

# How do you figure out *what is painful or distressing* to a non-speaking person?



**Many do not show outward signs consistent with internal stress/state.**

Image courtesy of [John Glenn](#) on flickr. License CC BY-NC-SA.



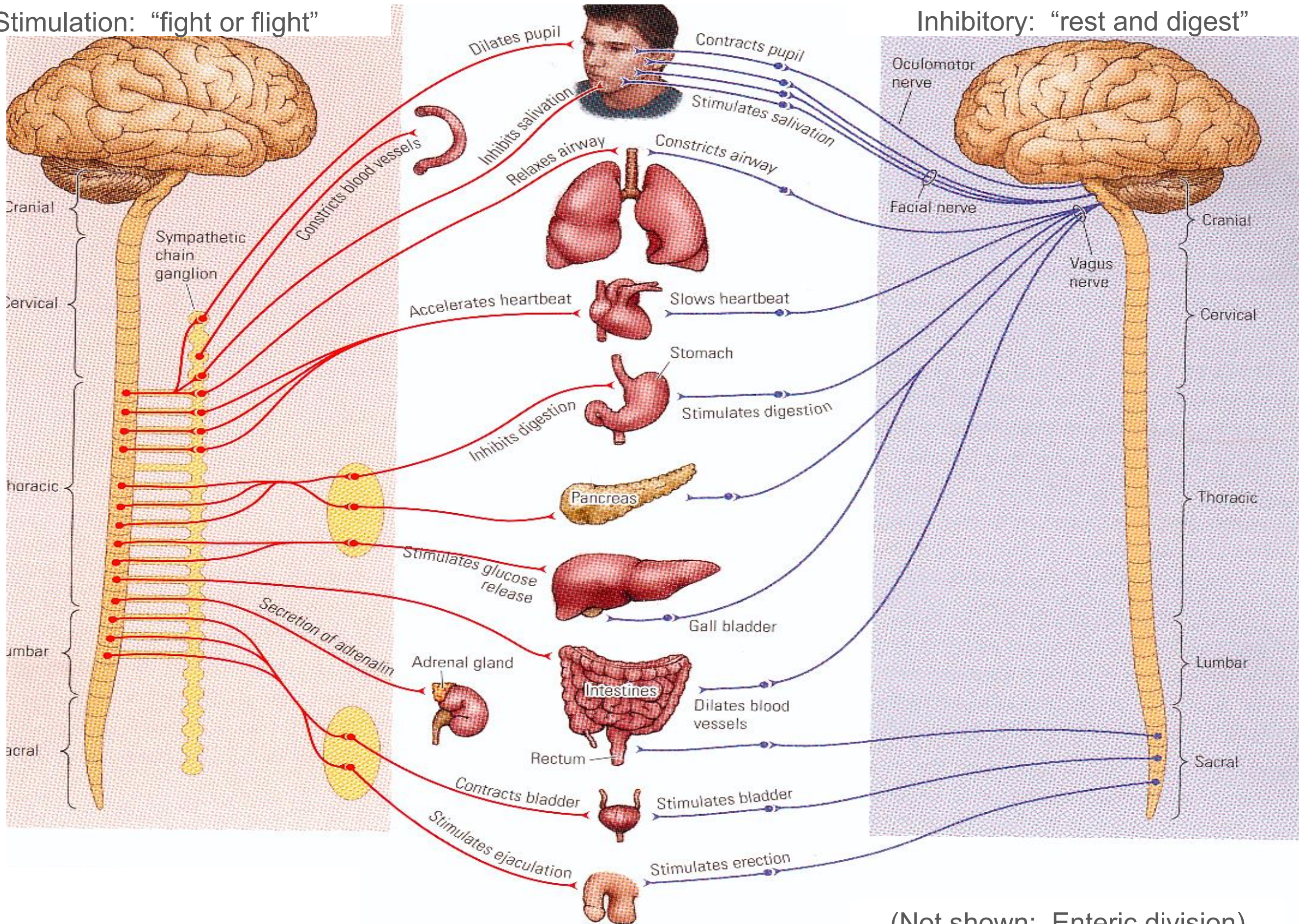
# AUTONOMIC NERVOUS SYSTEM

Sympathetic division

Parasympathetic division

Stimulation: "fight or flight"

Inhibitory: "rest and digest"



(Not shown: Enteric division)



