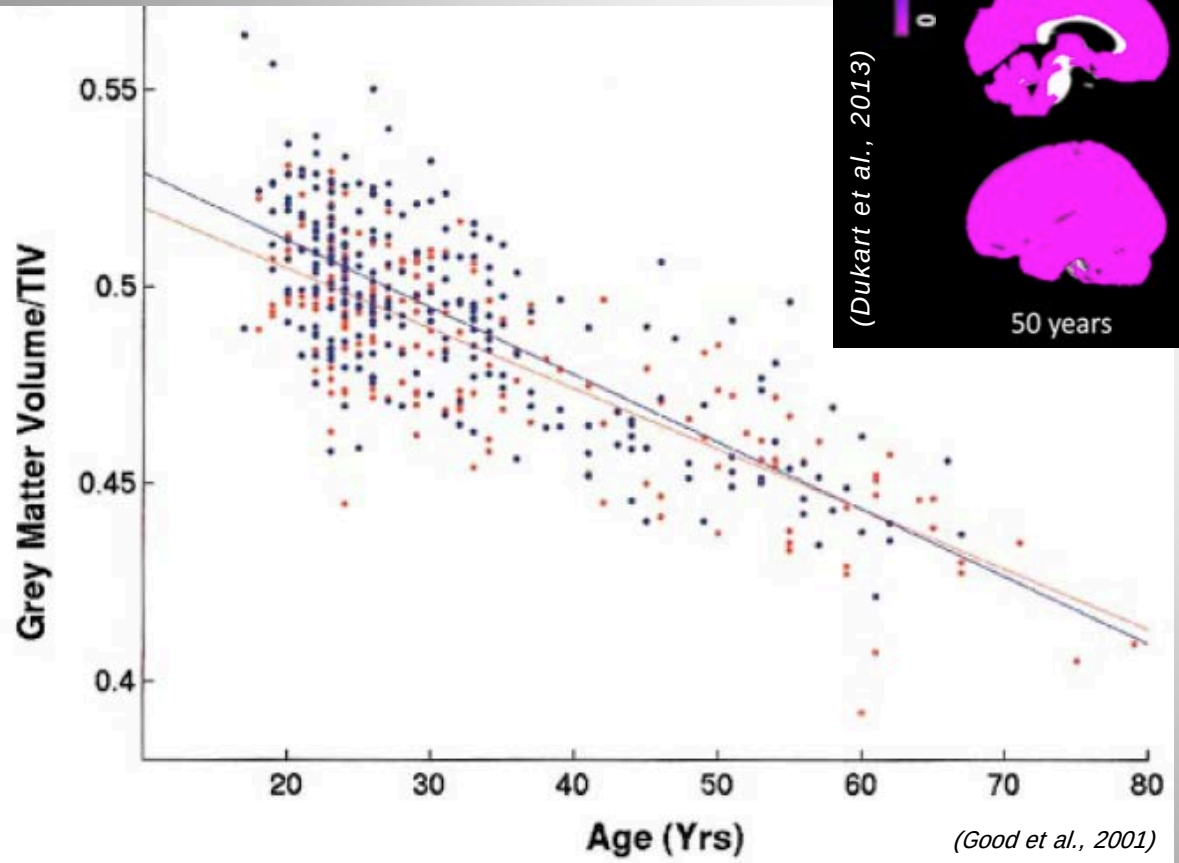
Healthy aging → Characteristic atrophy patterns

➔ complex & **characteristic** atrophy patterns over time



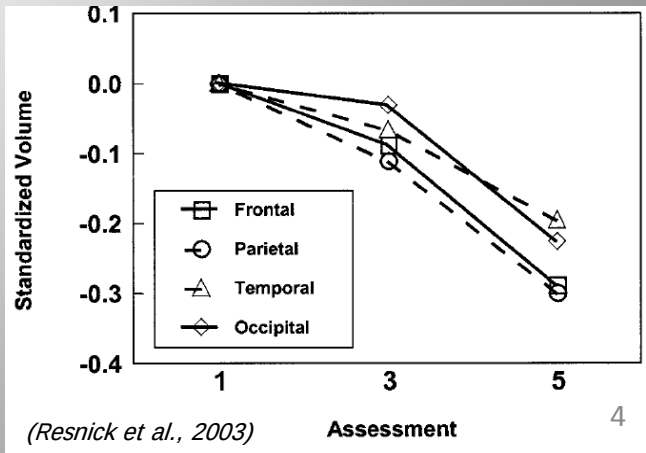
(Dukart et al., 2013)

➔ with **inter**individual variability



(Good et al., 2001)

