Developing speech-based clinical measures that generalize

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Disclosures

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Relevant industry partners include Boehringer Ingelheim and Google

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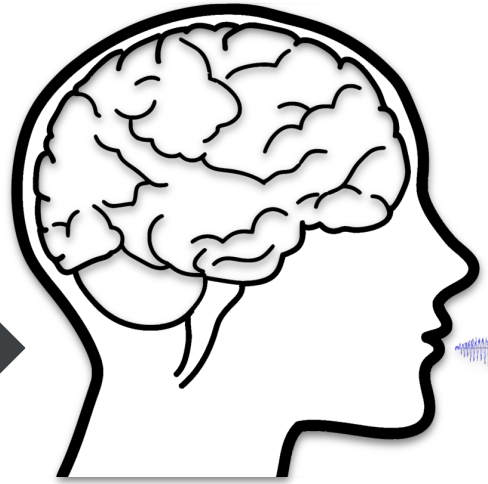
The promise of speech-based clinical measures



Disease

Pre-clinical AD, PD

Meaningful Measures

Reduced social abilities; increased loneliness

We don't know where the **information** is in this **high-dimensional, high-velocity data** stream

The current approach: data-driven supervised learning

The starting point is a labeled dataset

Healthy vs. AD

Extract features using existing tools

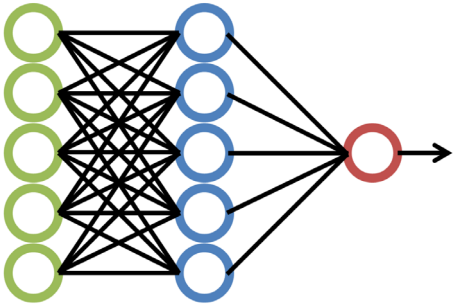
OpenSMILE

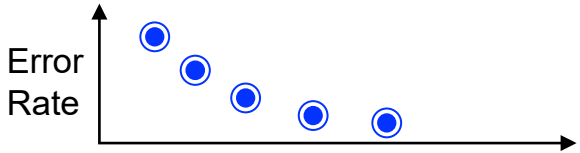
wav2vec

NLP features

Mel spectra

Predict a clinical variable of interest

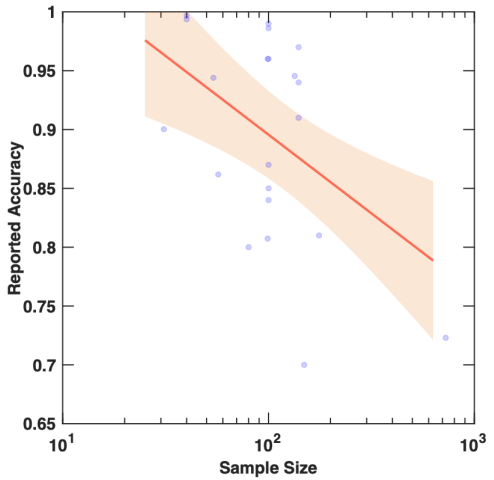




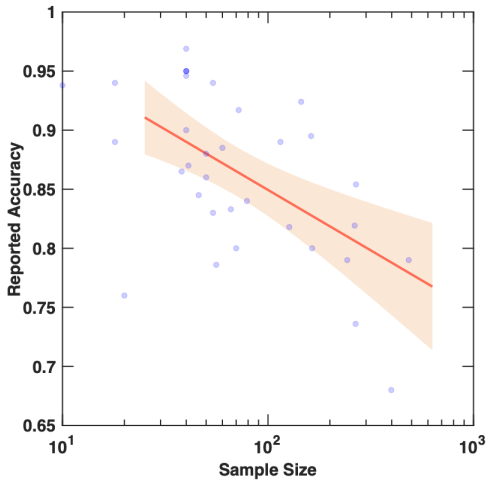
If the estimated accuracy is “**good**”, then **publish**; otherwise, relegate it to the **proverbial file-drawer**

Purely data-driven solutions are not likely to generalize

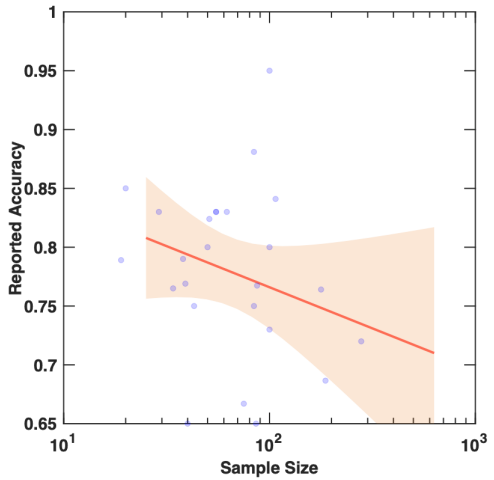
Parkinson's Disease



Alzheimer's Disease



Other Cognitive Impairment



Clinical data is sparsely available and these models provide **no natural way to make connections to the existing knowledge-base**

Berisha et al "Digital medicine and the curse of dimensionality." *Nature npj Digital Medicine*, October 2021.
Berisha et al, "Are reported accuracies in the clinical speech machine learning literature overoptimistic", *Interspeech 22*.