# Electrodermal Activity (EDA) Sensors



Traditional



MIT Media Lab  
Innovations

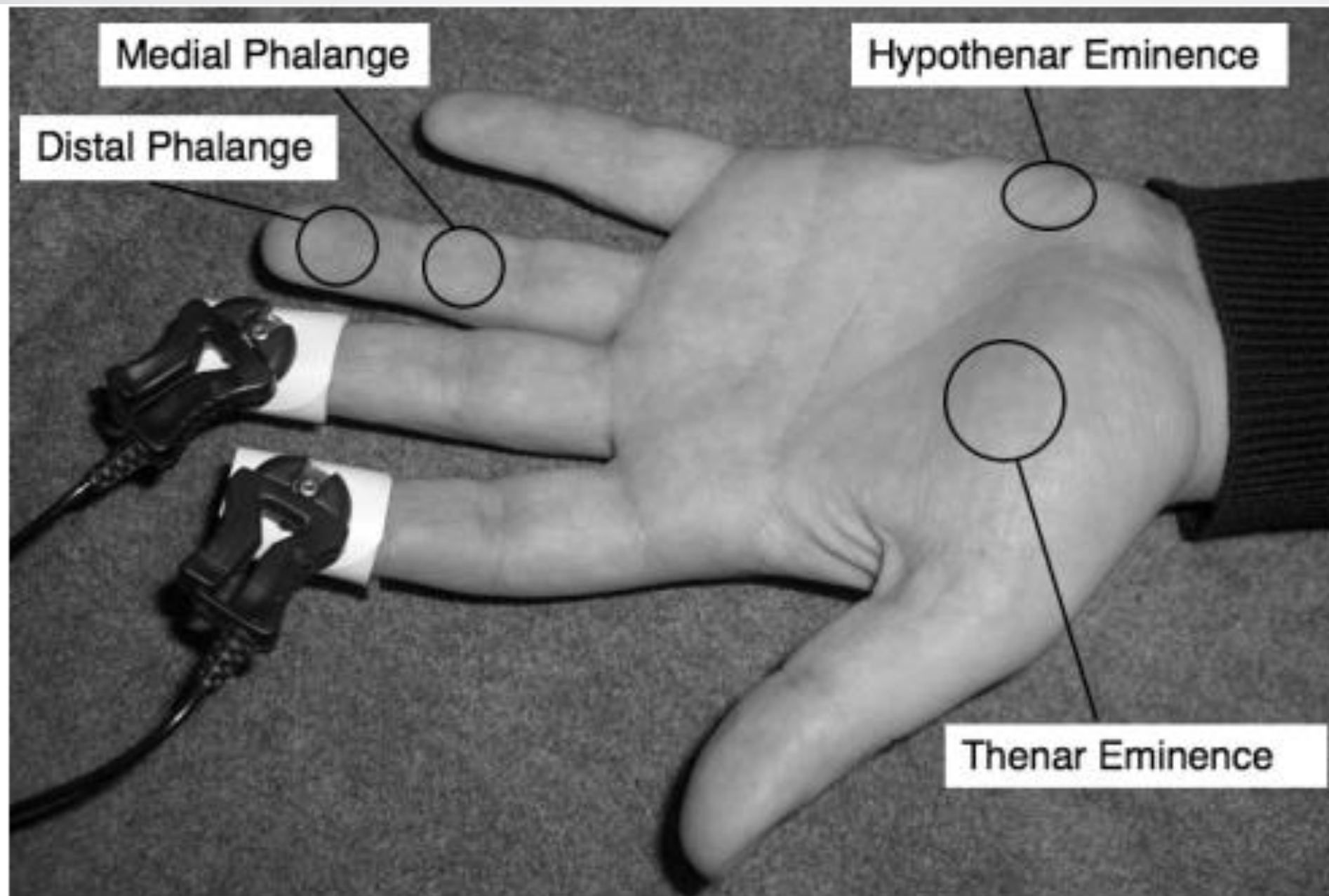


Affectiva Q™

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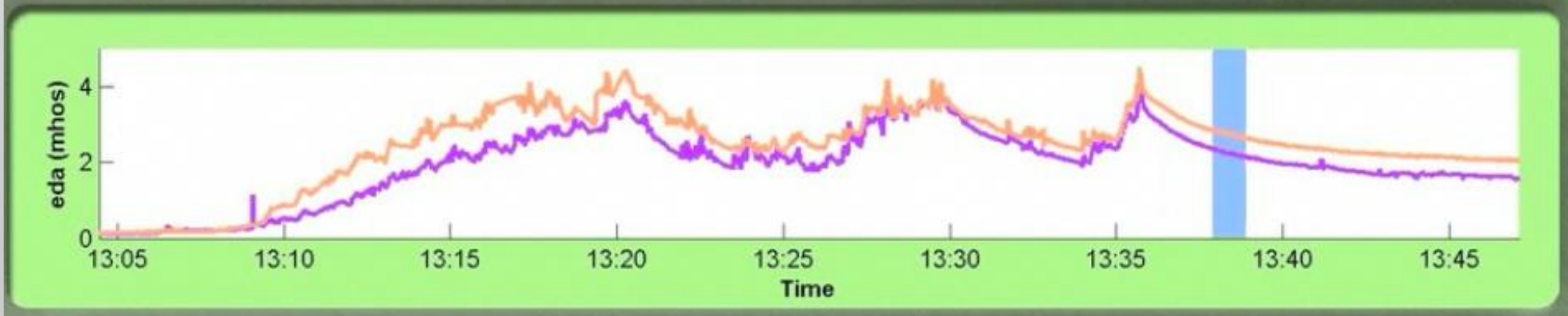
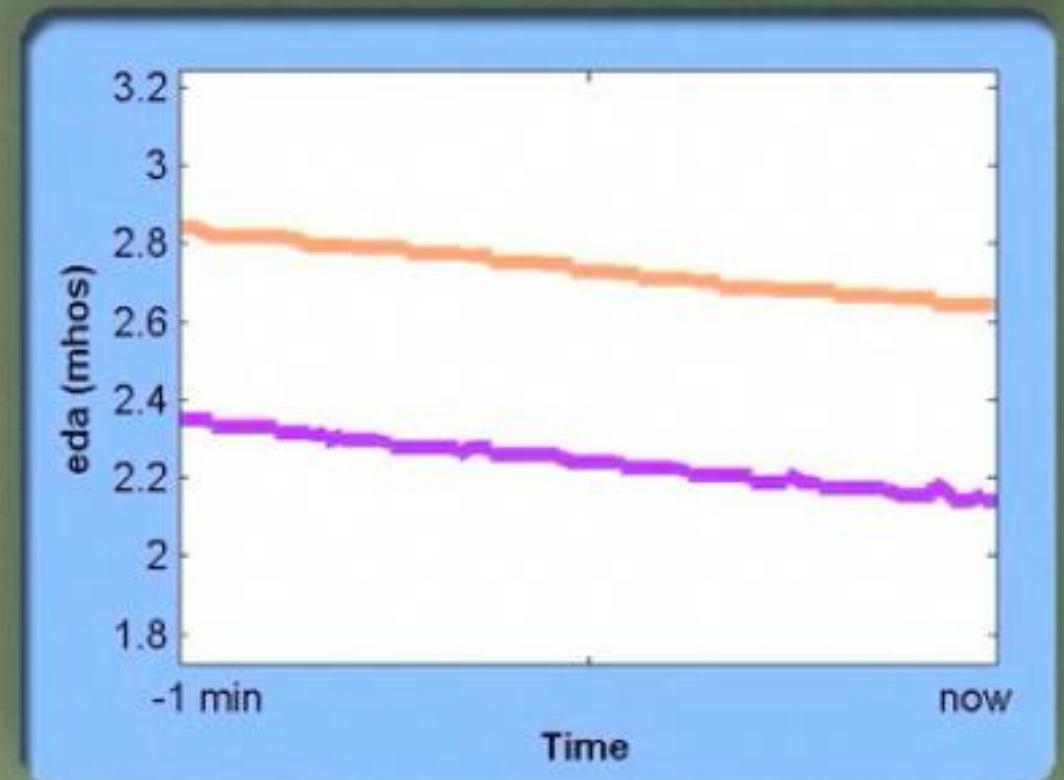
# Typical placement skin conductance electrodes (figure 4 from Figner-Murphy)



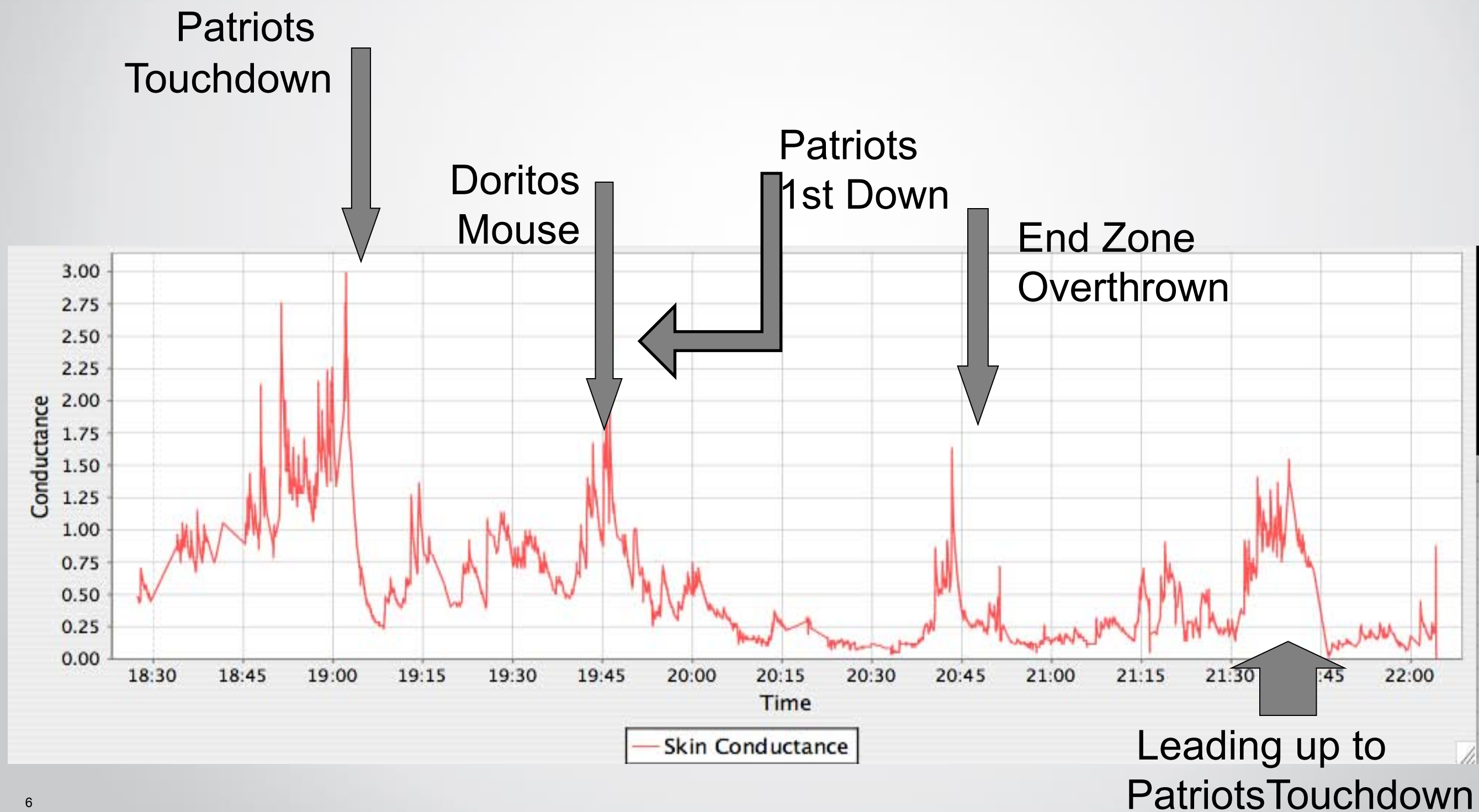
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# Example: Measuring sympathetic nervous system response via electrodermal activity (EDA) on lower legs



