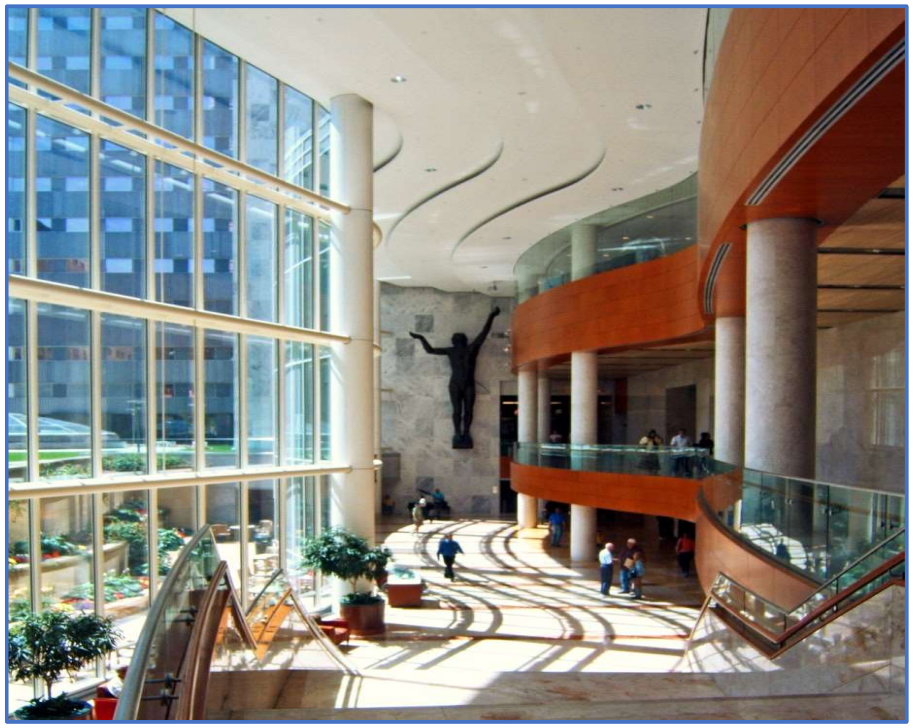
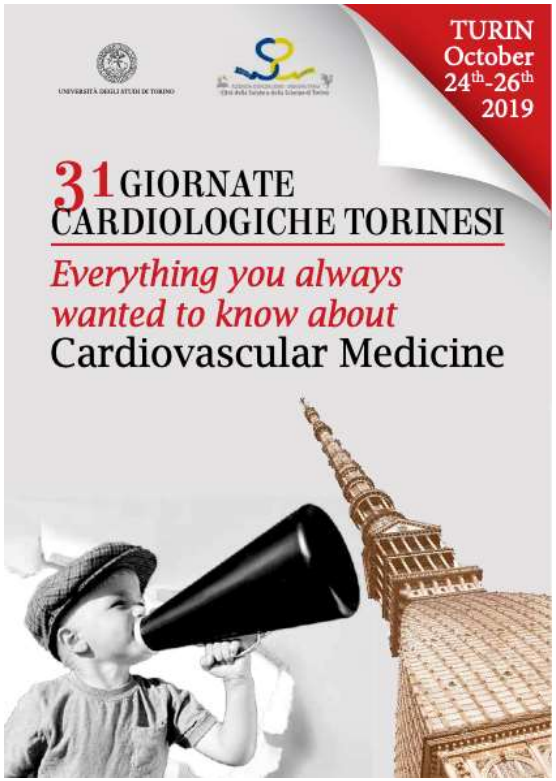




Use of voice signal in cardiovascular disease

Amir Lerman, MD

Barbara Woodward Lips Endowed Professor

Director Cardiovascular Research Center

Mayo Clinic, Rochester, MN

DISCLOSURE

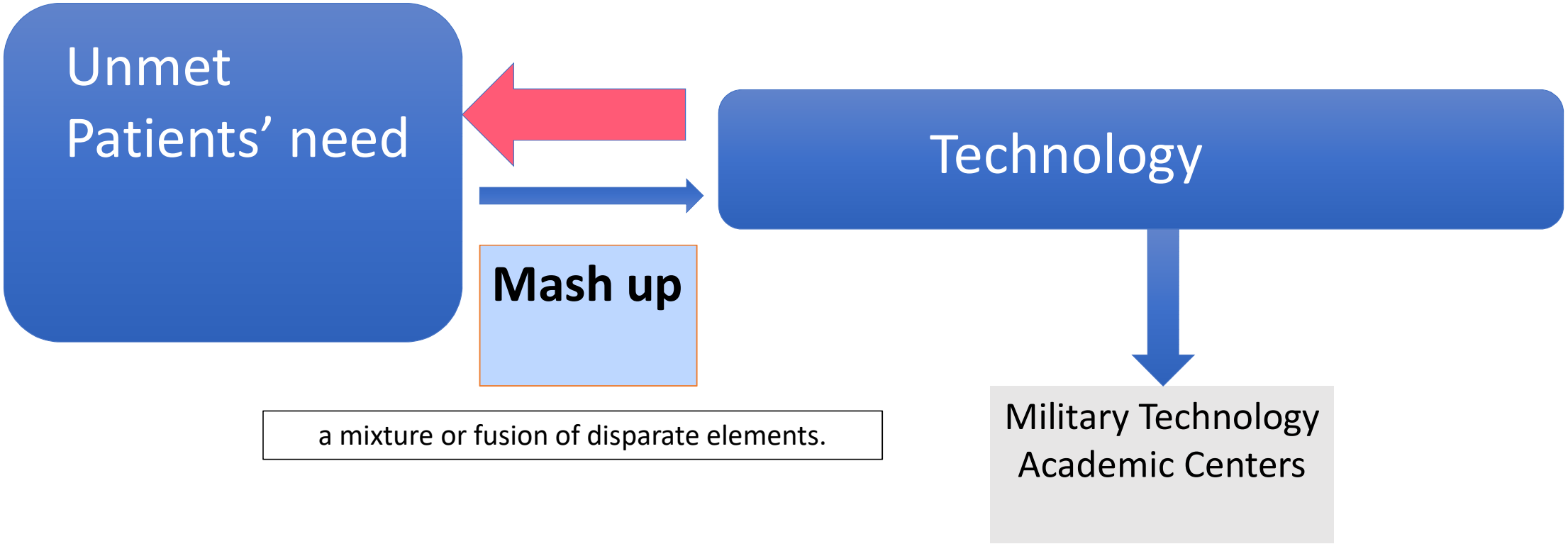
None Relevant financial relationship

Studies were supported in part by an unrestricted grant from Beyond Verbal

Off Label Usage

None

Where are the Future Opportunities in the Cardiovascular Field?

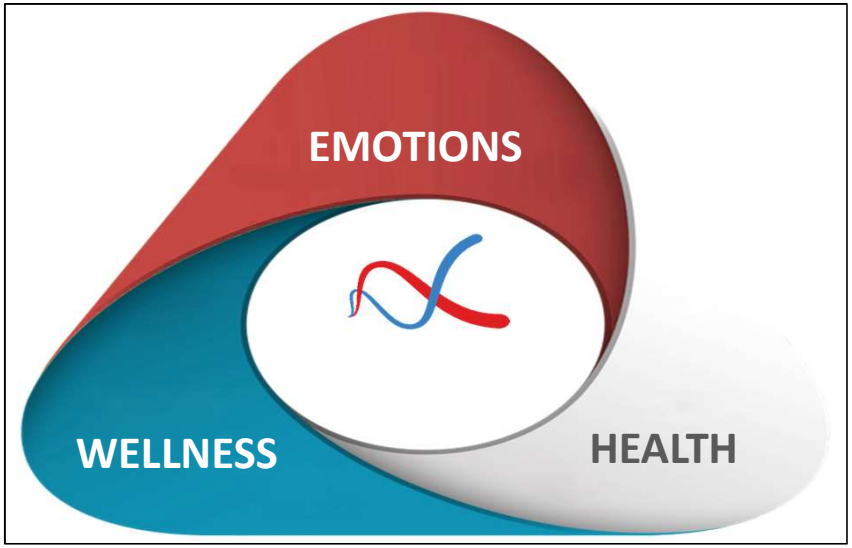


“Listening” to our body

Frank’s sign (NEJM 1973)