Classification between healthy controls and patient group X based on data from modality Y

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AI in Medicine Is Overhyped

AI models for health care that predict disease are not as accurate as reports might suggest. Here's why

By Visar Berisha, Julie Liss on October 19, 2022

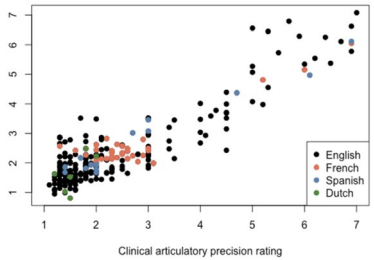
Arbabshirani, M, et al. "Single subject prediction of brain disorders in neuroimaging: Promises and pitfalls." Neuroimage 145 (2017): 137-165.
Vabalas, Andrius, et al. "Machine learning algorithm validation with a limited sample size." *PloS one* 14.11 (2019): e0224365.

A *measurement model* for clinical speech analytics

Feature engineering

Machine learning and signal processing used to develop measures for theoretical constructs of clinical interest

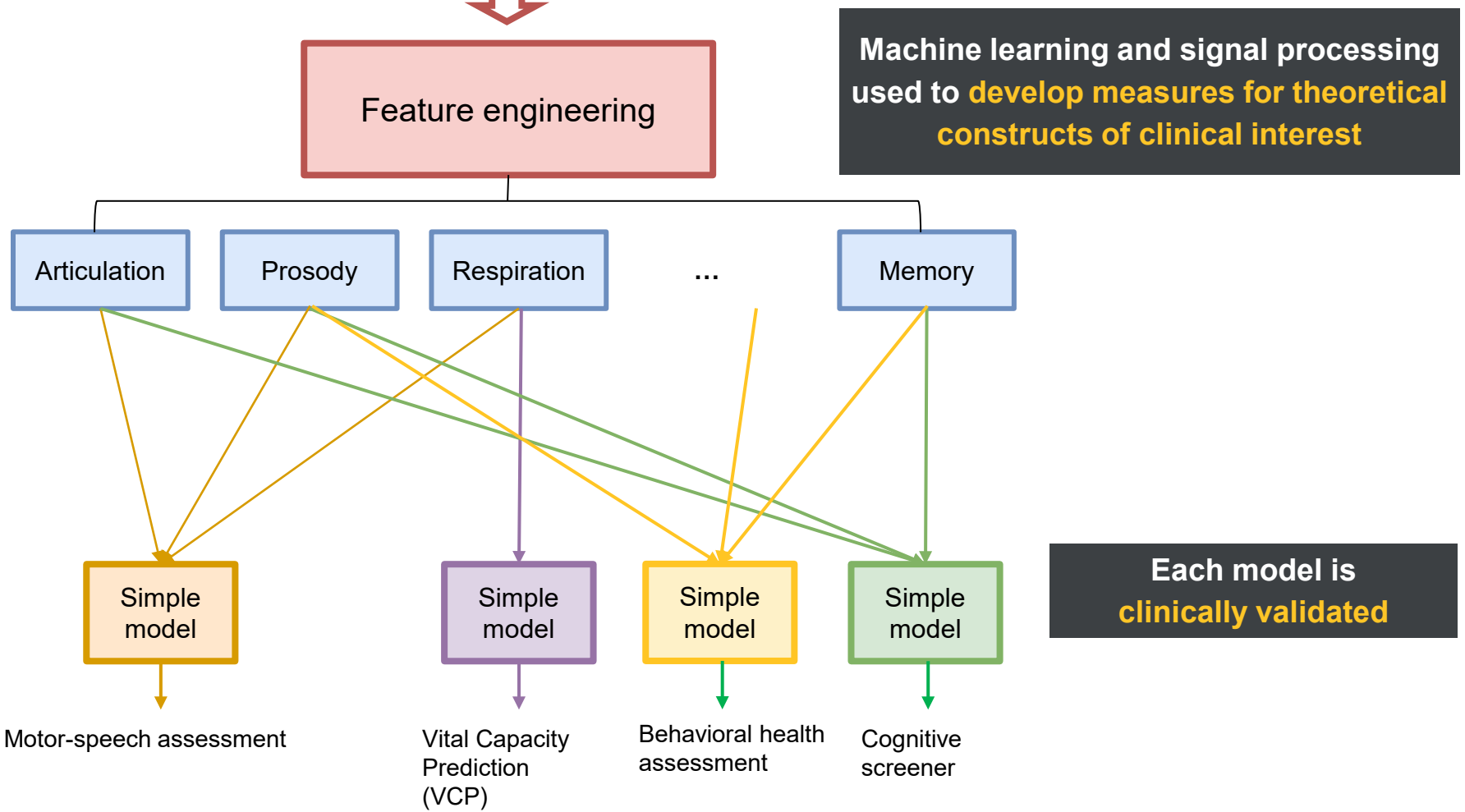
Articulation | Prosody | Respiration | ... | Memory



