A Comparative Study of Auditory Attention Decoding Algorithms

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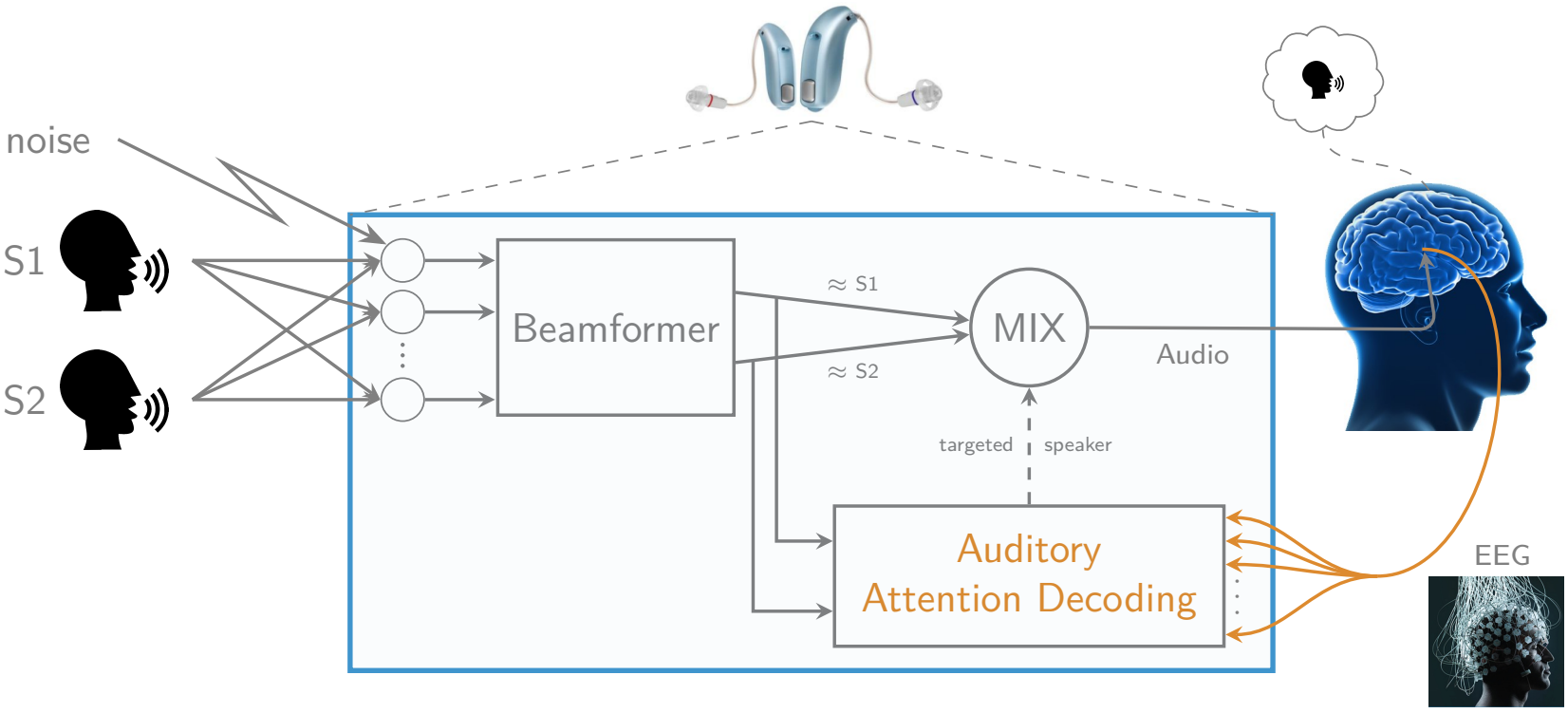
17/09/2019

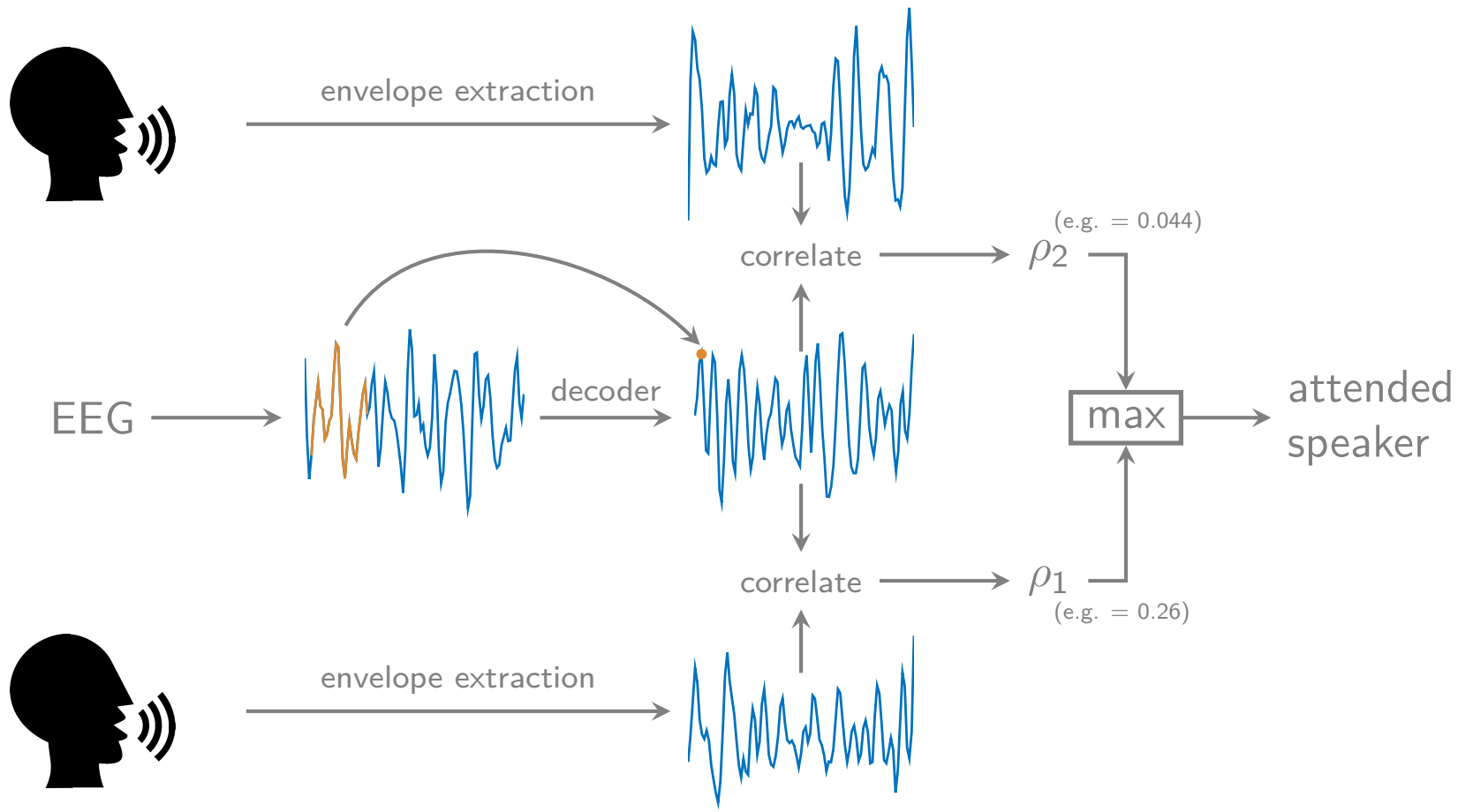
fwo Research Foundation Flanders
Opening new horizons

erc European Research Council

The concept of neuro-steered hearing prostheses



A backward decoding framework for AAD: stimulus reconstruction



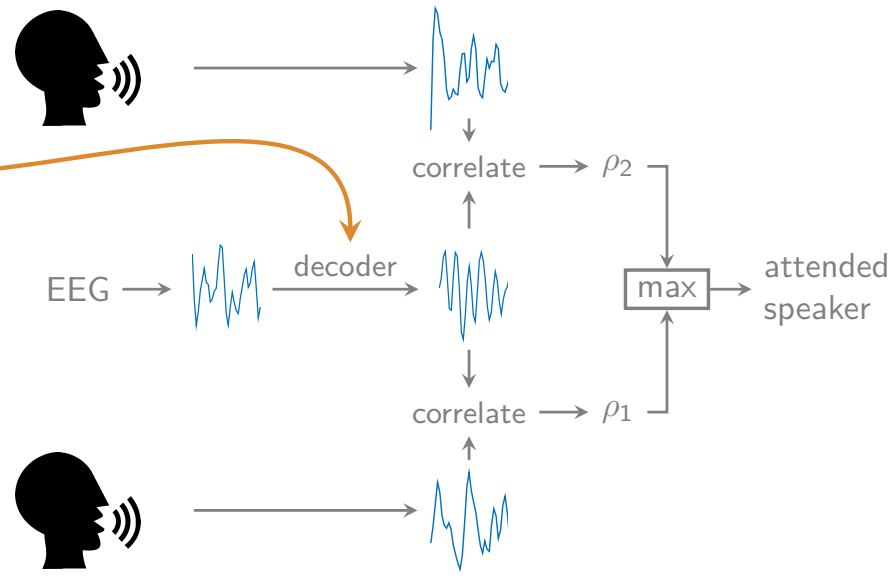
AAD = auditory attention decoding

A backward decoding framework for AAD: stimulus reconstruction

Training

- Lots of data to fit the decoder (~minutes)

Testing



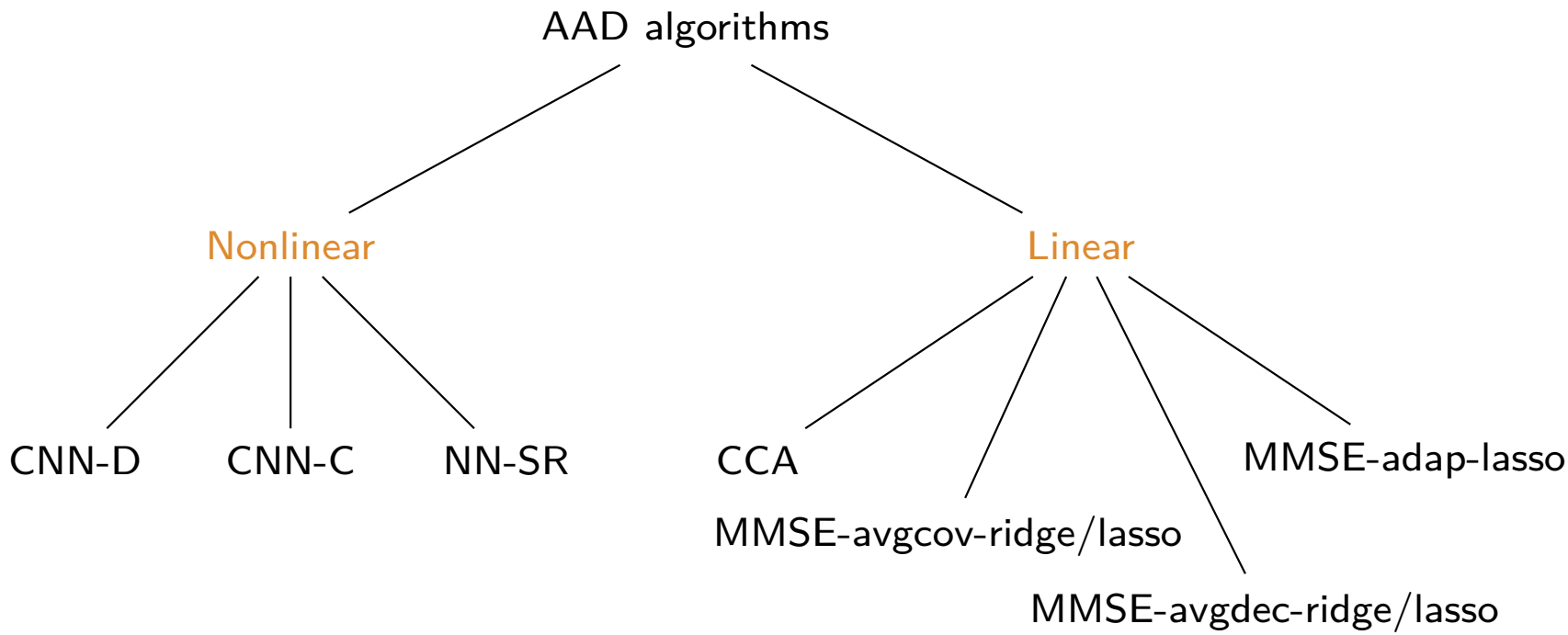
- Small decision window (~seconds)