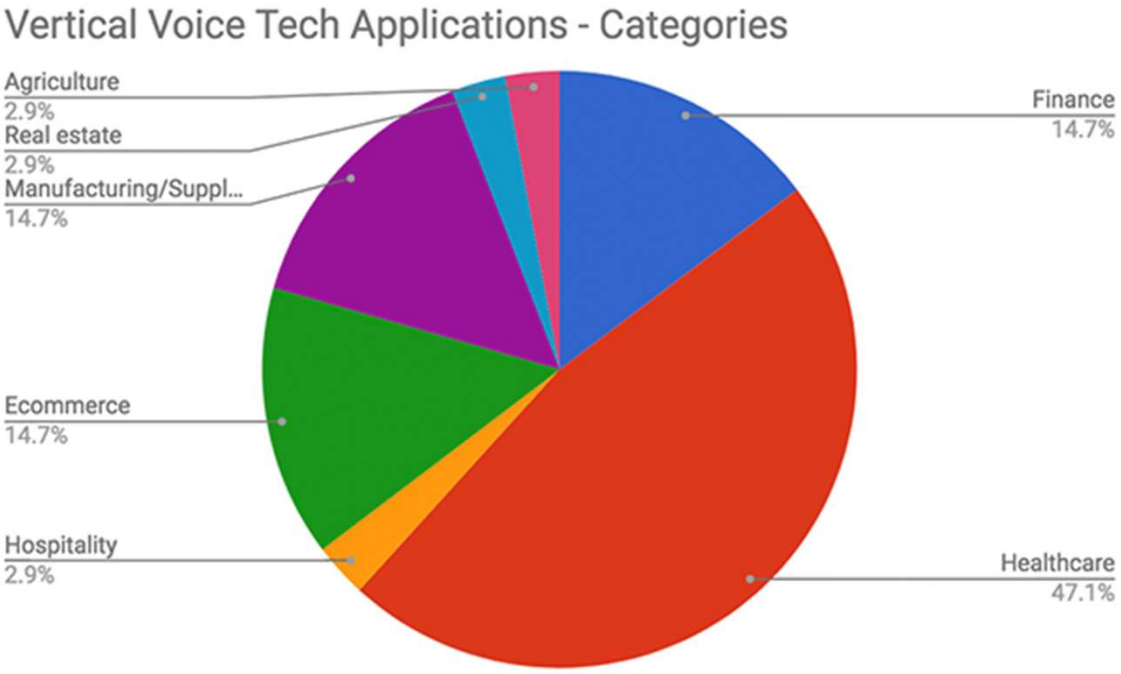
Just Blink: New Device DetectsDisease Through Eye Movement

It’s not what we say, It’s HOW we say it



Genetics and epigenetic play a large role in determining face shape,

Startups building voice applications for healthcare



Voice & the Future of Medical Applications

The new UI/UX

Powerful tool in technology applications

Digital assistants feature

- voice recognition
- predictive analytics
- language processing

AI and big data enable extraction from voice

Vocal patterns contain powerful biomarkers

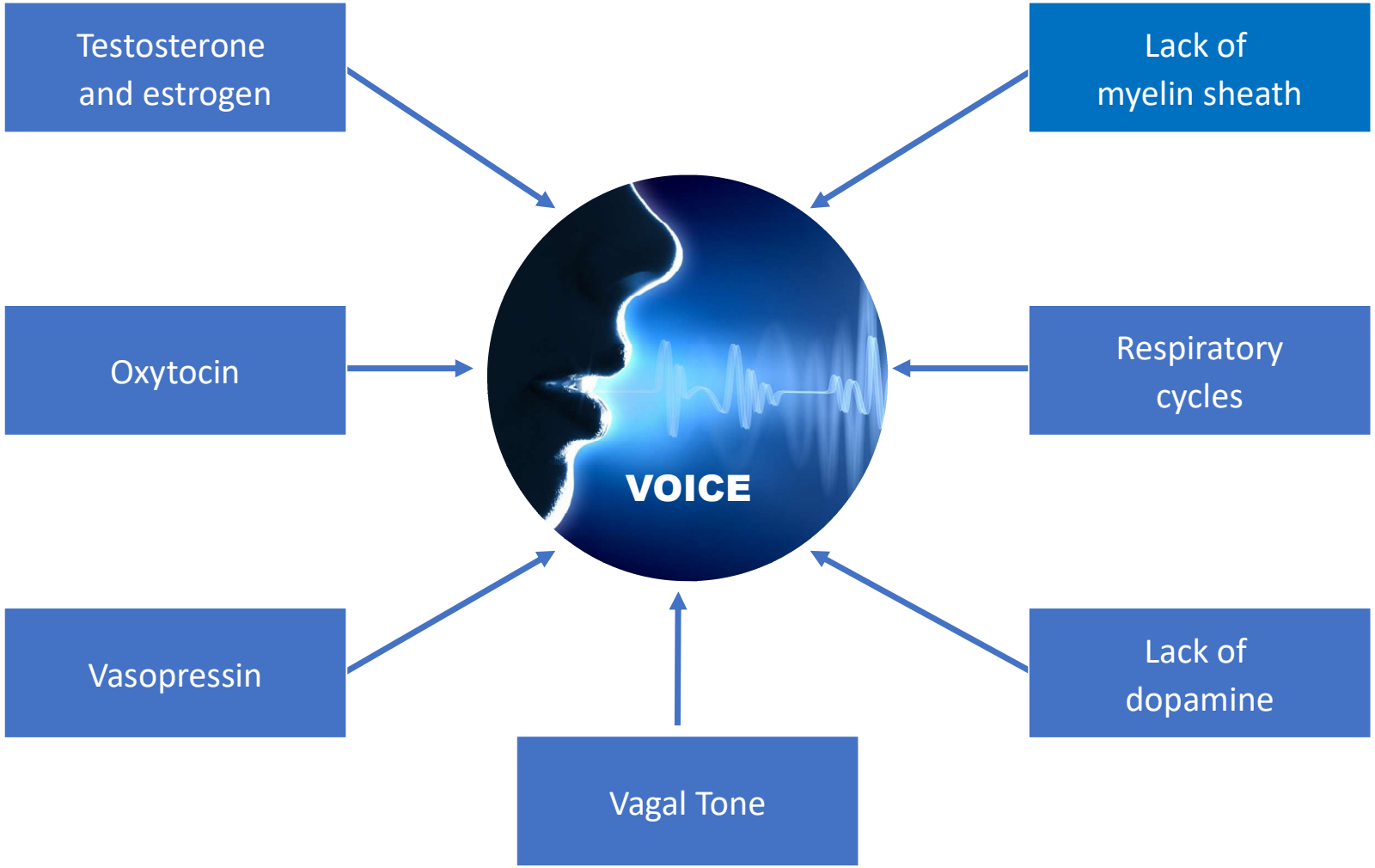
>50% of searches will be voice-based & >55% of households will have a smart speaker by 2022[1]

Voice carries health information

- Natural
- Non-intrusive
- Convenient
- Capable technology
- Fast & Accessible
- Critical mass

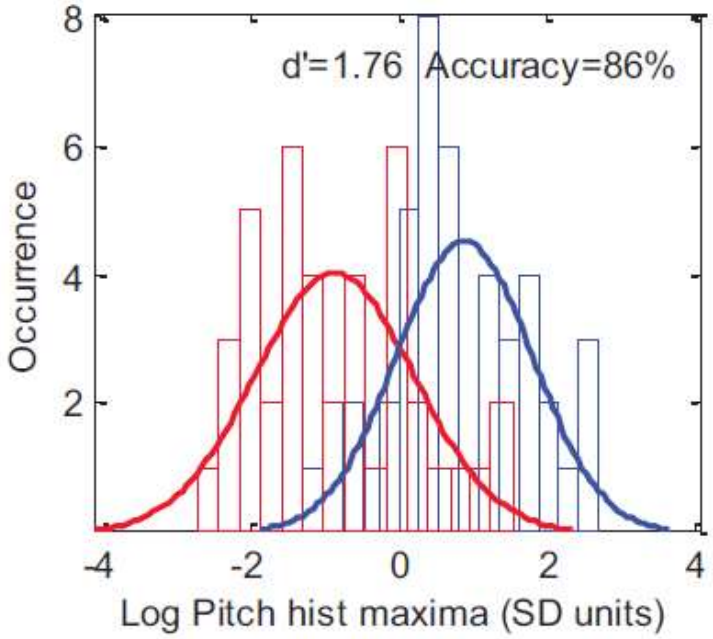
1. 33 Voice Search Statistics to Prepare You for the Voice Search Revolution. www.wordstream.com/blog