# Arousal predicts memory and attention





# What makes EDA go up? | Demo

**EDA = Electrodermal Activity**

**(measured as skin conductance)**



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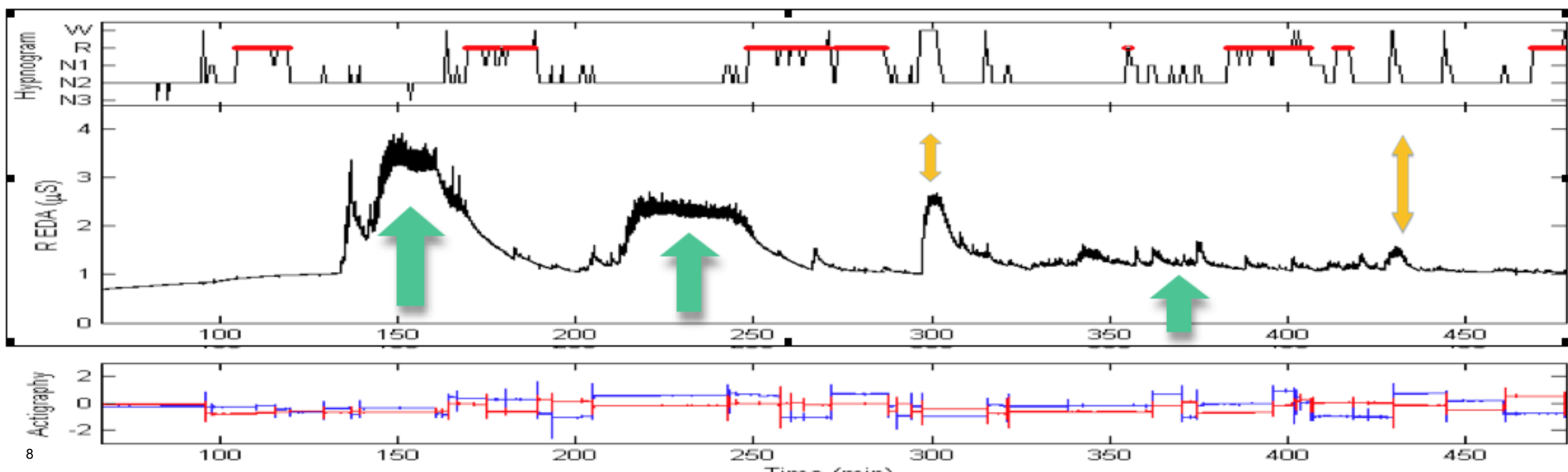
**Affectiva Q Sensor measures:**

- 1. Skin conductance**
- 2. Skin temperature**
- 3. 3-axis accelerometer**

## State of the art:

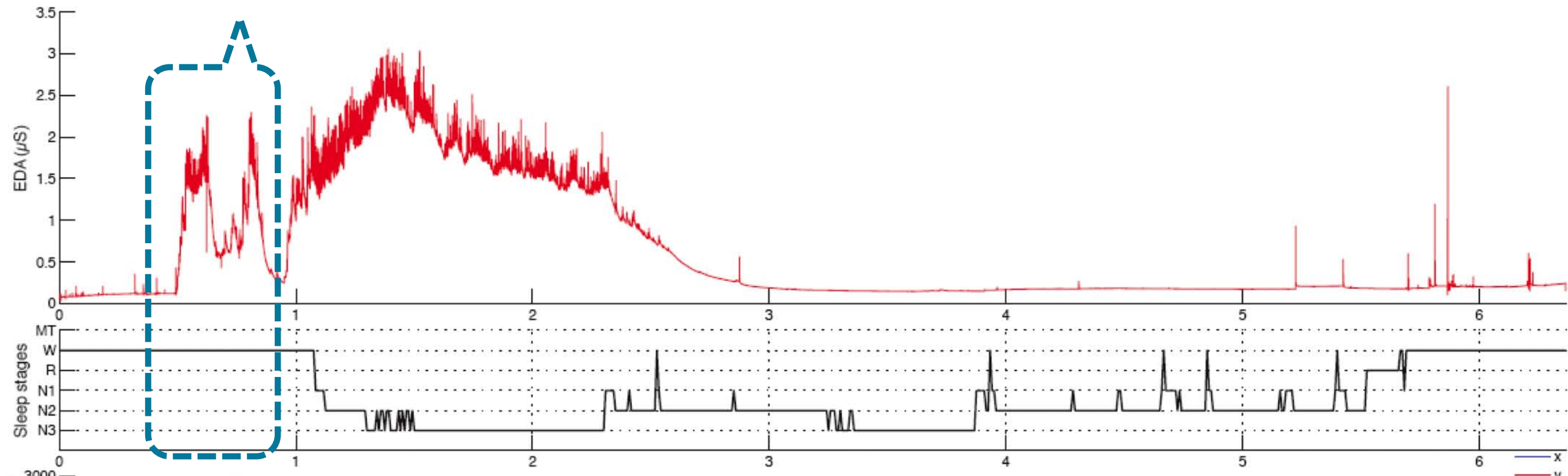
- Built sensor & algorithms
- Detects “peak storms” (92% in Non-REM)
- Measuring connections to learning & memory & stress

(Sano & Picard; MIT, EMBC 2011, collaborations with Bob Stickgold, Harvard & Beth Israel hospital, Chuck Czeisler, Harvard & Brigham & Women’s hospital)