Benchmarking of different AAD algorithms

Paper	Code/Method
O'Sullivan et al., 2014	MMSE-avgdec-ridge
Biesmans et al., 2017	MMSE-avgcov-ridge
Alickovic et al., 2019	MMSE-avgdec-lasso
Alickovic et al., 2019	MMSE-avgcov-lasso
Miran et al., 2018	MMSE-adap-lasso
de Cheveigné et al., 2018	CCA
de Taillez et al., 2017	NN-SR
Deckers et al., 2018 (**P30**)	CNN-D
Ciccarelli et al., 2018	CNN-C

The implementations of the algorithms have been validated by the authors of the corresponding papers

Benchmarking of different AAD algorithms



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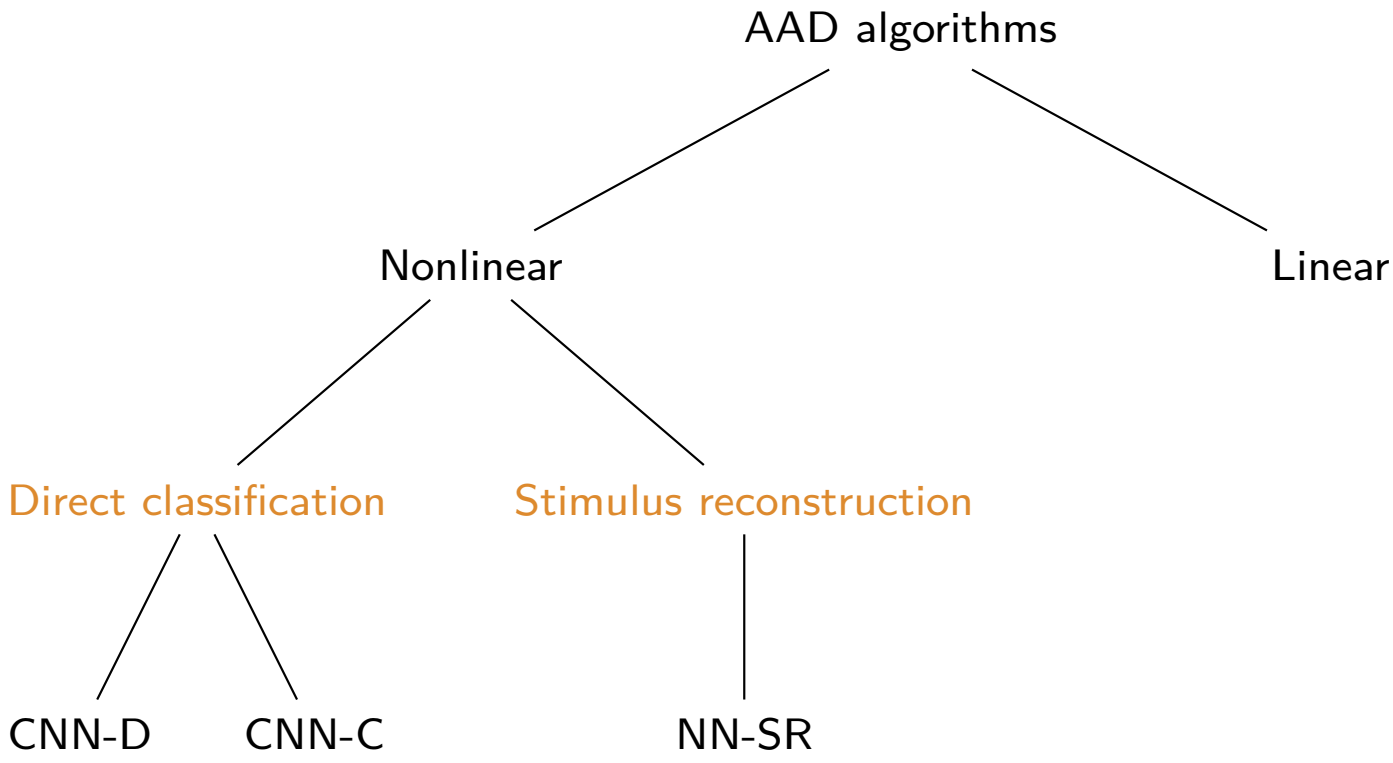

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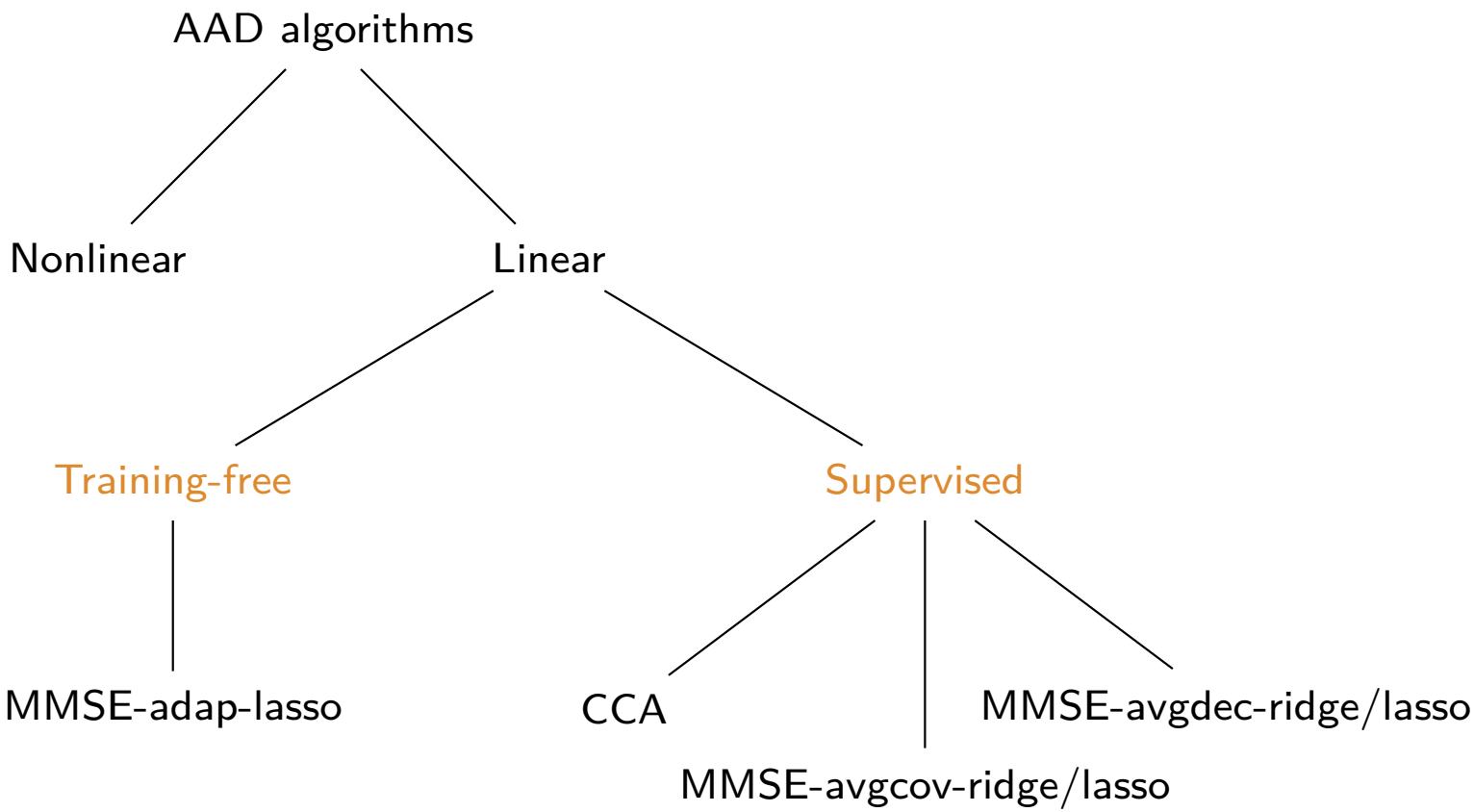

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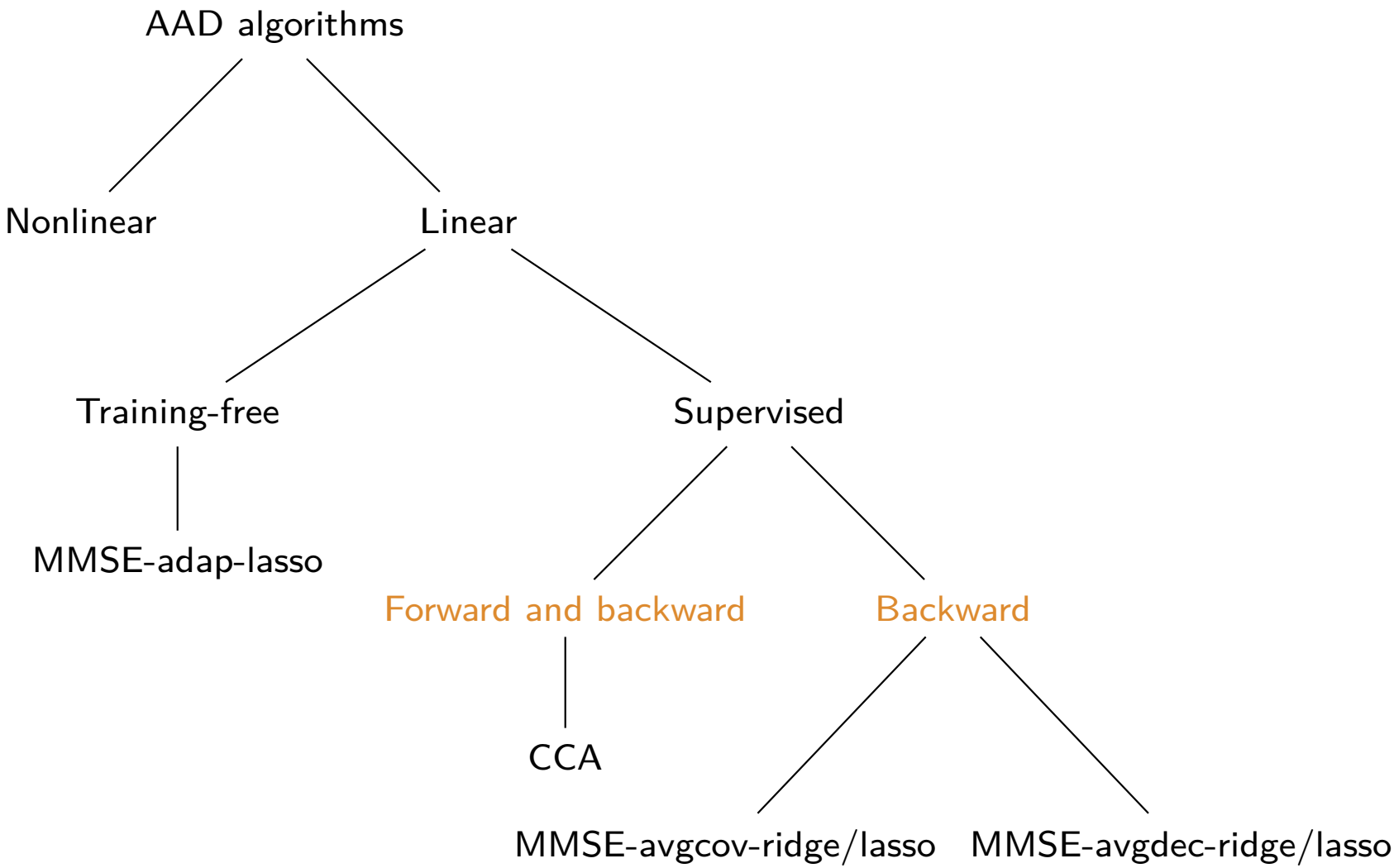

