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University Medical Center Rotterdam

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**Biomedical Imaging and Genetic (BIG) Data Analytics
in Dementia and Oncology**

“Deep Learning for Precision Medicine”

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Quantib (disclosure)

Precision medicine: what do we want?

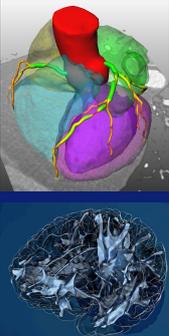
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*Taking individual variability into account to
optimize diagnosis, prognosis and treatment*

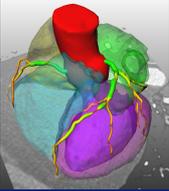
Precision medicine: what does it mean?

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- Cardiovascular disease:
knowing who to treat
- Cancer treatment:
predict what treatment is likely successful
- Dementia:
prognosis to support preventive strategies

Precision medicine: what does it mean? 



- **Cardiovascular disease:**
knowing who to treat
- **Cancer treatment:**
predict what treatment is likely successful
- **Dementia:**
prognosis to support preventive strategies







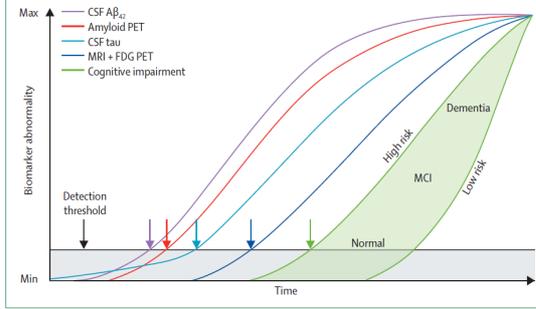
1967 – 34 years



2000 – 67 years

William Utermohlen
(1933-2007)

Possible early markers for dementia 



Max

Min

Detection threshold

Time

CSF $A\beta_{42}$

Amyloid PET

CSF tau

MRI + FDG PET

Cognitive impairment

Normal

MCI

Dementia

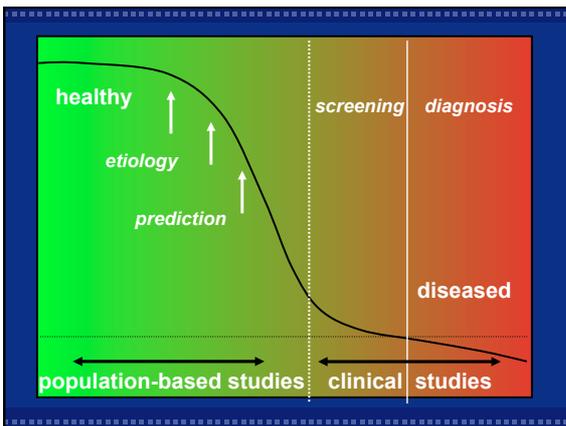
High risk

Low risk

Jack et al., 2010; 2013



Rotterdam Study
Population Study initiated in 1990



Population imaging study Erasmus MC
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Risk factors:

Genetic

Lifestyle

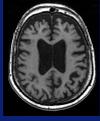
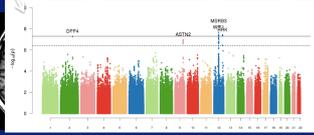
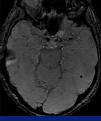
Smoking

black box

Outcome:

Dementia

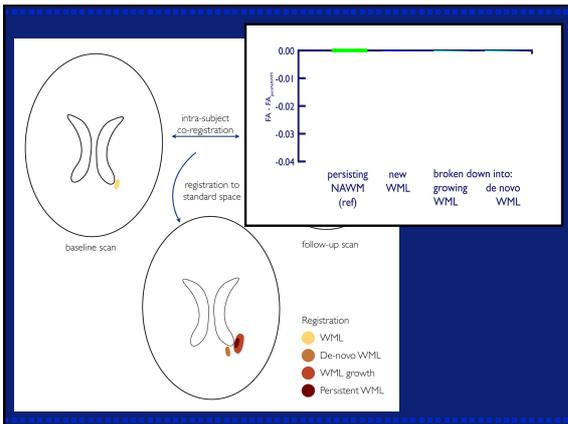
Stroke

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Can this approach succeed?

De Groot et al, "Stroke 2013 Progress and Innovation award"



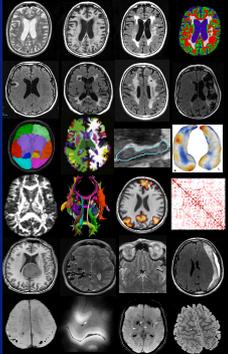
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Conclusion

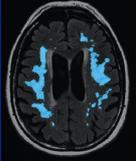
What we currently see visually (as appreciable white matter lesions) is only the tip of the iceberg of white matter pathology: searching for QIBs logical next step

Rotterdam Scan Study (> 14.000 MRI data acquired) 

- Tissue quantification
- Lesion assessment
- Segmentation & shape
- Microstructure & function
- Incidental brain findings
- Cerebral microbleeds



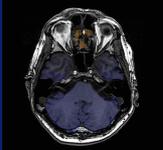
Library of quantitative imaging biomarkers 



Subcortical WMH



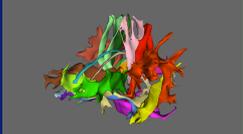
Hippocampal shape and volume



Brain structures



Structural connectivity



White matter tracts

Role deep learning 

- Quantitative imaging biomarker (QIB) extraction is increasingly replaced with deep learning
- Deep learning promising for extracting QIB that hitherto were difficult to detect/extract.