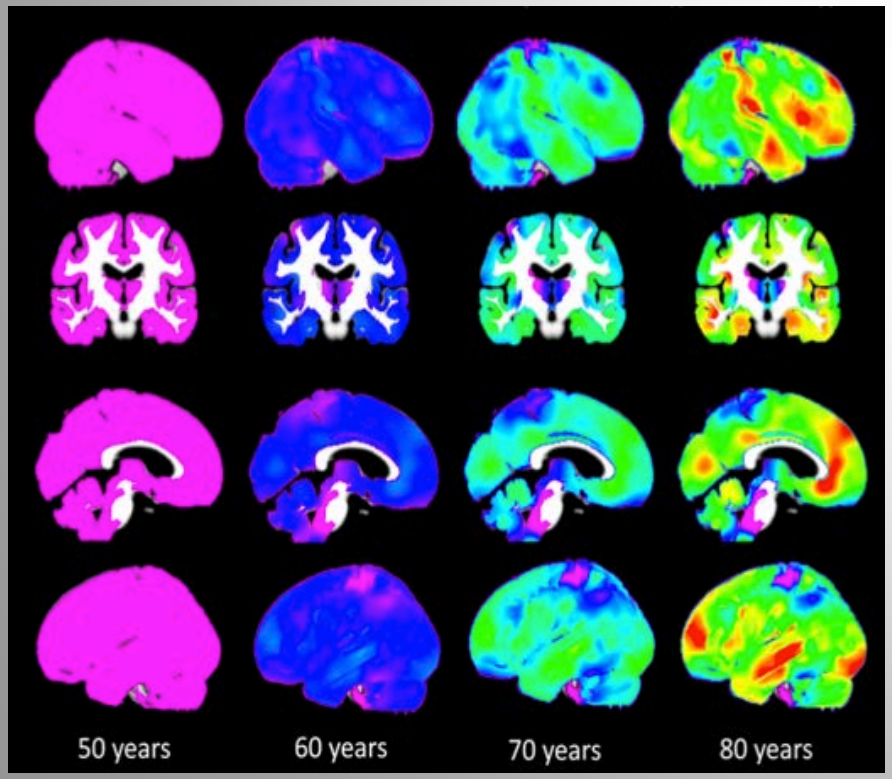
➔ with **intra**individual variability



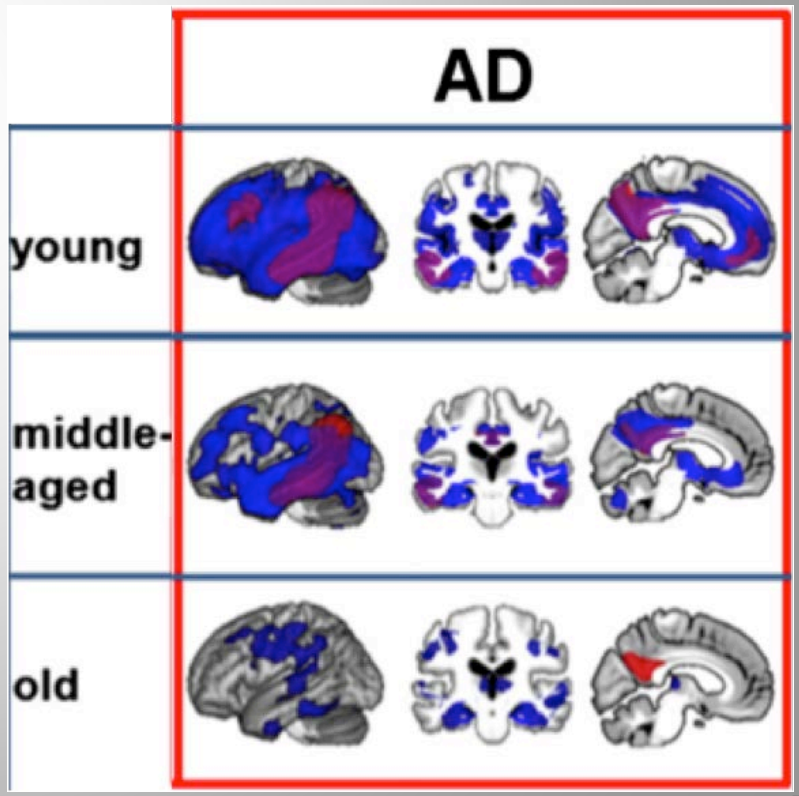
(Resnick et al., 2003)

Brain atrophy in Alzheimer's dementia

(Advanced) age-related atrophie + Disease-specific atrophie



(Dukart et al., 2013)



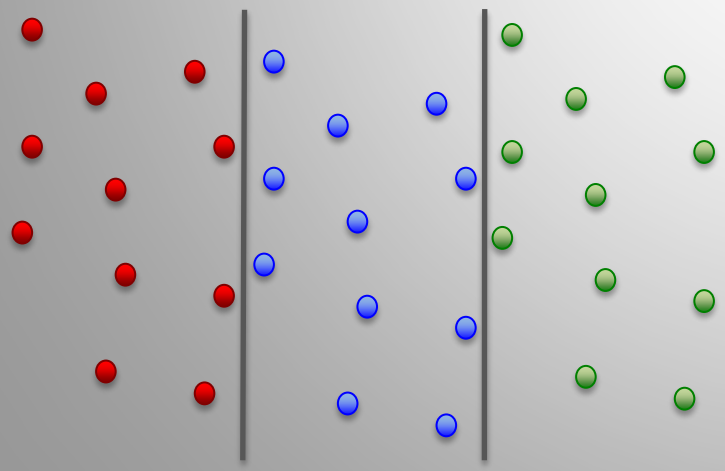
(Dukart et al., 2013)

Prediction based on healthy brain aging

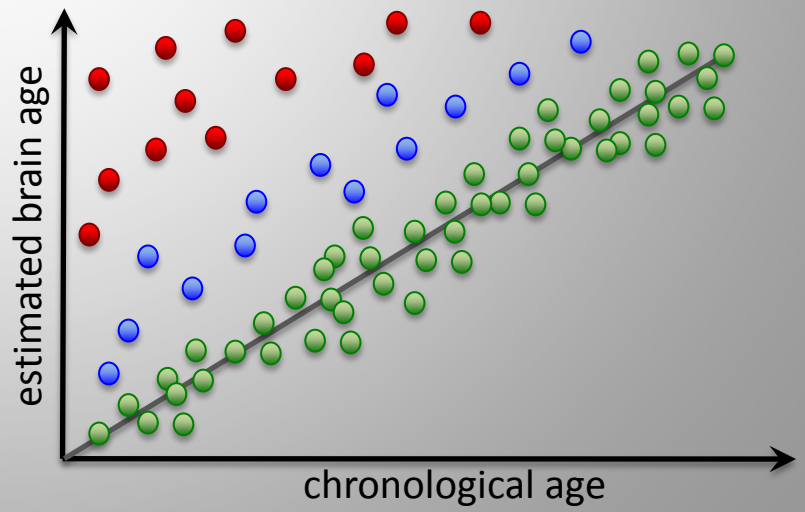
Baseline data (structural MR image)

Individual prediction: ***AD***, ***MCI***, *or* ***healthy***?

Typical approach: classification of disease-specific atrophy patterns



BrainAGE approach: deviation from normal aging-related atrophy patterns

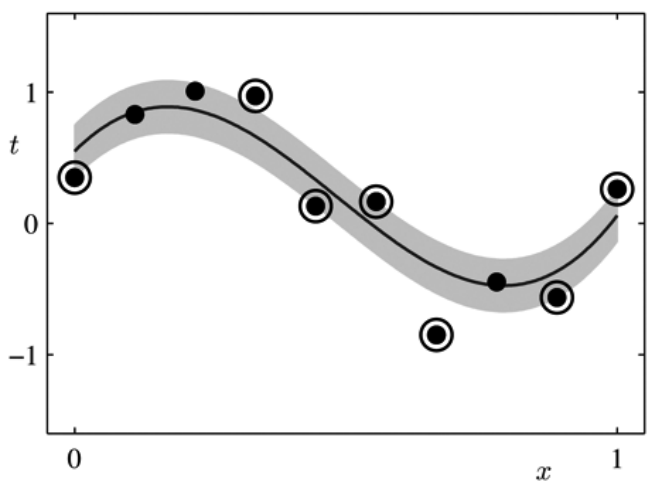


Modeling of structural brain aging

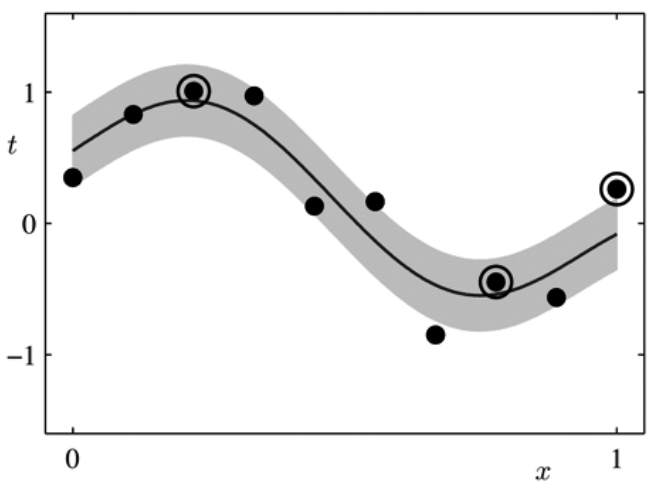
complex & characteristic atrophy patterns