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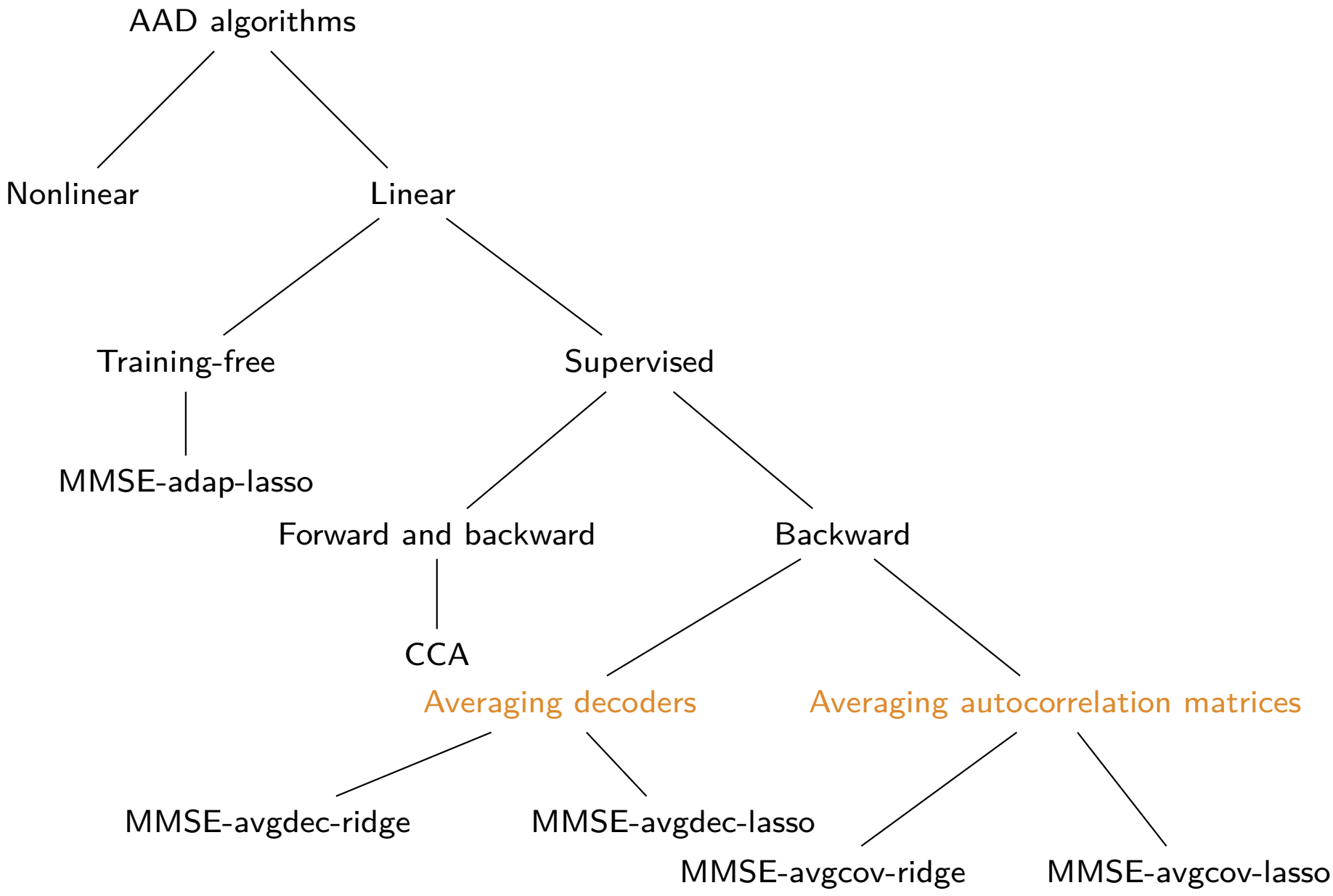

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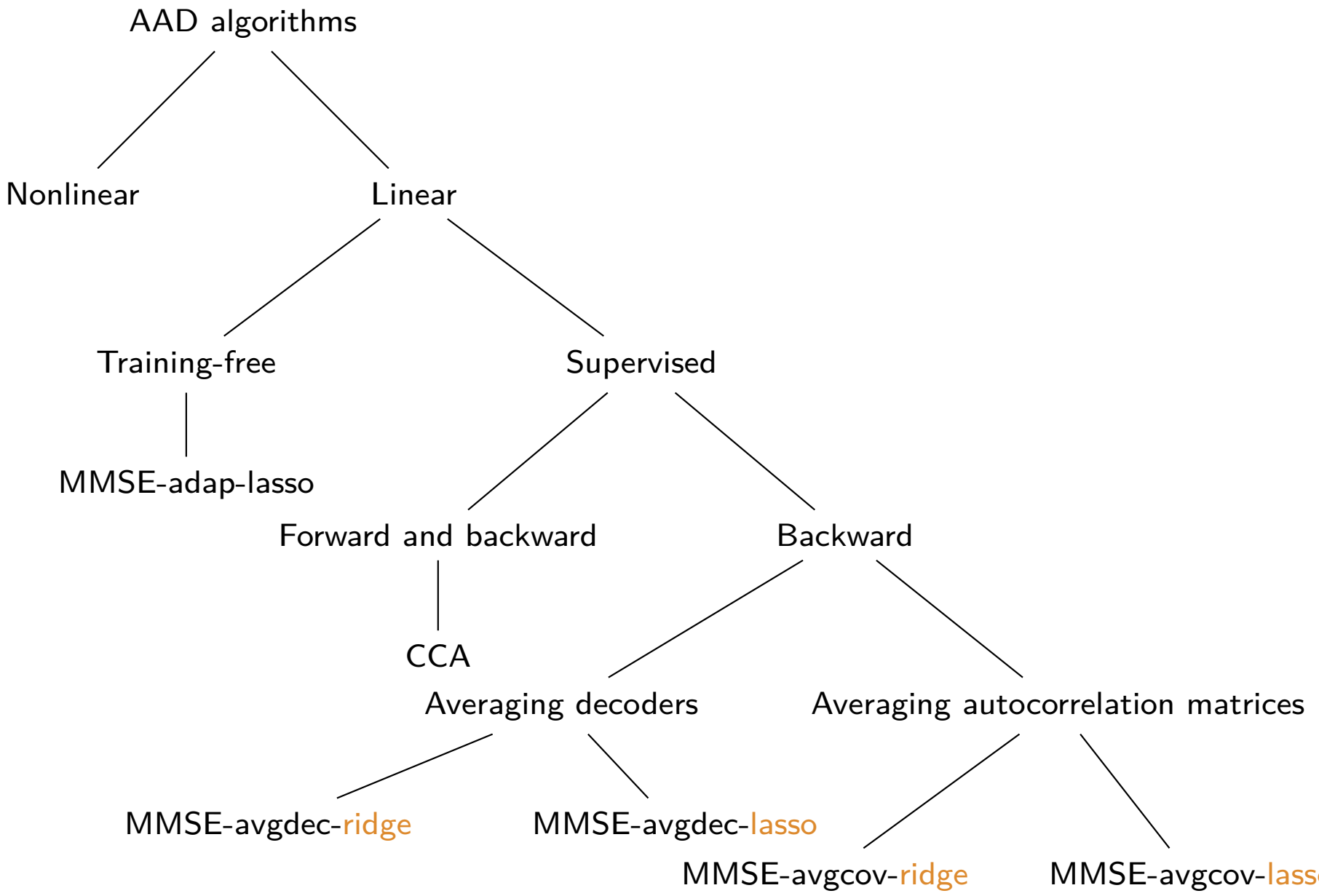

Take-home messages

I

Deep learning methods *can* achieve very high performances, but suffer from computational complexity and high variability

II

Within linear methods, a combination of backward and forward modeling works best (CCA)

III

Average covariance matrices, rather than decoders

The setup: data, testing procedure

Two independent datasets are used:

AADKUL-2015	Fuglsang-2018
	

All performances and hyperparameters are cross-validated

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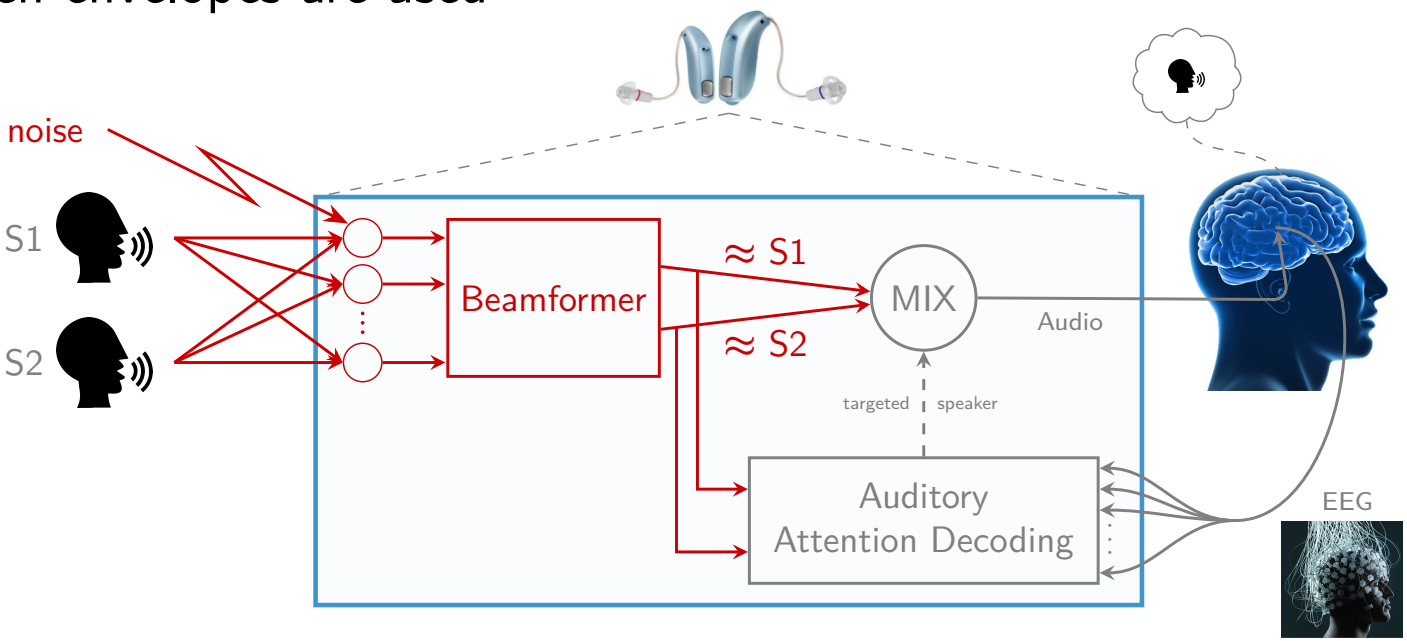
Clean speech envelopes are used



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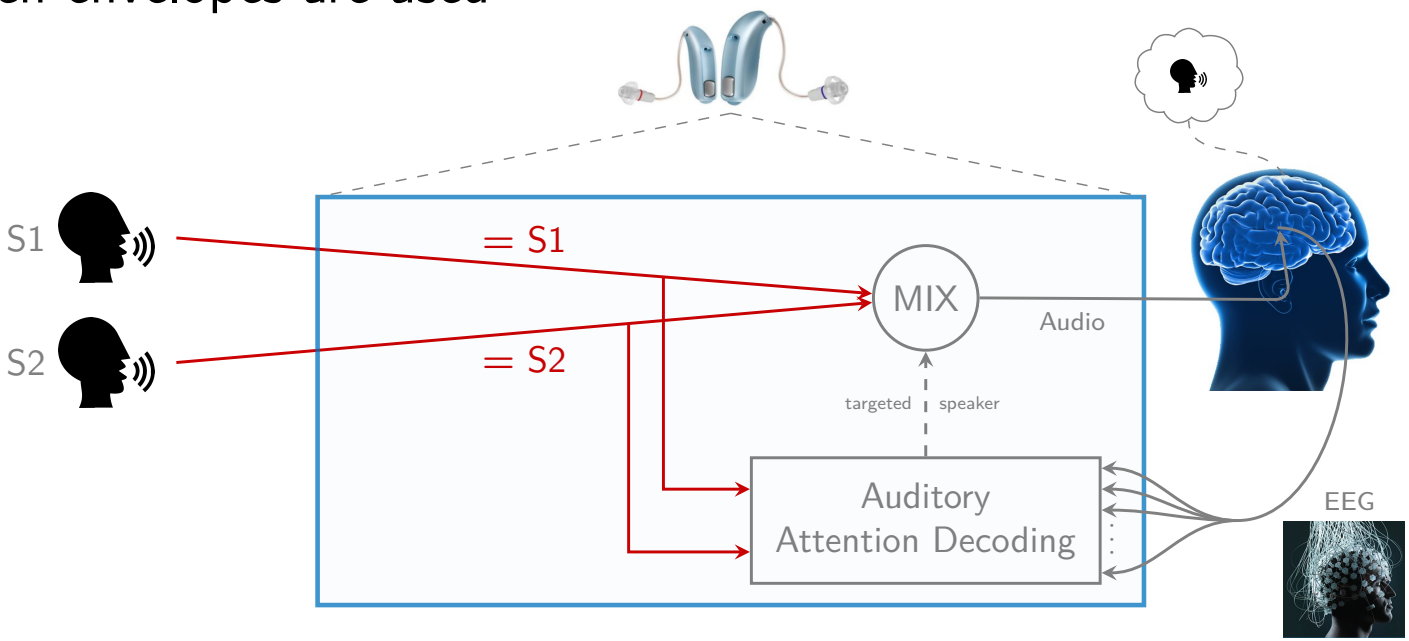

