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# Interoceptive technologies. New technological solutions for stress management and human neuroenhancement.

Daniele Di Lernia<sup>1,2</sup>, Silvia Serino<sup>1</sup>, Giuseppe Riva<sup>1,2</sup>

<sup>1</sup>Humane Technology Lab, Università Cattolica del Sacro Cuore di Milano

<sup>2</sup>ATNpLab, Istituto Auxologico Italiano



## Interoception:

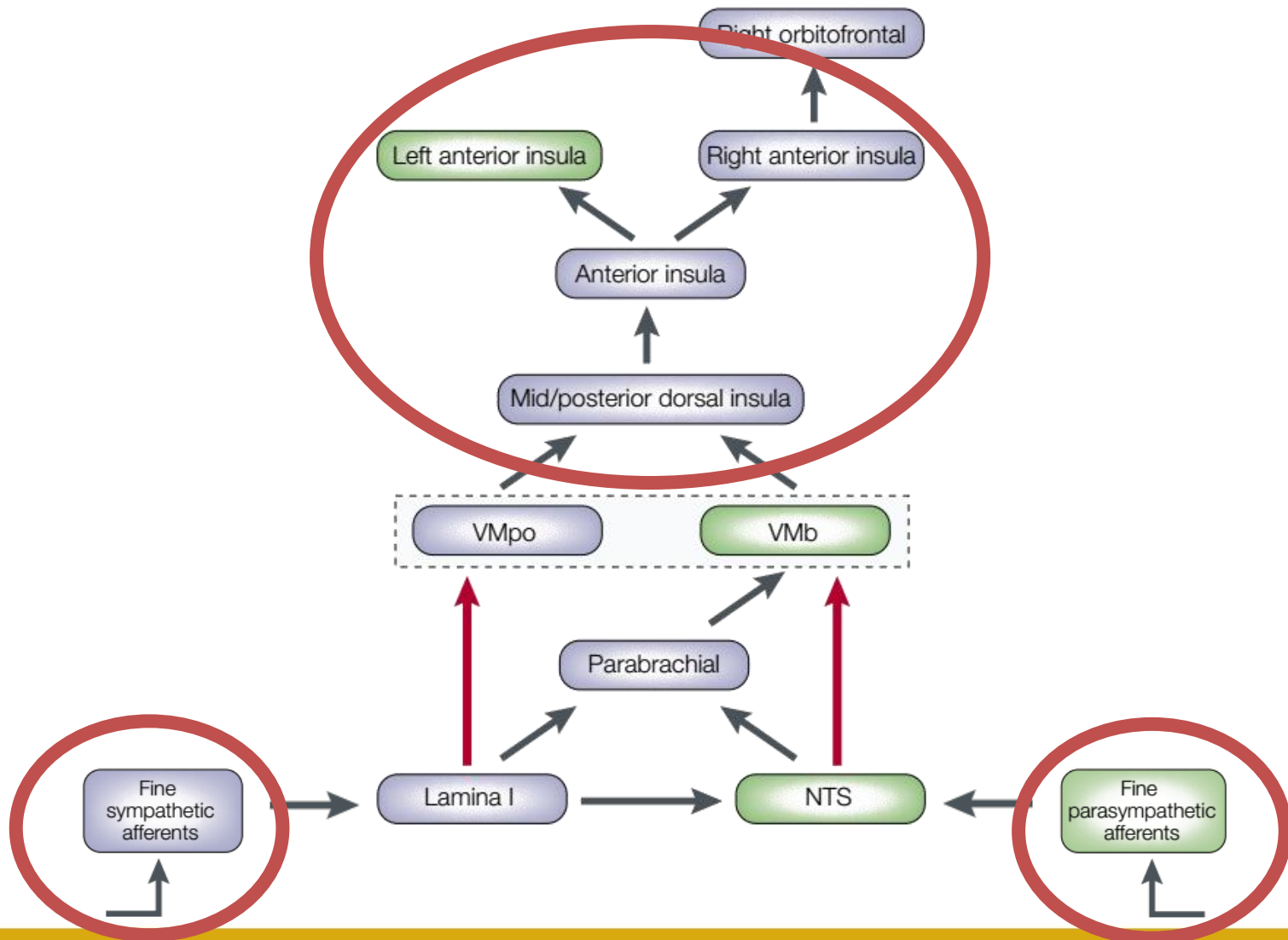
sense of the physiological condition of the **entire organism** (Craig, 2003)

