



Soft, Wireless Electronic and Microfluidic Sensors for Monitoring Physiological Health

John A. Rogers, PhD, Northwestern University

Longevity and Healthy Aging Symposium



Northwestern

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QUERREY SIMPSON INSTITUTE FOR
BIOELECTRONICS

QICS

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Research Areas ▾

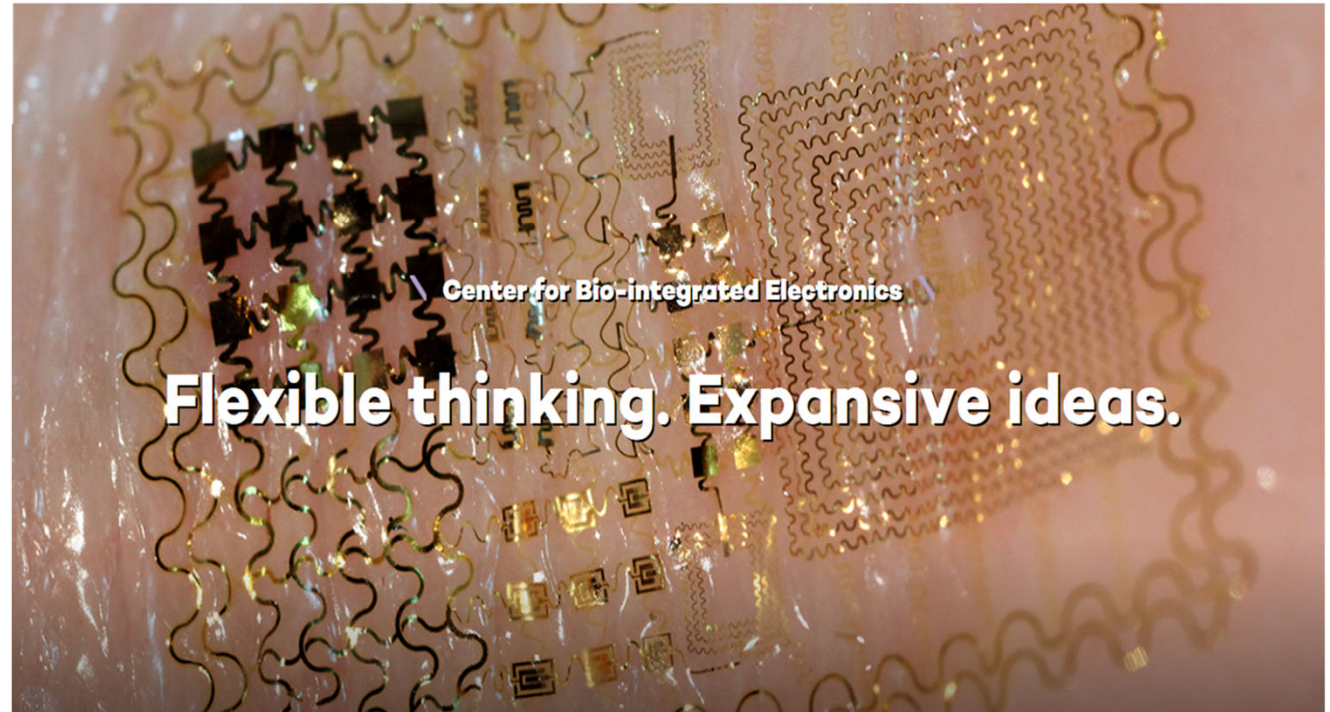
People ▾

Collaborations

Publications

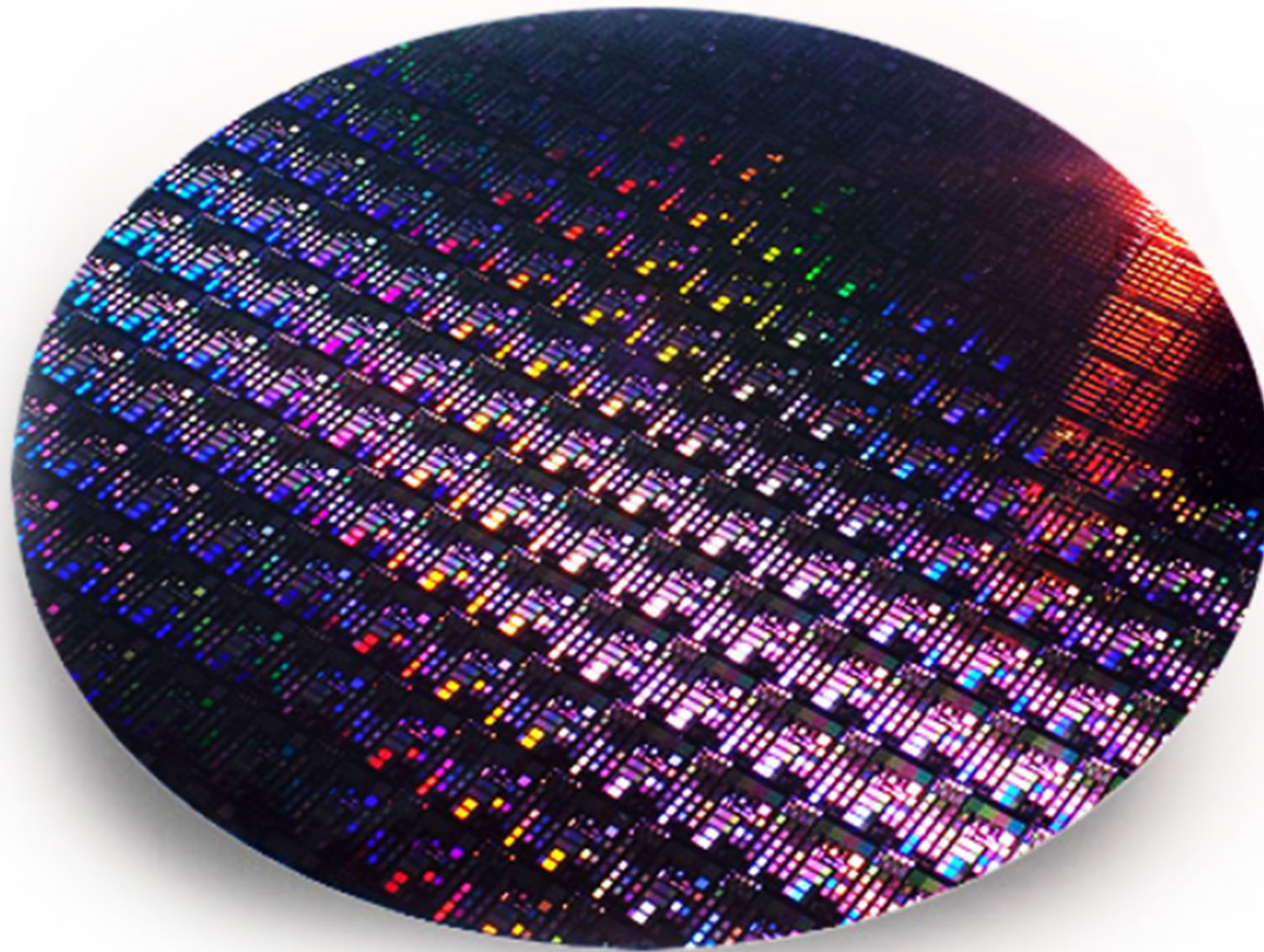
Videos & Images

News & Events



Center for Bio-integrated Electronics

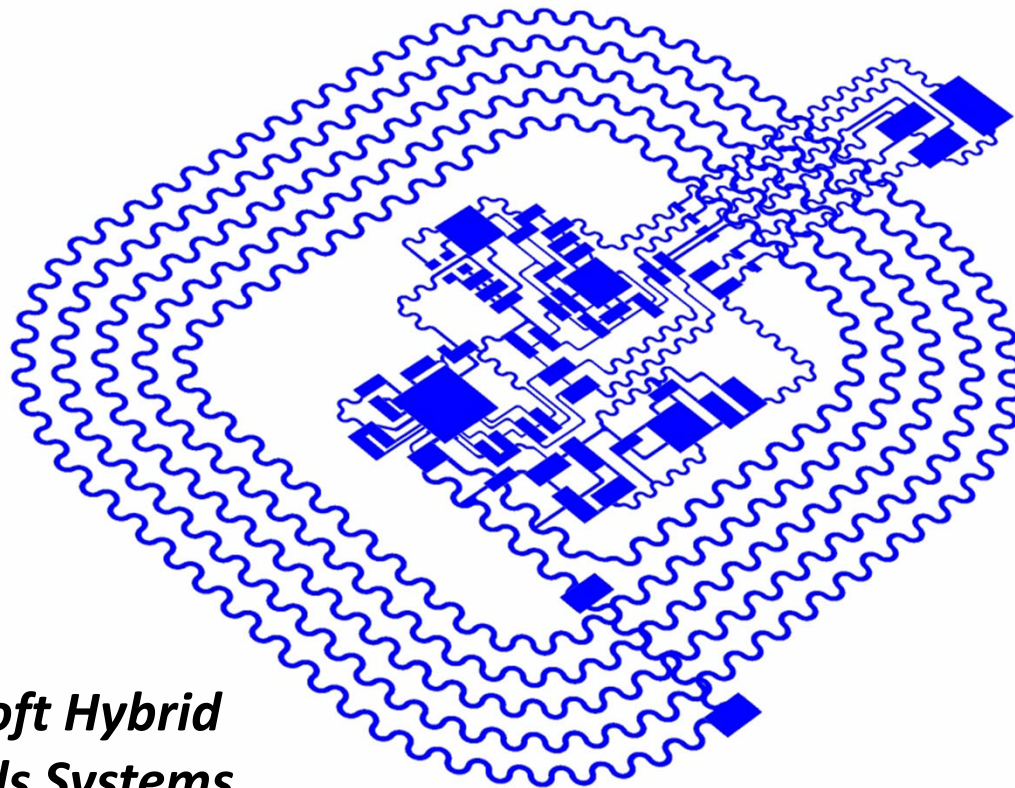
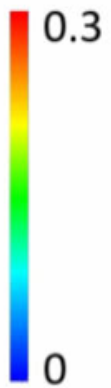
Flexible thinking. Expansive ideas.



