

# Device for Studying Reanimation of Unilateral Facial Paralysis

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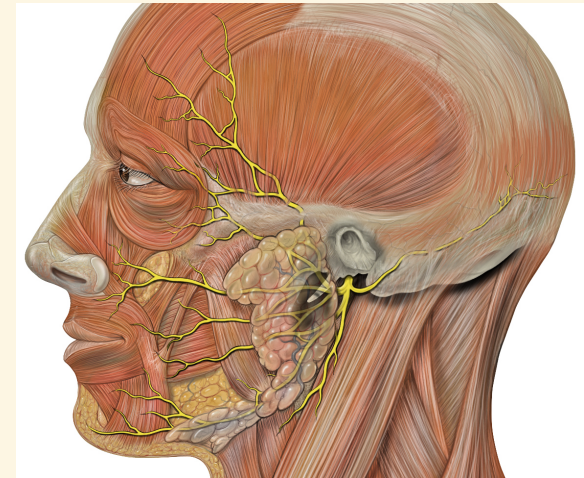
# What is Unilateral Facial Paralysis

- Paralysis of the facial nerve on one side of the face
  - Temporary or permanent
  - Partial or total
- Paralysis causes problems
  - Blinking
  - Eating and speaking
  - Social interaction
  - Facial expressions



Bell's palsy

Sue Campbell/U.S. Air Force (2006).  
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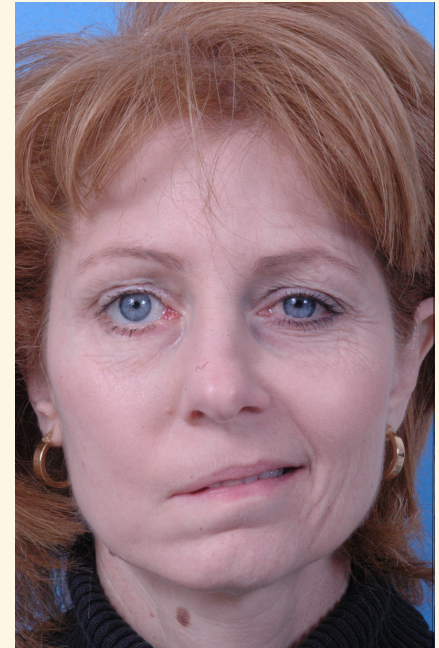


Facial nerve

Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD,  
cardiologist (2006). Licenced under CC BY 2.5:  
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# What Does Reanimating Facial Paralysis Mean

- Regaining lost functions
  - Eye blink
  - Smile
  - Symmetry of lips
  - Muscle tonus
- Only very short delay between movement of the healthy side and the paralysed one is allowed
  - Few tens of milliseconds in order to be observed as simultaneous



Bell's palsy  
Sue Campbell/U.S. Air Force (2006).  
Public domain image.

# Possible Ways for the Reanimation

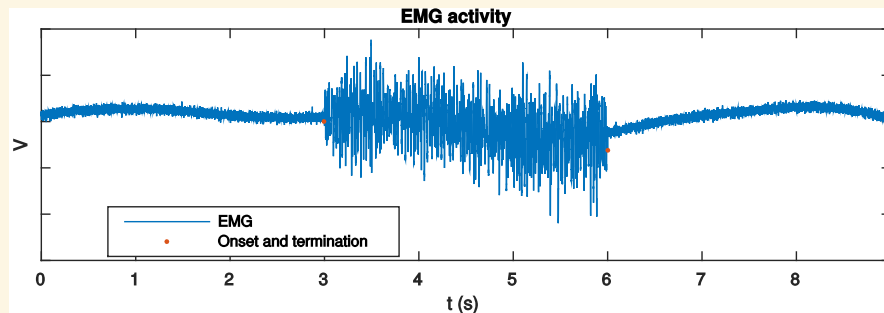
- Surgical operations
  - Complex, possibility for complications
  - Can be used also for regaining form without reanimation
- Prosthetic pacing technology
  - Measurement of muscle activity or facial expression from the healthy side
  - Functional electrical stimulation to activate the paralysed
    - Muscle activates via the nerve (if possible) or directly
  - Transcutaneous or implantable devices

# Objectives of Our Work

- To develop transcutaneous facial pacing
  - Measurement of the healthy side of the face with electromyography (EMG)
  - Activation of the paralysed side with electrical stimulation to achieve symmetrical facial actions
- To overcome limitations of transcutaneous facial pacing
  - Most prior research focuses on reanimating the eye blink
  - Transcutaneous stimulation tends to activate muscles synchronously
    - All motor units contract at the same time