Insular cortex integrates **input from all the tissues** through specific afferent primary fibres (A $\delta$  and C). And it is selectively activated by:

- temperature,
- pain,
- cardiorespiratory function,
- hunger,
- thirst,
- local metabolism information,
- immune and hormonal activity,
- mechanical stress
- emotions and feelings (anxiety, stress, depression, anger, fear, etc)



# Organizational chart for interoception





## Clinical conditions connected to **altered interoception**

- Chronic and Acute Pain (Di Lernia et al., 2016, 2020)
- Anxiety and Stress (Dunn et al., 2010; Pollatos et al., 2009)
- Depression (Stephan et al., 2016; Wiebking et al., 2015)
- Addictions (Naqvi and Bechara, 2009; Verdejo-Garcia et al., 2012)
- Post-Traumatic Stress Disorder (Hughes and Shin, 2011)
- Insomnia (Chen et al., 2014)
- And others (Chatterjee and Mitra, 2015)



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# Manipulate the interoceptive system

The development of a scientifically-grounded technology, capable of accessing and manipulating the interoceptive system would be a breakthrough with unprecedented potential to **enhance human health, performances and wellbeing.**

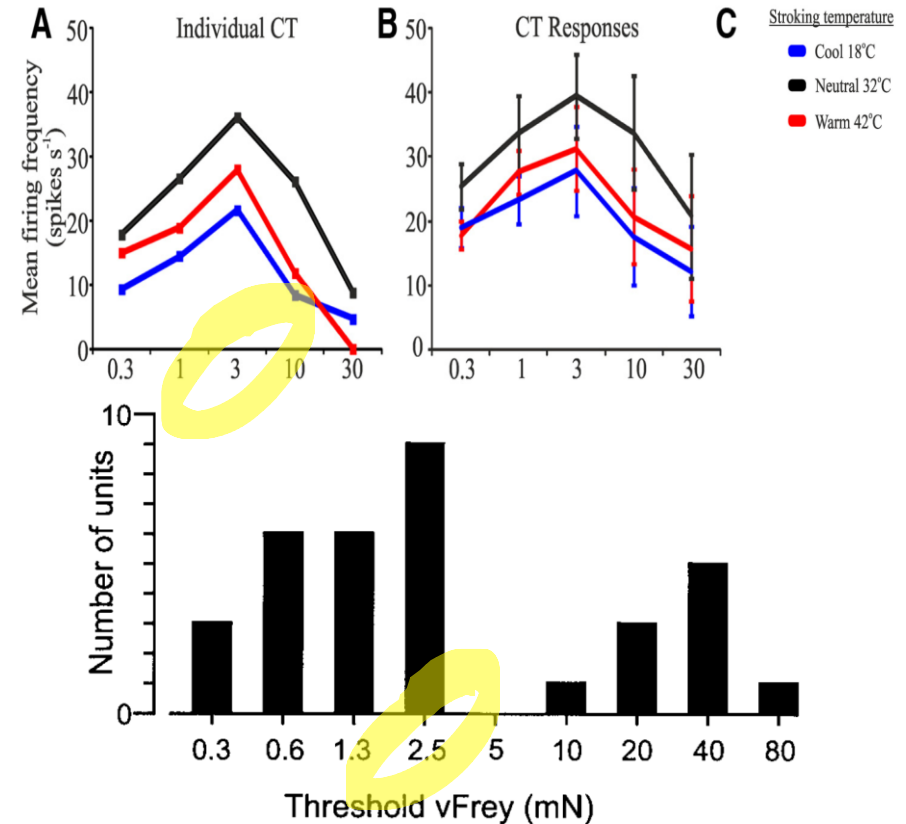
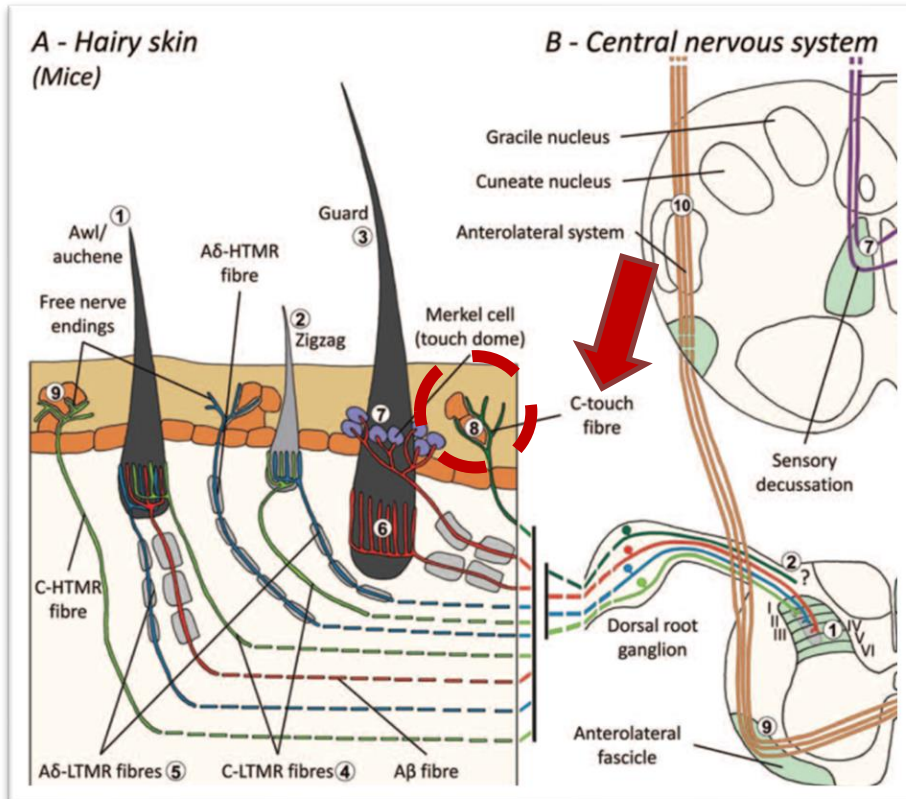