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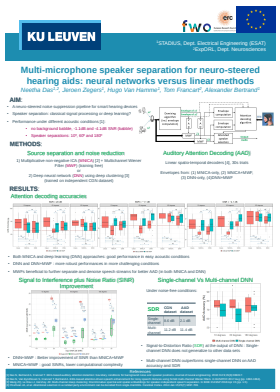
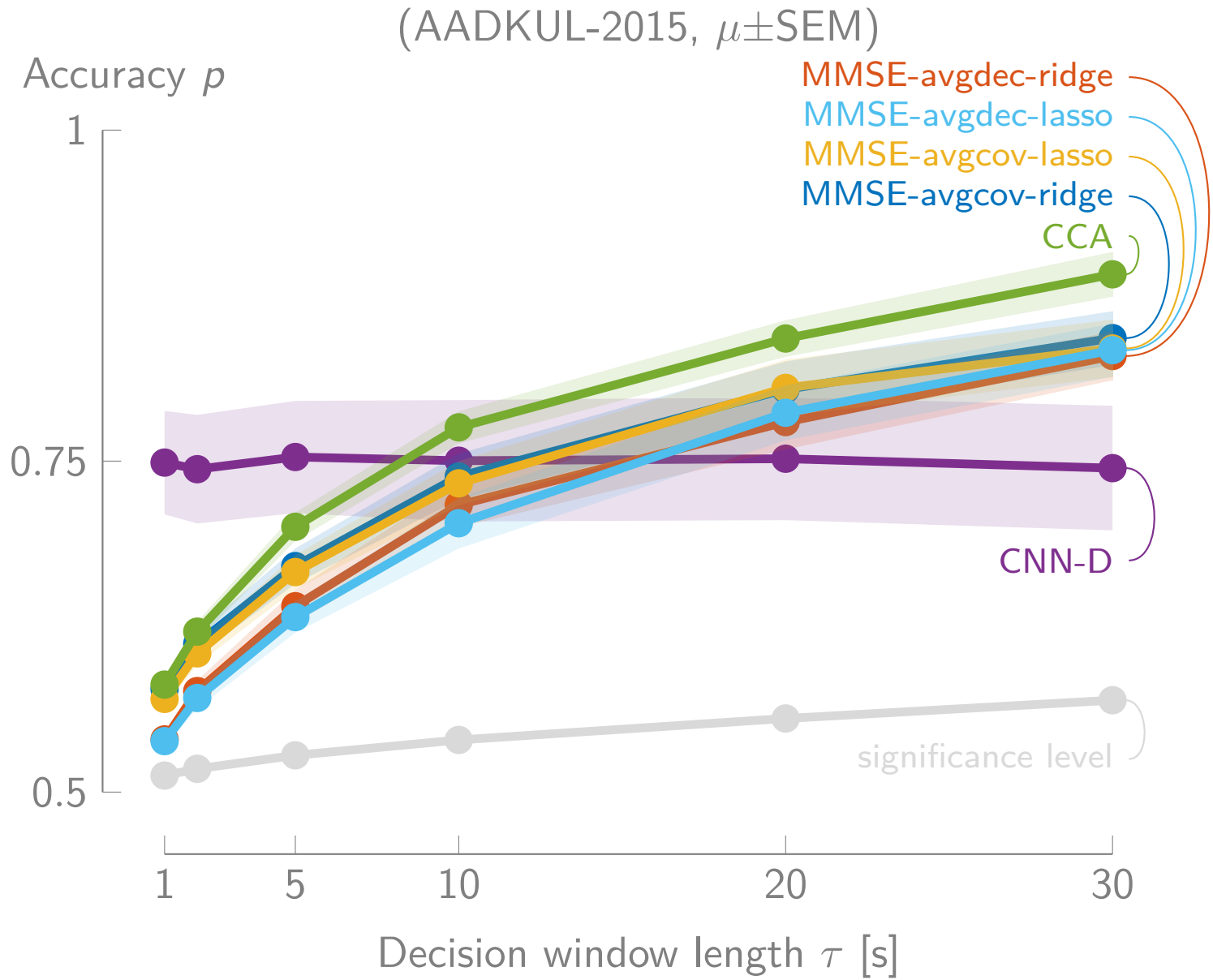
Clean speech envelopes are used, but covered in . . .

- (Van Eyndhoven et al., 2016), (Han et al., 2019), (Aroudi et al., 2019), . . .
- Poster *Multi-microphone speaker separation for neuro-steered hearing aids: neural networks versus linear methods* of Neetha Das (**P24**)



The $p(\tau)$-performance curves: a visual analysis



Disclaimer: these are preliminary results (some algorithms still missing)

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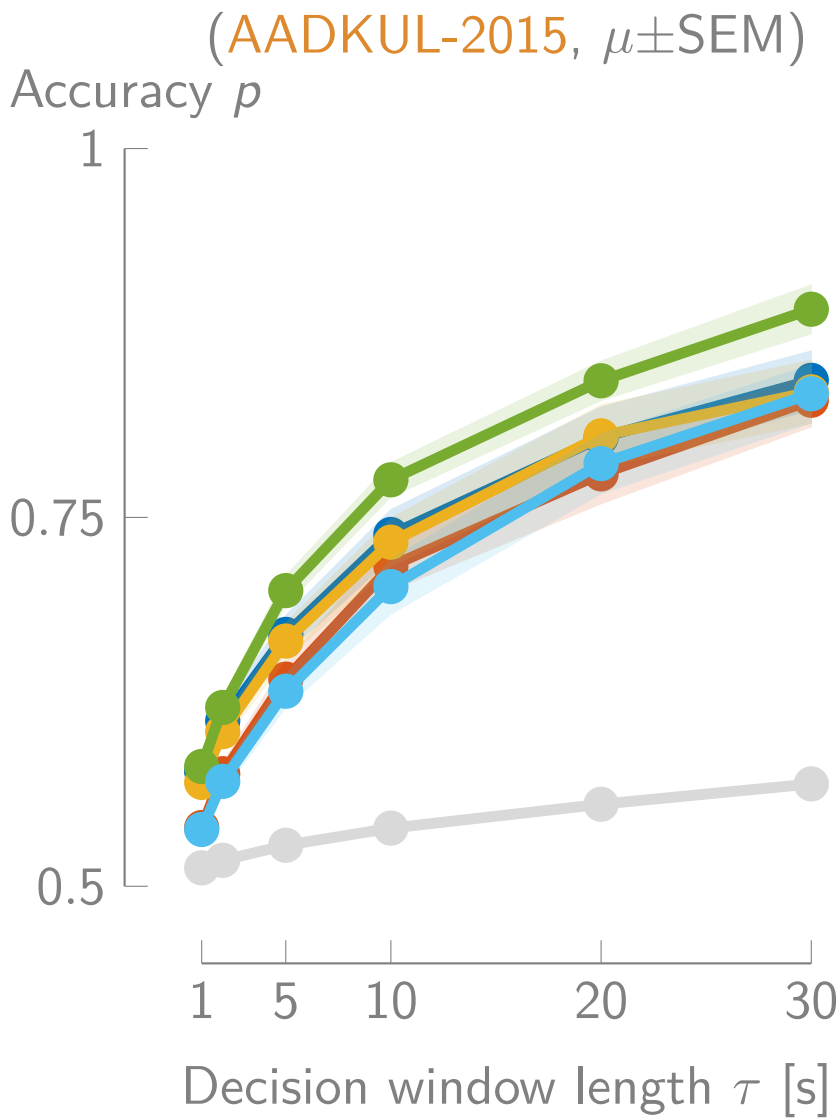

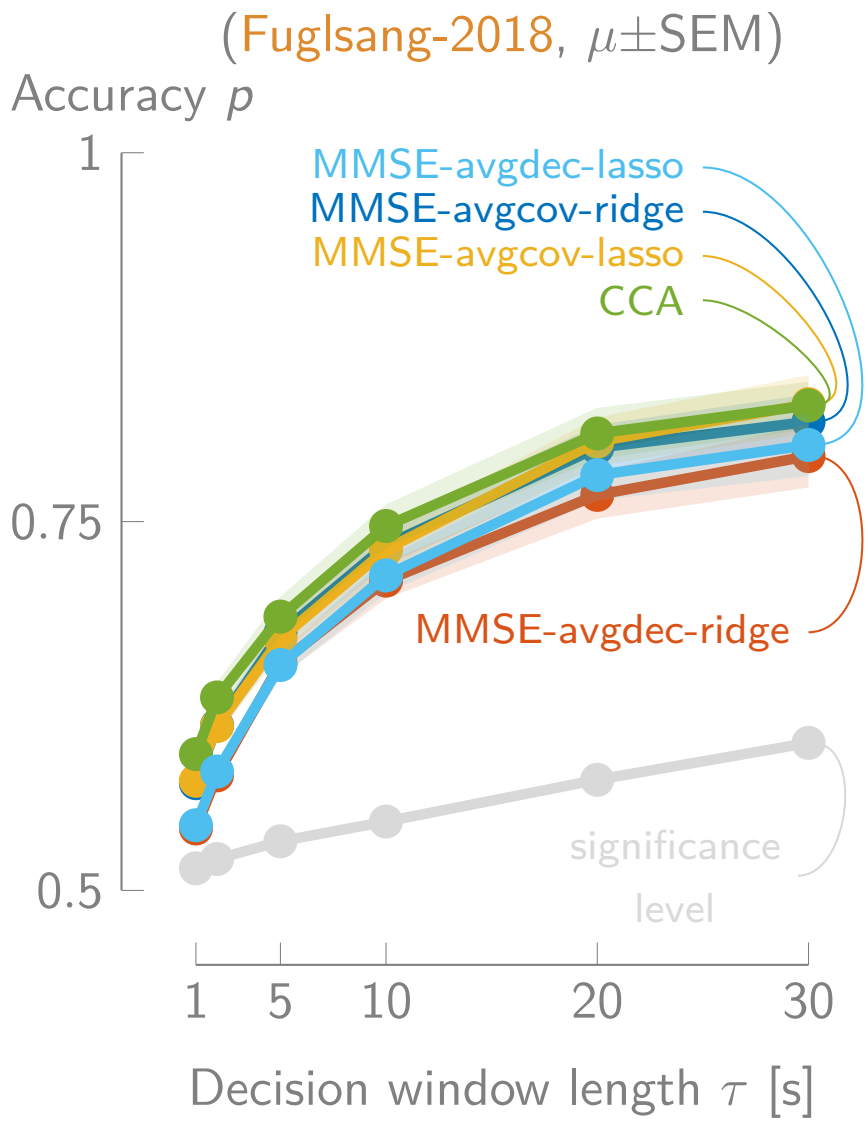

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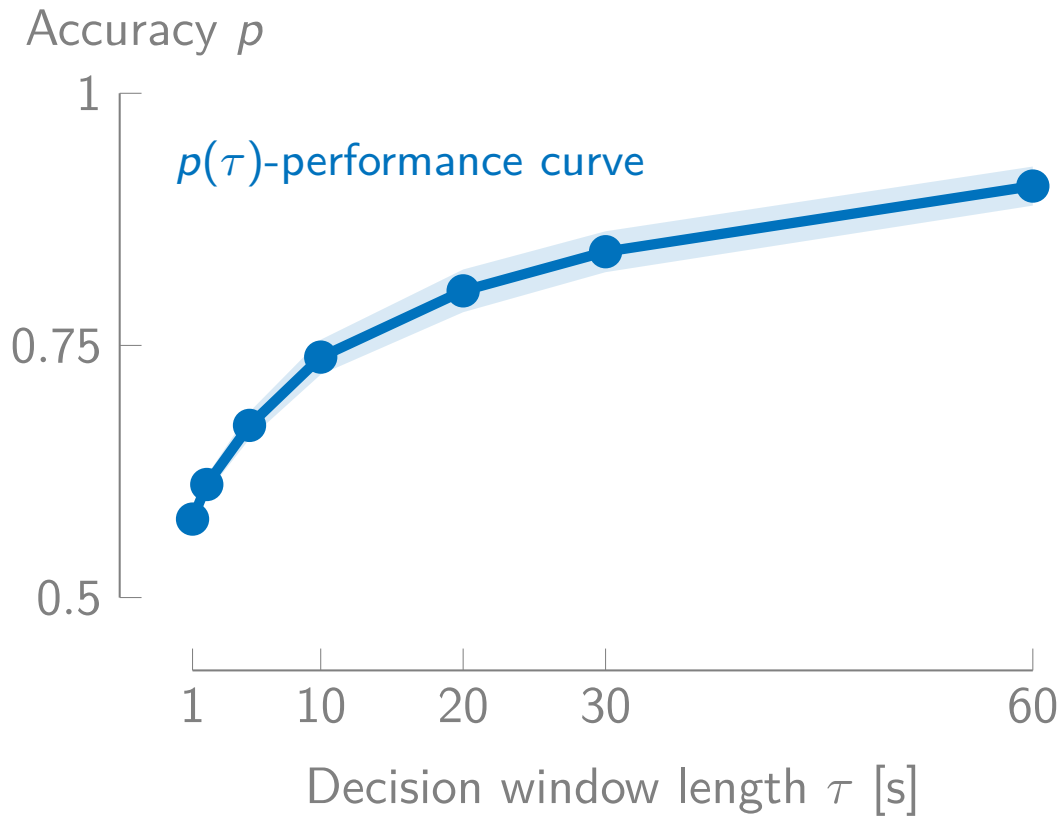
A new performance metric: the MESD



Which point is most practical for an attention-tracking gain control system?