Validate each feature individually for repeatability, generalizability, etc.

Each measure is analytically validated

Goldsack, Jennifer C., et al. "Verification, analytical validation, and clinical validation (V3): the foundation of determining fit-for-purpose for Biometric Monitoring Technologies (BioMeTs)." Nature *npj digital Medicine* 3.1 (2020): 1-15.



Machine learning and signal processing used to develop measures for theoretical constructs of clinical interest

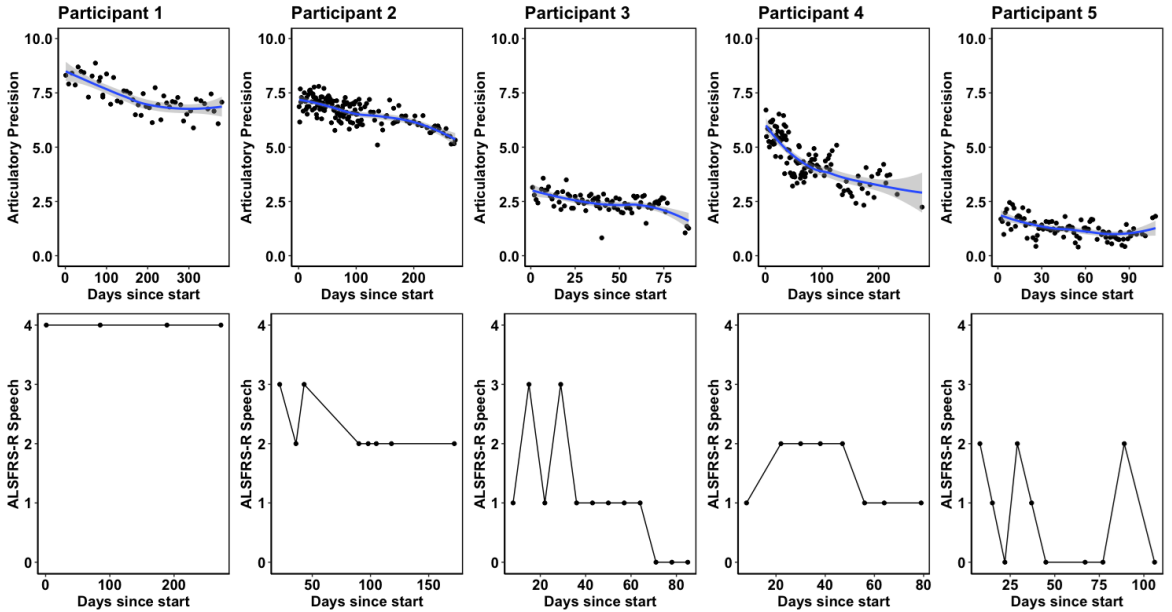
Each model is clinically validated

Goldsack, Jennifer C., et al. "Verification, analytical validation, and clinical validation (V3): the foundation of determining fit-for-purpose for Biometric Monitoring Technologies (BioMeTs)." Nature *npj digital Medicine* 3.1 (2020): 1-15.

Case study: Assessing motor and respiratory symptoms in ALS

Collected remotely on personal devices

Standard clinical scale



In Pridopidine trial, analytics suggested slowing of decline in several markers related to speech and bulbar function in participants taking Pridopidine, while the primary endpoint did not meet the criterion for success

Stegmann, G.M., Hahn, S., Liss, J., Shefner, J., Rutkove, S., Shelton, K., Duncan, C.J. and Berisha, V., 2020. Early detection and tracking of bulbar changes in ALS via frequent and remote speech analysis. *Nature npj Digital Medicine*, 3(1), pp.1-5.

Stegmann, Gabriela M., et al. "Estimation of forced vital capacity using speech acoustics in patients with ALS." *Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration* 22.sup1 (2021): 14-21.

Beyond ALS

Alzheimer’s disease and related dementias

Stegmann, Gabriela, et al. "Automated semantic relevance as an indicator of cognitive decline: Out-of-sample validation on a large-scale longitudinal dataset." *AIzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring* 14.1 (2022): e12294.