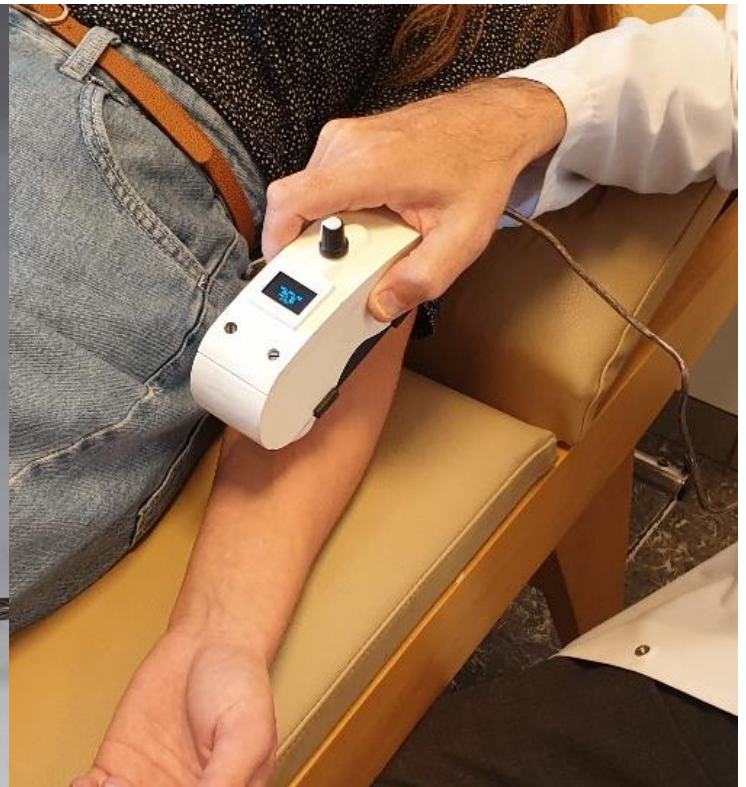
FIG. 2. Distribution of thresholds to von Frey bristle stimuli of 34 mechanosensitive C afferents. Bimodal distribution suggests that the sample consists of 2 different unit types, i.e., low-threshold or tactile units and high-threshold units (see text).



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# Interoceptive Stimulation : Our technology

## Our Lab: iStim - Interoceptive Portable Stimulator



Di Lernia, D., et al., Sensors (Basel), 2018. 18(8).