- Fast but inaccurate?
- Slow but accurate?

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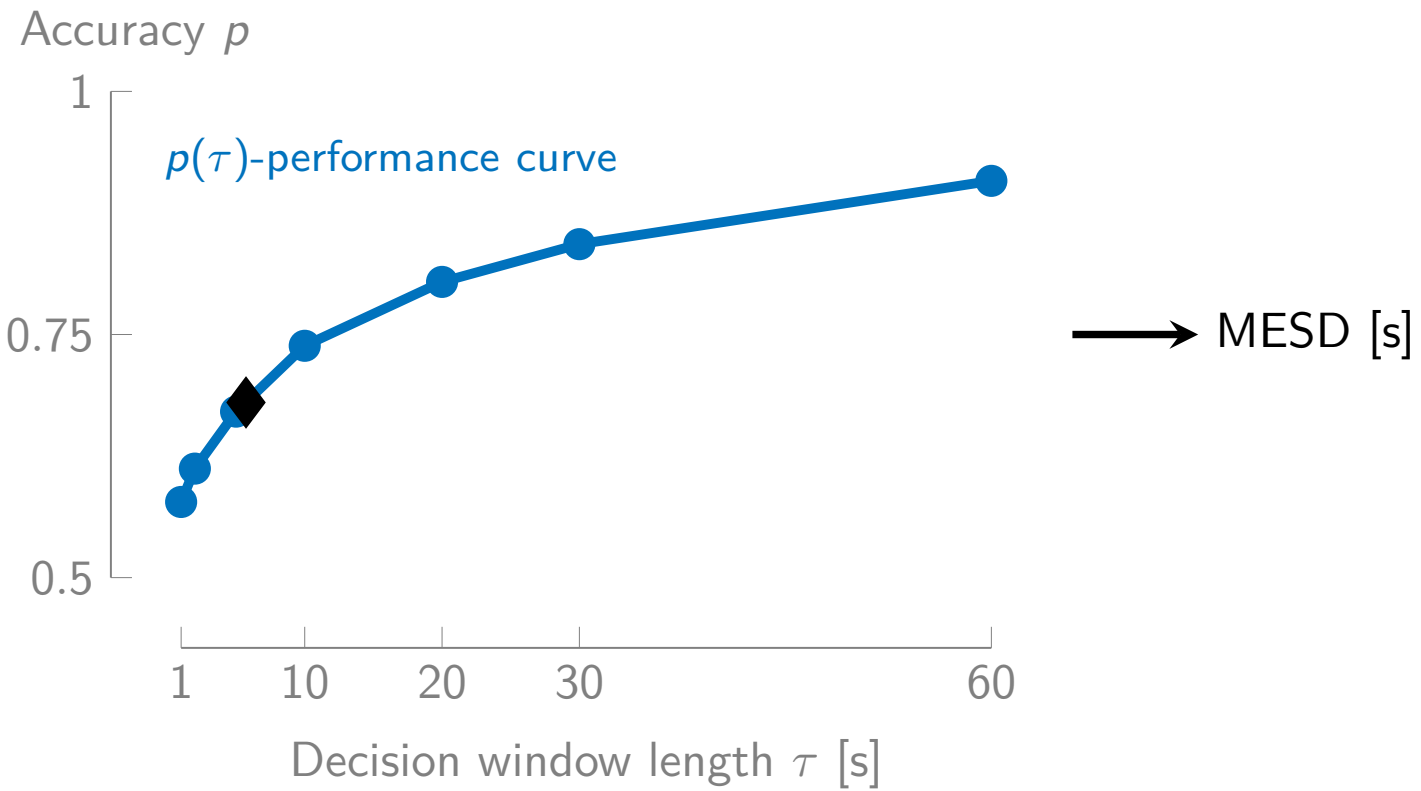
Optimizing the attention-tracking gain control system leads to the minimal expected switch duration (MESD) performance metric



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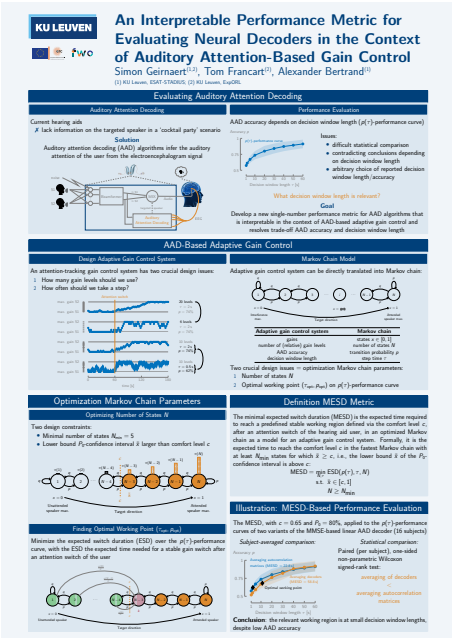
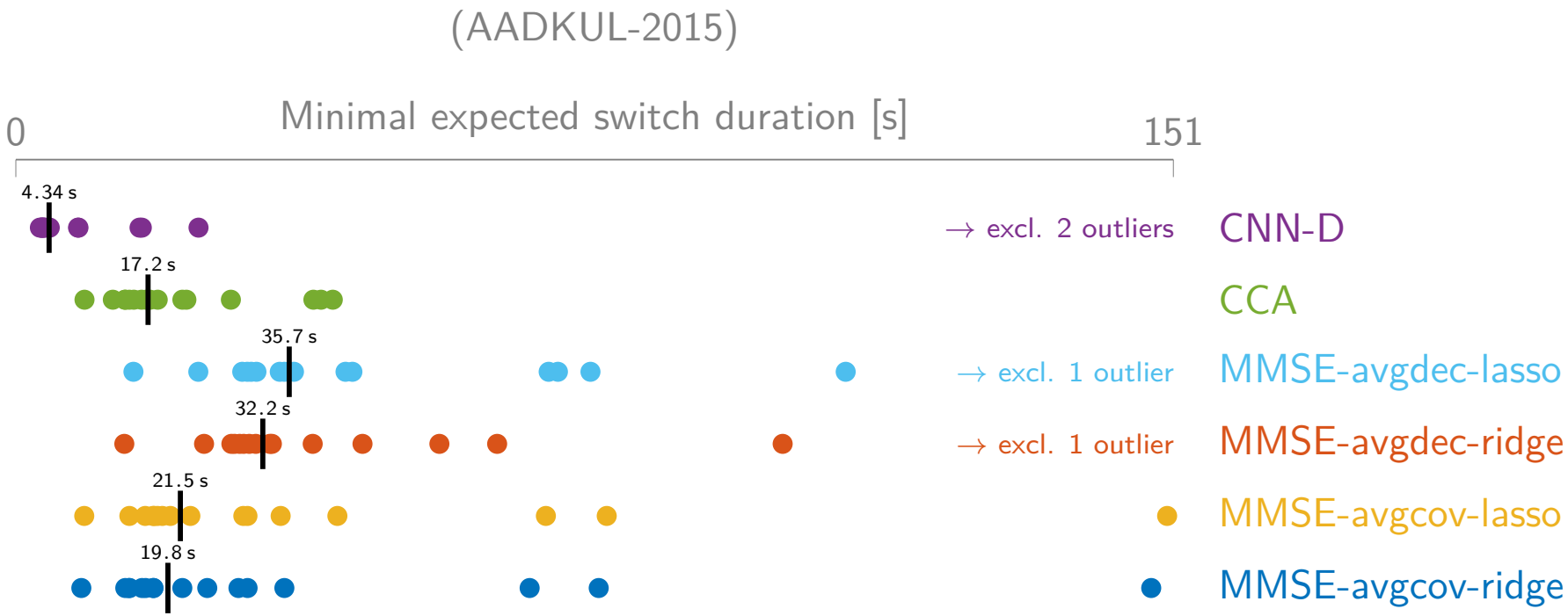
*Find out more at poster **P32**!*



Comparing the per-subject MESDs



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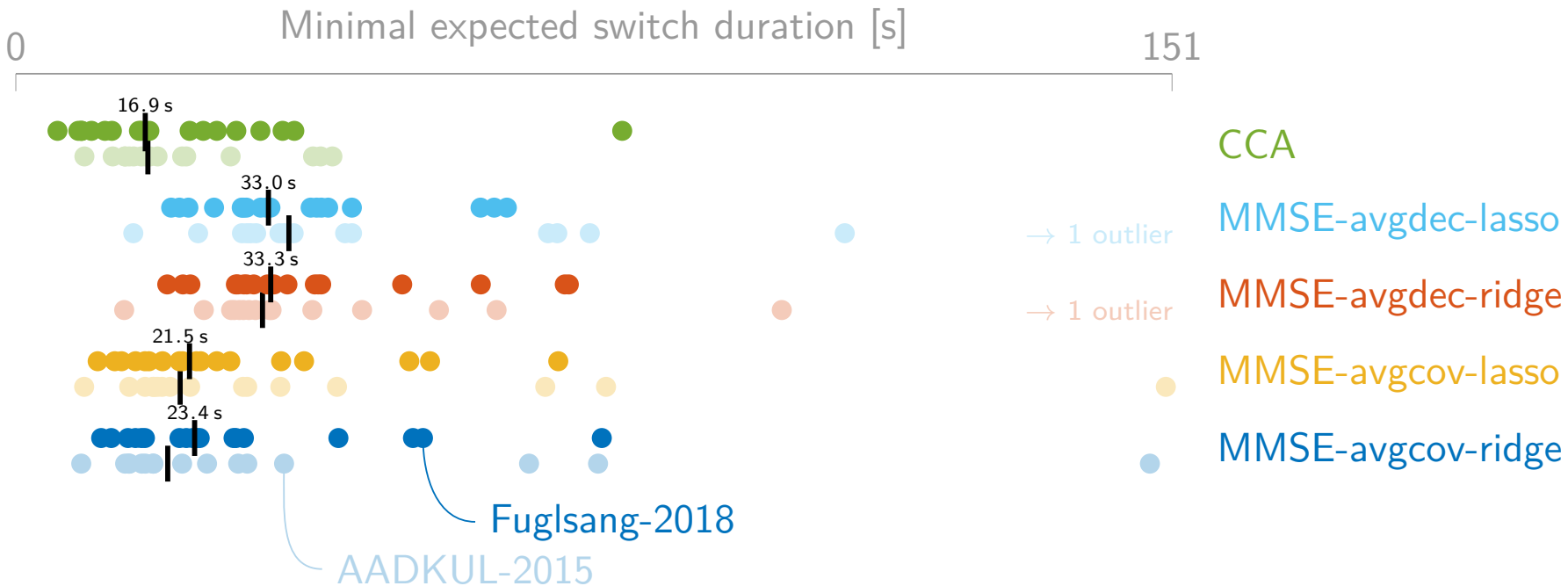