In, On & Around Soft Living Tissues

Mechanics Design + Circuit Design

Strain (%)



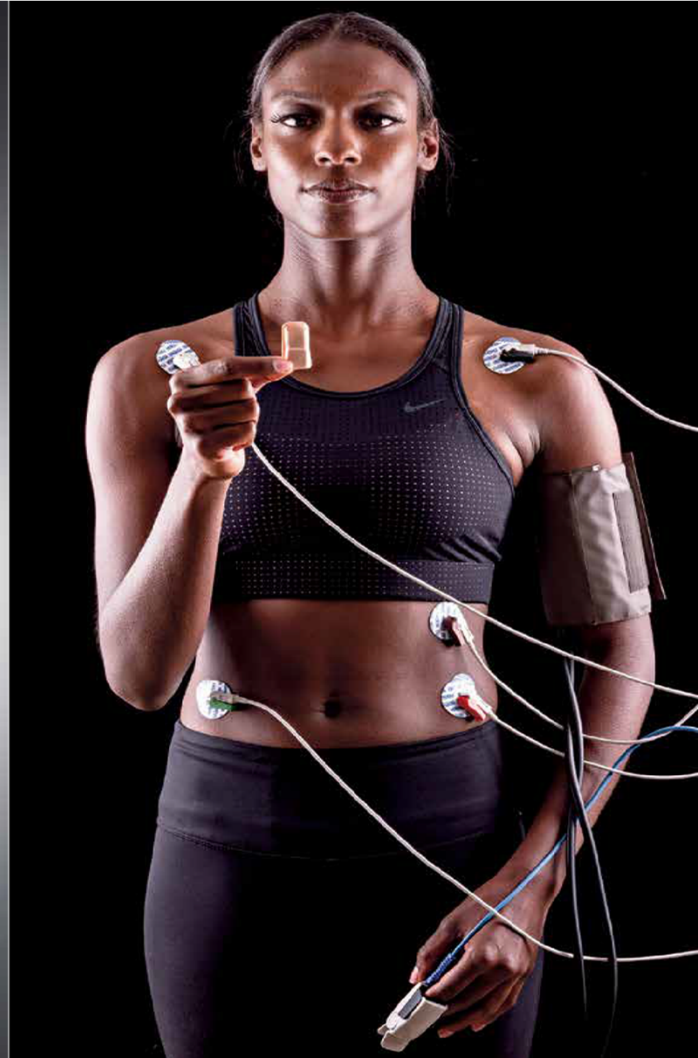
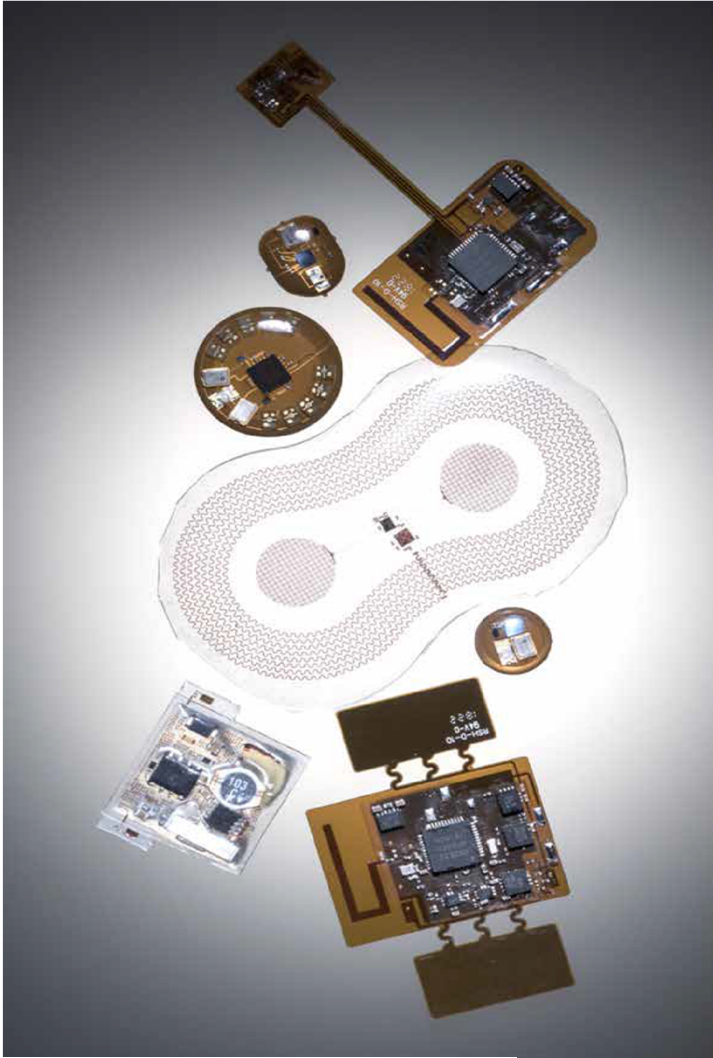
*Hard/Soft Hybrid
Materials Systems*