# Goals for EMG Measurement Development

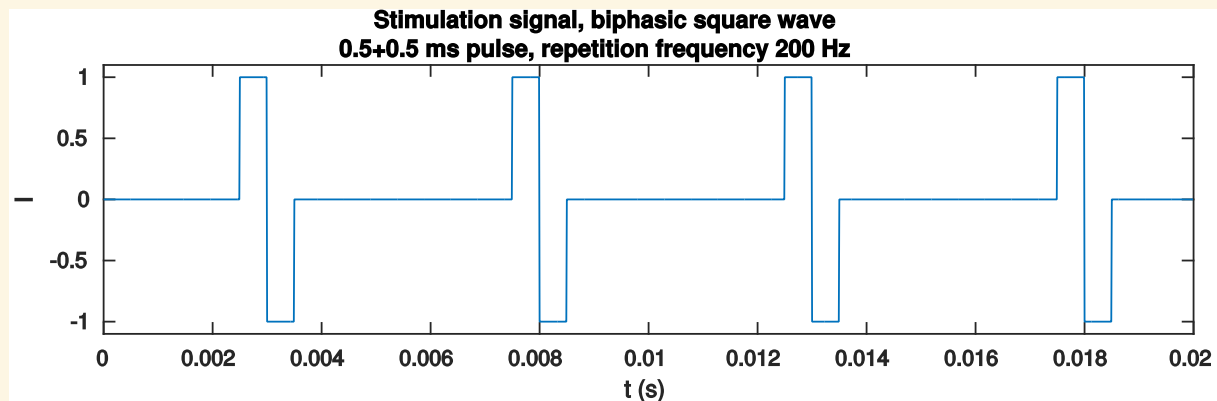
- Low latency detection of muscle activity onset and termination
- Low latency amplitude estimation
  - To determine contraction intensity
- Measurement electrode development: more convenient ones



Facial surface EMG

# Goals for Stimulation Development

- Asynchronous recruitment of muscle motor units transcutaneously
  - Producing different levels of muscle contraction
  - Producing muscle tonus
  - Avoiding muscle fatigue
- Stimulation with real-time input from measured EMG activity
- Stimulation electrode development
- Optimizing stimulation waveform



# Device Developed for Studying Reanimation

- A tabletop device
  - Custom, isolated amplifiers for EMG measurement and electrical stimulation (4 channels each)
  - National Instruments (NI) myRIO embedded hardware device for real-time operation
- Commercial medical grade power source
- Computer for UI and data logging
- Software programmed with NI LabVIEW