Di Lernia, D., et. al. Cham: Springer International Publishing, 2018.



## Artificially enhancing the parasympathetic HRV component

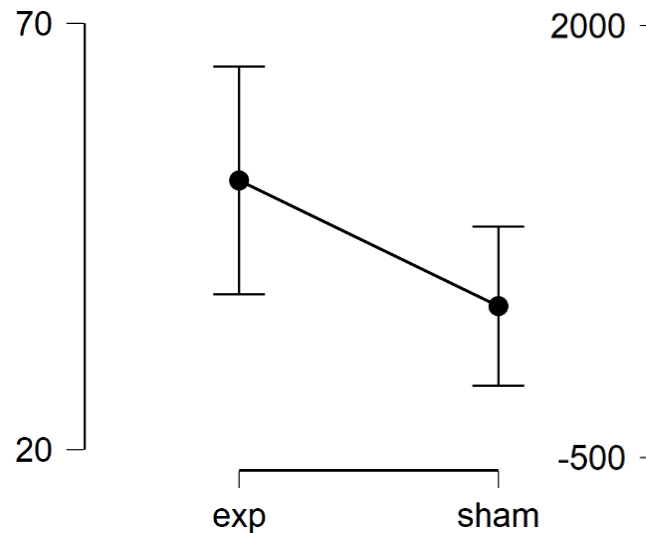
13 healthy participants [8 females; mean age = 38.09 years, SD = 18.53; BMI mean = 22.57, SD = 1.91].

Single-blind between-subjects. 11 minutes of:

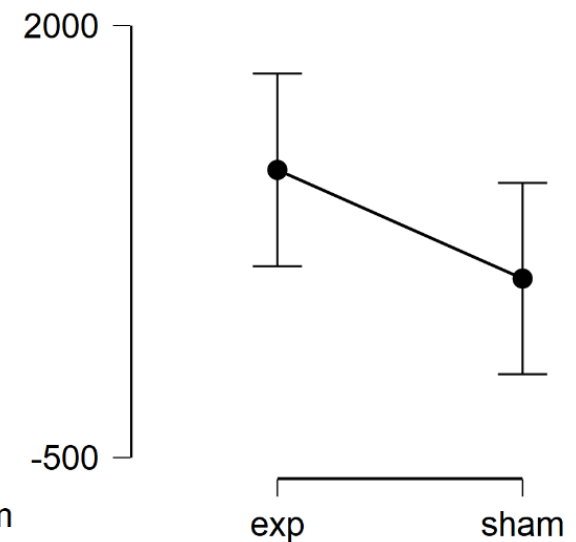
- C-T Interoceptive (EXP)
- Proprioceptive (SHAM)

DV: ECG recordings.