Potential Mechanisms of the Changes in Voice Characteristics



Initial steps and clinical trials

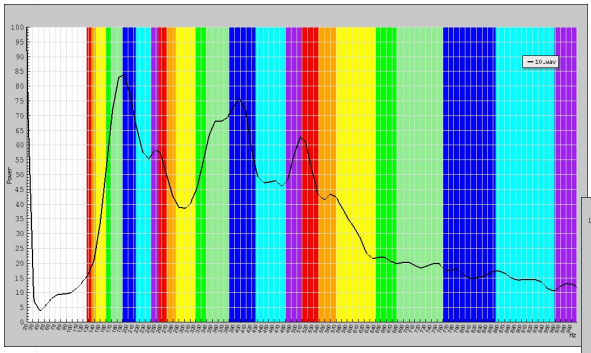
Autism – lack of Oxytocin and misunderstanding of expressed emotions will cause certain low intensities and shift of normal intonations



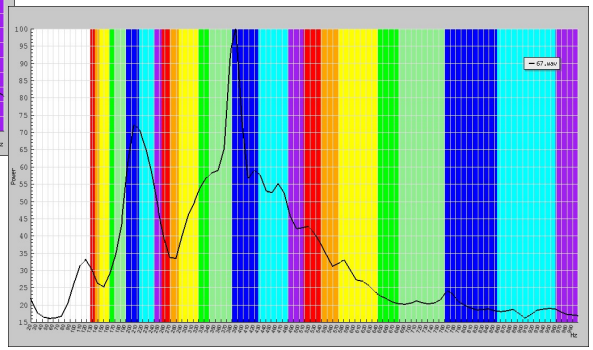
- Yoram S. Bonneh, Yoram Levanon et al. Abnormal speech spectrum and increased pitch variability in young autistic children. Frontiers in Human Neuroscience 2011

Parkinson – abnormal mechanisms as a result of lack of Dopamine and need to allocate small quantities between multiple tasks will cause instabilities (like vibrations , reduced intensities , etc.)

Healthy Voice



PD Patient Voice



Yoram Levanon et al. Digital Voice Analysis in Parkinson's Disease. Hadassah Medical Center 2007

Approach

FREE SPEECH

Enables scalable and passive analysis

BIG DATA

Access to over **150K** patients

PLATFORM

Speaker diarization
Automation
Scalability

VOCAL BIOMARKERS

The BVC algorithm & product might be subject to regulatory review based on the specific use case

CAD STUDY HYPOTHESIS AND OBJECTIVES

- We hypothesize that atherosclerosis process might involve anatomic structures associated with voice production

- The purpose of the current study was to identify association between voice characteristics and CAD among patients referred for coronary angiogram

ORIGINAL ARTICLE

MAYO CLINIC

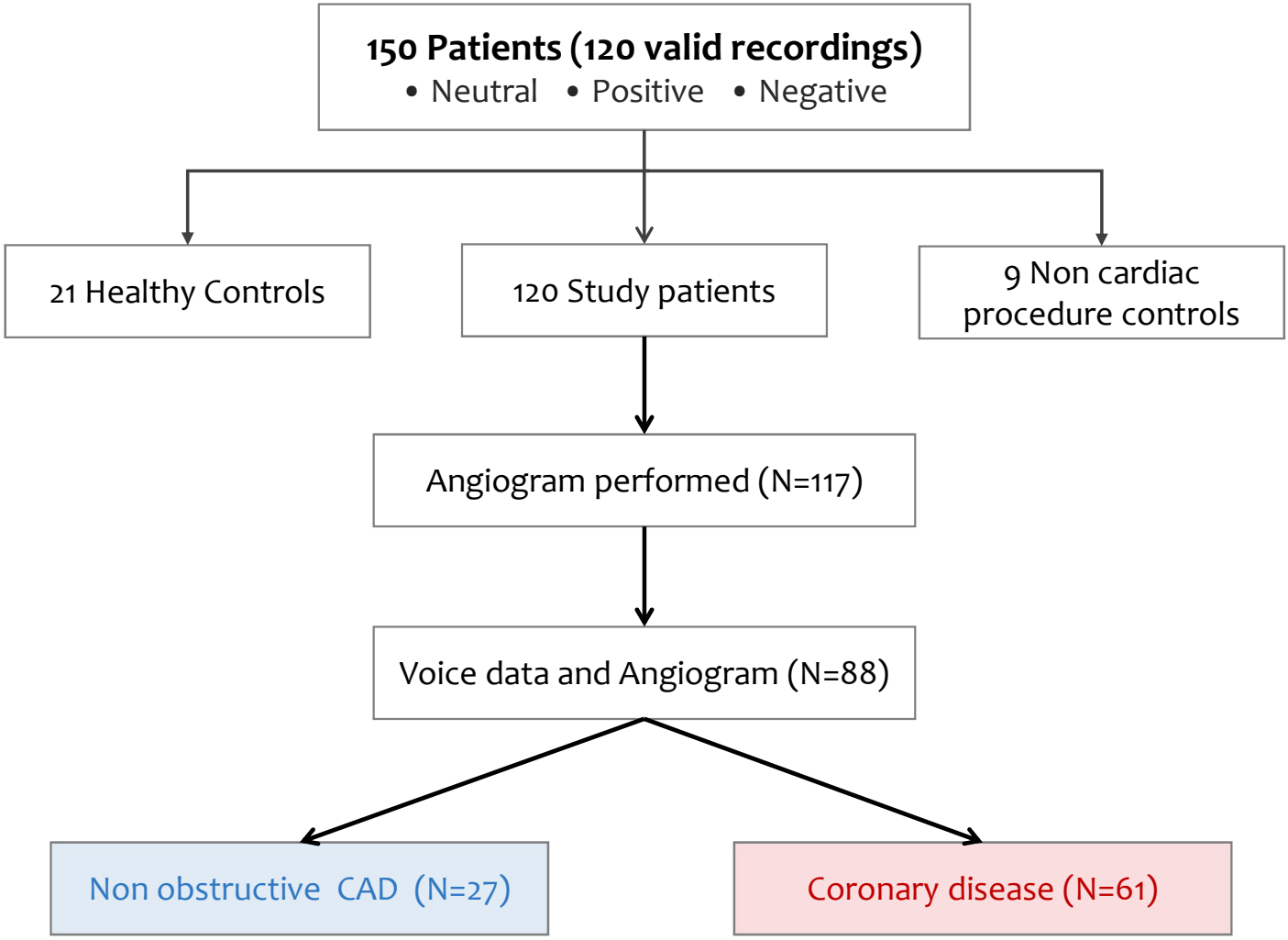
Voice Signal Characteristics Are Independently Associated With Coronary Artery Disease

Elad Maor, MD, PhD; Jaskanwal D. Sara, MBChB; Diana M. Orbelo, PhD; Lilach O. Lerman, MD, PhD; Yoram Levanon, PhD; and Amir Lerman, MD

Abstract

Objective: Voice signal analysis is an emerging noninvasive diagnostic tool. The current study tested the hypothesis that patient voice signal characteristics are associated with the presence of coronary artery disease (CAD).