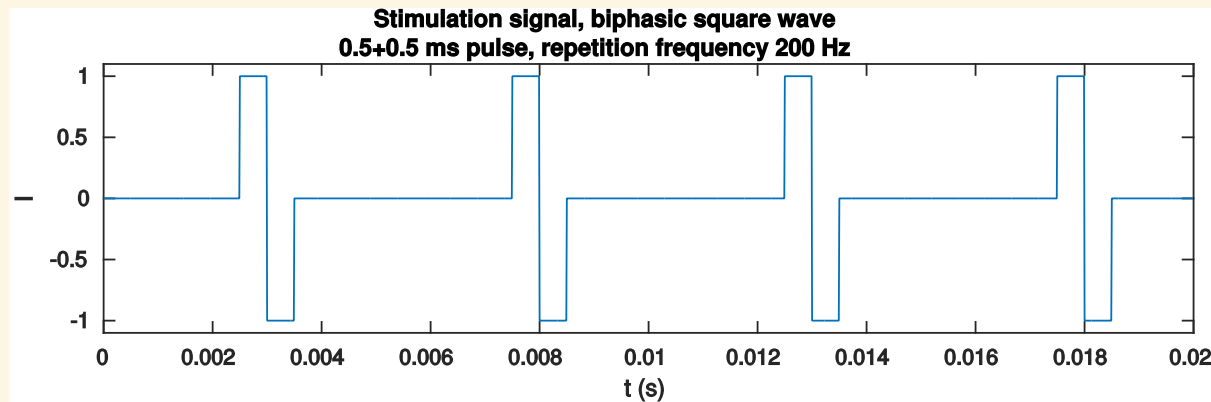


# Device Developed for Studying Reanimation

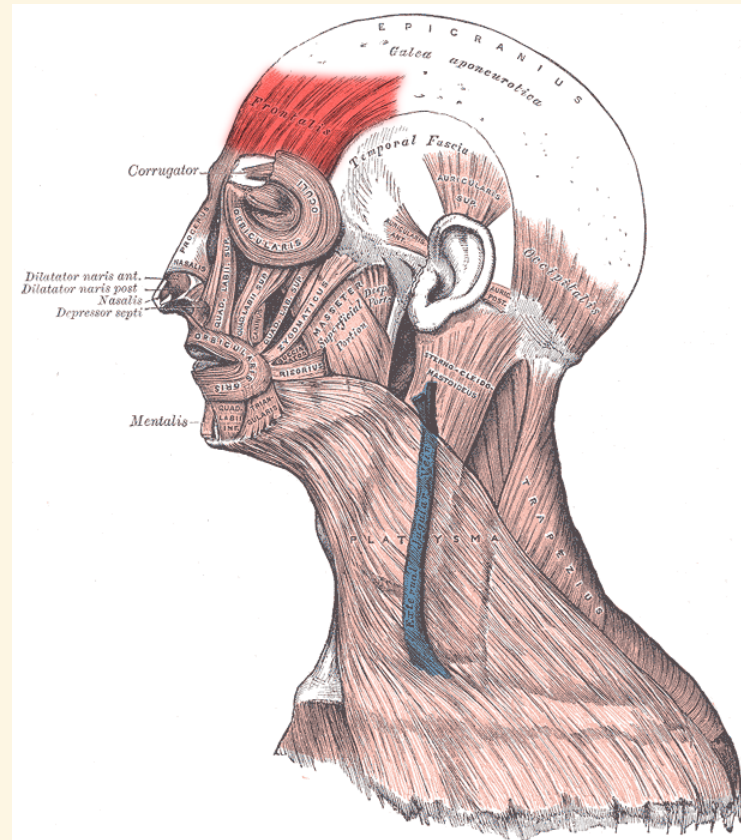
- Designed to fulfil requirements for medical devices within EU
  - Council Directive 93/42/EEC of the European Union
  - IEC 60601 standards
    - IEC60601-1 *Medical electrical equipment - Part 1: General requirements for basic safety and essential performance and collateral standards*
    - IEC60601-2-10 *Particular requirements for the basic safety and essential performance of nerve and muscle stimulators and other particular standards*
  - Approved by National Supervisory Authority for Welfare and Health (Valvira) and Pirkanmaa hospital district (PSHP) for use in clinical trials

# Problem Statement of the First Stimulation Trials

- Can certain facial muscles be activated transcutaneously?
  - Find out the required stimulation signal waveform parameters
    - Amplitude first
- What is the comfort level when activating the muscles?
- With healthy subjects (ongoing)
- With patients that have unilateral facial paralysis (to be started)



# Frontalis Stimulation as a First Experiment



Frontalis muscle

Edited from Henry Vandyke Carter - Henry Gray: Anatomy of the Human Body (1918). Public domain image.

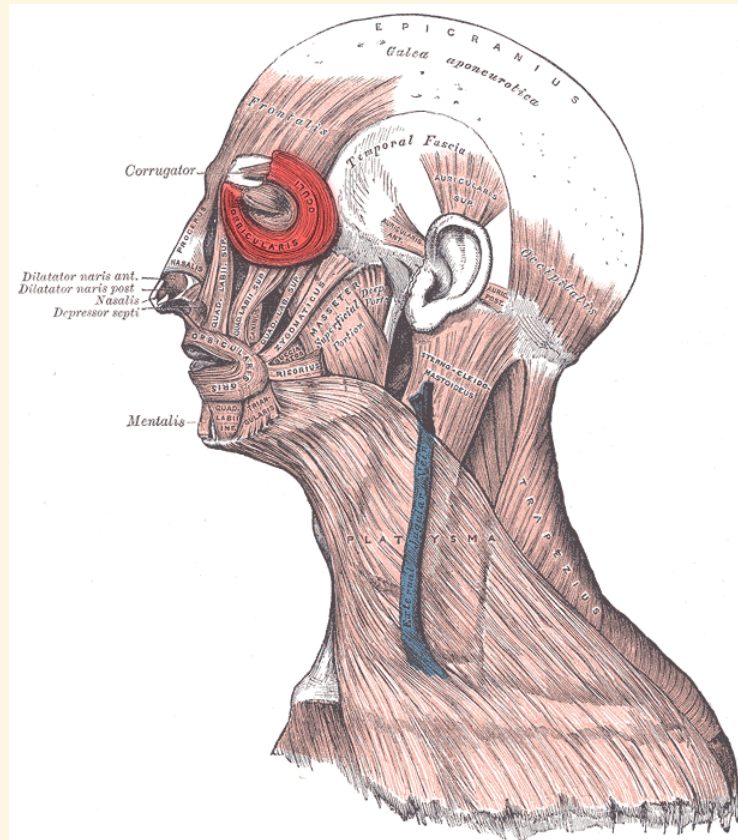
# Frontalis Stimulation as a First Experiment