**RMSSD component (ms)**



**HF component (mV)**



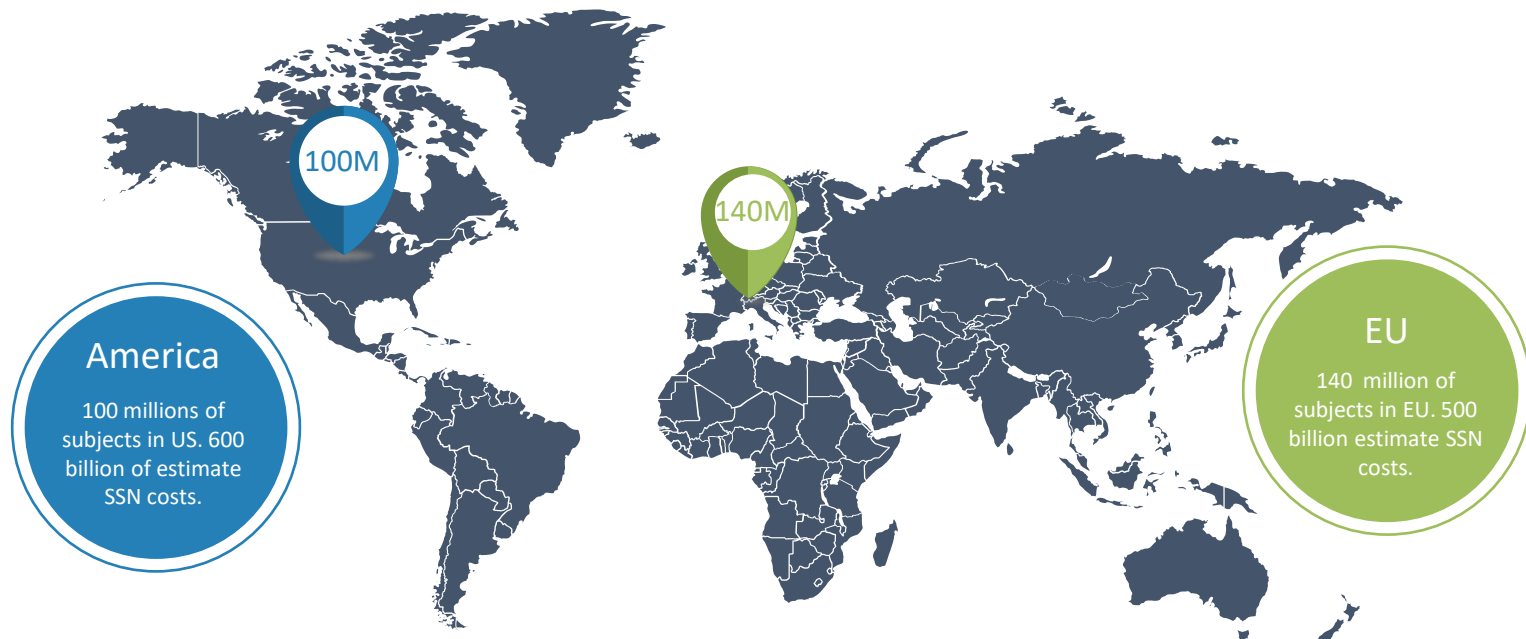




## CHRONIC PAIN (CP)

**Pain persisting for 3 months or longer** (Merskey, Bogduk et al. 1994)

- ▶ 500 million in the world. 1 over 4 in Europe.
- ▶ More than cardiovascular and oncological diseases costs.
- ▶ NO CURE.





49 CP patients (39 females;  
Age M = 57.92, SD = 14.48):

- 13 Secondary Musculoskeletal Pain;
- 19 Primary Pain (PP);
- 17 Neuropathic pain (NP).

Single-blind between-subjects. 11 minutes of:

- C-T Interoceptive (EXP)
- Proprioceptive (SHAM)

DV: PainNRS pre and post stimulation.