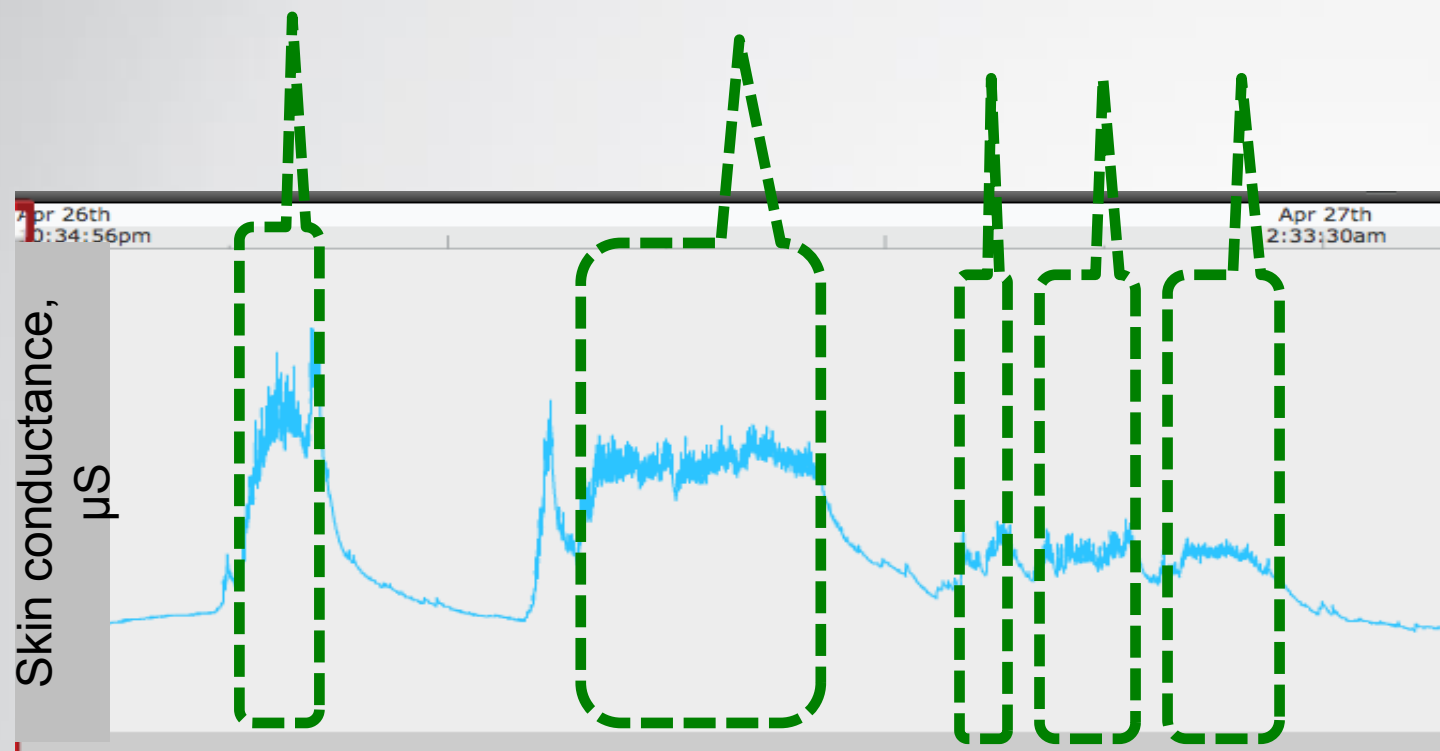


arousals picked up  
by wristband while  
trying to fall asleep



EDA arousals relate to quality of sleep in Autism Spectrum Disorders  
Sano, Picard, el Kaliouby, Malow, Goldman, IMFAR 2011.

# EDA “Storms” during sleep



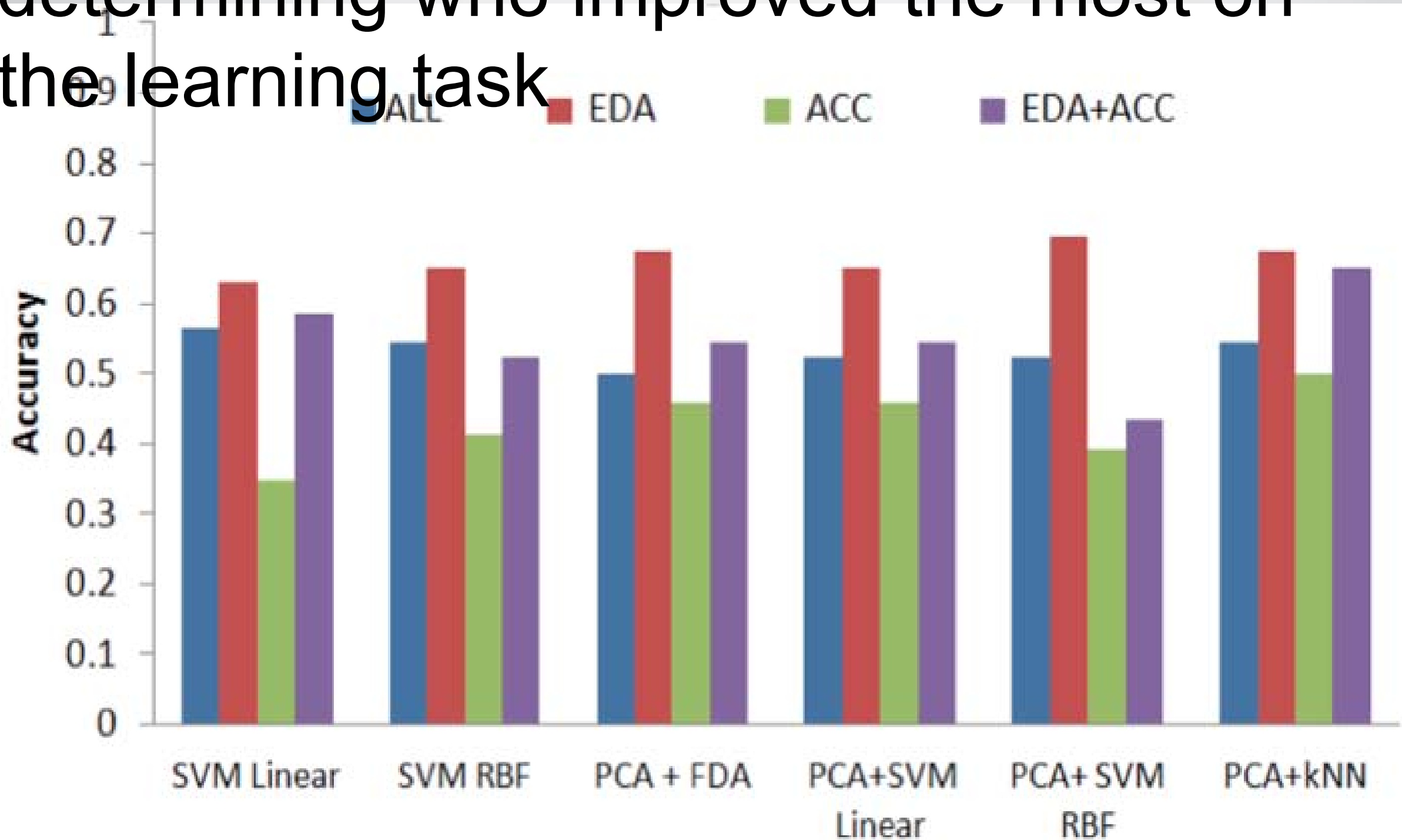
Investigating relation to sleep quality and to improvement on a visual discrimination task

*Sano, Picard, Wang, Stickgold, APSS 2011.*



# EDA gives the highest accuracy

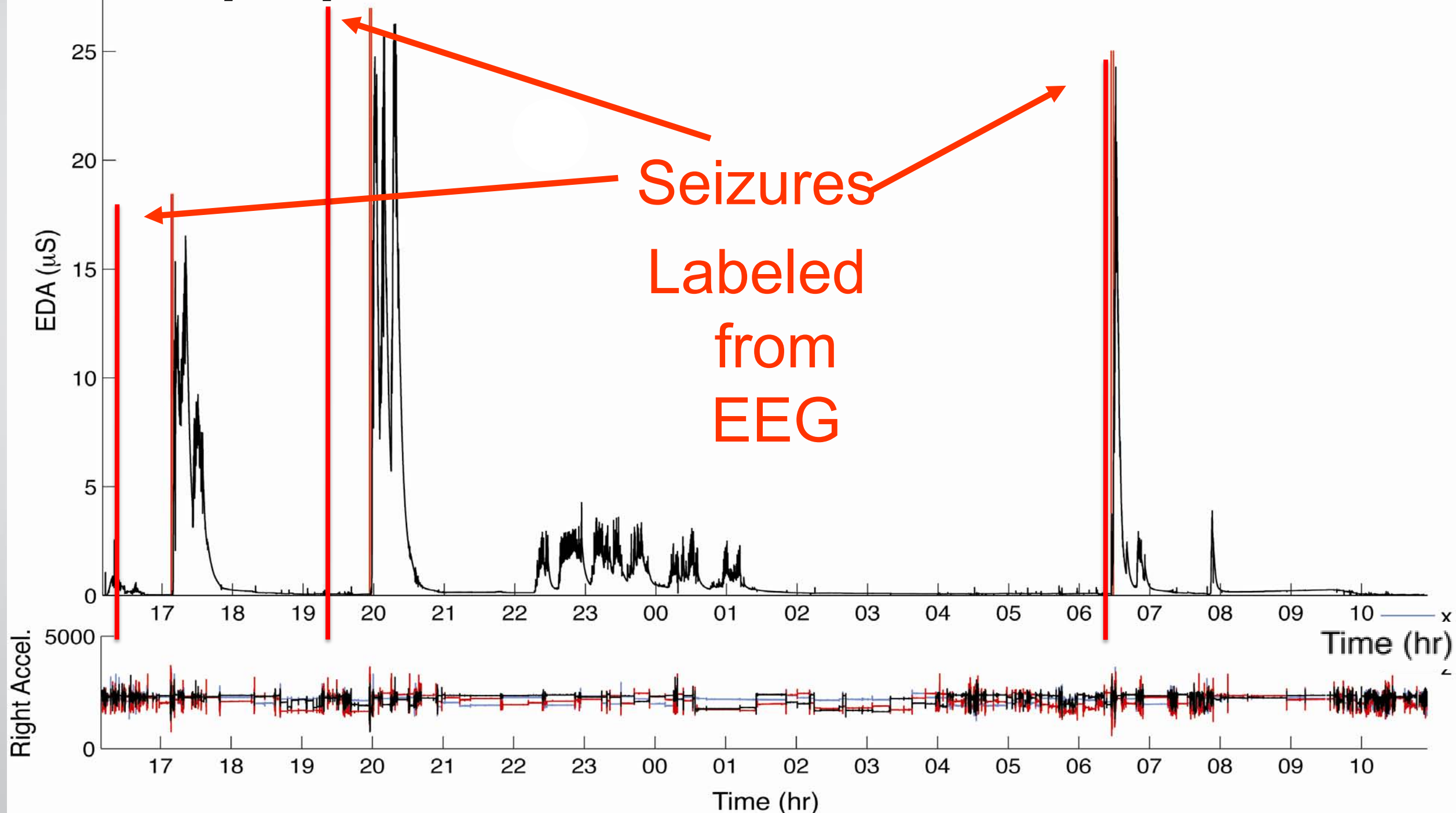
## determining who improved the most on the learning task