# Frontalis Stimulation as a First Experiment



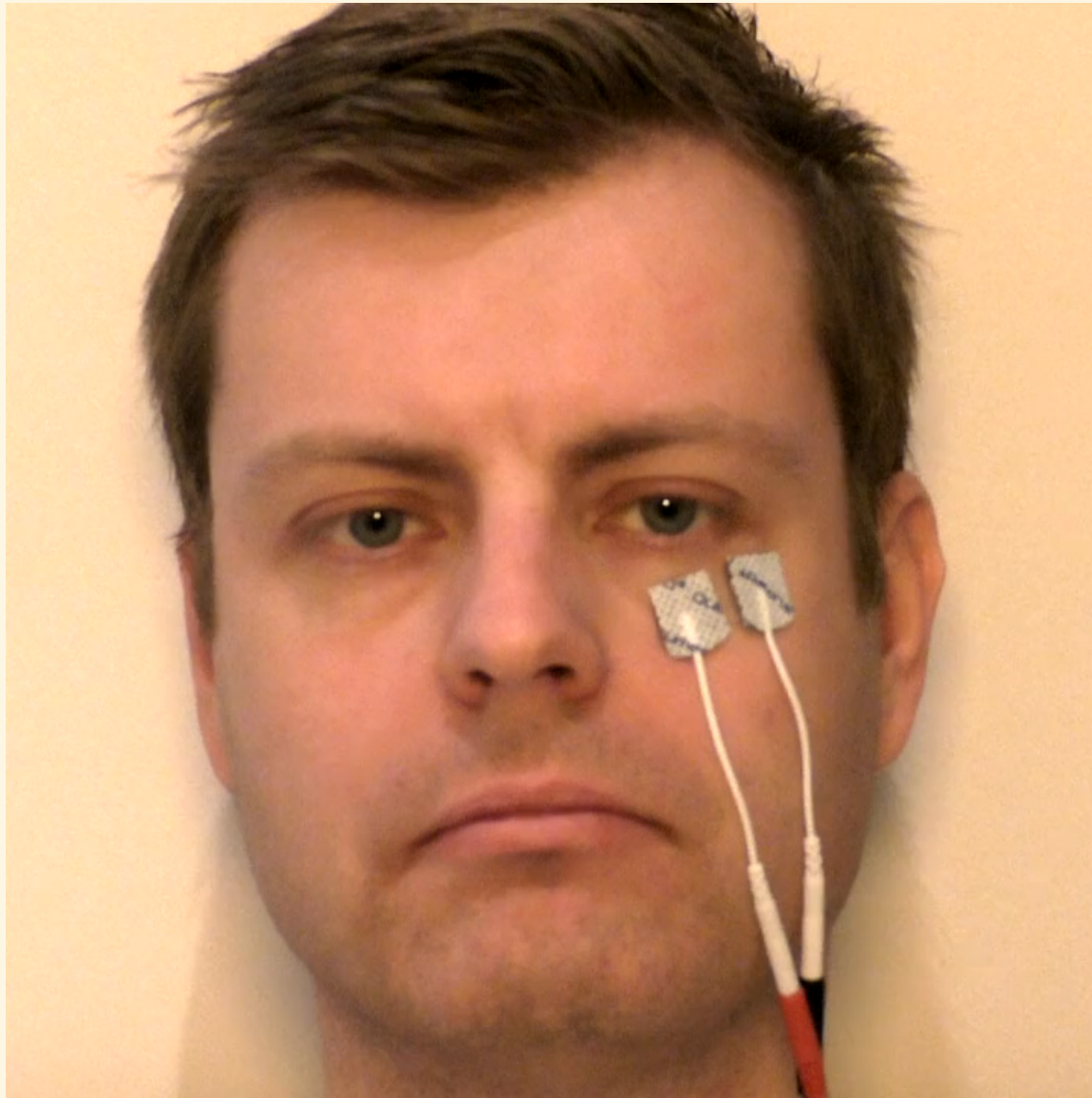
# Orbicularis Oculi Stimulation for Blinking



Orbicularis oculi muscle

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# Orbicularis Oculi Stimulation for Blinking