Pattern recognition / Machine-learning

Support Vector Regression

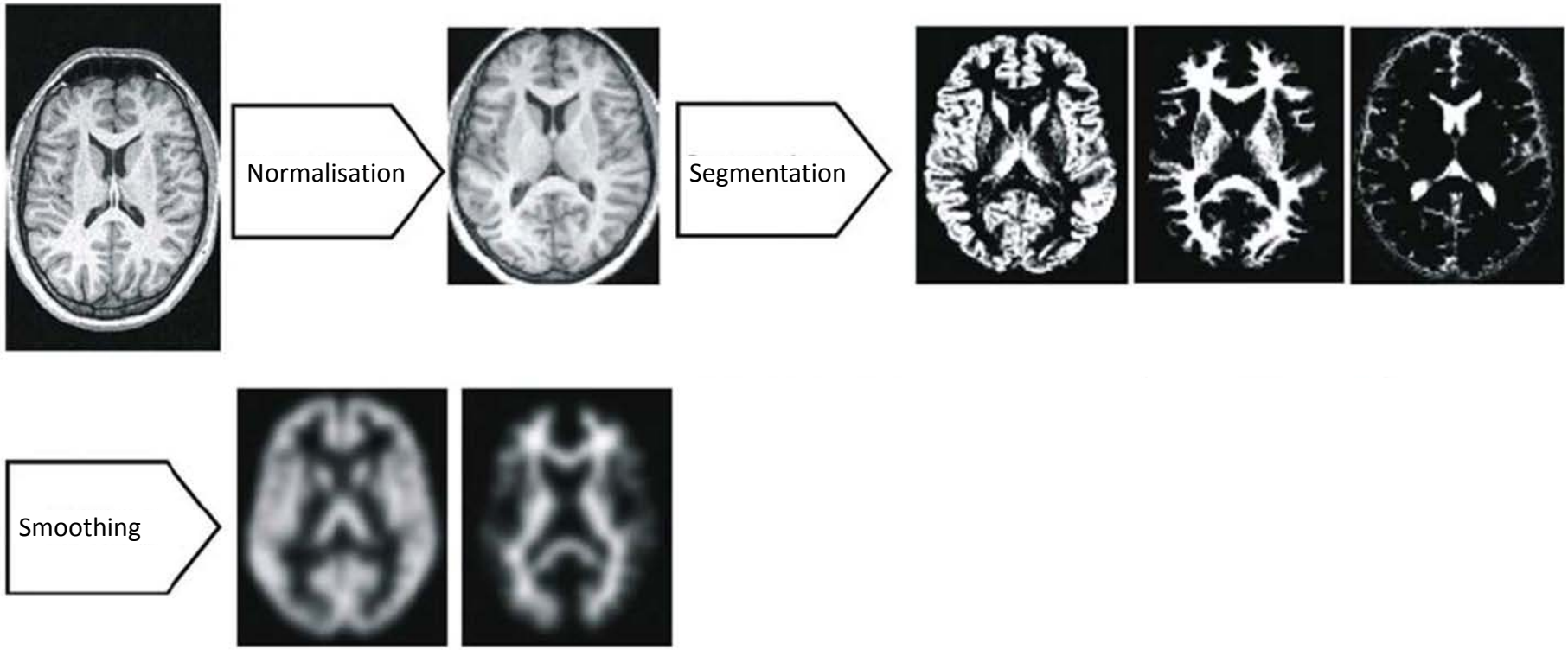


Relevance Vector Regression



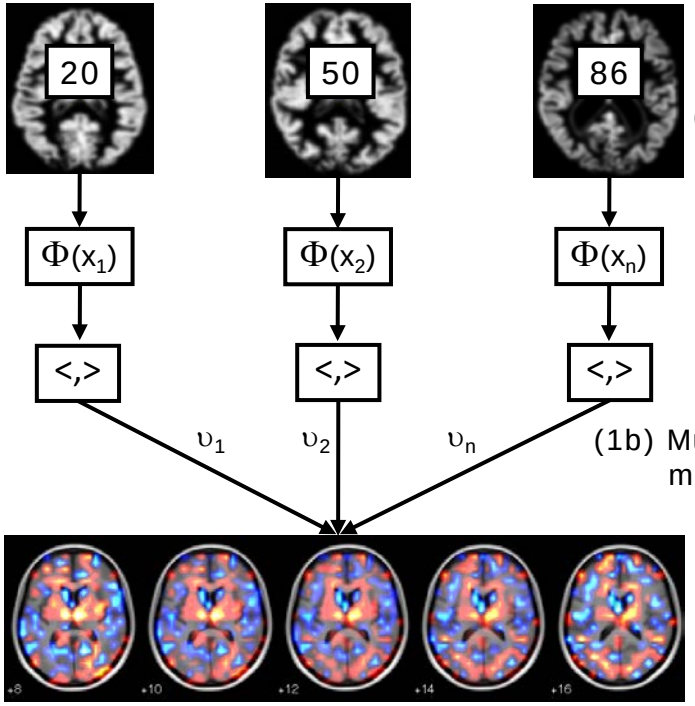
- Bayesian approach
- crossvalidation NOT necessary
- sparse

Preprocessing of MR images



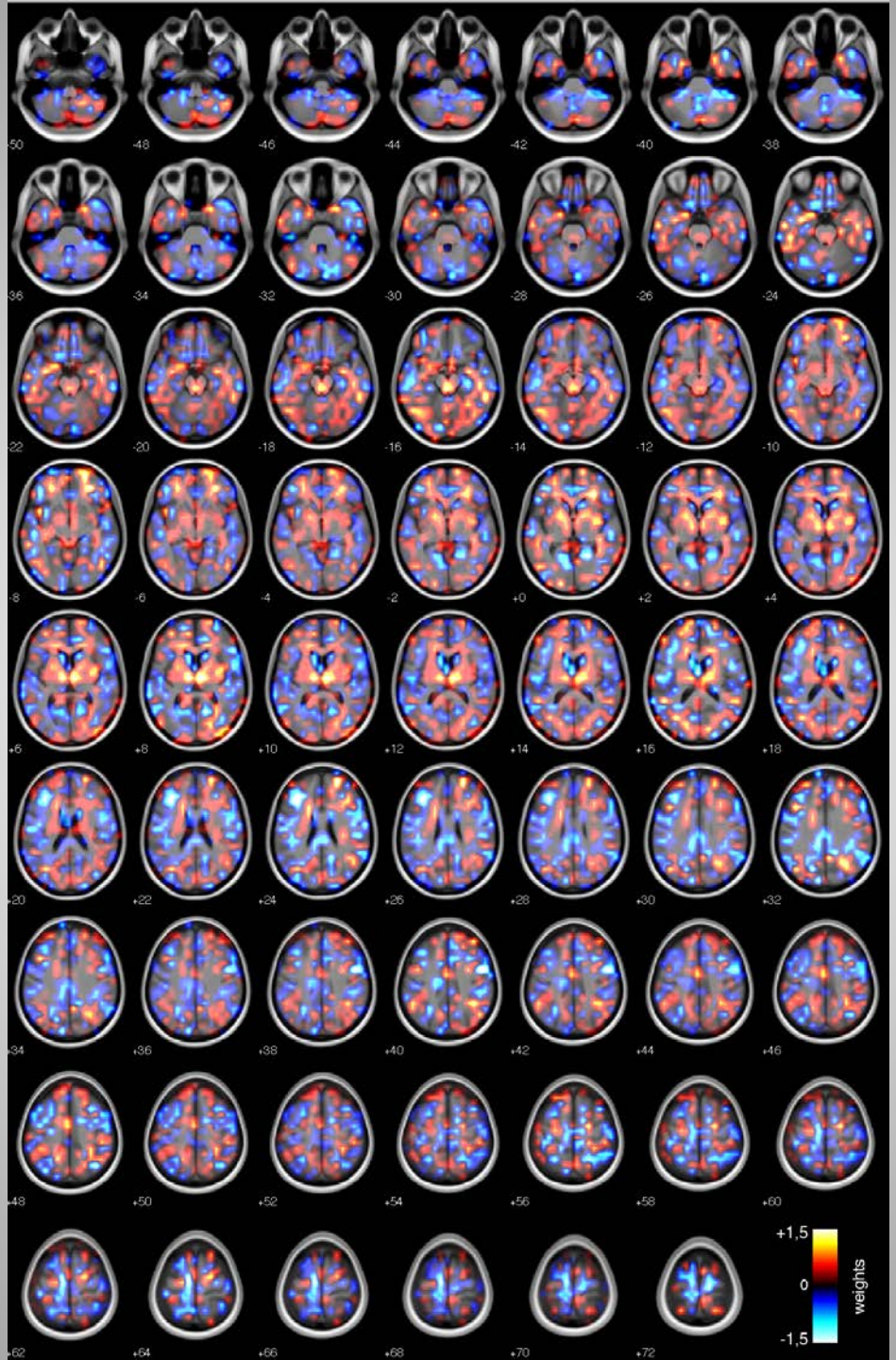
Identification of individual atrophy patterns