'Epidermal' Electronics

Multimodal, Clinical Quality Data

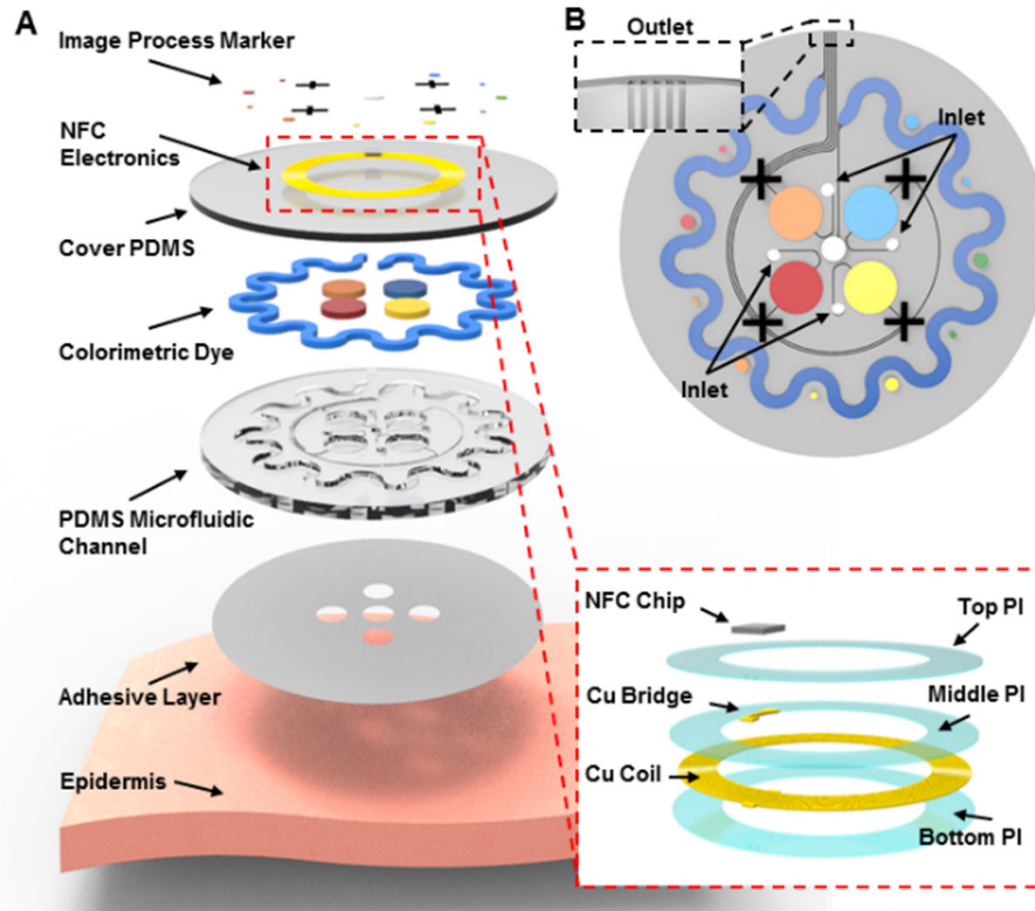


Science **344**, 70 (2014).
Science **333**, 838 (2011).



National Geographic, 2019

Epidermal Microfluidic Devices and Sweat Analytics



Sci. Transl. Med **8**, 366ra165 (2016).



Sci. Transl. Med **8**, 366ra165 (2016).

Measurement Capabilities in Epidermal Electronics

Thermal: Thermography, Thermal Transport, Hydration

Electrical: Biopotential (ECG, EMG, EEG), Hydration

Fluidic: Sweat (loss and chemistry), blood flow

Mechanical: Strain, motion, modulus, pressure

Optical: UVA/UVB, oximetry, PPG, vein mapping

Mechano-acoustic – cardiac auscultation, etc.

***Multimodal, Clinical Quality, Continuous Low Cost
& Available to Everyone***

Neonatal Intensive Care

Current



Future







26 week delivery

***IRB approved studies
Lurie Children's Hospital
~200 babies; on-going***

Scaled Deployments into India, Pakistan,
Zambia, Kenya and Ghana – through 2022

BILL & MELINDA
GATES *foundation*



Save the Children®

Scaled Deployments into India, Pakistan,
Zambia, Kenya and Ghana – through 2022

BILL & MELI
GATES



Nature Med **26**, 418 (2020).

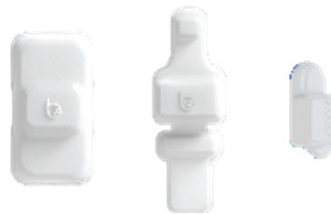


First Deployment – Training Session in Zambia



Accomplishments

Sensors Deployed: >4,000



Data Collected: >150,000 hrs



FDA Cleared

Device Name	Device Class
Apple Watch Series 4	Class II
Apple Watch Series 5	Class II
Apple Watch Series 6	Class II
Apple Watch Series 7	Class II
Apple Watch Series 8	Class II
Apple Watch Series 9	Class II
Apple Watch Series 10	Class II
Apple Watch Series 11	Class II
Apple Watch Series 12	Class II
Apple Watch Series 13	Class II
Apple Watch Series 14	Class II
Apple Watch Series 15	Class II
Apple Watch Series 16	Class II
Apple Watch Series 17	Class II
Apple Watch Series 18	Class II
Apple Watch Series 19	Class II
Apple Watch Series 20	Class II
Apple Watch Series 21	Class II
Apple Watch Series 22	Class II
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Apple Watch Series 95	Class II
Apple Watch Series 96	Class II
Apple Watch Series 97	Class II
Apple Watch Series 98	Class II
Apple Watch Series 99	Class II
Apple Watch Series 100	Class II

Countries Active: >20



Patients Monitored: >12,000



Papers Published

Science ScienceAdvances



Devices Entering the Translational Pipeline

Flow for Hydrocephalus



Pediatric fNIRS



Neuromotor Behavior



Speech, Swallow for
Aphasia, Dysphagia



Neonatal EEG



Surgical Recovery
Neonates, Pediatrics



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Surgical Recovery
Neonates, Pediatrics