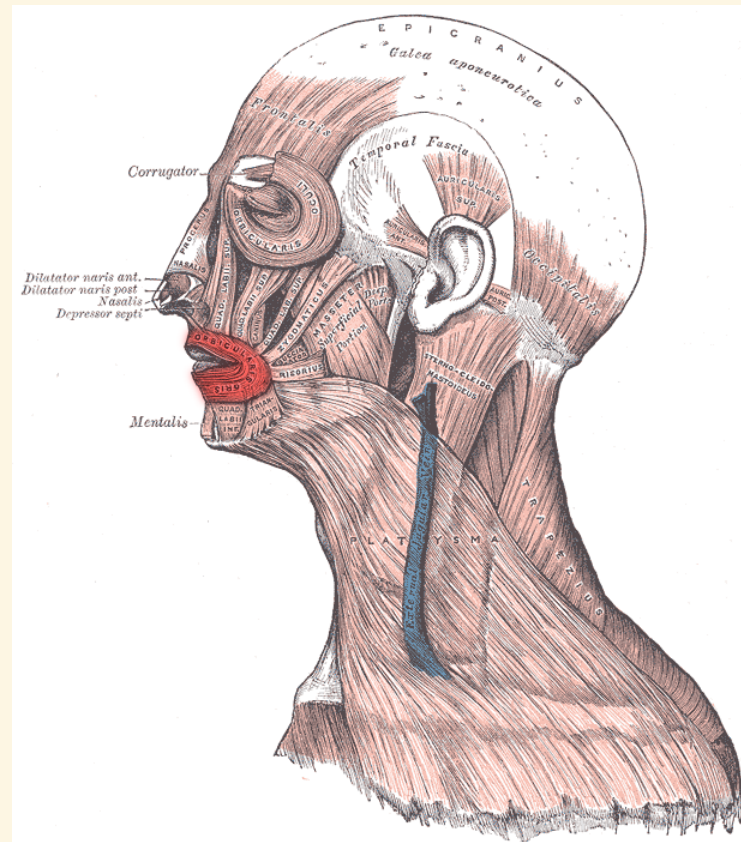


# Orbicularis Oculi Stimulation for Blinking





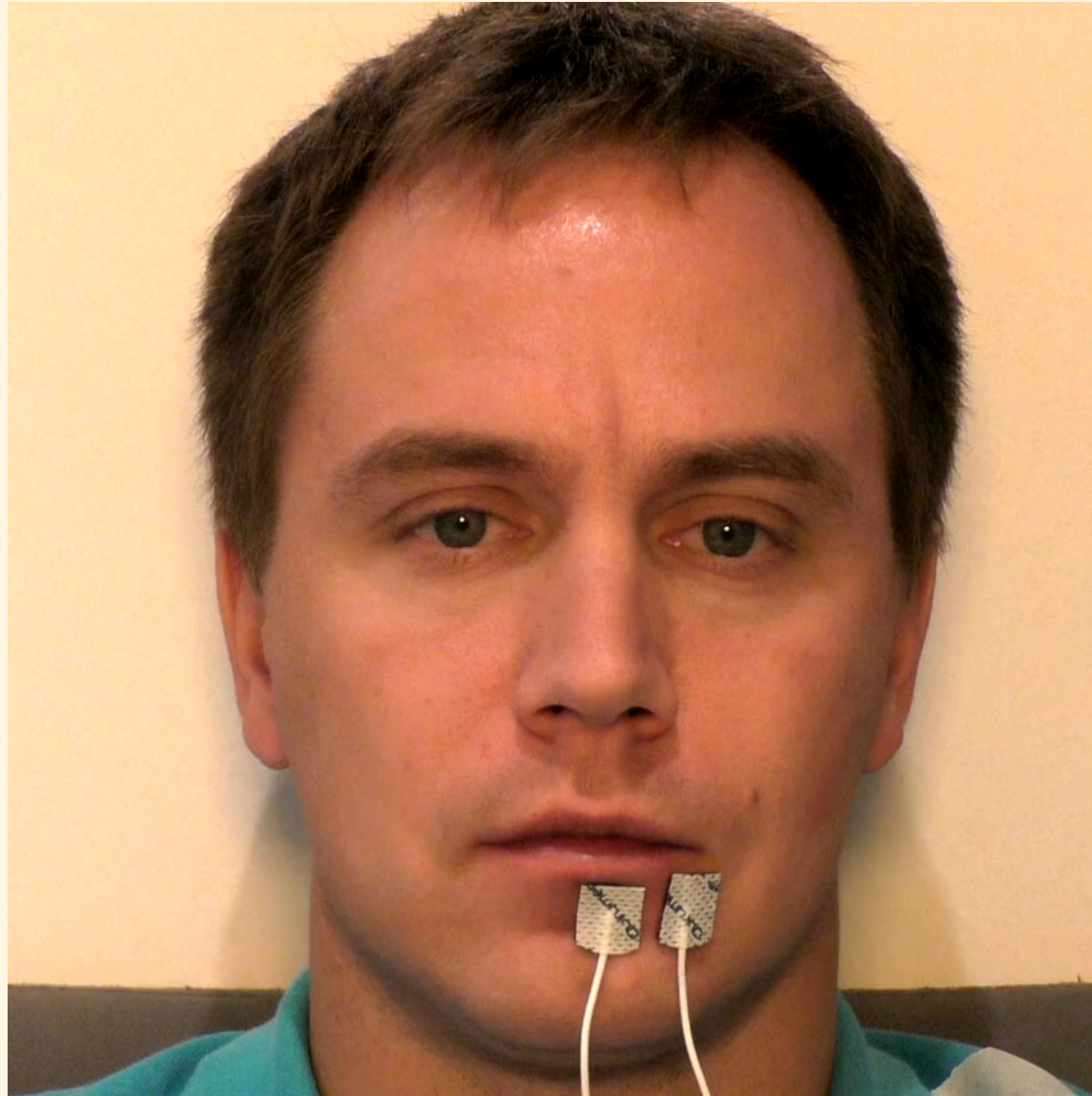
# Orbicularis Oris Stimulation to Prevent Mouth Corner Drooping