Modeling of normal brain aging
[with Relevance Vector Regression (RVR; Tipping, 2000)]



(1a) training data: MRI & age (healthy subjects)

(1b) Multivariate pattern recognition: modeling healthy brain aging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+56
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+70
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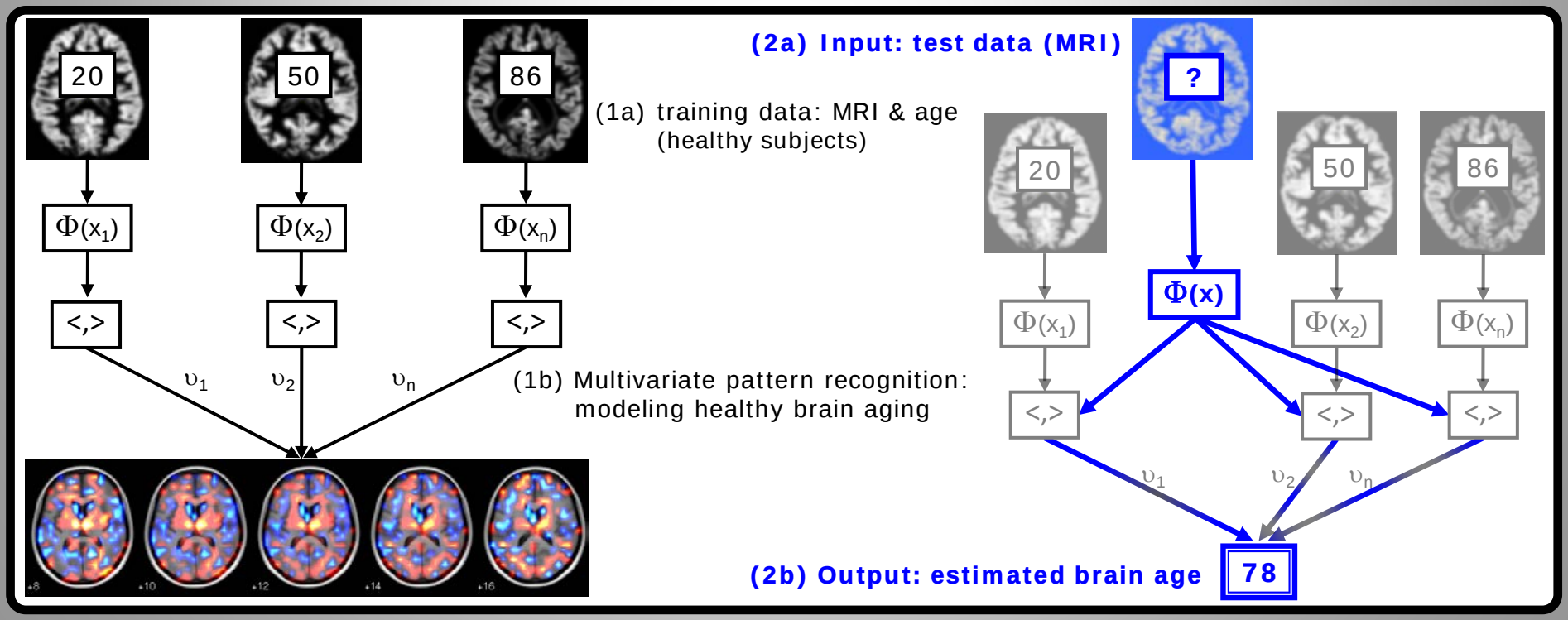
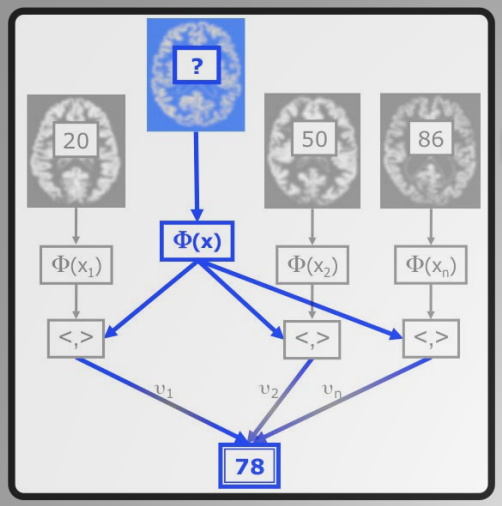
+1,5
0
-1,5
weights

Identification of individual atrophy patterns

Modeling of normal brain aging
[with Relevance Vector Regression (RVR; Tipping, 2000)]

Estimation of individual "brain age"
[complex individual brain structure is aggregated into <u>one</u> number]





Deviation from the individual age-related atrophy pattern?