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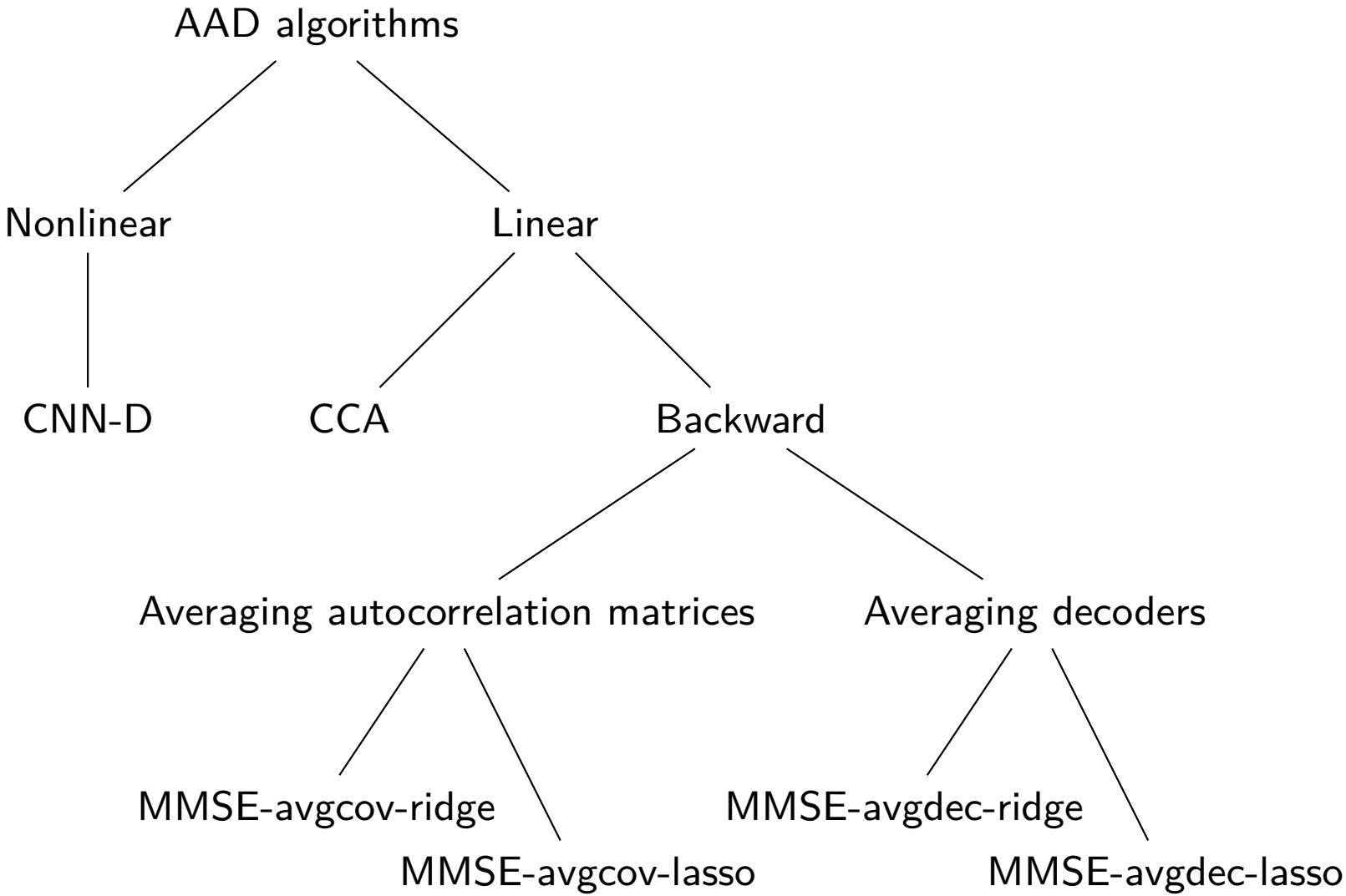
Statistical analysis on MESD: linear mixed-effects model



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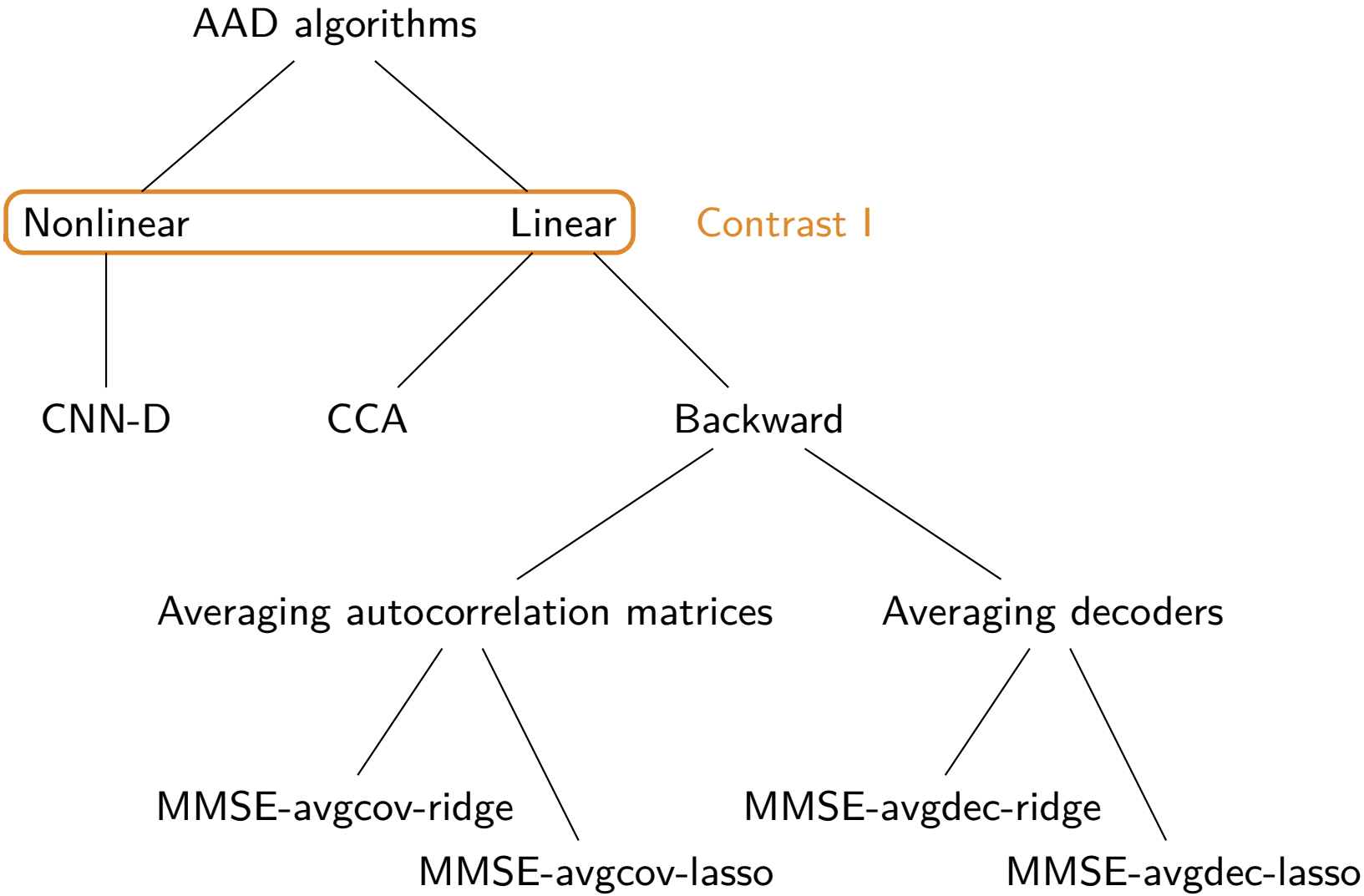

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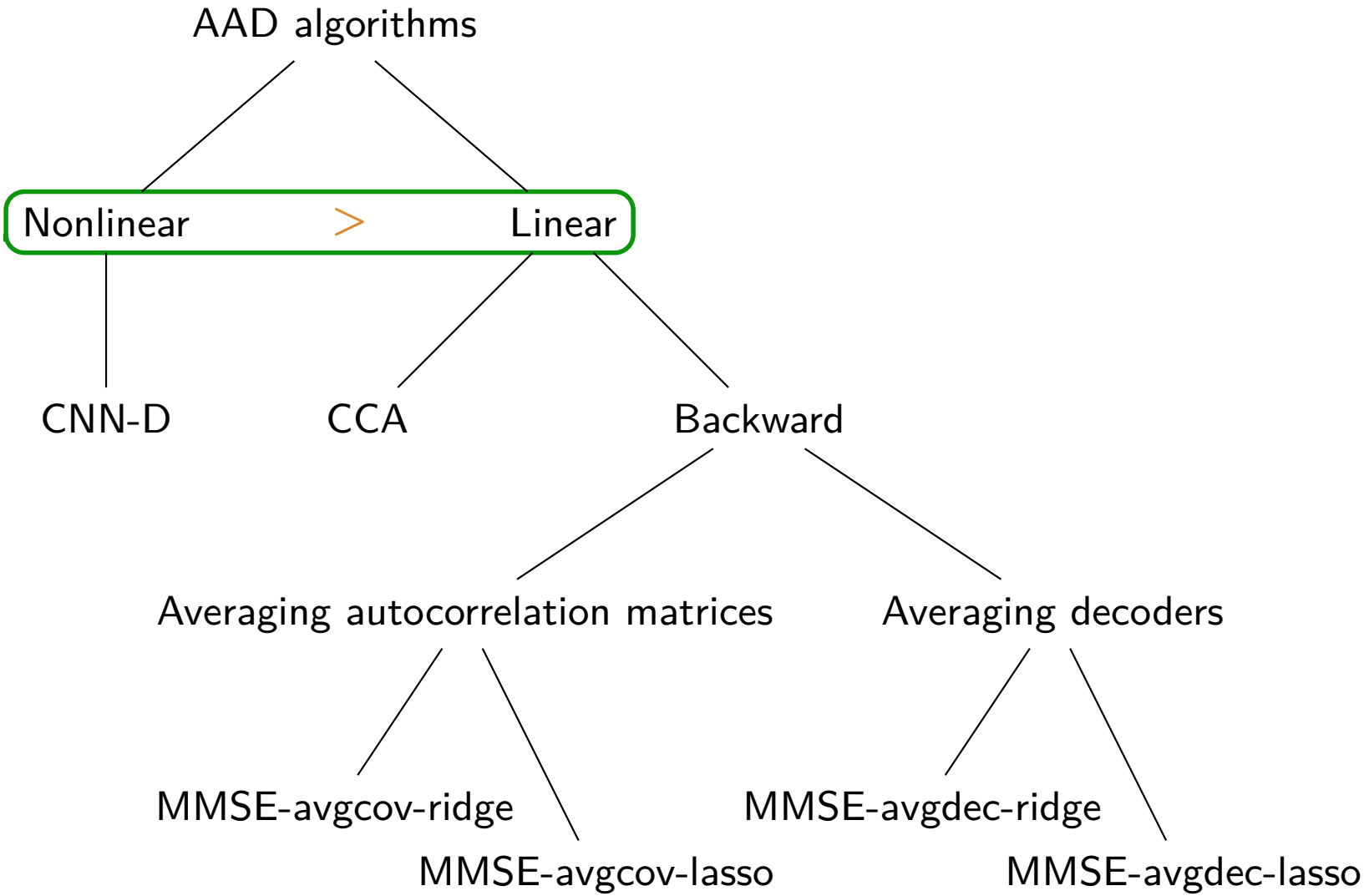

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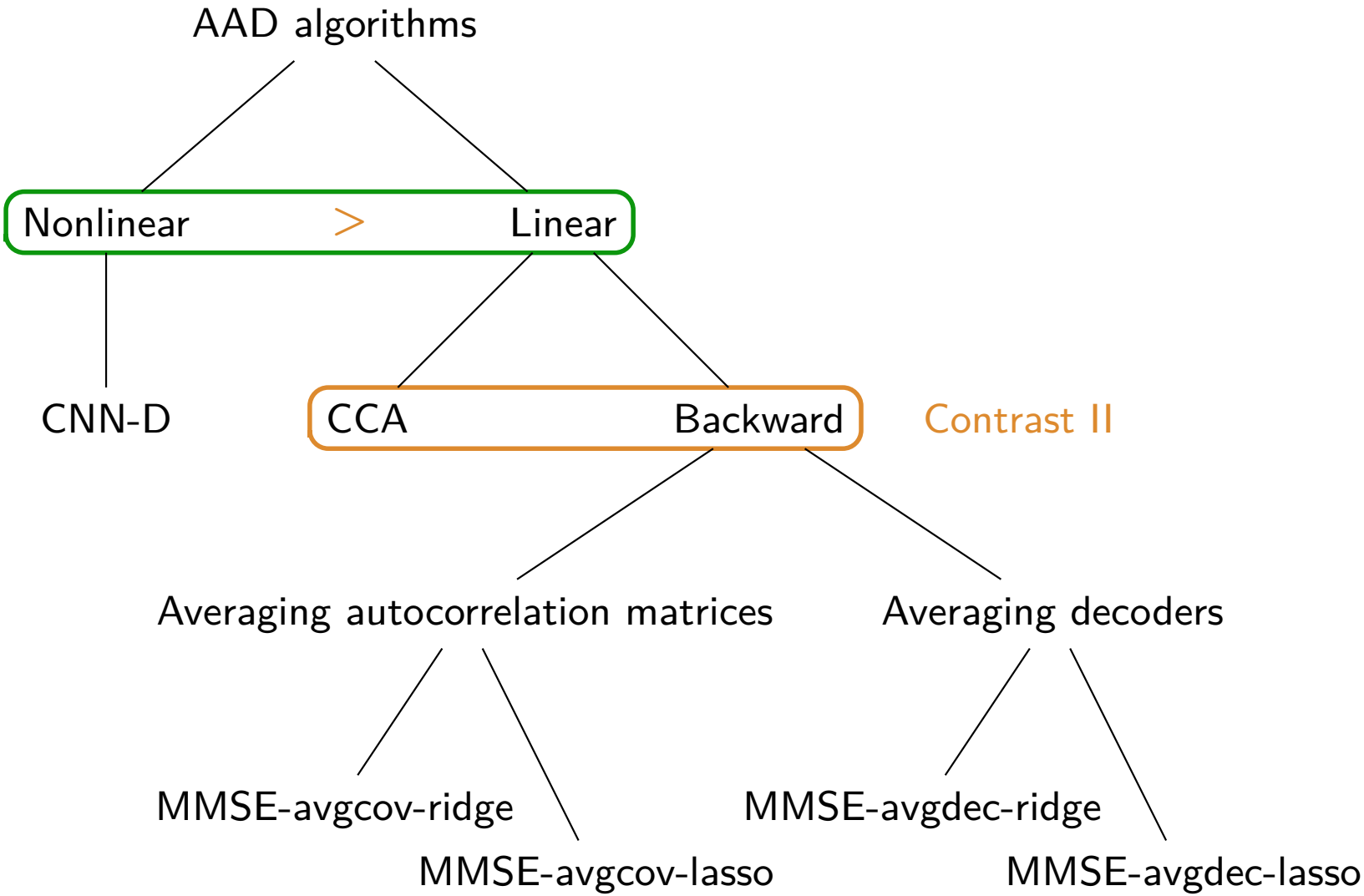