Sano A., Picard R.W., "Recognition of Sleep Dependent Memory Consolidation with Multi-modal Sensor Data", The 10th Annual Body Sensor Networks Conference 2013, Cambridge, USA, May 2013

94% accurate convulsive seizure detection using a wrist-worn electrodermal activity and accelerometry biosensor. Poh et al (2012),

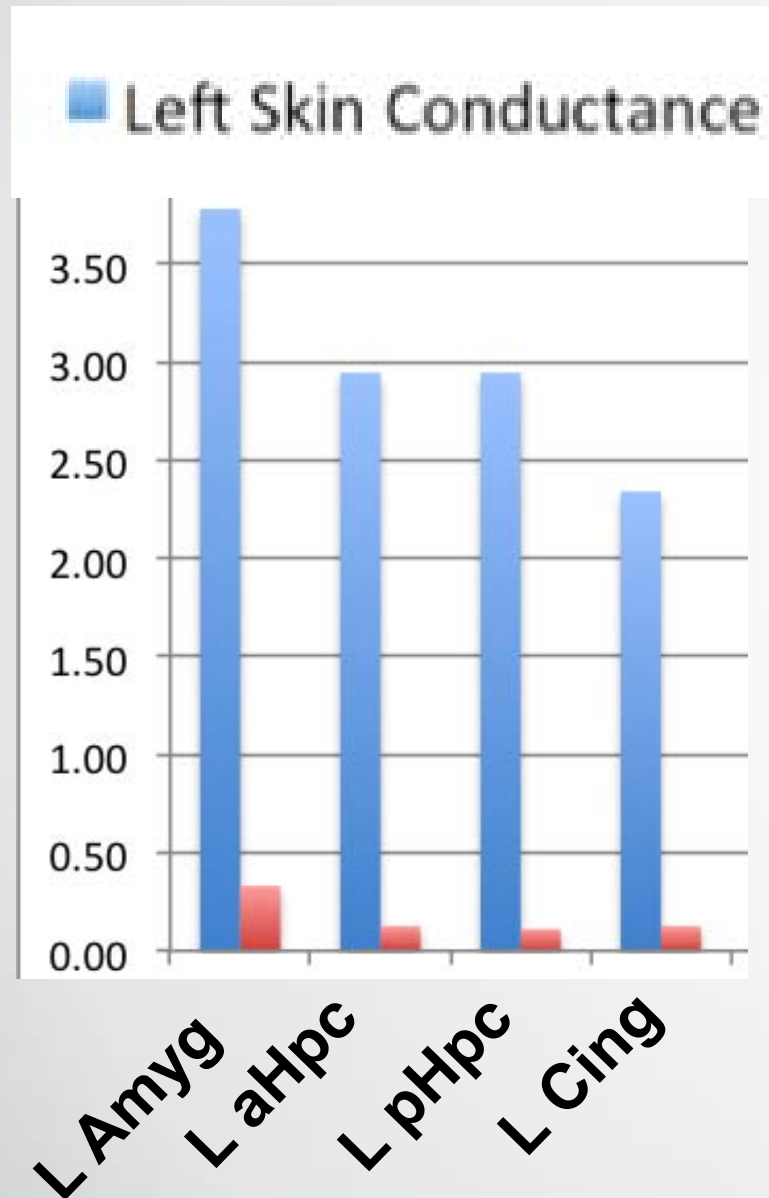
## *Epilepsia.*



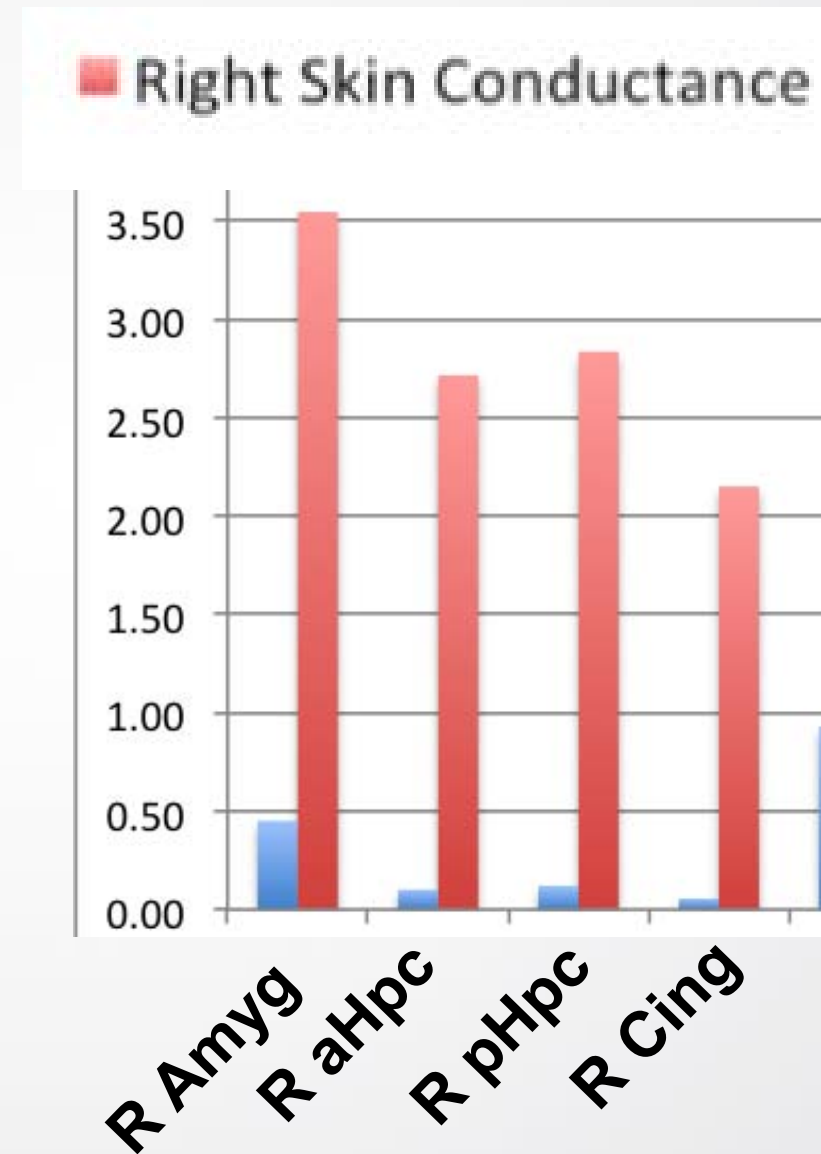


Canadian Epilepsy Alliance video:  