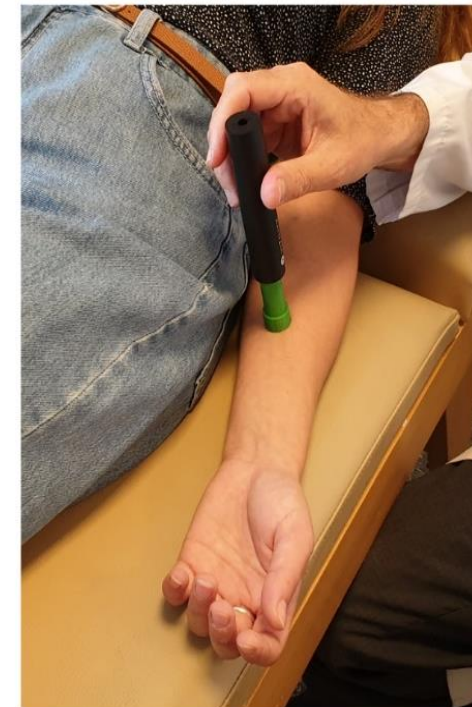
## Tactile stimulation procedure

.a - Experimental Condition



Interoceptive C-Tactile affective stimulation  
3 cm/s (+/- 0.5) and 2.5mN

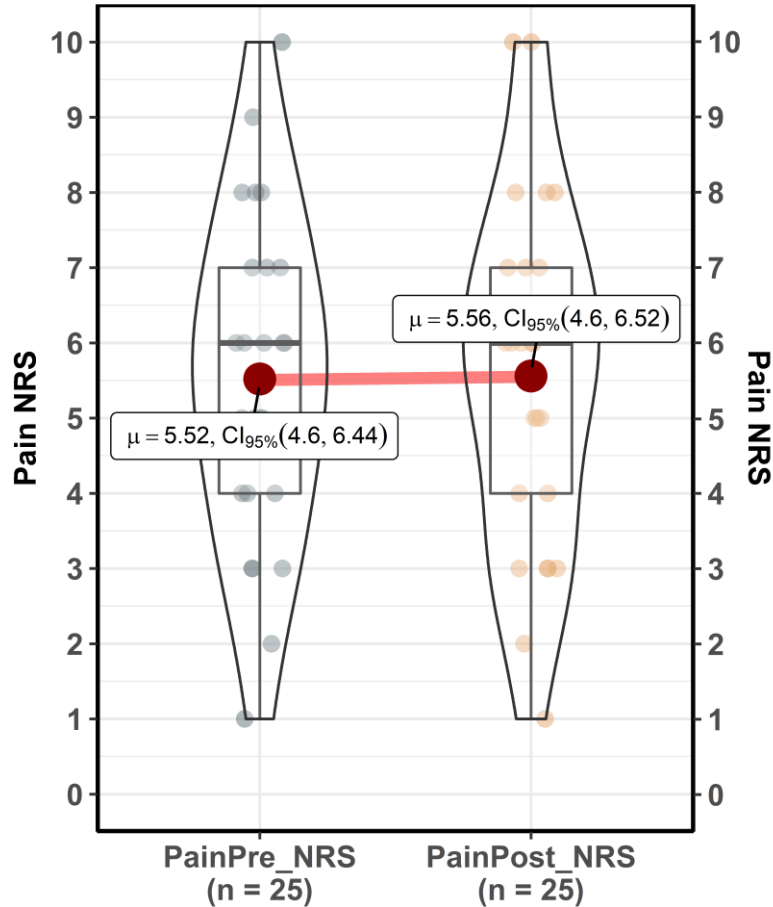
.b - Control Condition



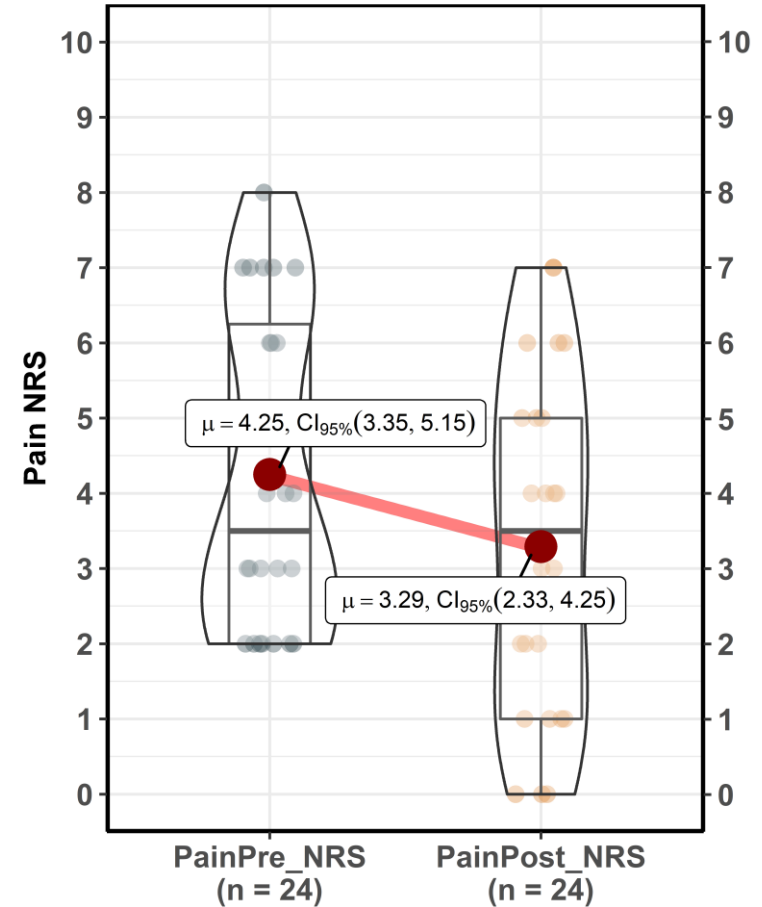
Static pressure control stimulation  
100mN



Condition: Control



Condition: Interoceptive Stimulation



CP subjects that received interoceptive stimulation reported a pain reduction of 22.58% (m) after 11 min. Independently from the pathology.