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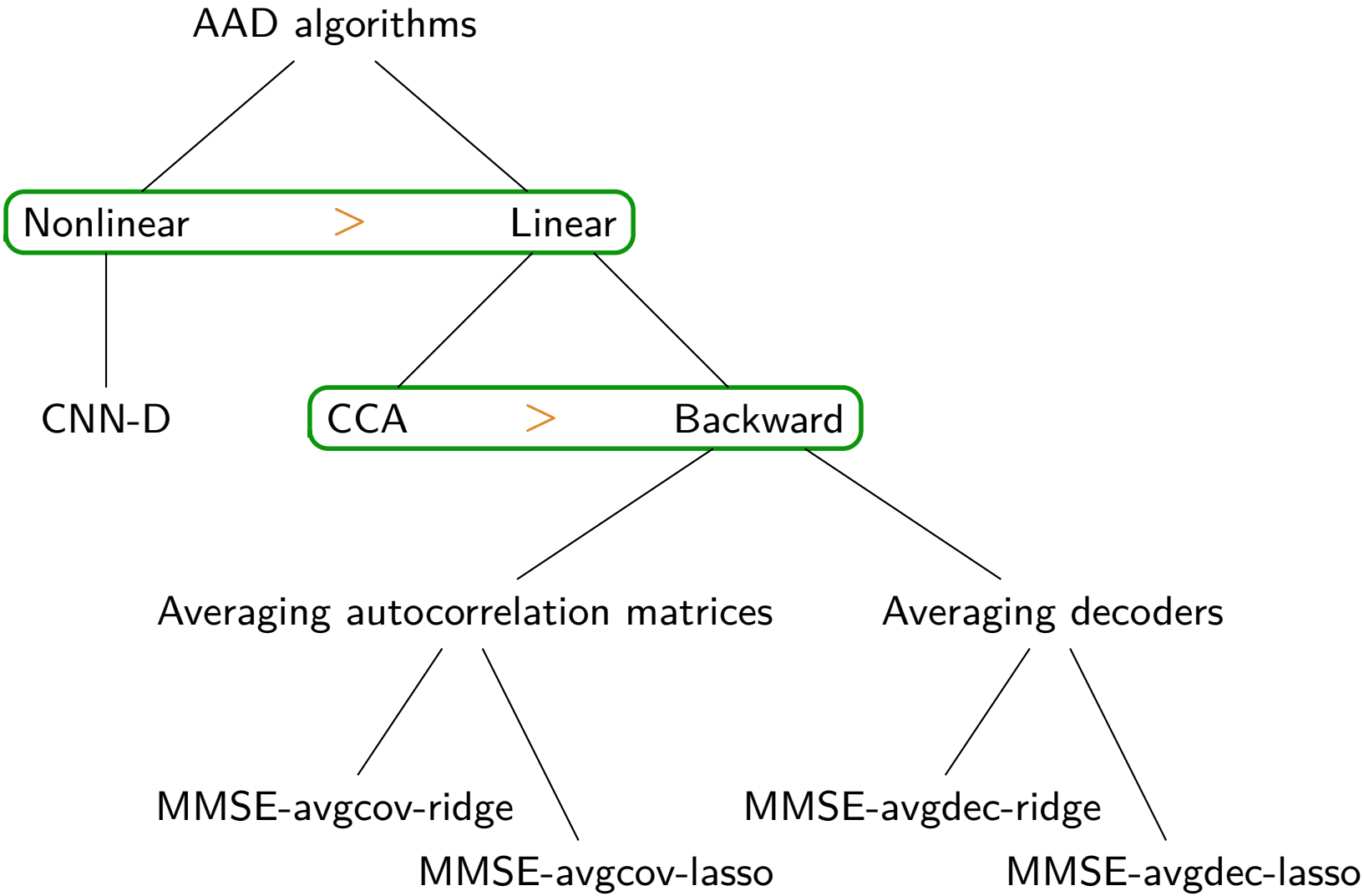

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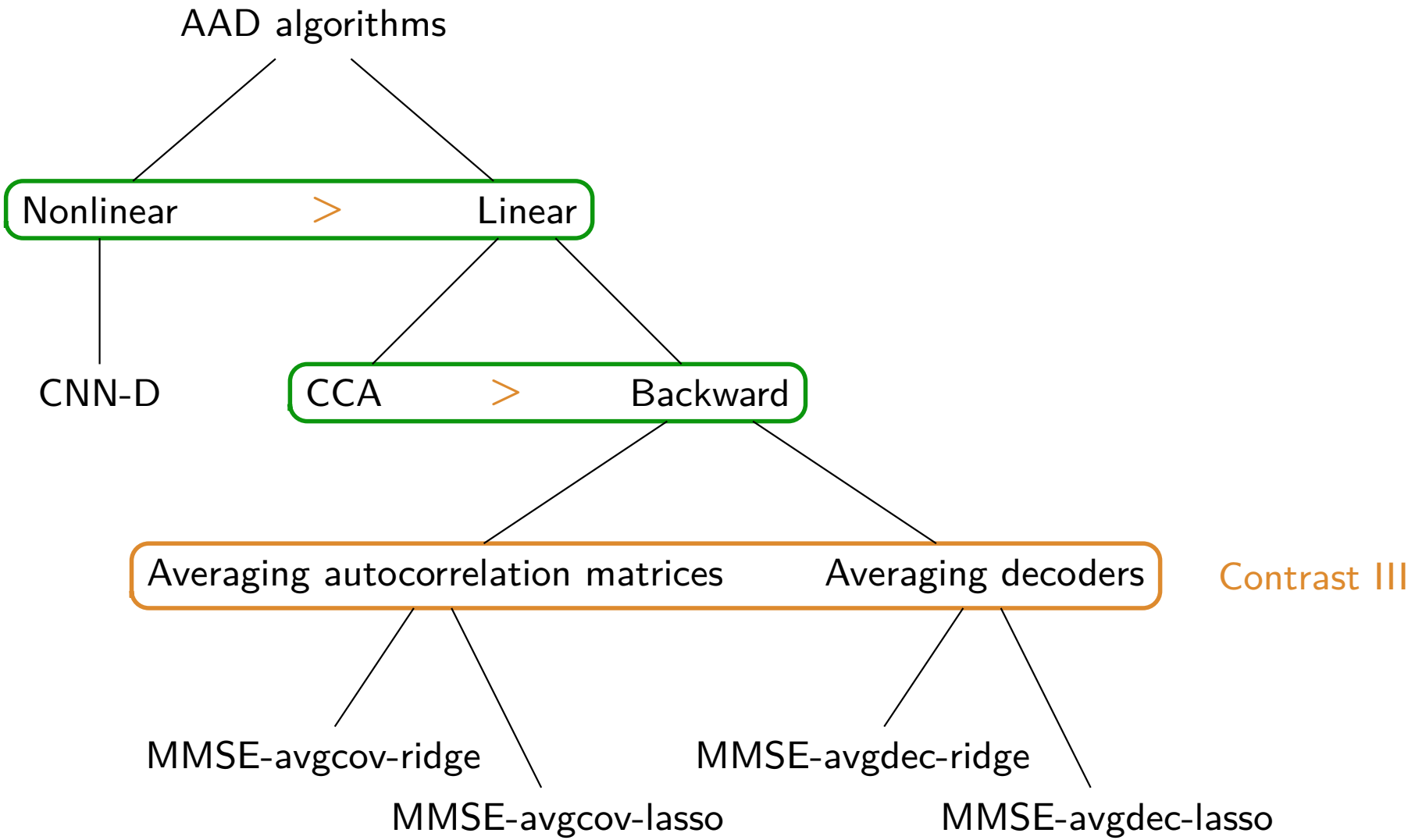

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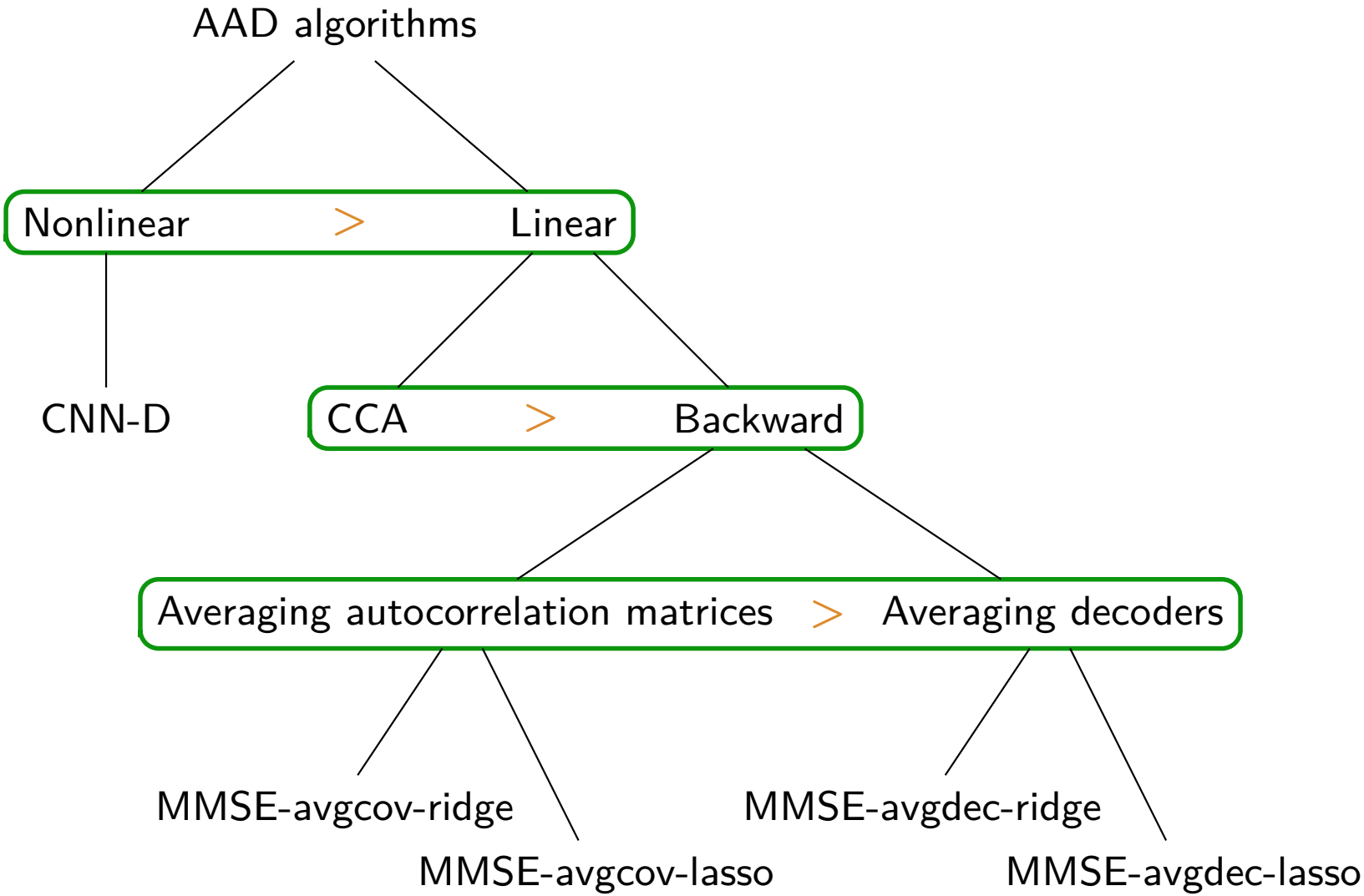