Methods: The study population included 138 patients who were enrolled between January 1, 2015, and February 28, 2017: 37 control subjects and 101 subjects who underwent planned coronary angiogram. All subjects had their voice signal recorded to their smartphone 3 times: reading a text, describing a positive emotional experience, and describing a negative emotional experience. The Mel Frequency Cepstral



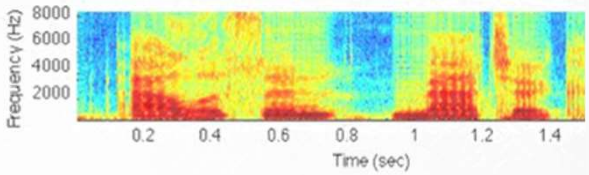
REMOTE VOICE RECOGNITION OF CAD

VOICE COLLECTION

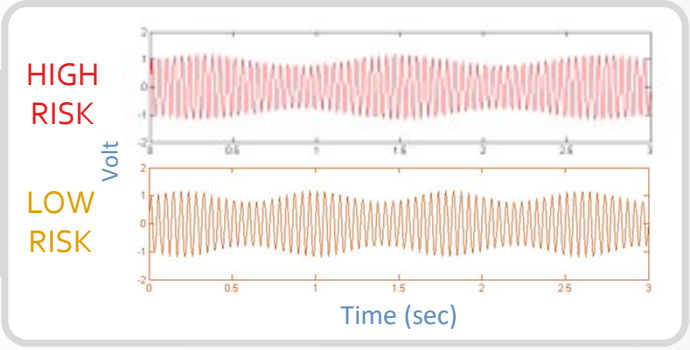
1. Neutral text
2. Induction of positive mood
3. Induction of negative mood

VOICE SIGNAL

VOICE SIGNAL SPECTROGRAM



CAD RELATED **ACOUSTIC FEATURE**



Coronary angiogram

MAYO CLINIC HEALTH SYSTEM

EDITORIAL

MAYO CLINIC

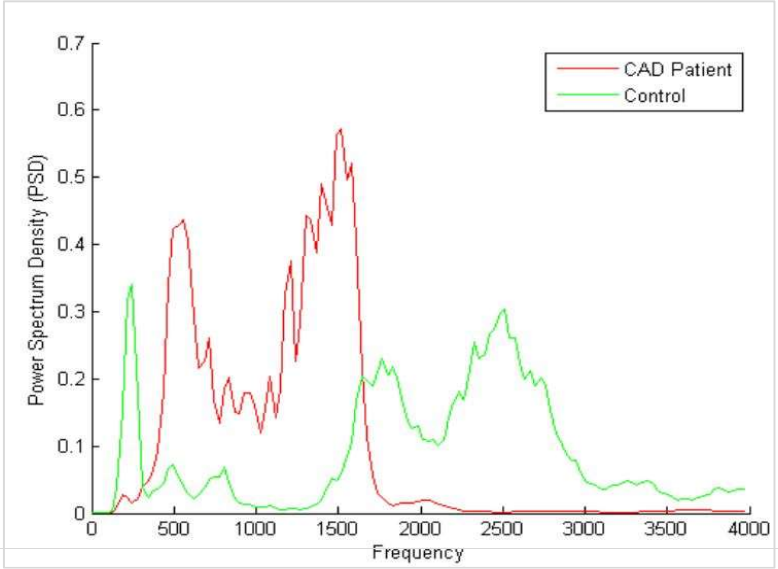
Check for updates

Hey Goglexiri, Do I Have Coronary Artery Disease?

A multivariate binary logistic regression, with adjustment for age, gender, and cardiovascular traditional risk factors, showed that this features was independently associated with a significant <u>2.6-fold</u> increased likelihood of CAD (95% CI 1.16-5.80, p=0.020).

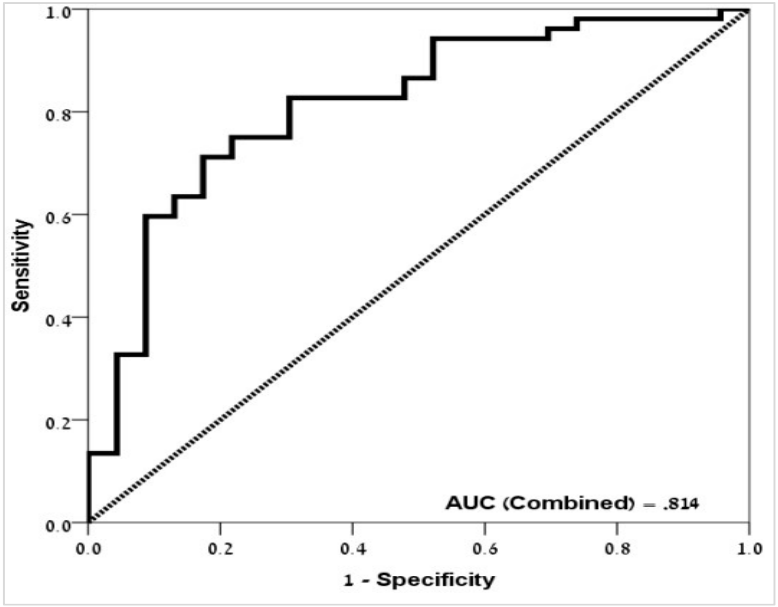
SAMPLE OF RECORDING

The red line for the CAD patient and green line for the control subject present the power spectrum density (PSD) of their speech frequencies expressed in the R3 recordings. The values were calculated by averaging over time the instantaneous PSD values calculated using Fourier transform on 25ms frames with 10ms shift

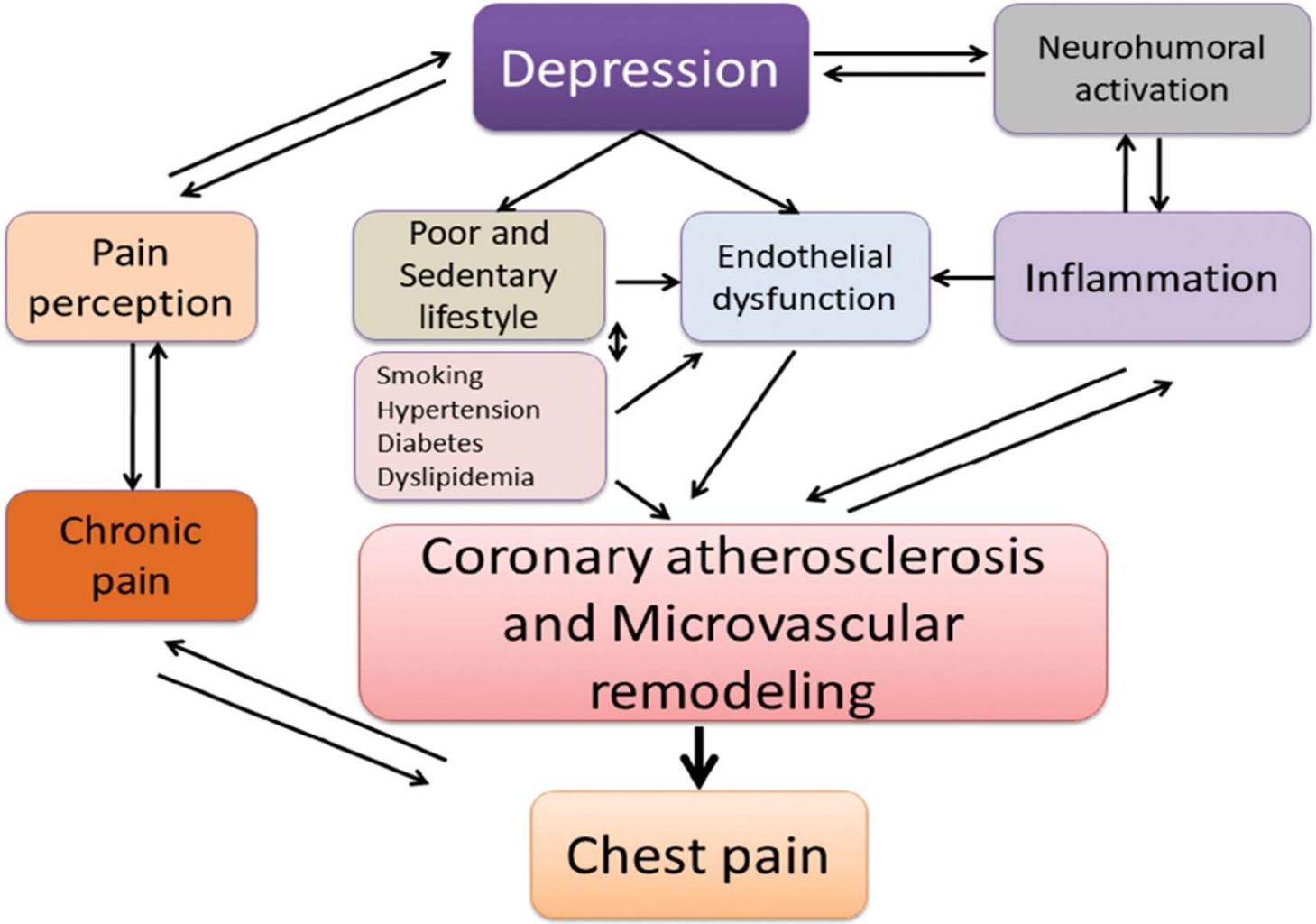


ROC

Areas under the ROC curves for Framingham score, and for a combined new score are shown. The AUROC of the Framingham score was 0.807. When a simple new score was used (Framingham + Feature 15), the AUROC increased to 0.814.