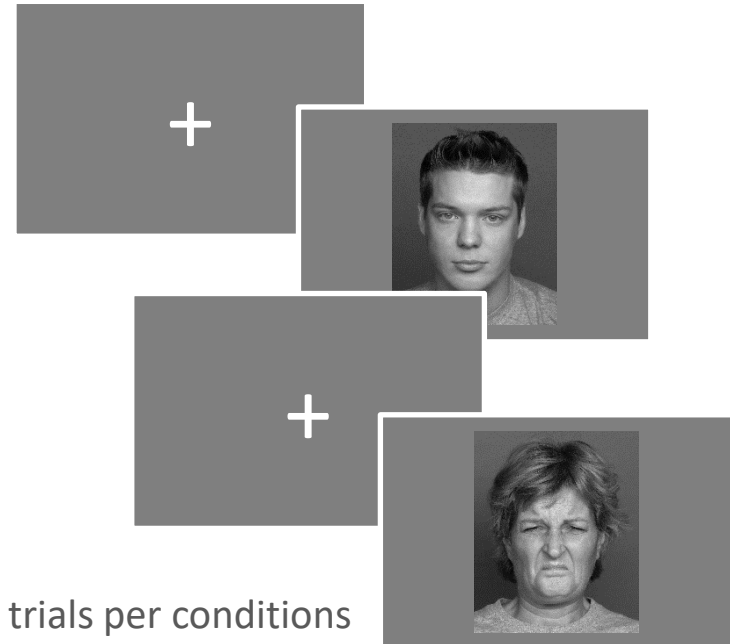
## Emotional GNG task:

- withhold prepotent behavioural responses
- in potentially interfering emotional context
- correctly and rapidly discriminate

## Sample & Design:

45 participants (Mean Age 23.64, SD 2.32, 34 females). 6 min of:

- C-T Interoceptive (EXP)
- Proprioceptive (SHAM)