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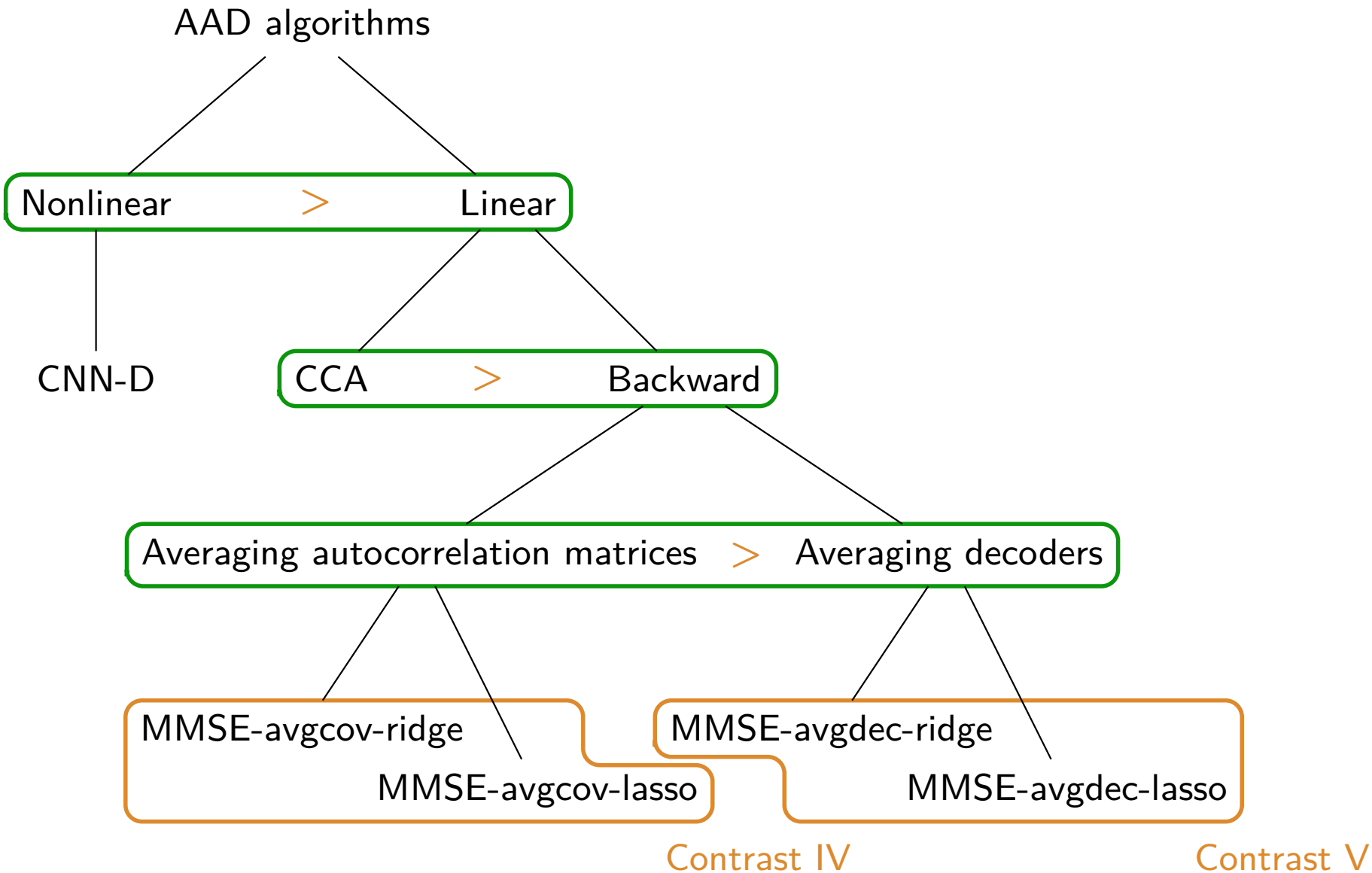

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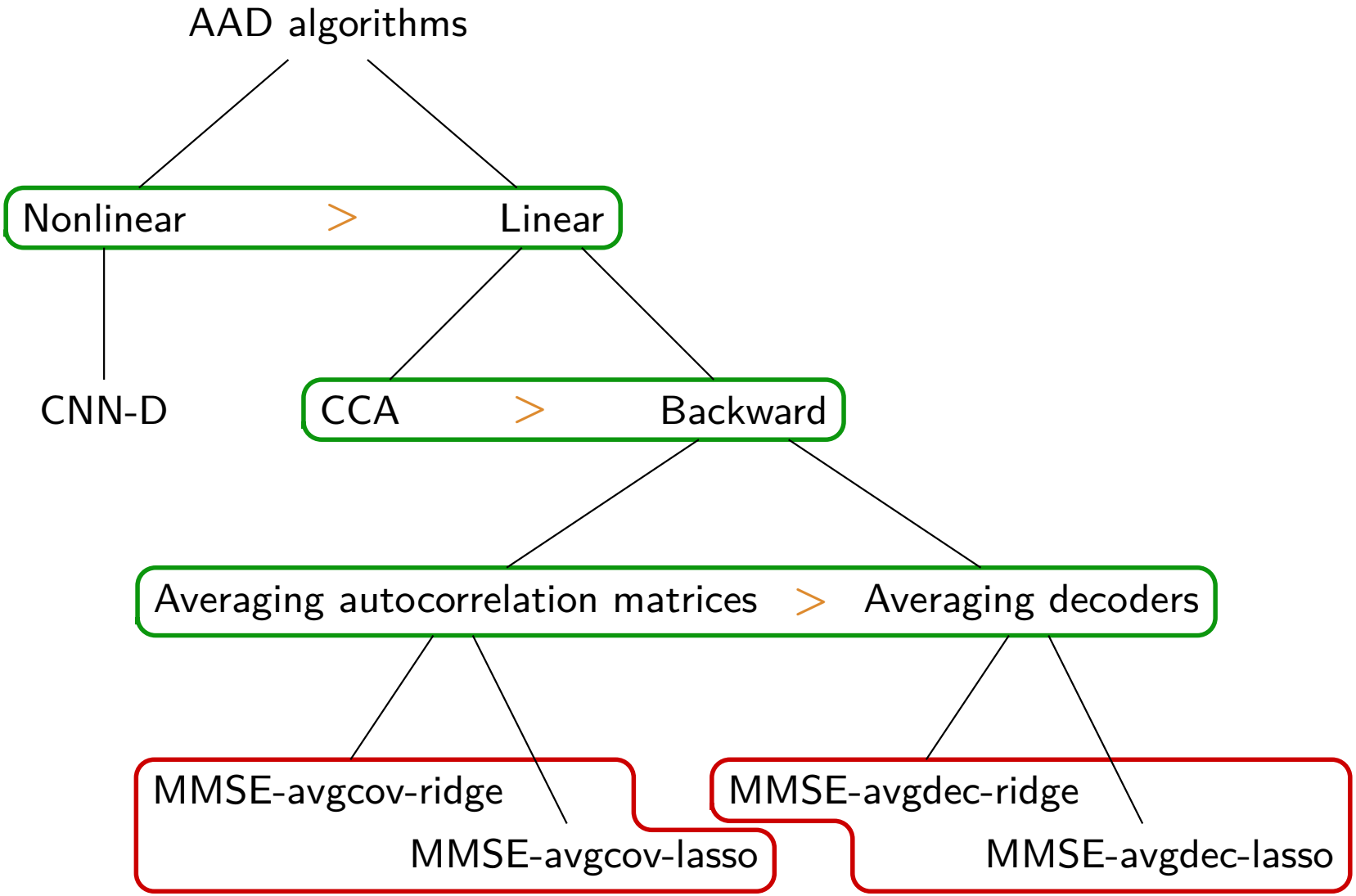

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Average covariance matrices, rather than decoders

Attention is vitality. It connects you with others. It makes you eager. Stay eager.

– Susan Sontag

Interested in more? Questions?

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Established by the European Commission

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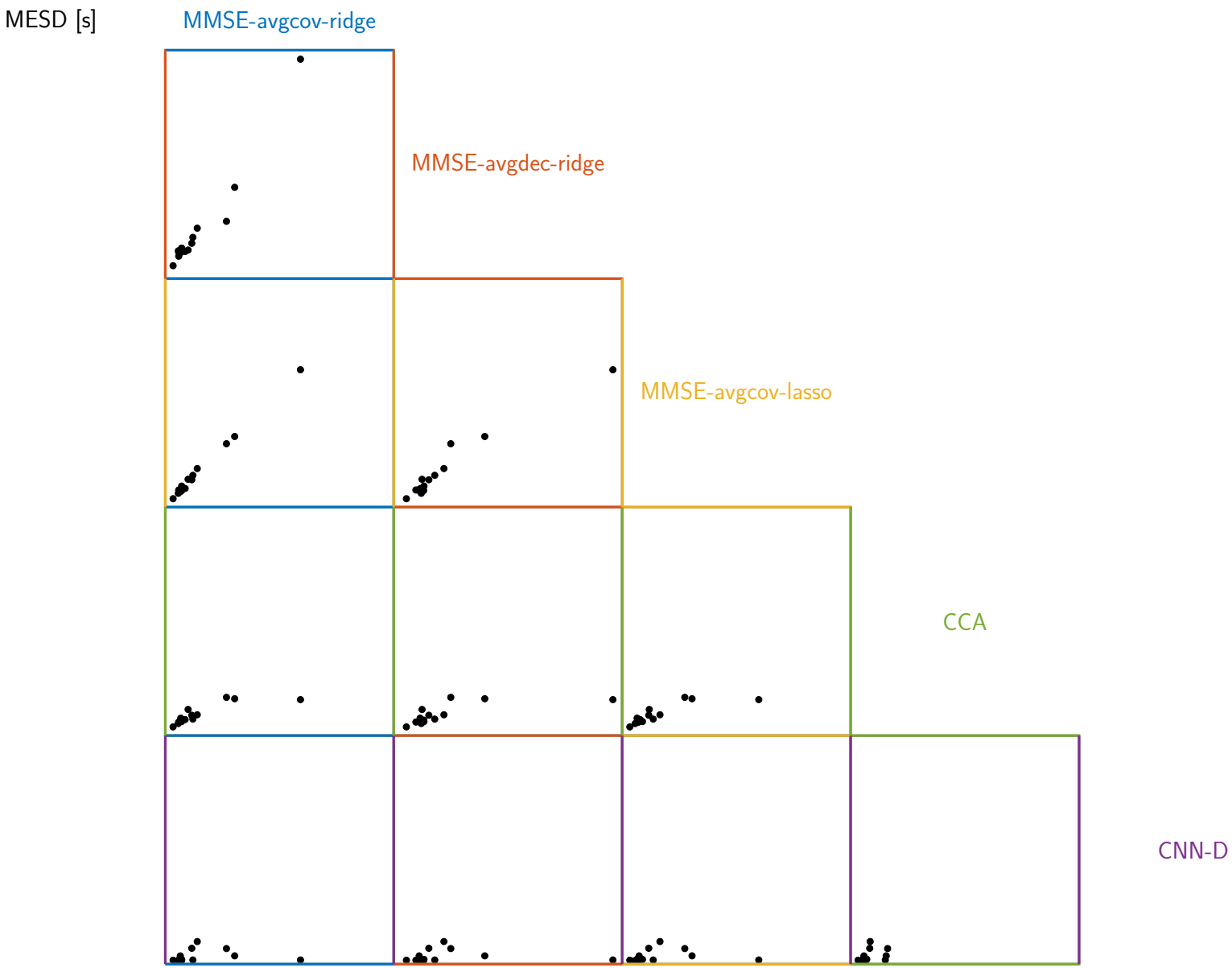
The setup: data, testing procedure

Two independent datasets are used:

AADKUL-2015	Fuglsang-2018
• 16 subjects	• 18 subjects
• 72 min of data per subject	• 50 min of data per subject
• 64-channel Biosemi EEG system	• 64-channel Biosemi EEG system
• Dry and HRTF-filtered stimuli ($-90°$, $+90°$)	• HRTF-filtered stimuli ($-60°$, $+60°$)
	• $\neq$ acoustic room conditions

Comparing the per-subject MESDs: correlations



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