**Playground Convulsive Seizure**

## Stimulation on brain's left side



## Stimulation on brain's right side



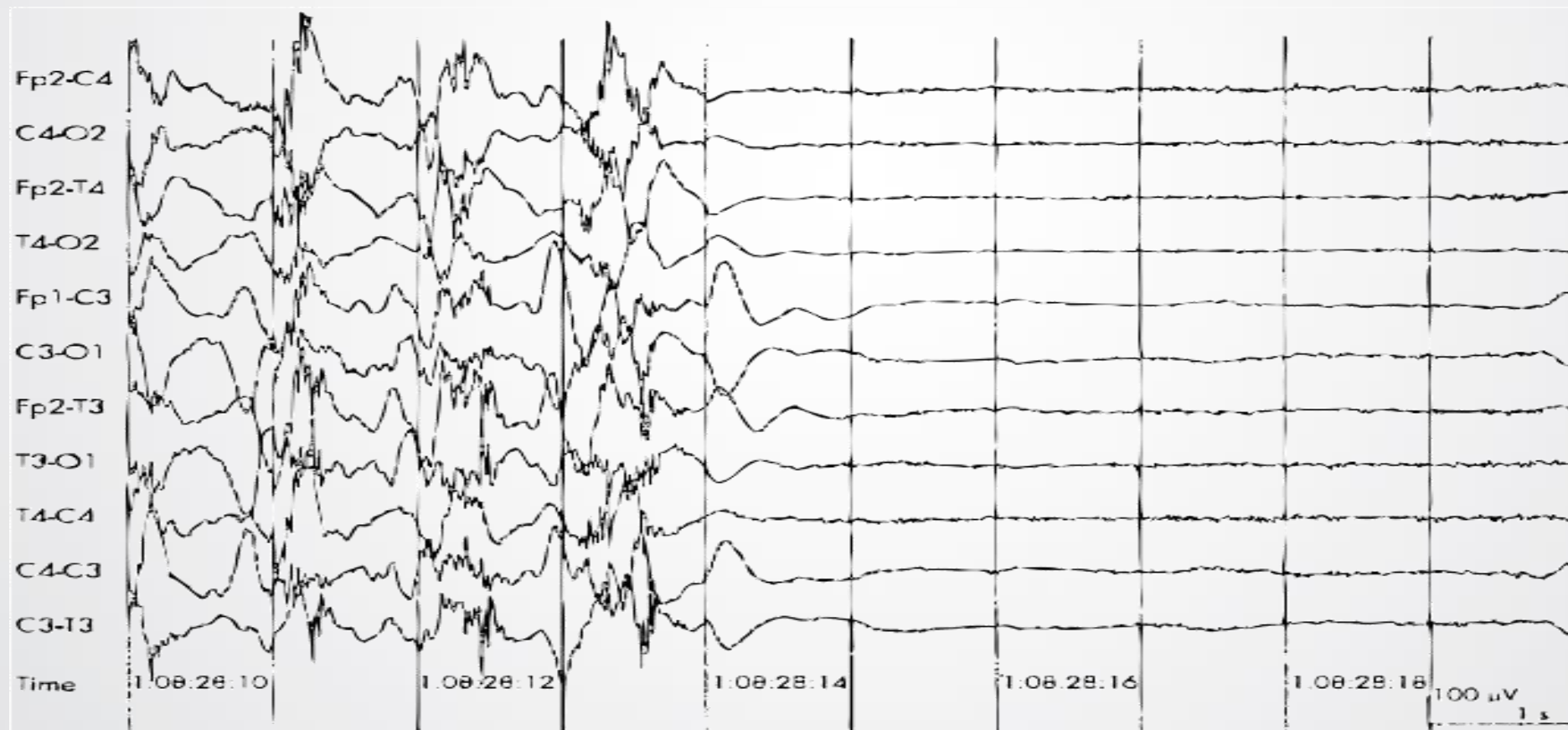
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*Mangina & Beuzeron-Mangina 1996, Int. J. Psychophysiology 22(1996)1-8.*



# Sudden Unexplained Death in Epilepsy (SUDEP)

**Post-ictal EEG Suppression:**  
Possible biomarker for SUDEP risk

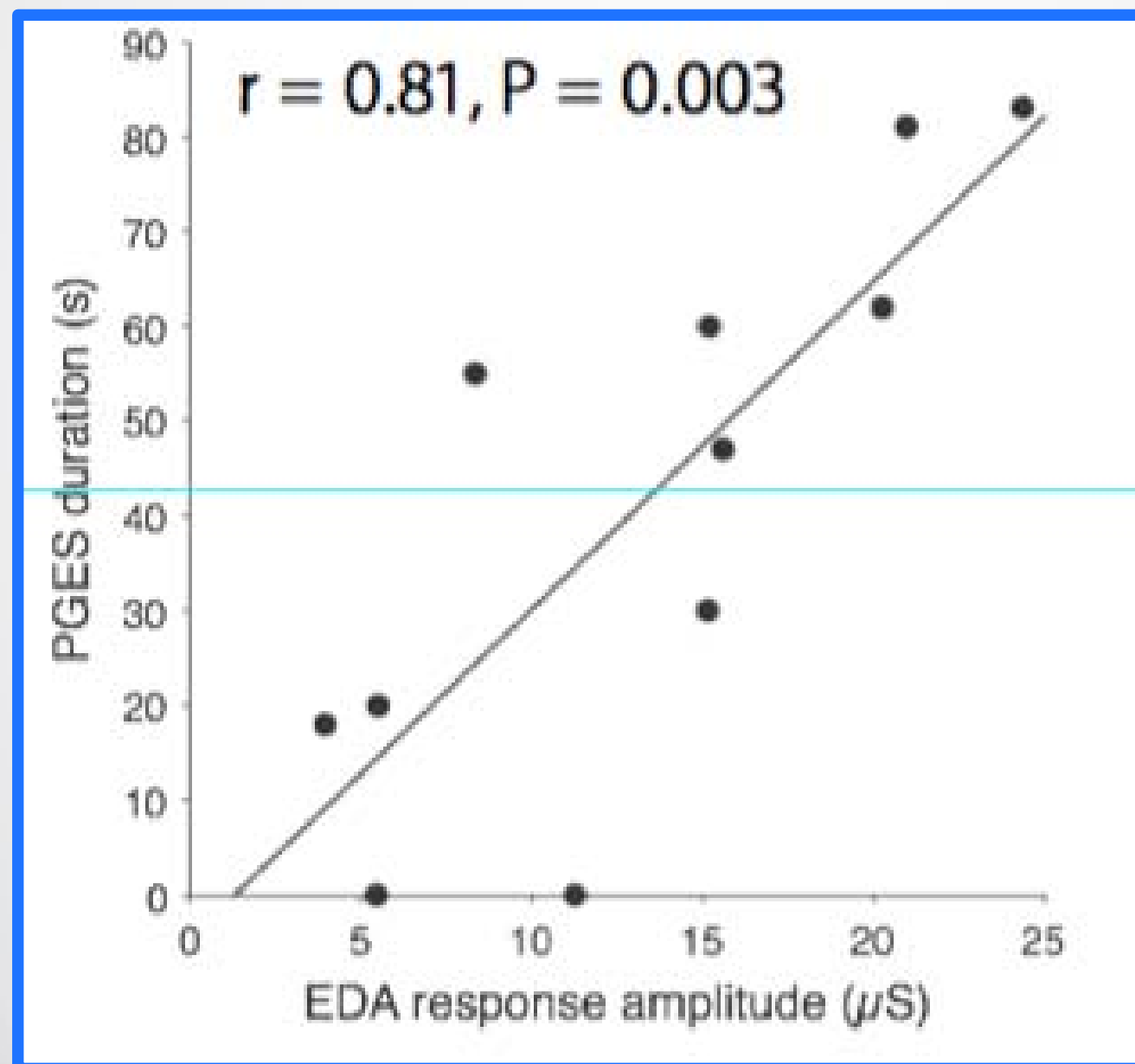


from McLean, B.N. *et al.*, *J Neurol Neurosurg Psychiatr* **78** (2007)

Lhatoo, S.D. *et al.*, *Ann Neurol* **68** (2010)