Common links between depression and coronary heart disease.



European Heart Journal, ehy913, https://doi.org/10.1093/eurheartj/ehy913

Ellipsis Health has created a voice-base vital sign to detect depression and anxiety

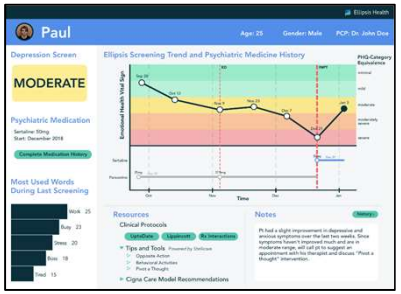
1. System askes questions that the user answers with natural speech

User can access through a smartphone app or web app

2. Ellipsis Algorithms analyzes speech

Algorithms consider both words and acoustics

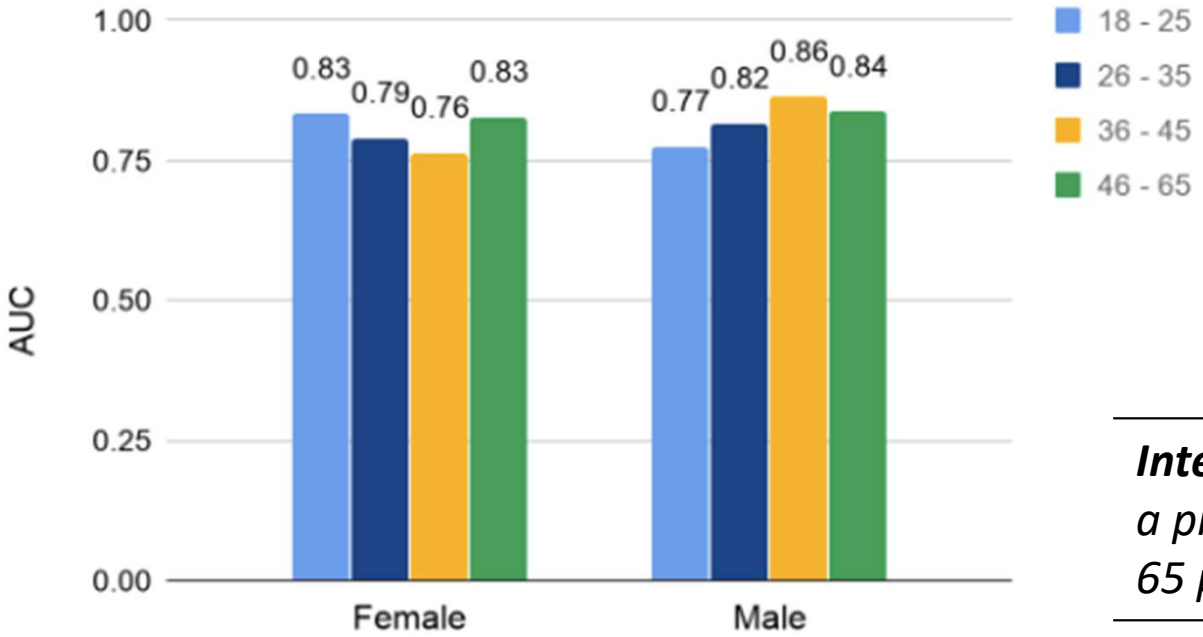
3. Ellipsis provides risk scores and confidence intervals for depression & anxiety



Ellipsis connects into existing provider workflow

Model Performance is across demographic cohorts

AUC Performance by Gender and Age Cohort
(Test set: N = 3034)

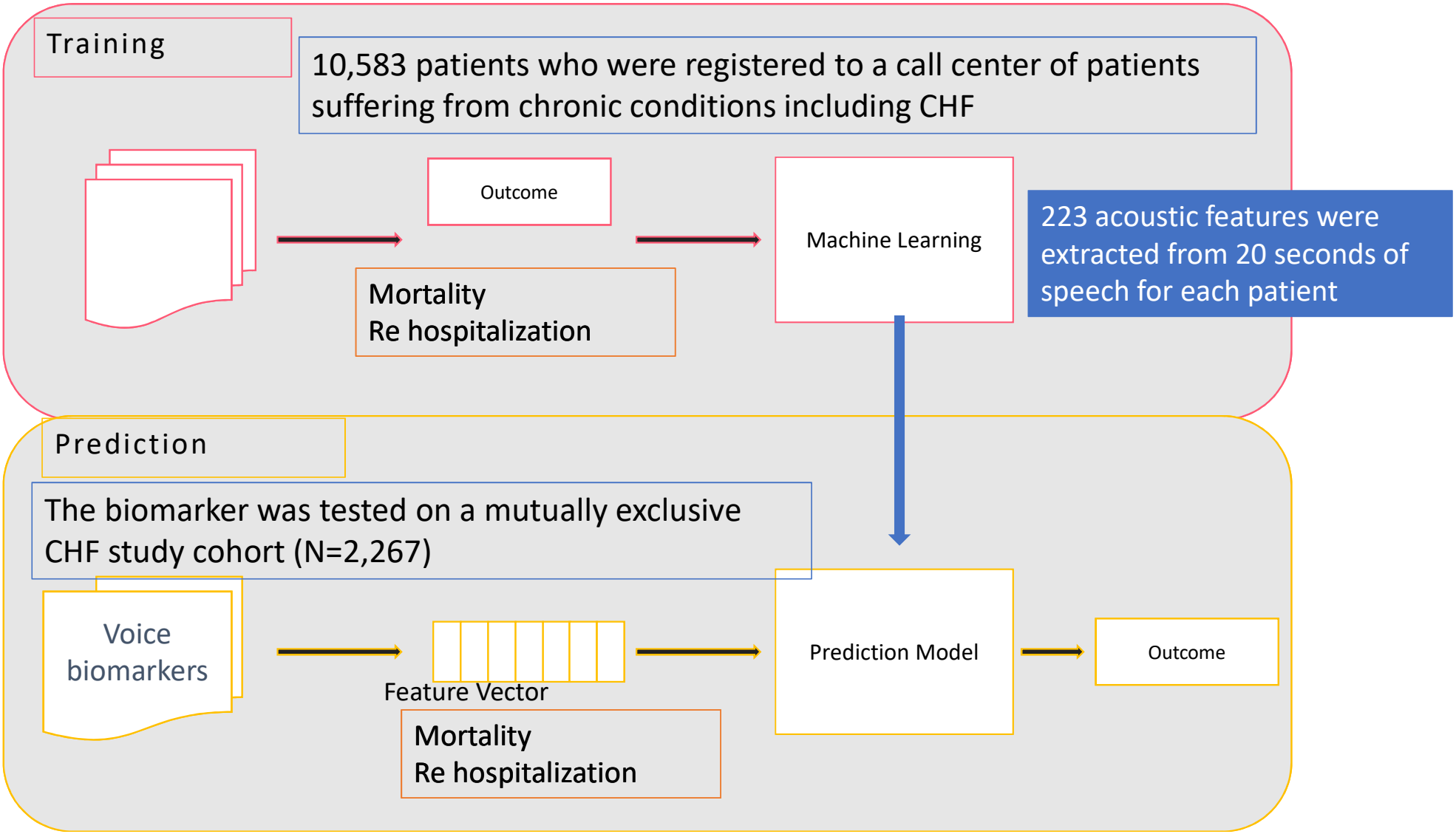


Factors that improved the AUC

- *On average, a stable vital sign emerges after 2 – 7 minutes of speech*
- *Speech elicitation approach can meaningfully impact algorithm performance*