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Correlation with visual scoring

Region	Interrater	Intrarater	Correlation Automatic/ Visual
Basal Ganglia	0.62	0.80	0.801 +/- 0.026
CSO	0.80	0.88	0.872 +/- 0.024
Hippocampus	0.82	0.85	0.819 +/- 0.030
Midbrain	0.75	0.82	0.622 +/- 0.042

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CADDementia Challenge

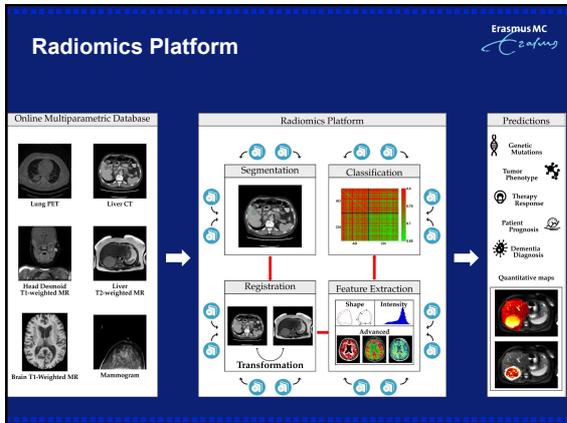
Computer-aided diagnosis of dementia based on structural MRI

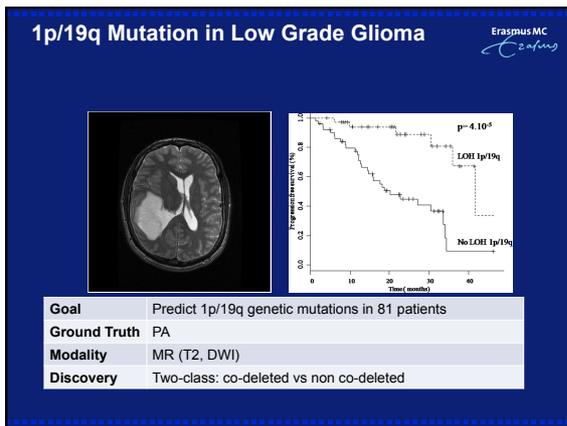
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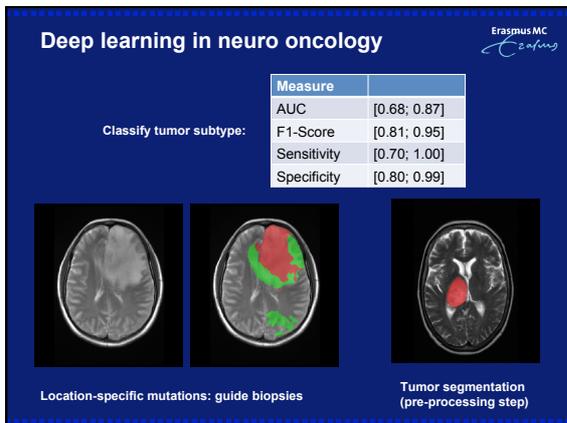
Oncology: Concept of Radiomics

Radiomics Hypothesis: There exists a correlation between medical image features and underlying biological information.

Image adopted from Lambin et al. 2012



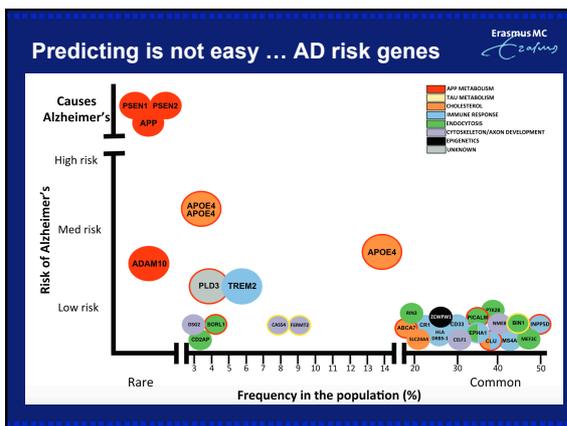




ImaGene

Population Imaging Genetics

Integrating imaging and genetics for improved understanding of disease processes, and improved detection, diagnosis and therapy planning & guidance



Future of imaging genetics

- Holy grail: Find phenotype = f (genotype, environmental factors)
- Current approaches: mostly massive number of linear regressions
- Promises in:
 - Larger datasets
 - Machine and deep learning for learning more complex relations
- Challenges
 - DL and ML cannot straightforwardly be applied (heterogeneous data, biological variability)
 - Modular approach, integrating prior knowledge with DL

Deep learning in population imaging genetics



- Increasingly the state of the art in QIB extraction
- Still challenging to solve "clinically relevant" applications
 - Complex, heterogeneous data; few training samples
 - Defining right scope
 - How to integrate prior knowledge
- Powerful tool to support investigating challenging relation between genetic data, environmental factors and phenotype

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