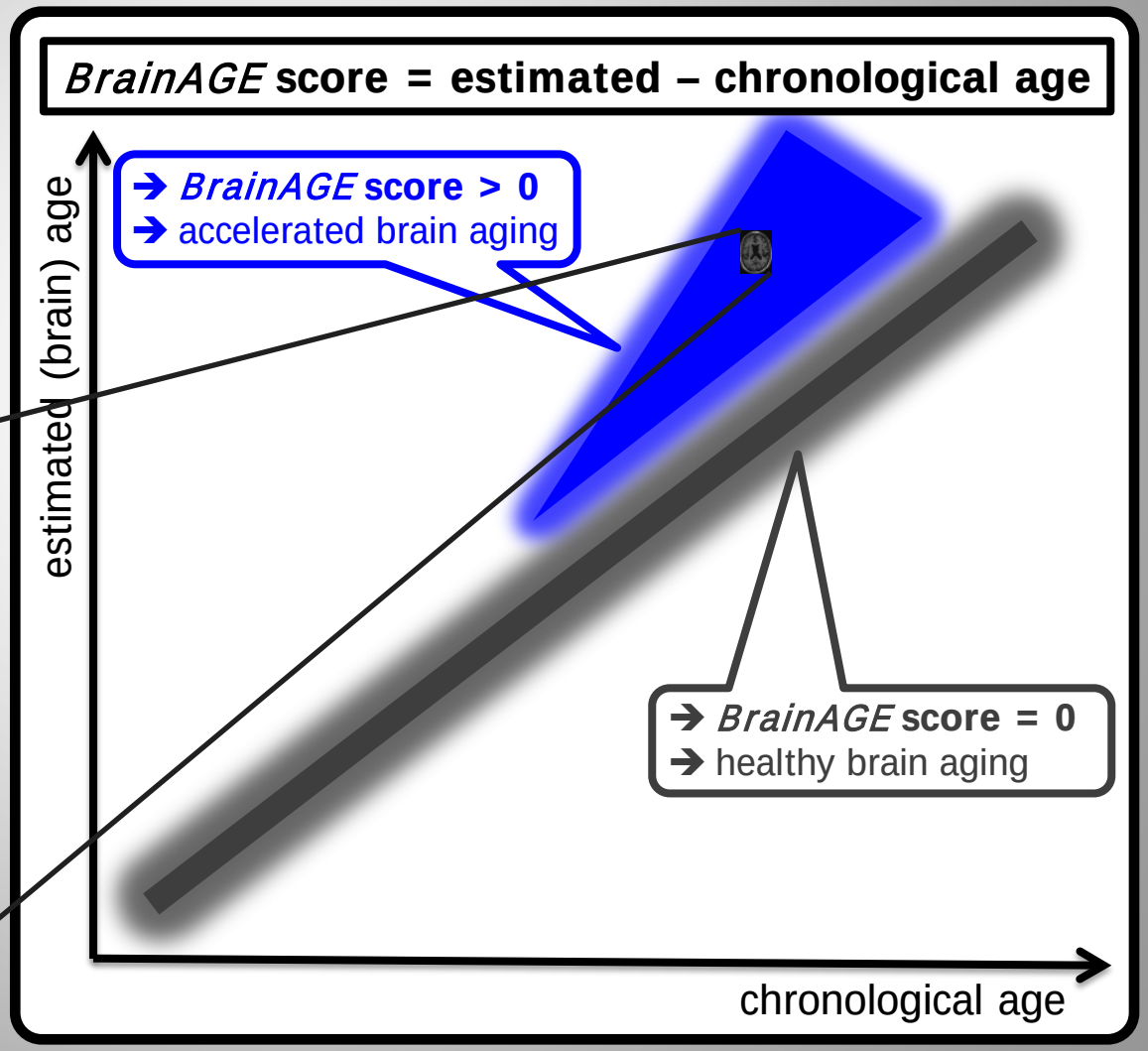
Example

Chronological age: 68 years

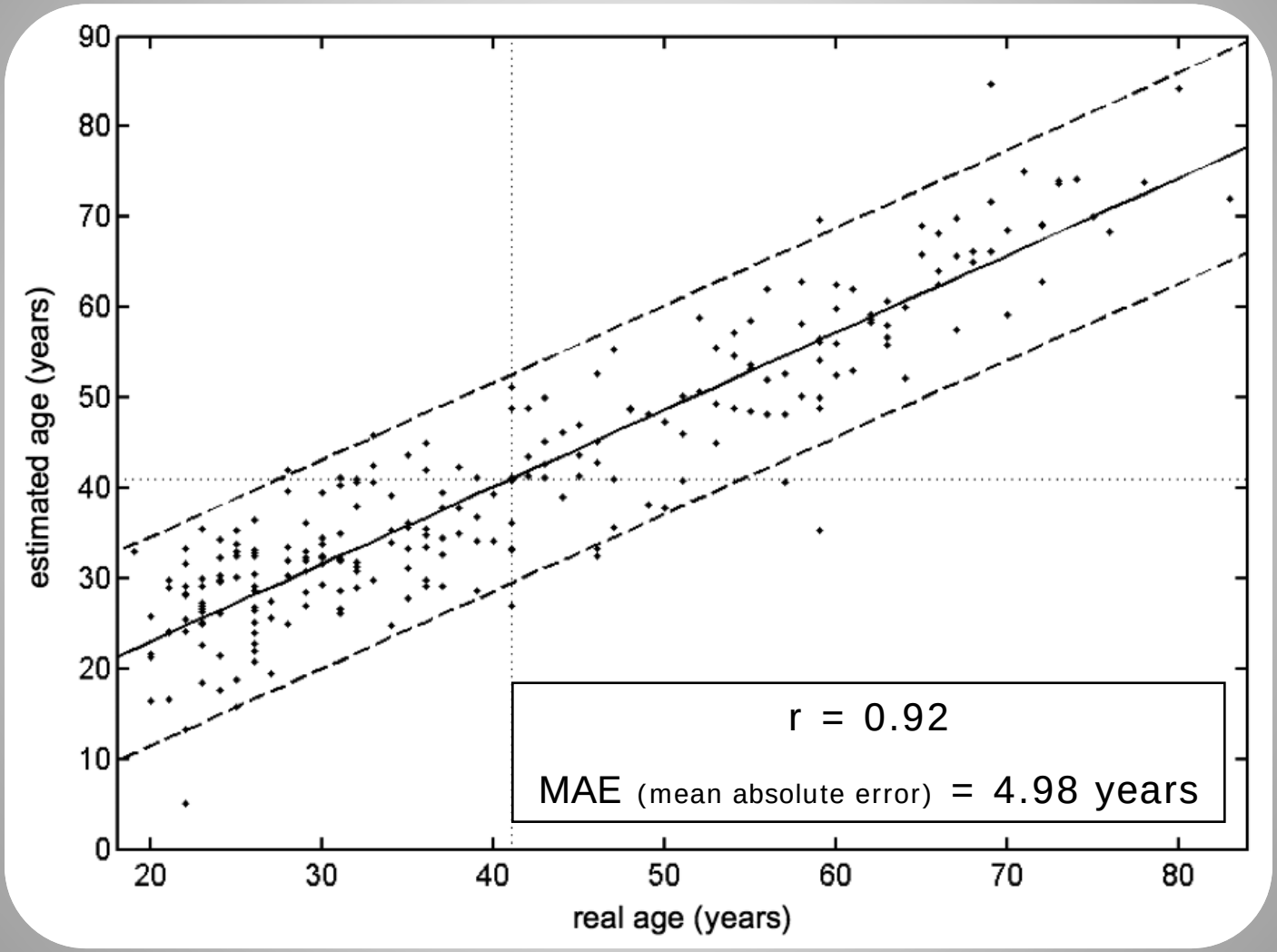
Estimated age: 78 years

➔ *BrainAGE* score: +10 years

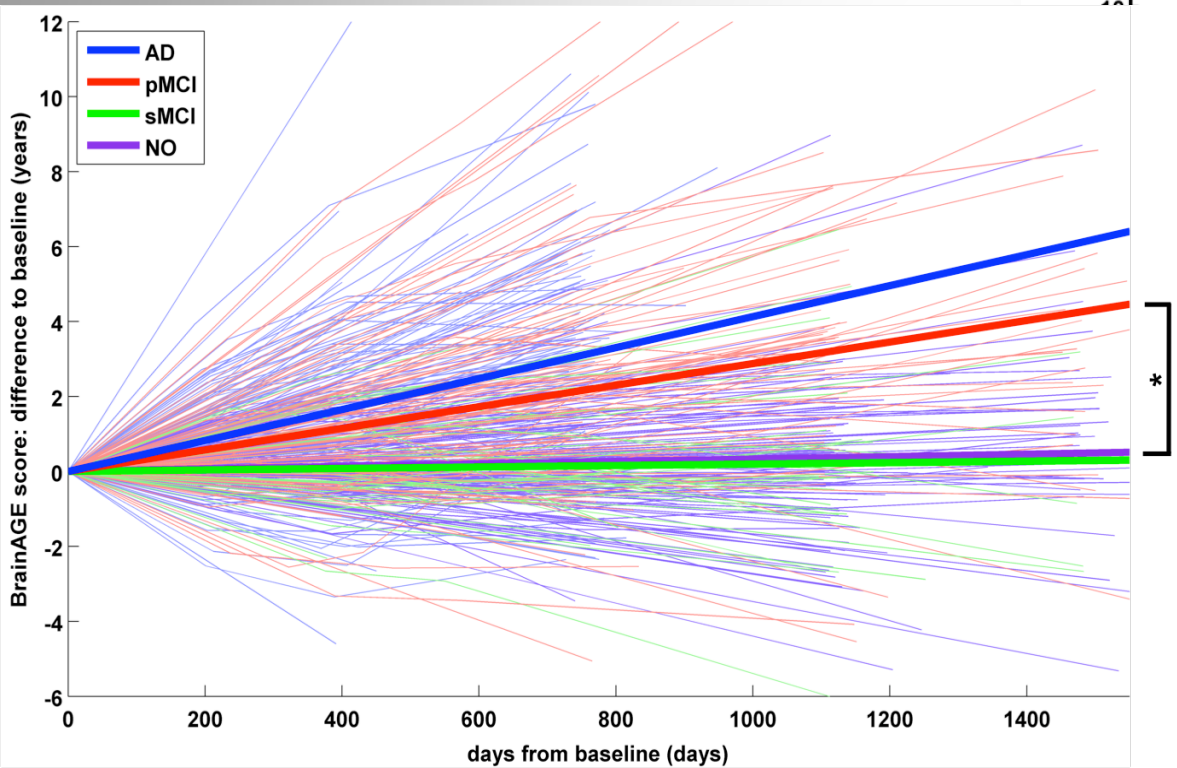