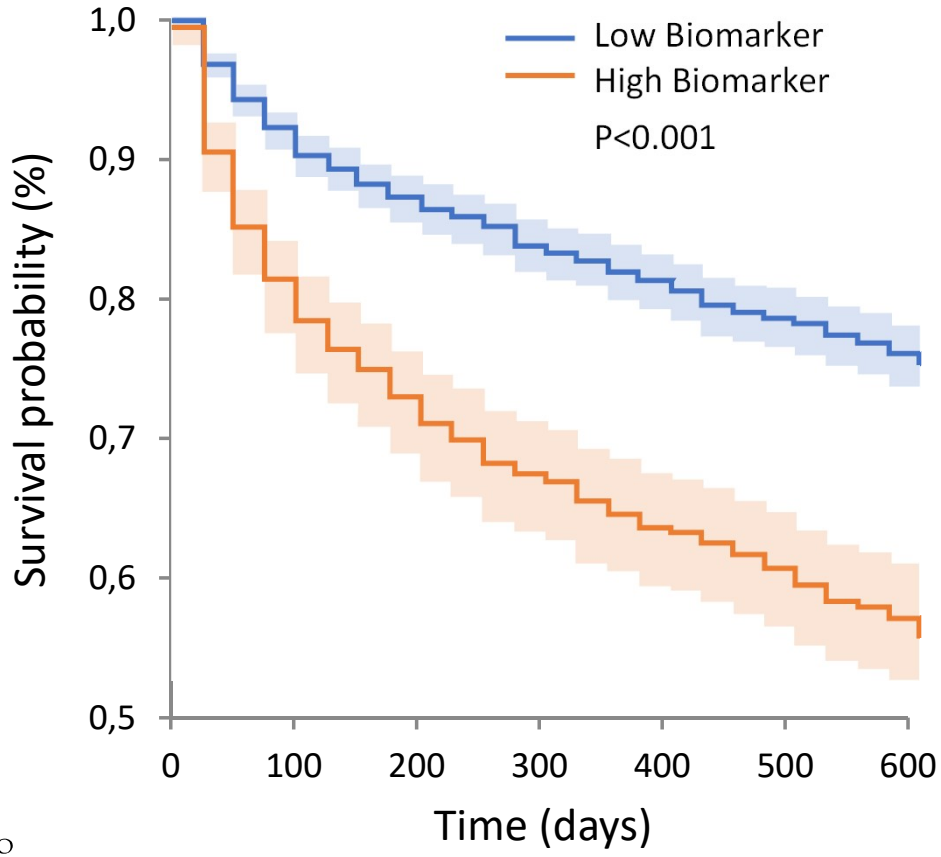
Interpretation: *Speech-based screening is a promising technology for the entire 18-65 population*

Voice Biomarkers and Heart Failure



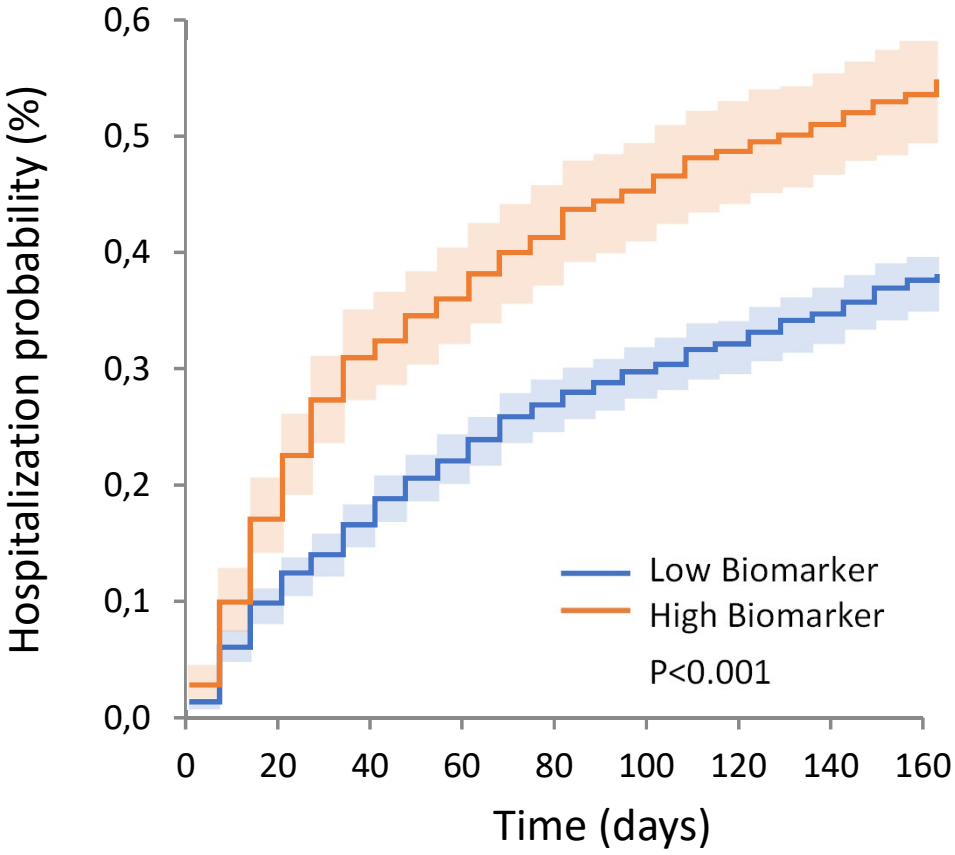
Vocal Biomarkers and Heart Failure

Kaplan Meier Survival Analysis



Language independent

Kaplan Meier Hospitalization Probability

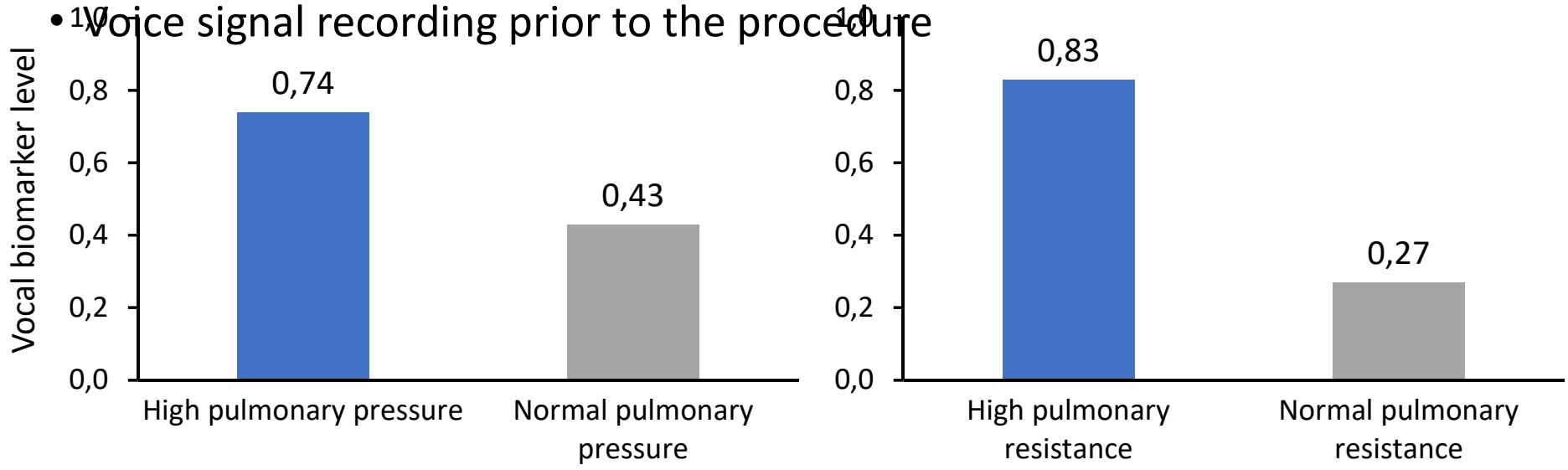


Maor E….Lerman A. et al JAHA (in press)