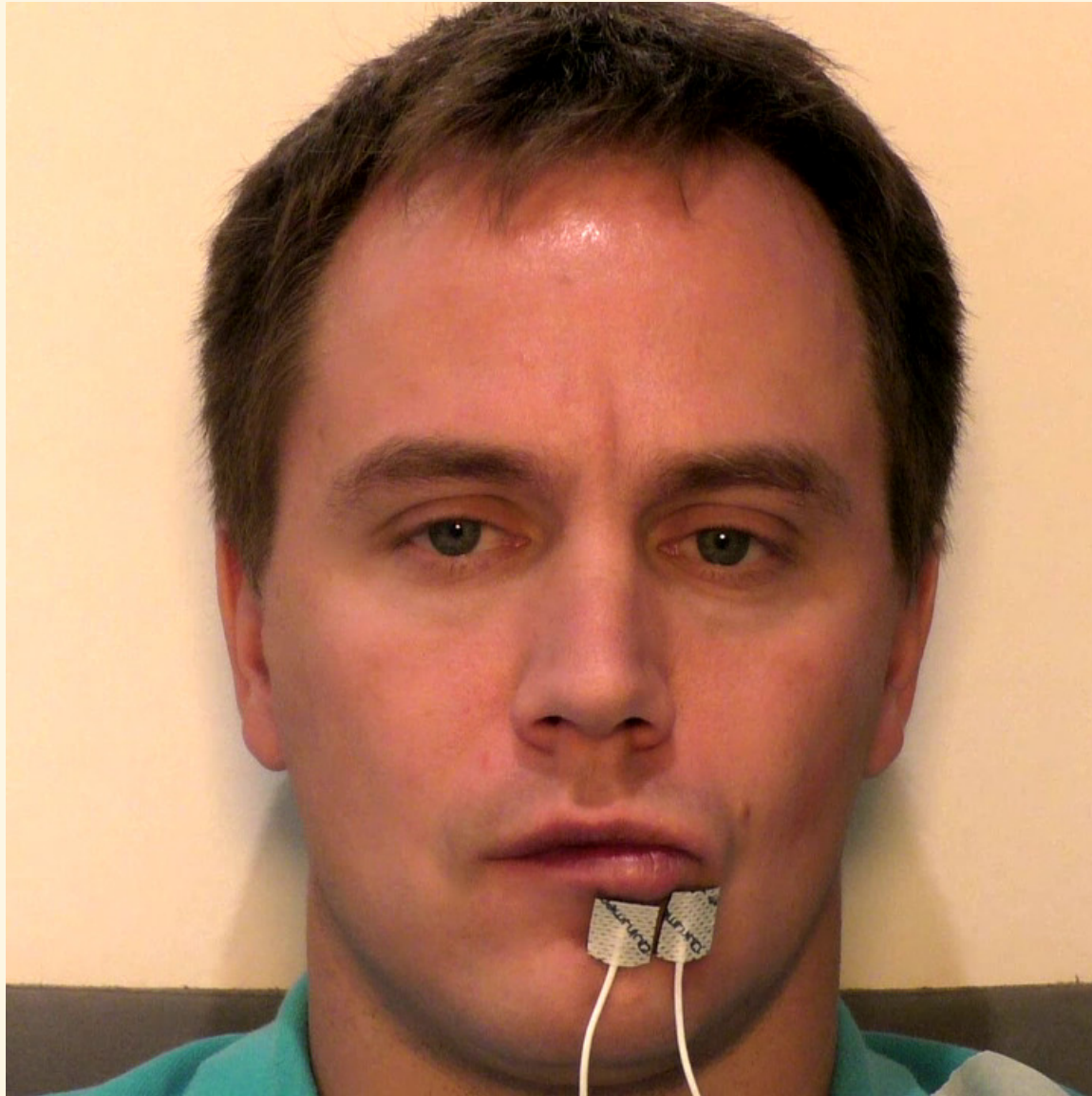
Orbicularis oris muscle

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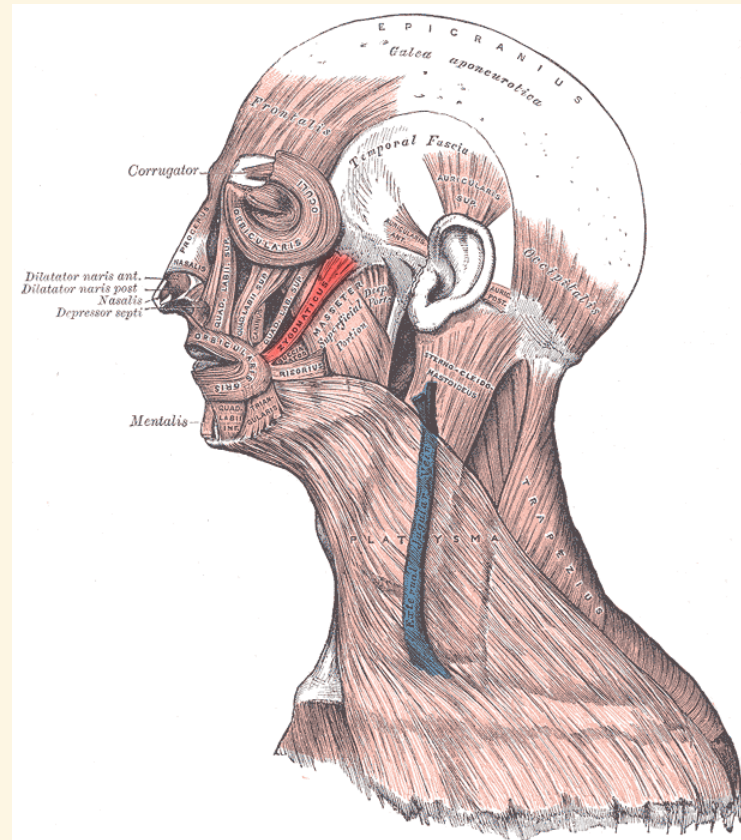