***BrainAGE* score = estimated – chronological age**

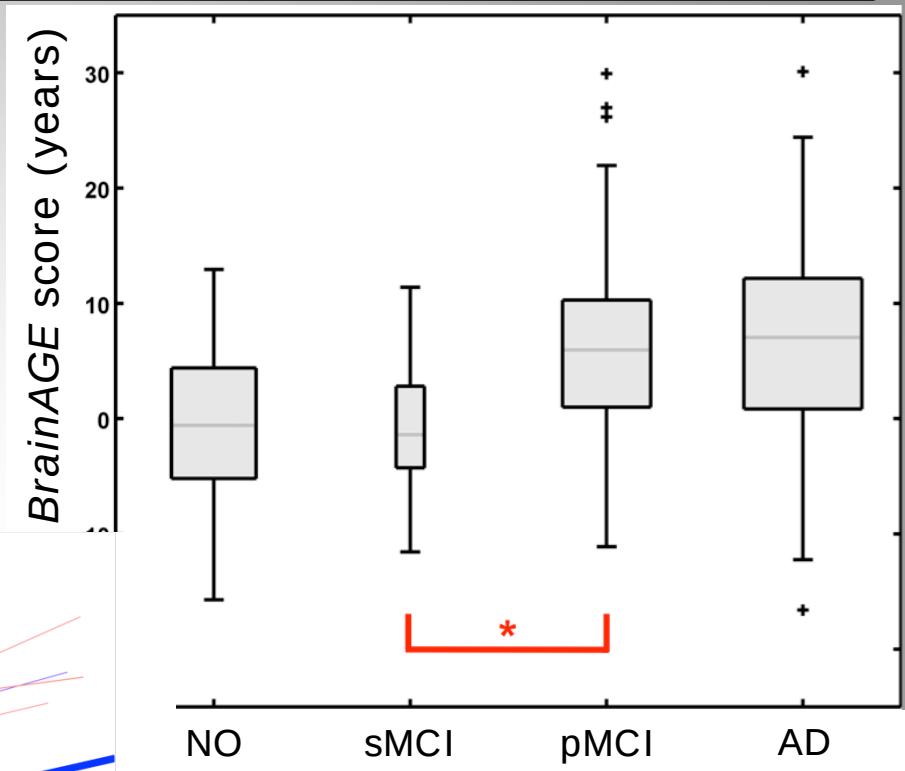


Reference curve for structural brain aging (Franke et al., 2010)



Advanced brain aging in progressive MCI & AD (Franke & Gaser, 2012)