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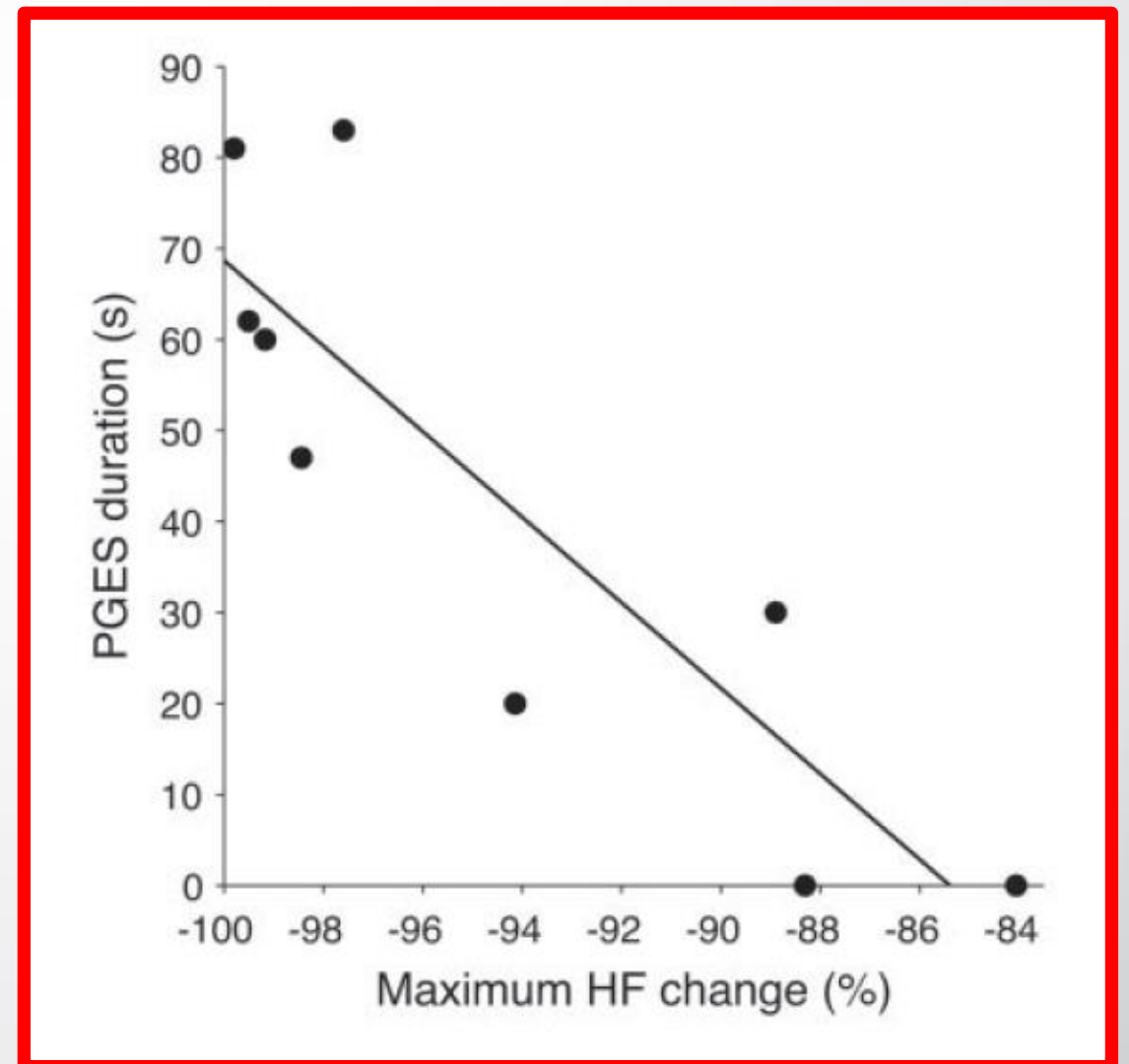
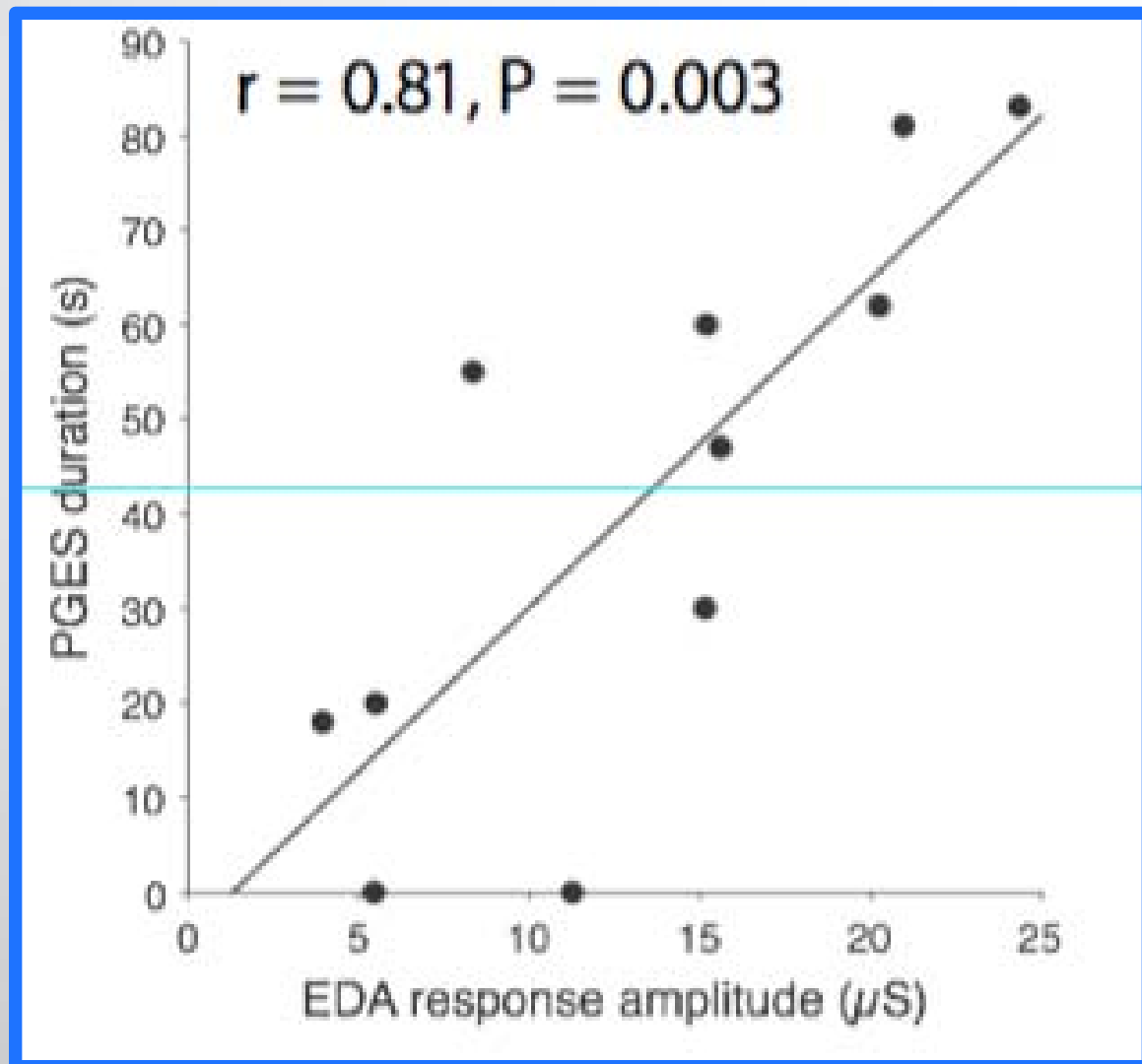
# Autonomic response (from wrist) is correlated with duration of EEG suppression (SUDEP biomarker)