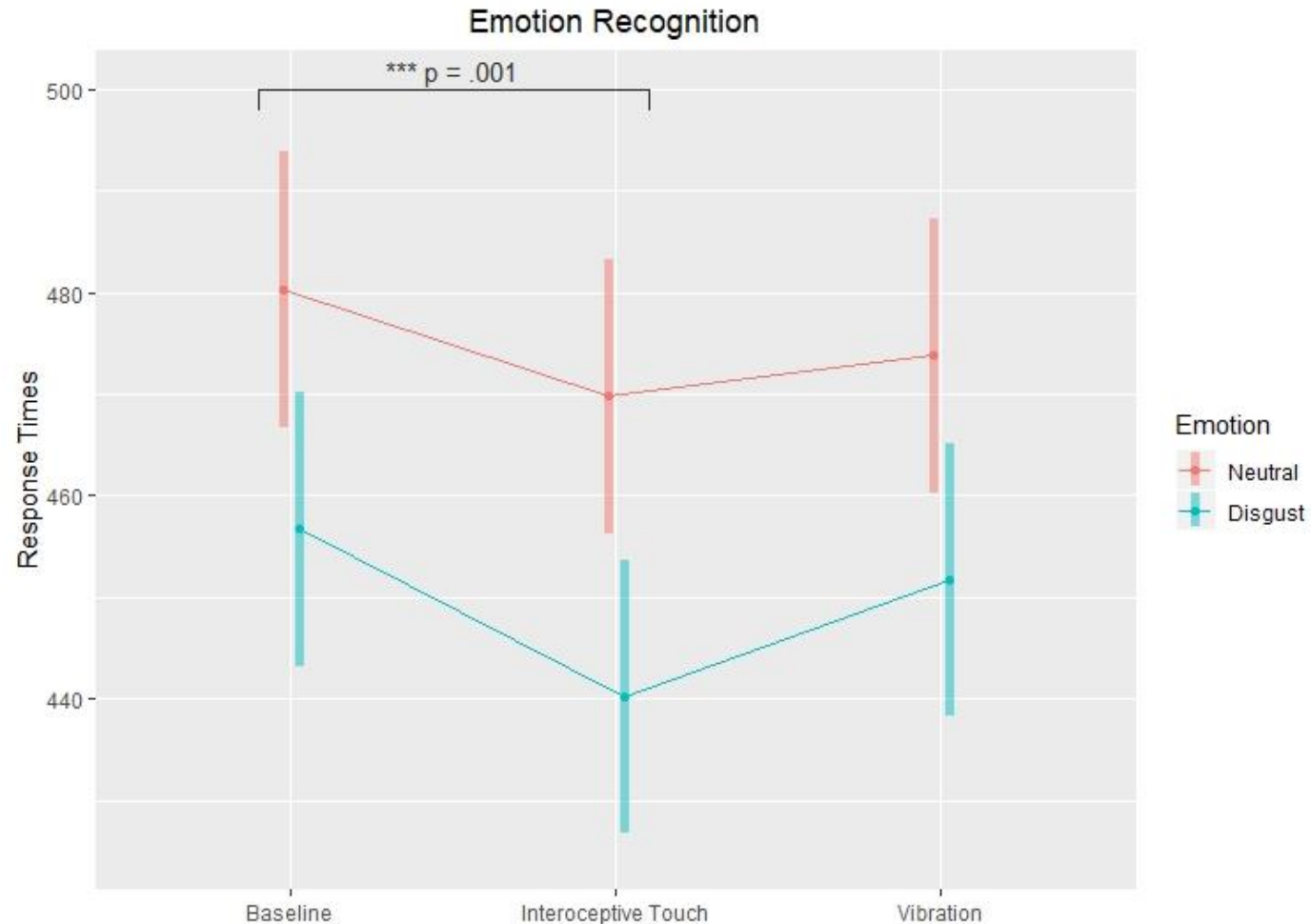


- 40 trials per conditions
- 70% (28) Go trials
  - 30% (12) NoGo trials



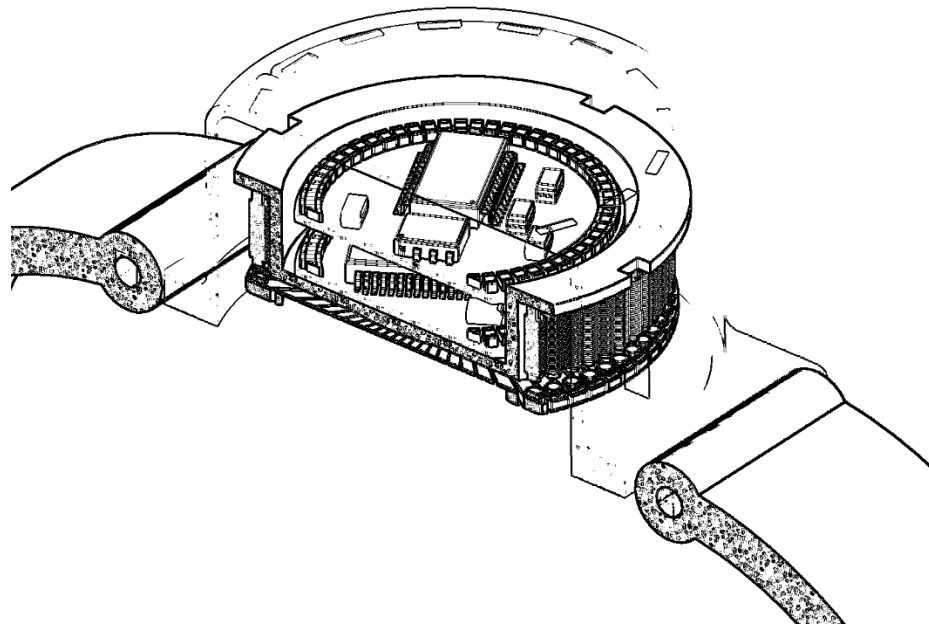
## Interoceptive stimulation:

- Faster RTs in recognizing the emotions.
- Reduced the percentage of missing indicating enhanced attention





We won a technological grant to develop a wearable, autonomous, noninvasive technology. MVP ready by February 2022.





## PHYSIOLOGICAL AUGMENTATION:

- Acute and chronic stress reduction (via parasympathetic enhancement)
- Pain analgesia (acute and chronic)

## COGNITIVE AUGMENTATION:

- Enhanced discrimination in (tactical) contexts that require impulse inhibition and cognitive control. Faster RTs.
- Neuroenhancement for emotion discrimination (e.g., intelligence, assessment, information evaluation, etc.)

## CLINICAL REHABILITATION:

- Medical treatment/enhanced recovery (e.g., Chronic and Acute pain, Stress and Anxiety, PTSD, Addictions, Insomnia)



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# Thank you

Daniele Di Lernia  
daniele.dilernia@unicatt.it