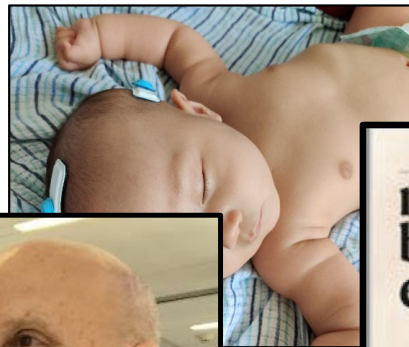


Devices Entering the Translational Pipeline

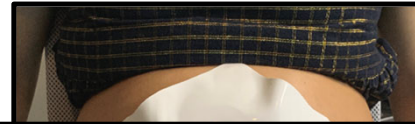
Flow for Hydrocephalus



Pediatric fNIRS

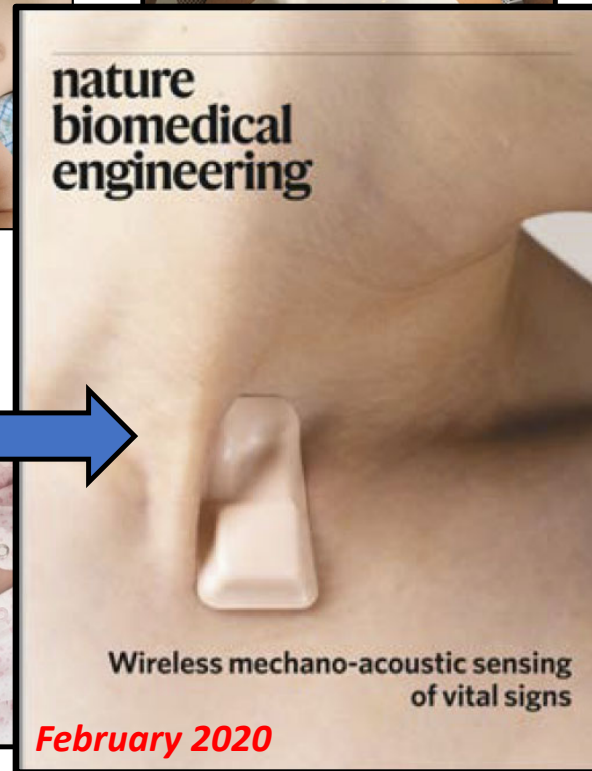


Fetal ECG

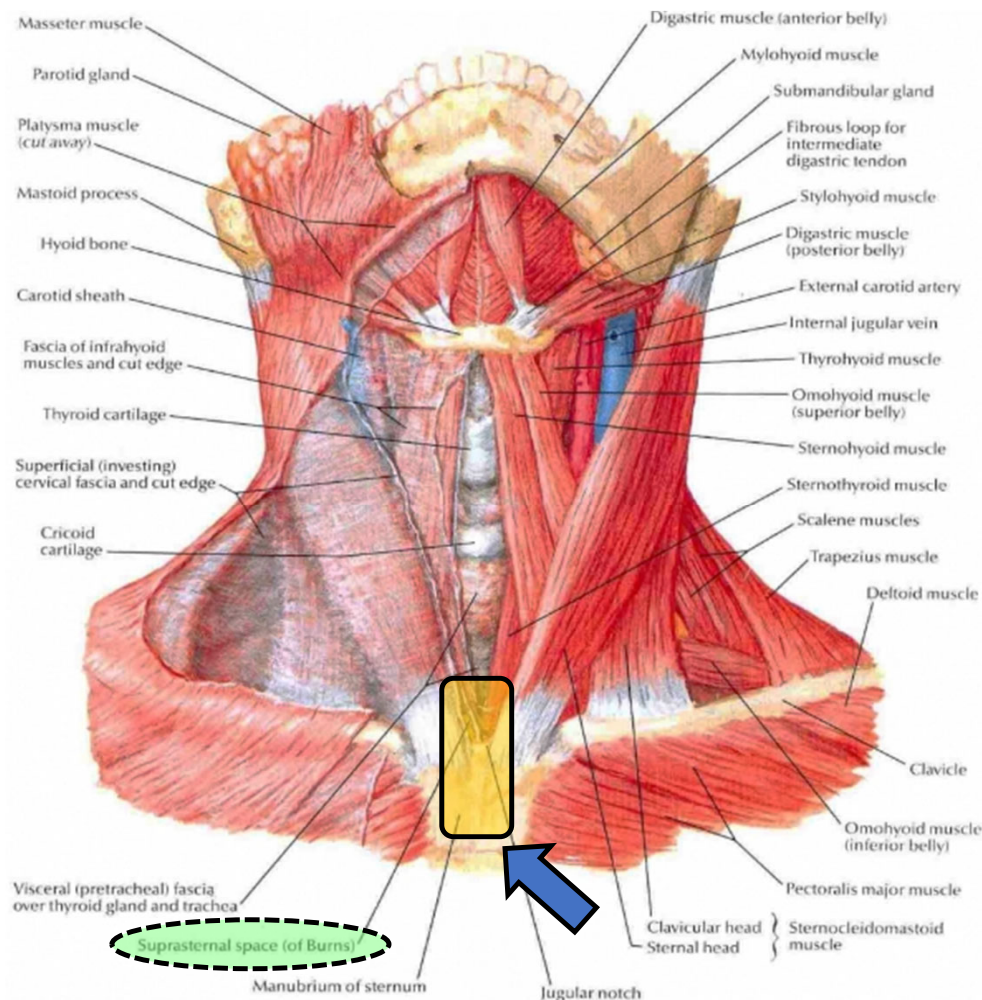


Shirley Ryan
Abilitylab

Fetal ECG



Mechano-Acoustic Sensing from the Suprasternal Notch

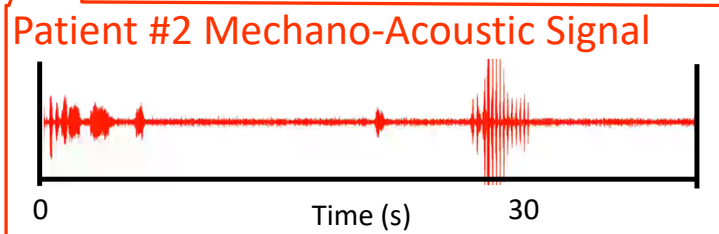
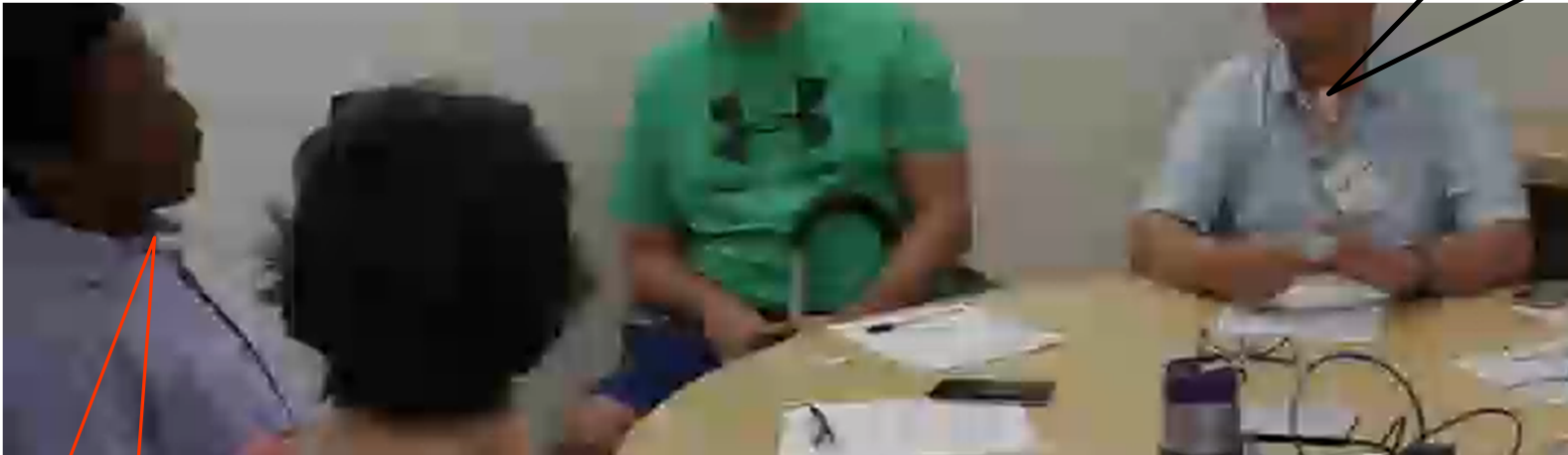
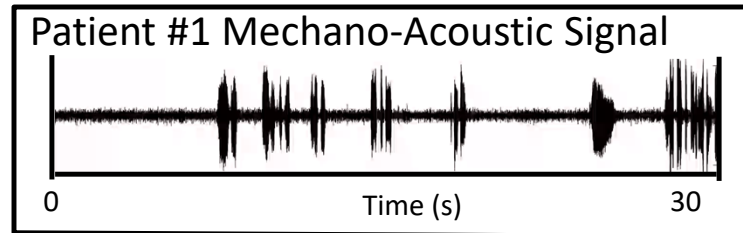


- 1) Speech (time, patterns)
- 2) Swallowing (freq, dyn)
- 3) Heart Rate, Variability
- 4) Respiration Rate
- 5) Respiration Sounds
- 6) Coughing
- 7) Sleep Dynamics
- 8) Motion / Steps
- 9) Orientation

**One Device:
Aphasia, Dysphagia
Sleep Apnea, Activity**

Clinical Studies – Multiple Patients, Simultaneously

w/ L. Cherney



Shirley Ryan
Abilitylab

OSHER COLLABORATIVE

A Loneliness Meter: Mitigating Cognitive Decline

The New York Times

By CEYLAN YEGINSU JAN. 17, 2018

U.K. Appoints a Minister for Loneliness

THE TIMES OF INDIA

Do we need a loneliness minister?

Namita Devidayal, Mohua Das, Avijit Ghosh, Himanshi Dhawan | Feb 25, 2018, 02:00 IST

**The
Economist**

All the lonely people

Loneliness is a serious public-health problem

The World's First Loneliness Meter

Social interaction is one of the few interventions that slows the progression of Alzheimer's dementia.

Parameters of Interest

1. How long did anyone talk to you today?
2. How long did you talk today?
3. What is your physical proximity to others?
4. Are you eating well (swallow count)?
5. How are you sleeping?
6. Are you being physically active?



w/ Angela Roberts PhD (School of Communication) and Lee Ann Lindquist MD (Gerontology)