Non-Invasive Vocal Biomarker is Associated with Pulmonary Hypertension

Each standard deviation increase in the vocal biomarker was significantly associated with a 49% increased likelihood of a high PA pressure (95% CI 1.07-2.08, P=0.019)

- 91 patients referred to right heart study
- Voice signal recording prior to the procedure



SCIENTIFIC REPORTS

OPEN

Received: 09 December 2014
Accepted: 20 April 2015
Published: 18 June 2015

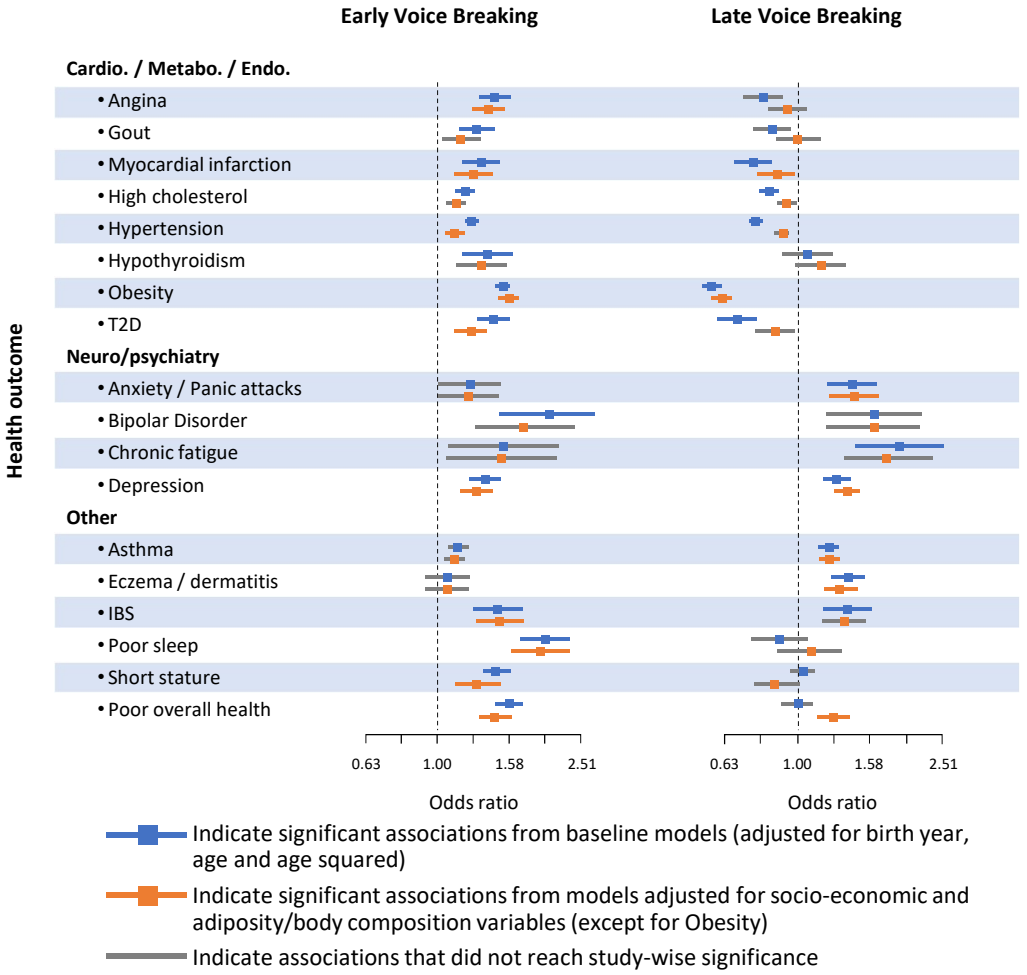
Puberty timing associated with diabetes, cardiovascular disease and also diverse health outcomes in men and women: the UK Biobank study

Felix R Day[1], Cathy E Elks[1], Anna Murray[2], Ken K Ong[1,3] & John R.B. Perry[1]

Recalled puberty timing and past/current diseases were self-reported by questionnaire.

Some adverse health associations with early puberty timing in men have been described, based on timing of voice breaking

Associations Between Early or Late Voice Breaking and Adverse Health Outcomes in Men



Day et al: Scientific Reports 5:11208, 2015

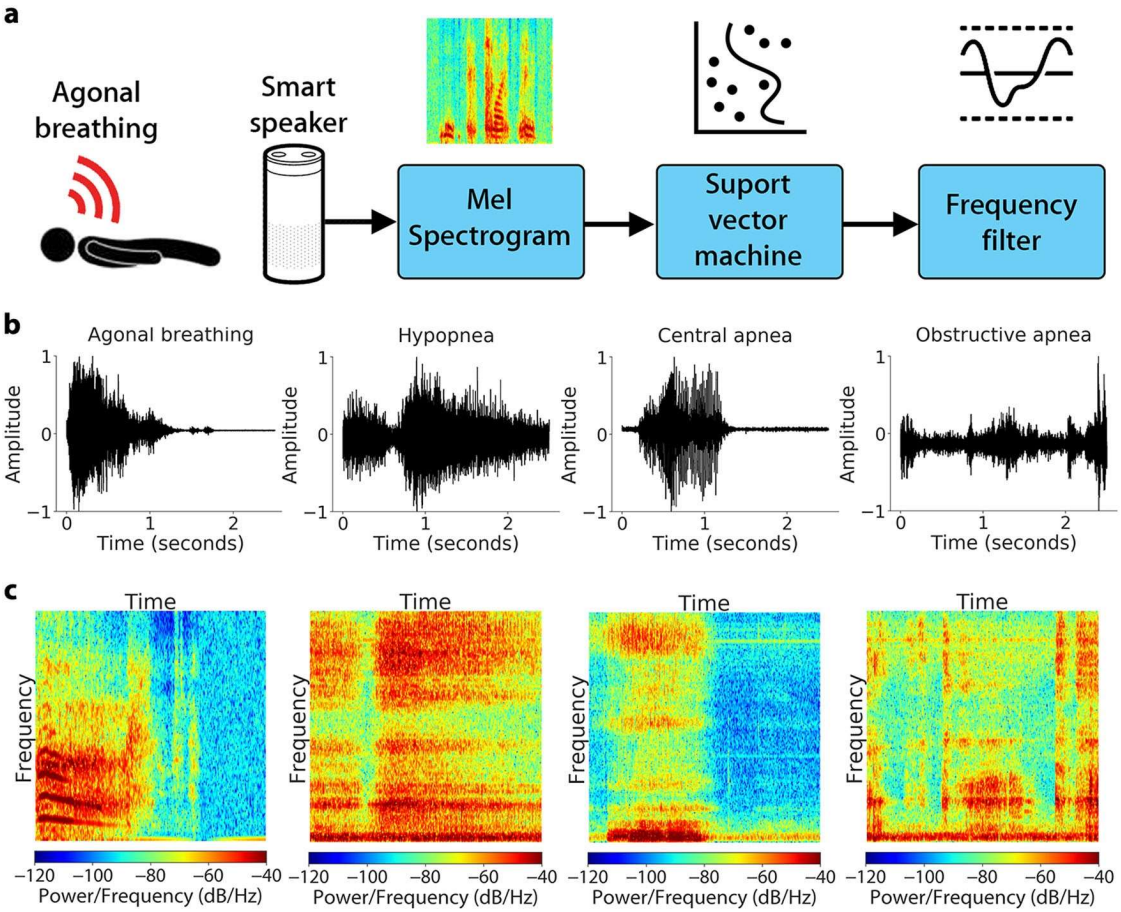
npj | Digital Medicine

www.nature.com/npjdigitalmed

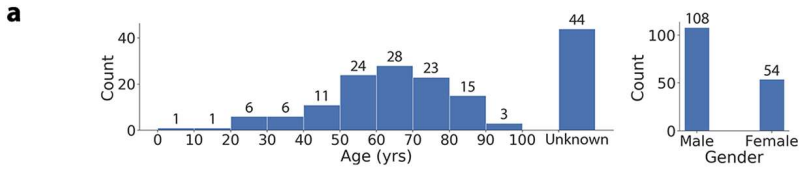
ARTICLE OPEN

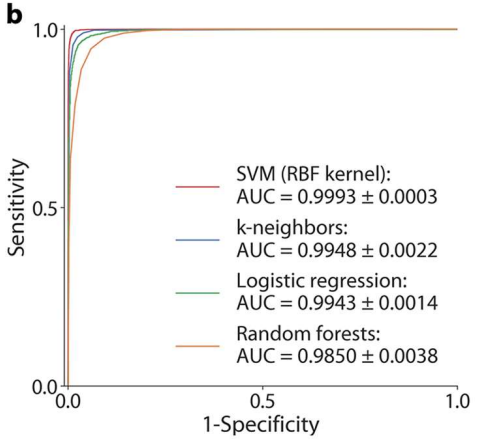
Contactless cardiac arrest detection using smart devices