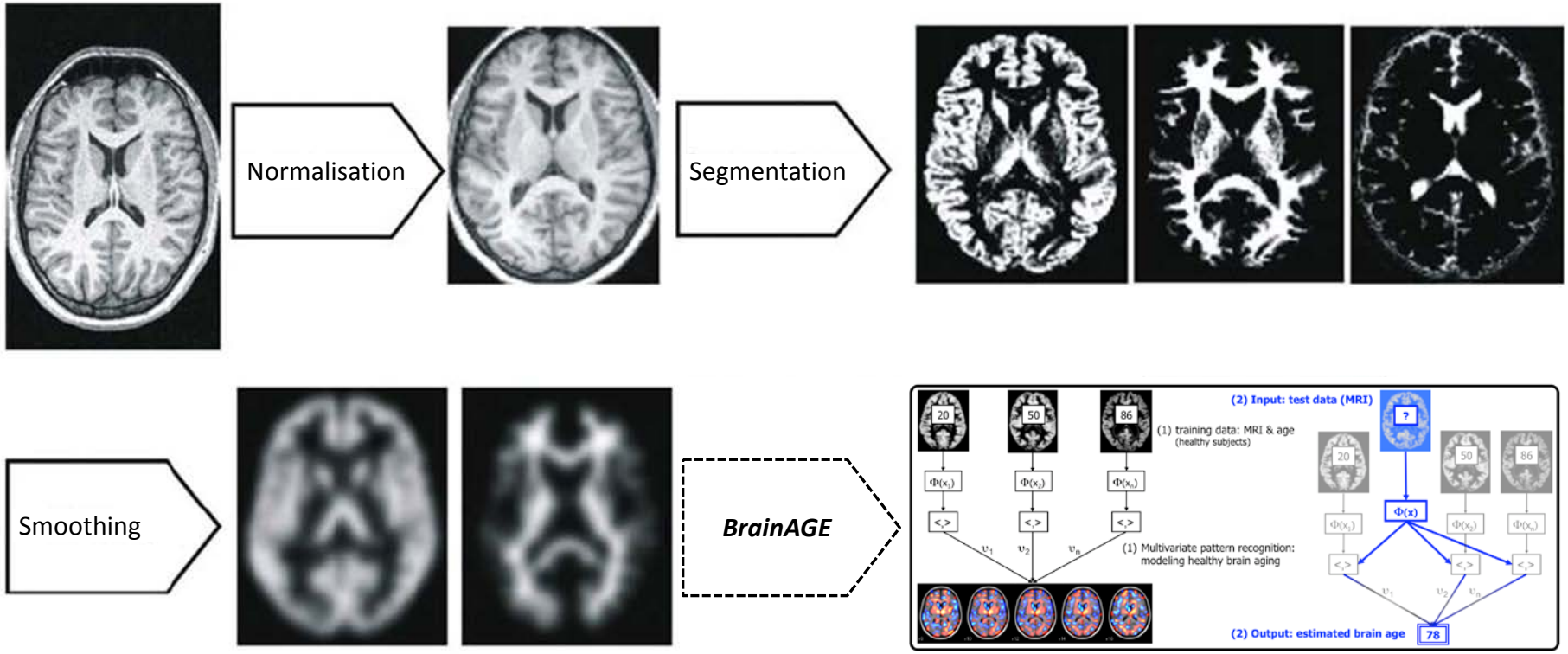




BrainAGE score =
estimated – chronological age

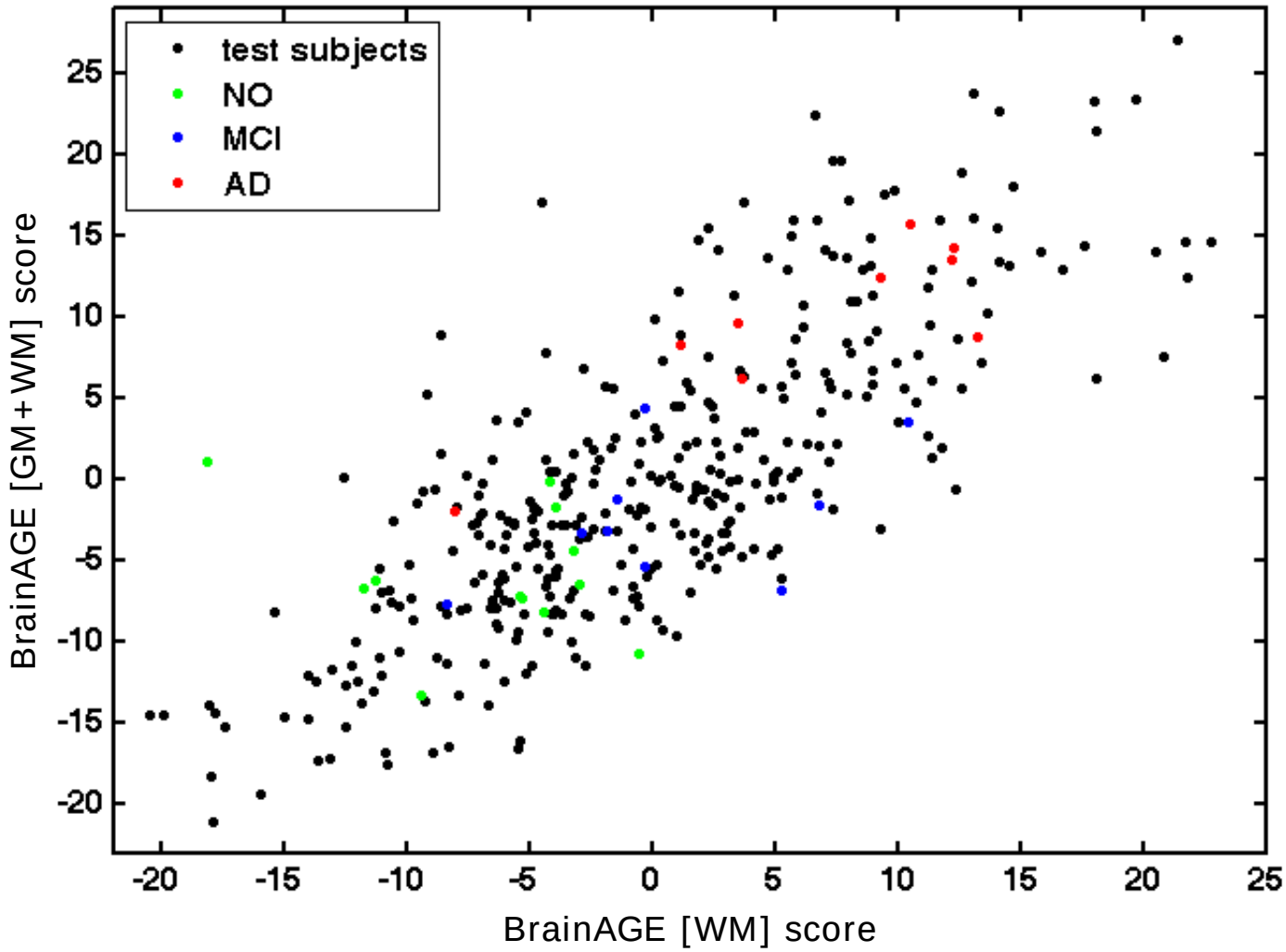
Pipeline for *BrainAGE* approach in *CAD Dementia*

- MRI preprocessing with voxel-based morphometry [affine registration, smoothing with ***(i)*** 4mm & ***(ii)*** 8mm FWHM smoothing kernels]
- Modeling of structural brain aging with 561 healthy subjects [aged 20-86 years]
- *BrainAGE* estimation with ***(i)*** linear combination of GM + WM images & ***(ii)*** WM images



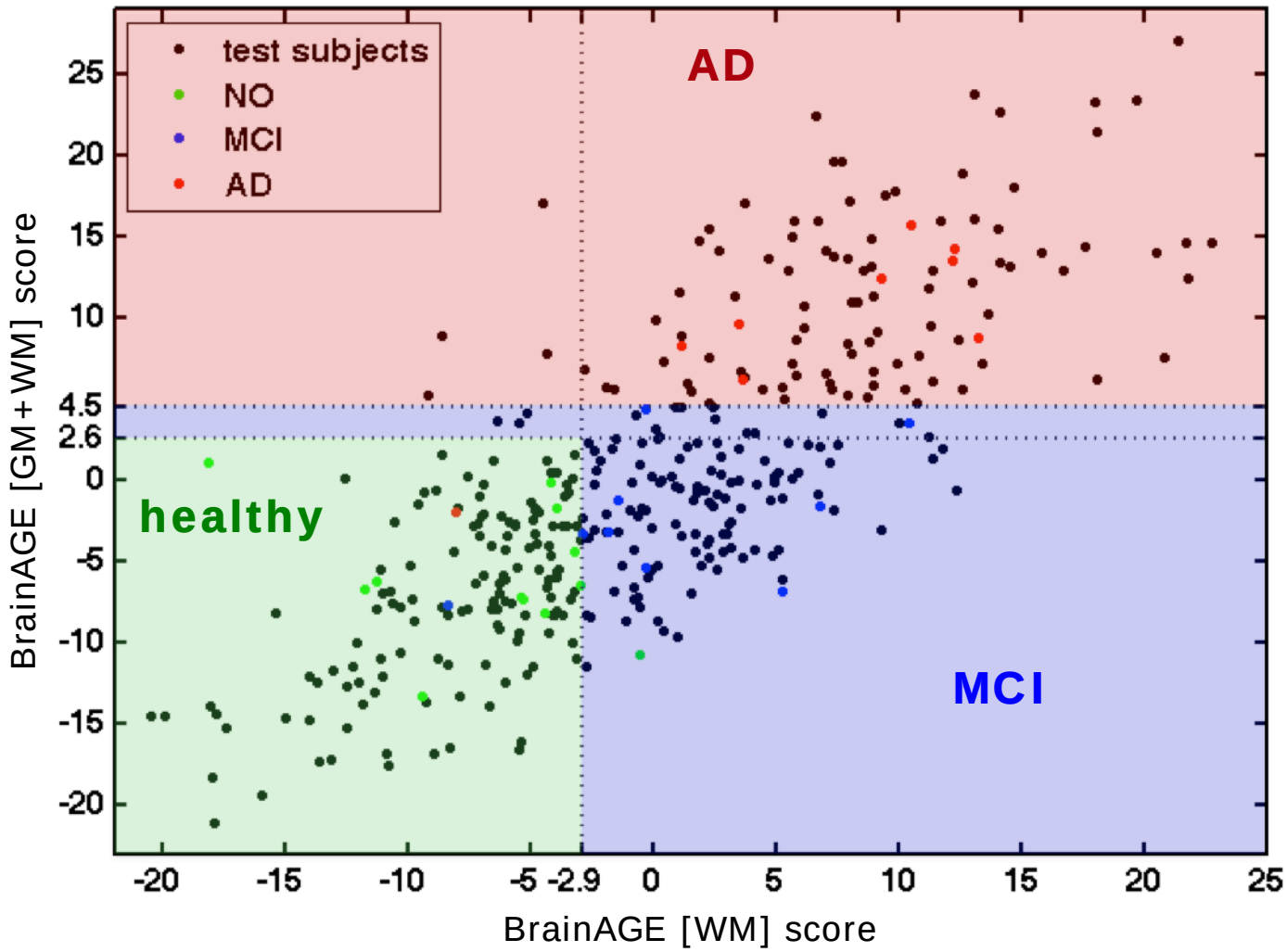
BrainAGE scores in *CAD Dementia*

[*BrainAGE* score = estimated – chronological age]