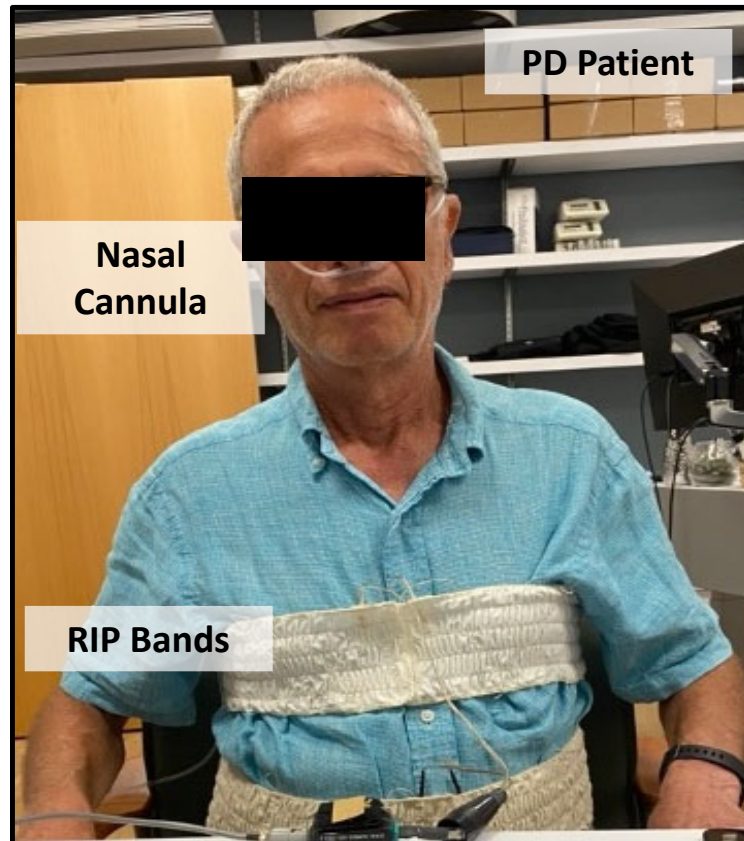
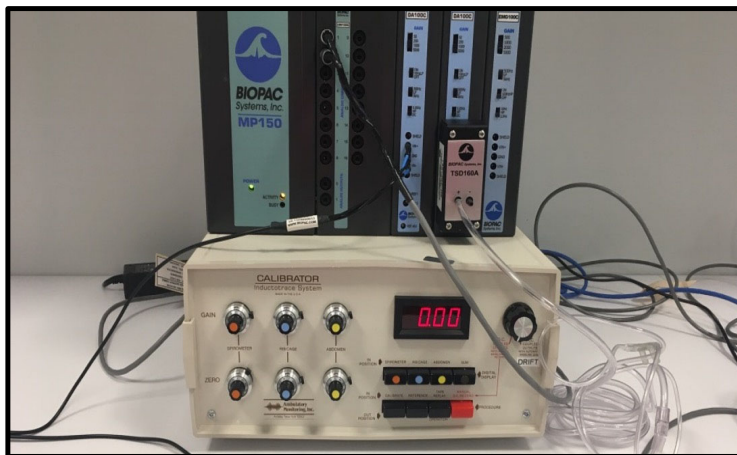
Systems for Measuring Swallowing, Respiration

1) Respiratory Inductance

Plethysmography (RIP) bands

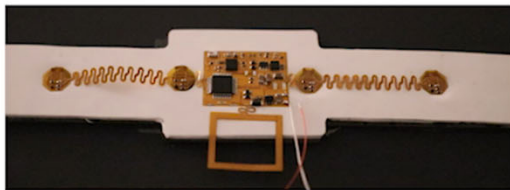
2) Nasal cannulas

3) Data acquisition electronics



Real-Time Measurement and Haptic Feedback on Swallowing and Respiration (w/ B. Martin-Harris)