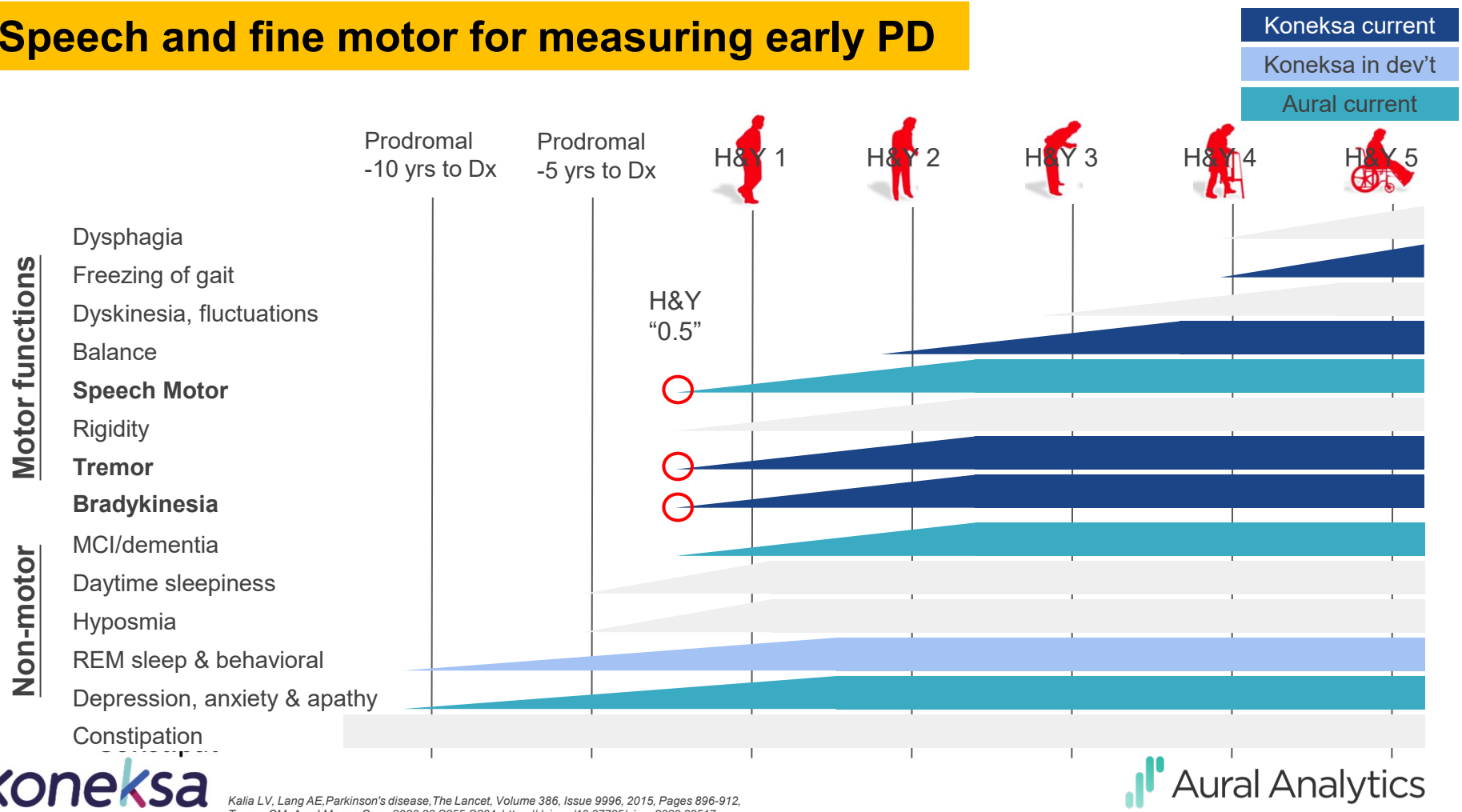
Schizophrenia and Bipolar Disorder

Voleti, Rohit, et al. "Language analytics for assessment of mental health status and functional competency." *Schizophrenia Bulletin*. In press. Pre-print available: https://psyarxiv.com/yw7c6/download?format=pdf

Parkinson’s disease and other motor disorders

Liss, Julie M., Sue LeGendre, and Andrew J. Lotto. "Discriminating dysarthria type from envelope modulation spectra." *Journal of Speech, Language, and Hearing Research*, (2010).

Speech and fine motor for measuring early PD



Kalia LV, Lang AE,Parkinson's disease,The Lancet, Volume 386, Issue 9996, 2015, Pages 896-912,
Tanner CM. Am J Manag Care. 2020;26:S255-S264. https://doi.org/10.37765/ajmc.2020.88517


Thank you