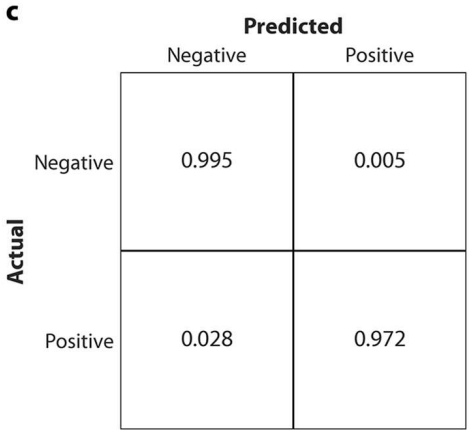
Justin Chan[1], Thomas Rea[2,3], Shyamnath Gollakota[1] and Jacob E. Sunshine[4]

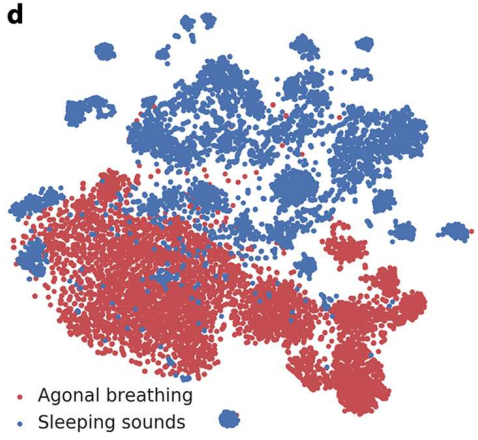


agonal breathing recordings are sourced from 9-1-1 emergency calls









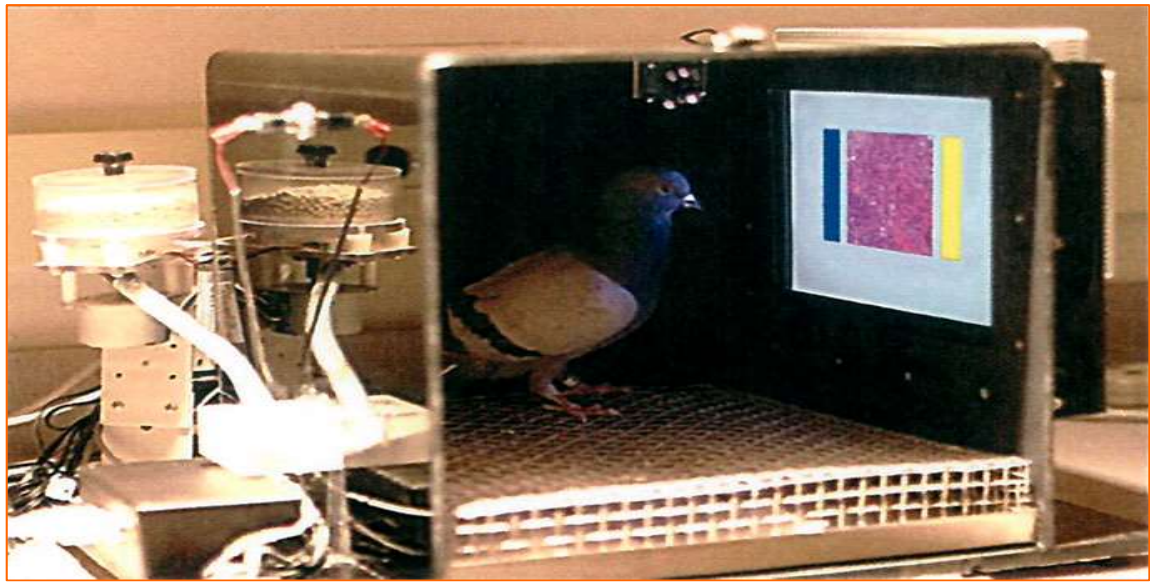
e

	False positive rate
Without frequency filter	0.14409% (170/117,985)
Frequency filter applied once	0.00085% (1/117,985)
Frequency filter applied twice	0.00000% (0/117,985)

RESEARCH ARTICLE

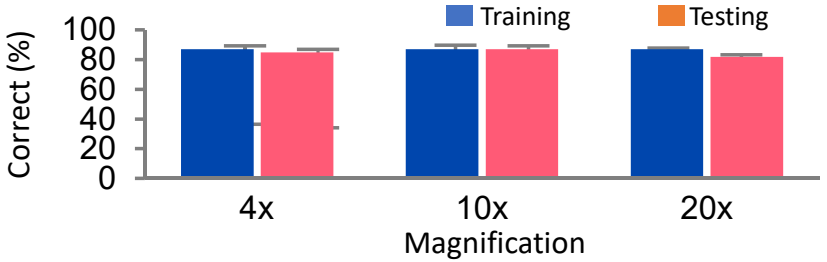
Pigeons (*Columba livia*) as Trainable Observers of Pathology and Radiology Breast Cancer Images

Pigeons (*Columba liva*) – share many visual system properties with humans – can serve as promising surrogate observers of medical images

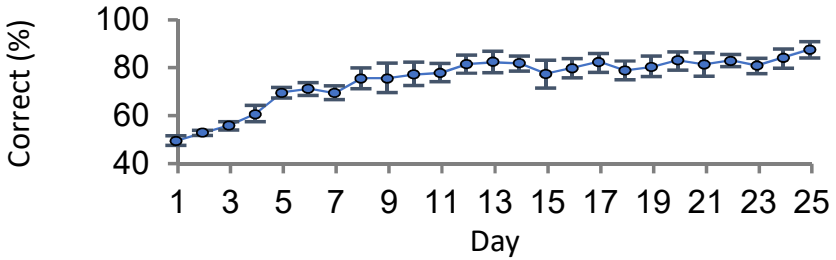


The pigeons' training environment

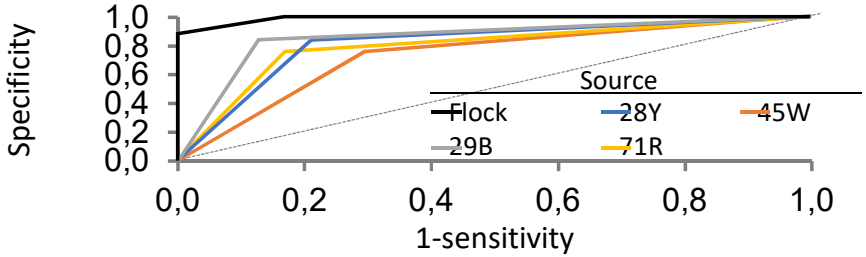
Generalization from training to test image sets. After training with differential reinforcement, the birds successfully classified previously unseen breast tissue images in the testing sets, at all magnifications, with no statistically significant decrease in accuracy compared to training-set performance.



Results of training and testing with mammograms with or without calcifications



Flock sourcing. Pooling the birds' decisions led to significantly better discrimination



Levenson et al: PLoS ONE 10(11):e0141357, 2015

Conclusion

- Using AI, the development of voice biomarkers may serve as a non invasive, non expensive adjuvant platform to identify patients at risk for cardiovascular disease.
- Voice features analysis holds the potential to assist physicians in estimating the pre-test probability of IHD in the setting of telemedicine – when clinical health care is provided at a distance.

Thank You

Lerman.amir@mayo.edu