Thresholds for individual classification

[*BrainAGE* score = estimated – chronological age]



➔ Classification accuracy in CAD Dementia training sample: **90 %**

Thank you!

This work was funded by the German Ministry for Education and Research (Bundesministerium für Bildung und Forschung – BMBF) [01EV0709 to C.G.; 01GW0740 to K.F.].

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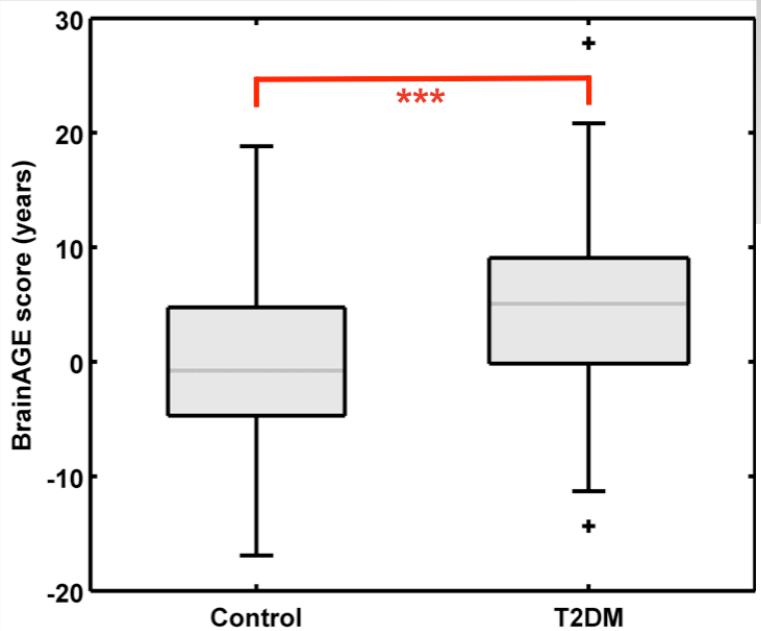
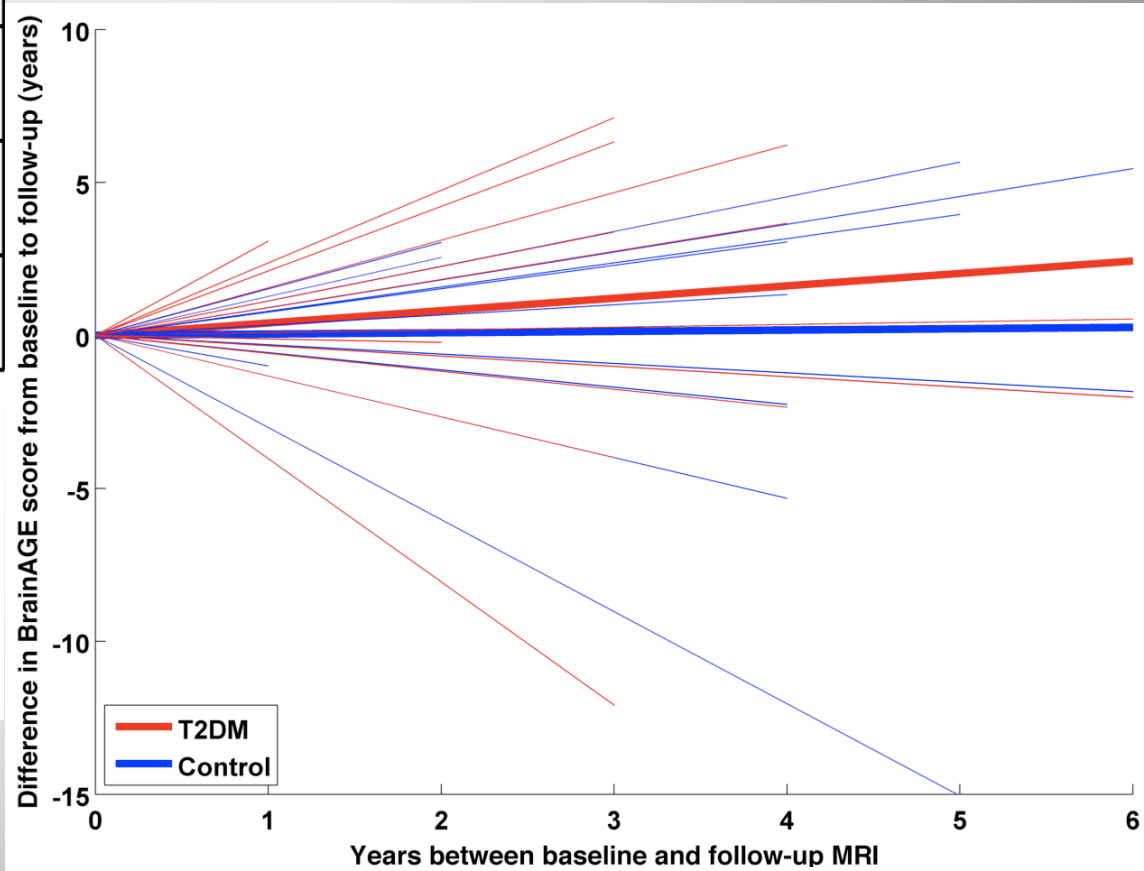
Anwendung: Advanced *BrainAGE* in older adults with type 2 diabetes mellitus

(Franke et al., sub.)



Box plots of *BrainAGE* scores for controls and patients with type 2 diabetes mellitus (T2DM). The *BrainAGE* scores differed between groups, with mean (± SD) *BrainAGE* scores of 0.0 ± 6.7 years in healthy controls and 4.6 ± 7.2 years in T2DM subjects ($P<0.001$). Gray boxes contain the values between the 25th and 75th percentiles of the groups, including the median (dashed line). Lines extending above and below each box symbolize data within 1.5 times the interquartile range (outliers are displayed with a +). Width of the boxes indicates the group size.

Beschleunigte Gehirnalterung in pre-symptomatischen Probanden mit Typ 2 *diabetes mellitus*



Longitudinal changes in *BrainAGE* scores for control subjects (blue) and T2DM patients (red). Thin lines represent individual changes in *BrainAGE* over time; thick lines indicate estimated average changes for each group. The change in *BrainAGE* over time was dependent upon group, providing preliminary longitudinal evidence that T2DM accelerates brain aging.

Alters-abhängige und Krankheits-spezifische Atrophie bei Alzheimer Demenz