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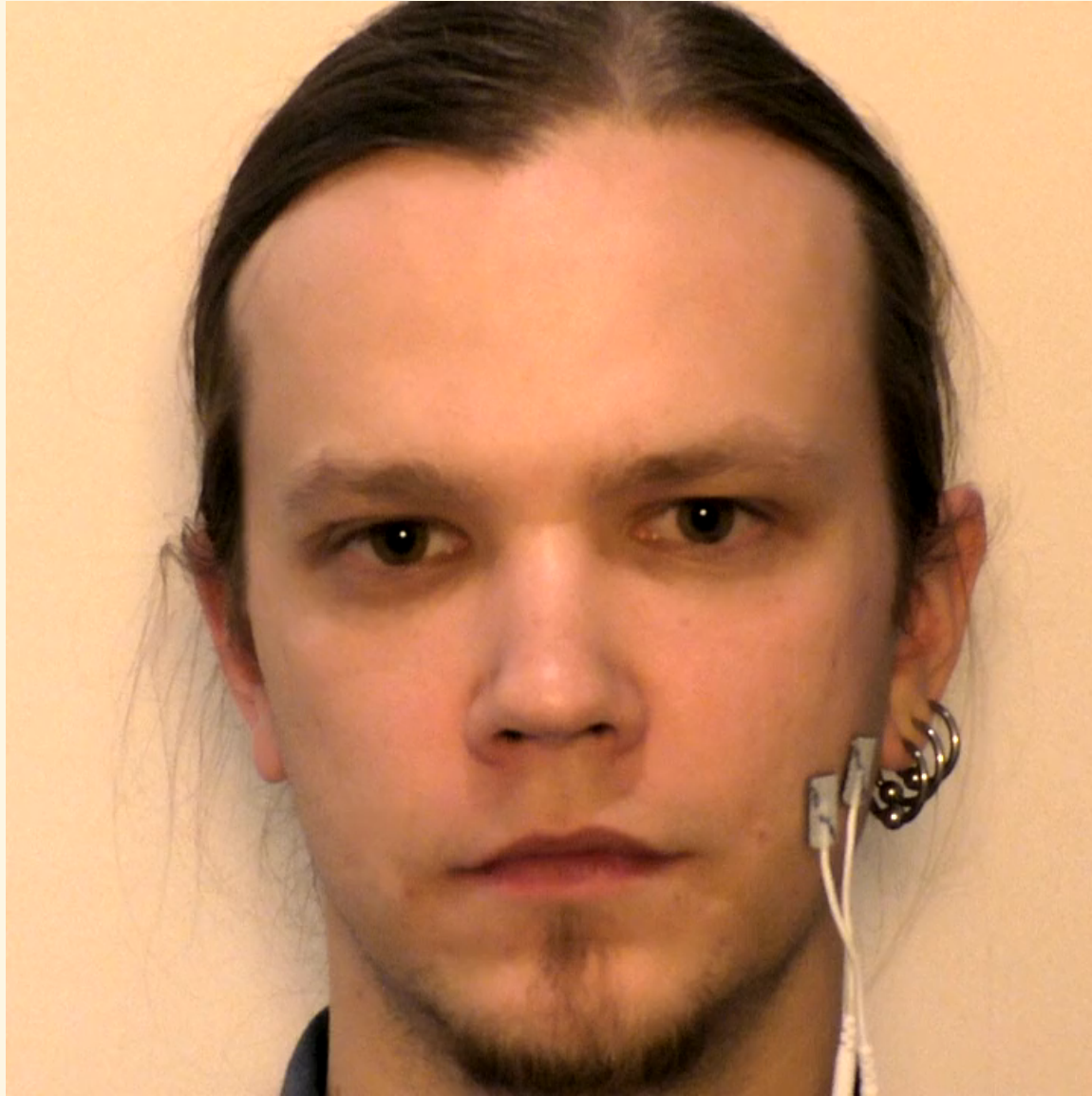
# Zygomaticus Major Stimulation for Smiling