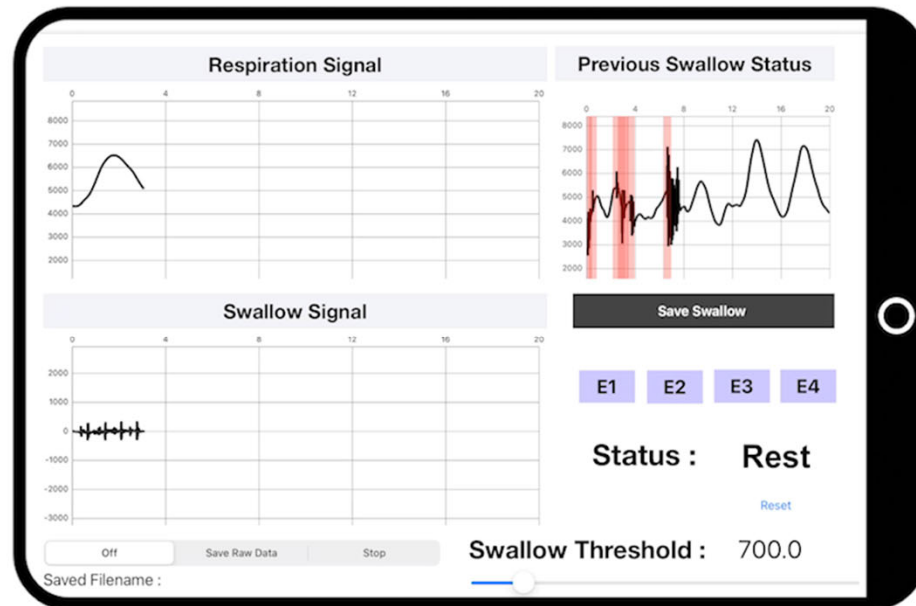
MA Sensor on the SN



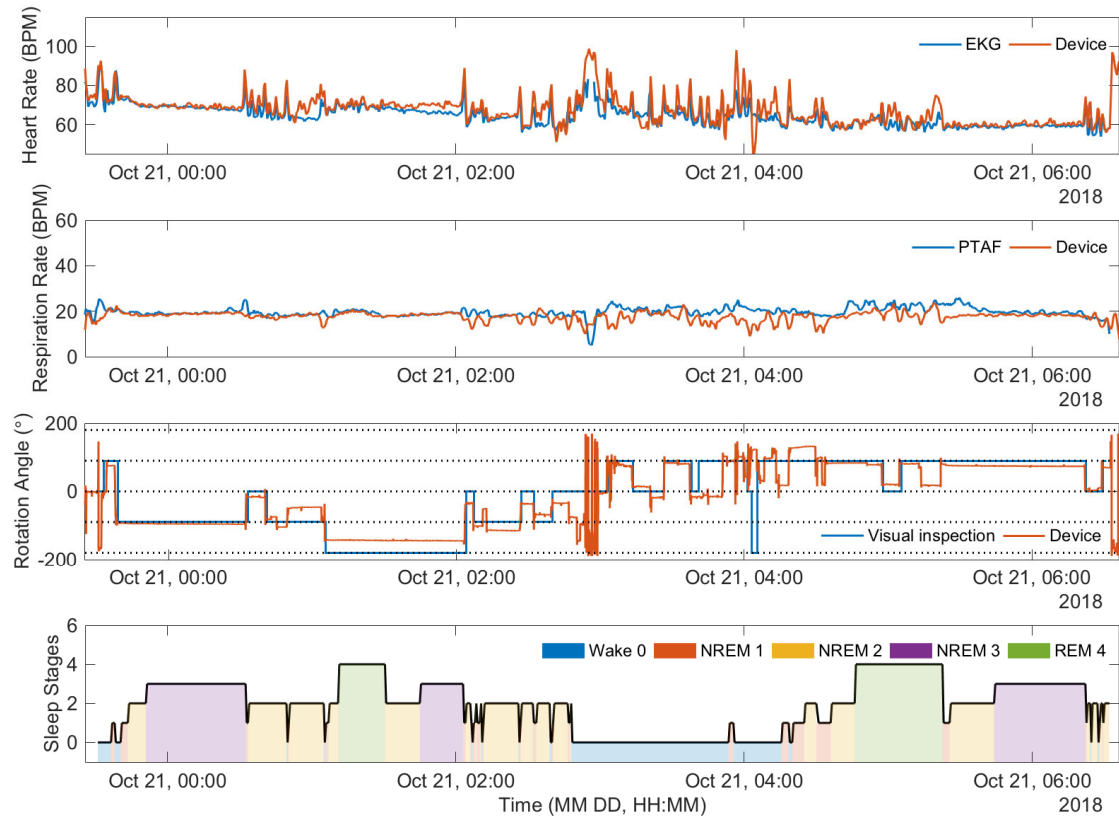
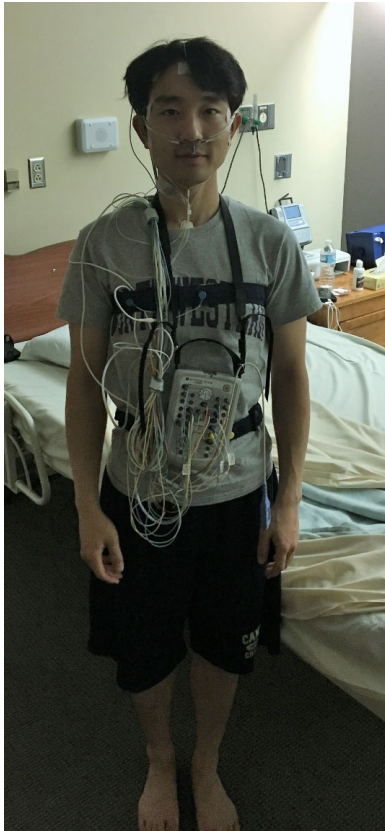
Haptic Interface

npj Digital Medicine 5, 147 (2022).

Real-Time, Graphical User Interface



Sleep Monitoring



Senior Collaborators

Engineering Science

Prof. Y. Huang (NU) – mechanics

Prof. P. Ferreira (UIUC) – manuf.

Prof. A. Jayaraman (SRAL) – analytics

Prof. R. Ghaffari (NU) -- interface

Clinical Medicine and Sports

Prof. A. Paller (NU) – dermatology

Prof. B. Martin-Harris (NU) – dysphagia

Prof. S. Xu (NU) – dermatology

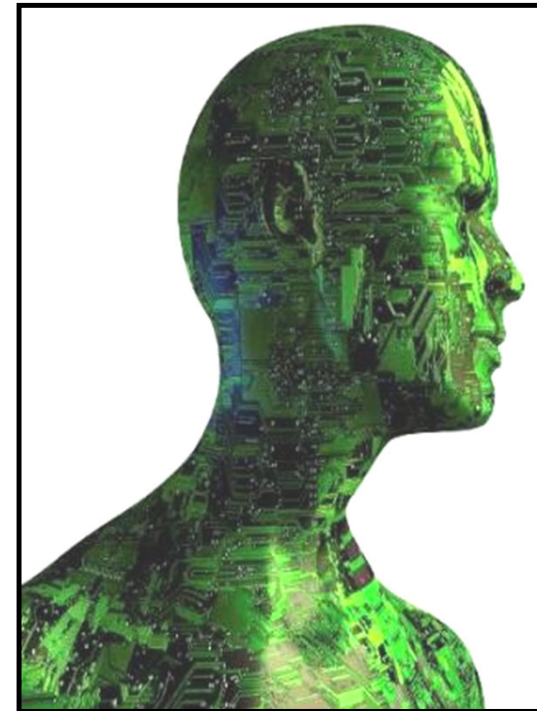
Prof. L. Cherney (SRAL) -- aphasia

Prof D. Weese-Mayer (NU) – neonatal

Prof. S. Slattery (NU) – neonatal pain

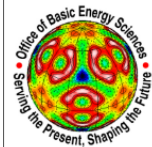
Prof. M. Potts (NU) – hydrocephalus

Prof. A. Bharat (NU) – lung sounds



Research Team

Undergraduates, MS Students, MD Students
PhD Students, Postdocs, Senior PIs





Longevity and Healthy Aging Symposium