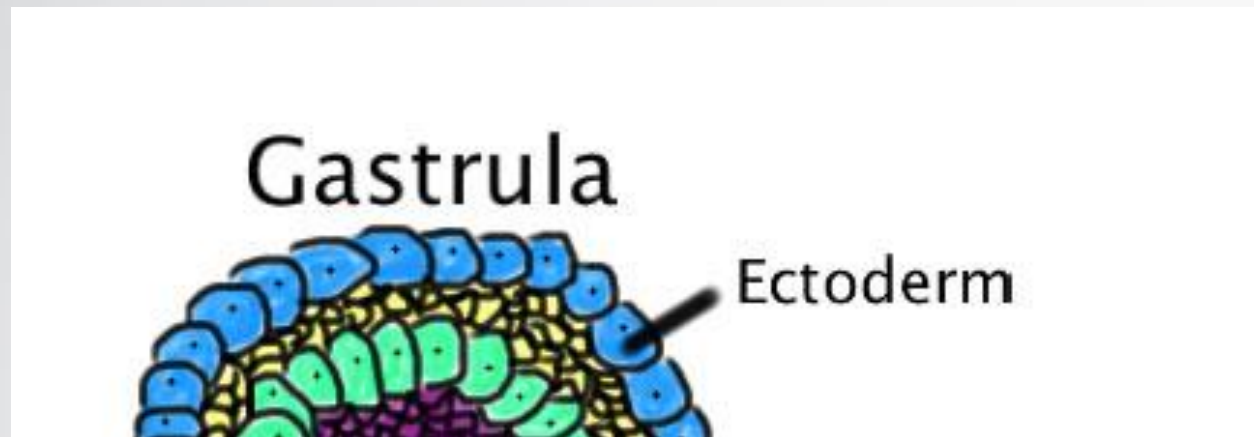


**Larger Sympathetic (EDA) occurs with longer post-ictal EEG suppression (PGES)**

**Lower Parasympathetic (Heart Rate Variability High Frequency) occurs with longer PGES**



# Human Embryo: Three tissue layers



This [image](#) is in the public domain.

<b>Ectoderm</b>	<b>Skin and neural tissue</b>
Endoderm	Digestive and respiratory track
Mesoderm	Muscle and bone



# Why look at both left and right EDA, separately?

**Right** amygdala is associated with **threat/negative** stimuli

Left amygdala is associated with a mix of positive and negative arousal.

*Ji G, Neugebauer V. (2009) "Hemispheric lateralization of pain processing by amygdala neurons" J Neurophysiol. 2009 Oct;102(4):2253-64. Epub 2009 Jul 22*

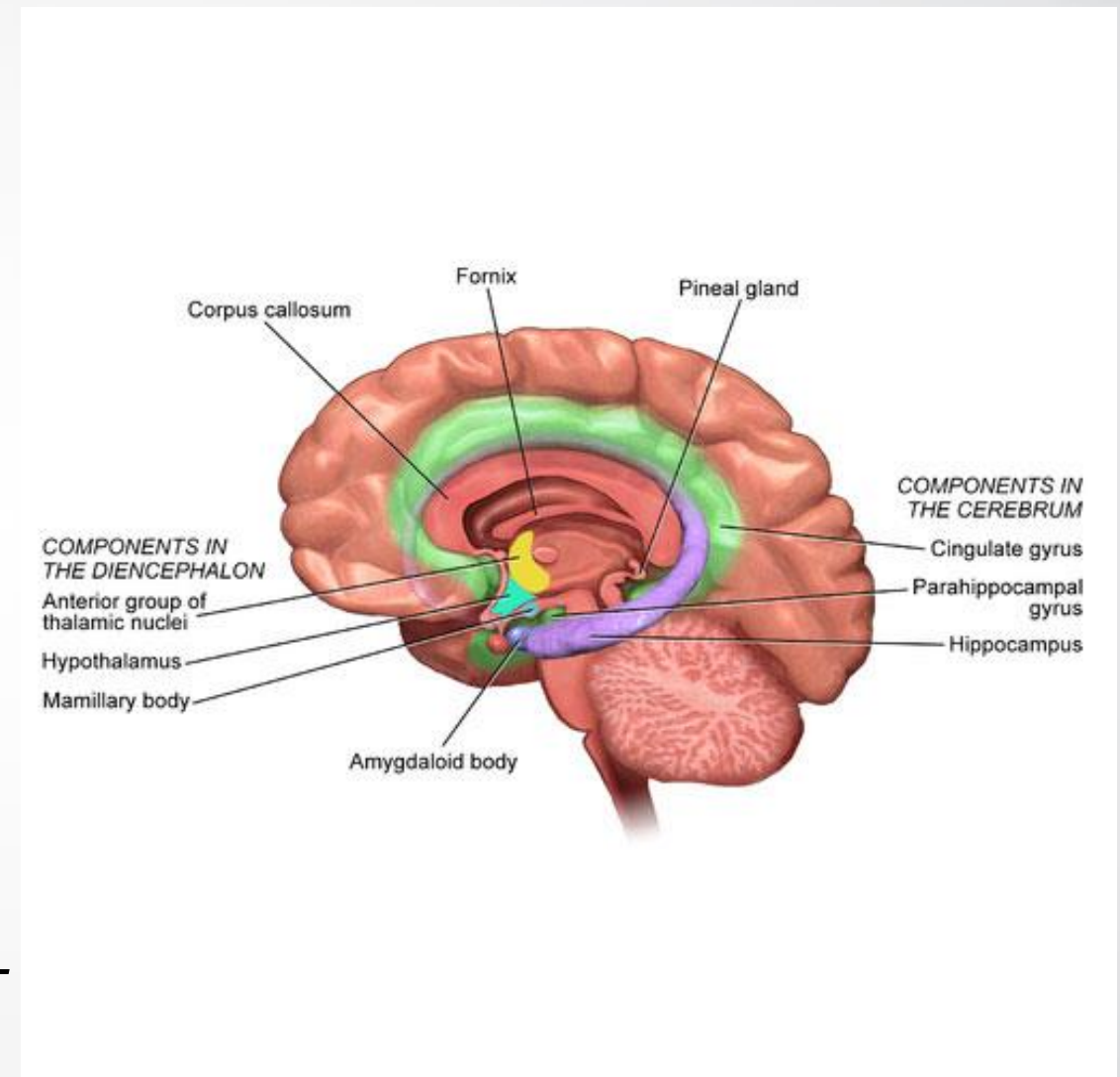


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## Why look at left and right EDA?

Left amygdala activates EDA on Left wrist



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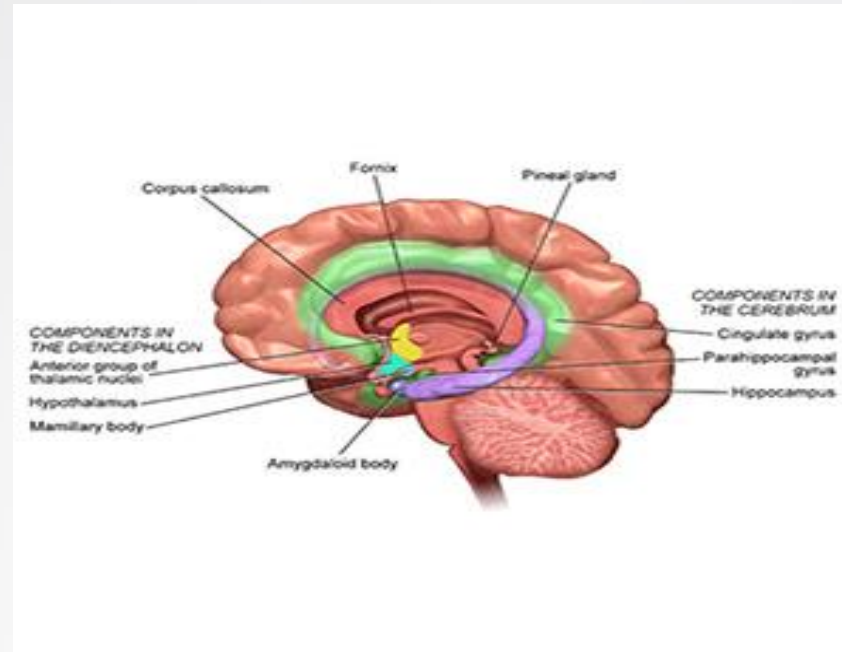


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Right amygdala activates EDA on Right wrist

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**Skin conductance (sympathetic nervous response) is ipsilateral to these limbic brain structures**

Amygdala  
 Posterior hippocampus  
 Anterior hippocampus  
 Anterior cingulate gyri

*Mangina & Beuzeron-Mangina 1996, Int. J. Psychophysiology 22(1996)1-8.*



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