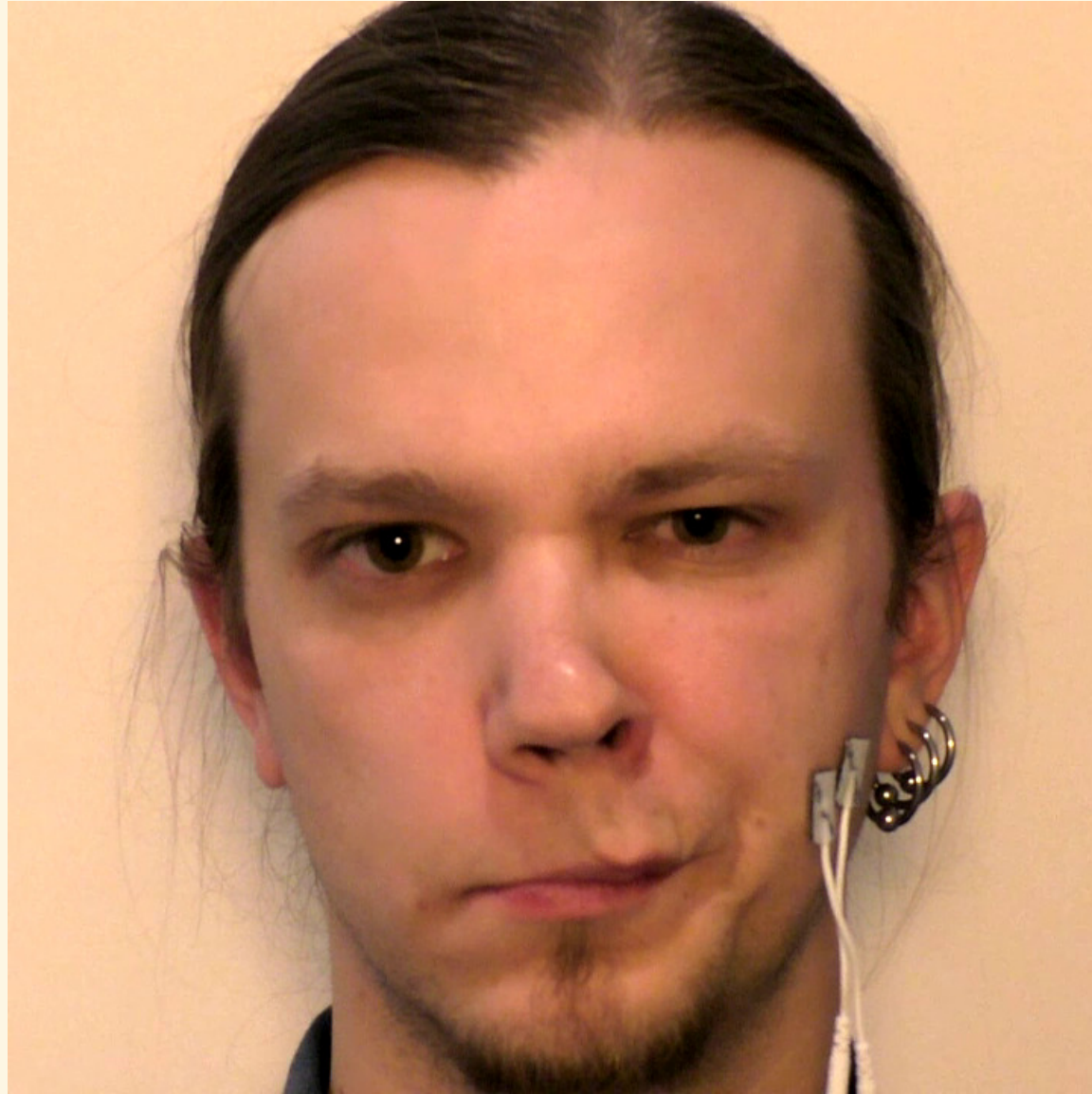
Zygomaticus major muscle

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# Zygomaticus Major Stimulation for Smiling



# Zygomaticus Major Stimulation for Smiling



# Summary

- A device for studying reanimation of unilateral facial paralysis was presented
- The device has been approved for clinical trials
- First results with healthy participants
  - Eyebrows can be raised easily with stimulation
  - A natural eye blink can be produced
  - Mouth corner can be activated
  - Smiling movement is difficult to produce due to subcutaneous fat
- Future challenges include
  - Producing muscle tonus and different levels of contraction
  - Real-time pacing by simultaneous measurement and stimulation



This work is a part of Mimetic Interfaces project funded by the Academy of Finland.