THE NEW WAY TO EXPLORE THE BRAIN FUNCTIONING

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IRCCS Neuromed, ITALY
Taking care of the BRAIN
Together for the BRAIN

Clinicians
Researchers
Geneticists
Engineers
Physicists
The BRAIN: the most complex human system...

...with still a lot of unexplored properties
To make the **BRAIN** understandable...a funny analogy
BRAIN: Structure and Function

Frontal
- Personality
- Emotions and arousal
- Intelligence
- Ability to concentrate, make decisions, plan, put things in order, solve problems
- Awareness of what is around you
- Voluntary movement
- Ability to speak and write
- Behaviour control

Parietal
- Sensations: pain, touch, temperature
- Understanding and interpreting sensory information, such as size, colour and shape
- Understanding space and distance
- Math calculations

Occipital
- Vision
- Interpreting what you see

Temporal
- Ability to understand language
- Hearing
- Memory, long-term storage of memories
- Organization and planning
- Behaviour and emotions

Brain stem
- Breathing
- Heart rate control
- Consciousness, alertness, wakefulness
- Swallowing
- Blood pressure
- Sweating

Cerebellum
- Balance
- Motor (movement) coordination
- Posture
- Fine motor skills
LOGIC vs EMOTION

**LEFT-BRAIN FUNCTIONS**
- Analytic thought
- Logic
- Language
- Reasoning
- Science and math
- Written
- Numbers skills
- Right-hand control

**RIGHT-BRAIN FUNCTIONS**
- Art awareness
- Creativity
- Imagination
- Intuition
- Insight
- Holistic thought
- Music awareness
- 3-D forms
- Left-hand control
Corpus callosum:
more than just a midline structure
SPLIT-Brain Syndrome

Dyslexia
The SCIENCE behind the human BRAIN is COMPLEX

Anatomy
Complex Networking
Computational power
The human BRAIN has 100 billion Neurons, each of which is connected to 10 thousand other neurons. Sitting on your shoulders the BRAIN is the most complicated object in the known universe.
The BIOLOGICAL Machine
100 billion Neurons
1 trillion Web pages

The COMPUTATIONAL network of human BRAIN
Neuron
BIGGER
One synapse, by itself, is more like a microprocessor—with both memory-storage and information-processing elements—than a mere on/off switch. In fact, one synapse may contain on the order of 1,000 molecular-scale switches.
Human BRAIN has more connection than every computer on Earth combined

100 trillion links

300 trillion synapses
Matter of Connections

REASON
MEMORY
EMOTION
BRAIN WIRING diagram and CONNECTOME

DMRI (diffusion Magnetic Resonance Imaging) to accurate map the BRAIN architecture and connections in HEATHY and DISEASE condition (new insights for autism and schizophrenia)

The physic circuitry of the average brain contains trillions of synapsis and this complex network is known as CONNECTOME.
CLARITY: to visualize neurological wiring in nonliving brain
DIVING INTO THE UNKNOWN
The big issue in **Neuroscience** is to understand how pieces of the brain fit and work together...

The big issue in **Medicine** is to objectively diagnose and treat brain disorders.
Why so much interest in Human Brain?

Human BRAIN

SOCIETY
Animals EVOLUTION
WORKING model DISEASES
Knowledge Experimentation
DATA

> 2 billions of patients
The urgent NEED

1:3 European citizen
Looking INSIDE the BRAIN to DIAGNOSE mental diseases

- Partial or complete paralysis
- Seizures
- Disorganized speech
- Muscle weakness
- Abnormal motor behaviour
- Difficulty reading and writing
- Unexplained pain

Symptoms

NOT sufficient to make diagnosis
Brain Imaging Technologies to look at STRUCTURE …

In structural imaging, machines take snapshots of the brain's large-scale anatomy and allow researchers to look inside the brain.

…and FUNCTION

Functional imaging provides a dynamic view of the brain, showing which areas are active during thinking and perception.

The fMRI and EEG are very important tools mostly used in diagnosis of different neurological condition that affect the normal functioning of the brain also without any apparent structural alteration.
... to learn about BRAIN disorders

Brain cancer

Ischemic stroke

Arteriovenous malformation

Mild Cognitive Alzheimer’s

Atrophy of the Cerebellum

Epilepsia

MRI findings in HD

Dopaminergic Loss Imaged with DATSCAN/SPECT

Healthy Control

PD H&Y II
... to make a differential diagnosis between BRAIN diseases

Movement Disorders
Imaging differentiates progressive supranuclear palsy from Parkinson disease

PD

PSP
...and to make a diagnosis before the appearance of disease symptoms in RARE diseases

18F-FDG PET uptake in the pre-Huntington disease caudate affects the time-to-onset independently of CAG expansion size.

Carmiello A, Giovacchini G, Orobello S, Bruselli L, Elifani F, Squitieri F.

FIGURE 1. Display of region weights of scaled SSM topography associated with HD overlaid on standardized Talairach MRI sections (13,20). Regional metabolic covariance pattern was identified in PET data from combined group comprised of 6 neurologically normal, presymptomatic HD gene carriers with normal striatal D2 receptor binding and 8 age-matched, gene-negative control subjects. Topography was characterized by relative decreases in striatal and mediobasal temporal metabolism co-varying with metabolic increases in occipital region. We designated this topography as HDRP.
Is the DEEP LEARNING the Solution?
DEEP LEARNING and its increasing popularity in medical images

Computer-Aided Diagnosis with Deep Learning Architecture: Deep Learning to Applications to Breast Lesions in US Pulmonary Nodules in Medical Image Analysis

Large scale deep learning for computer aided detection of mammographic lesions

Fully automatic acute ischemic lesion segmentation in DWI using convolutional neural networks
Still little is known about the BRAIN

AUTISM
Early defective connectivity
To explore and better understand human brain and its diseases and use this knowledge to build new computing technologies.
The BIG Challenge

Looking for what is missing
To achieve the goal of more appropriate diagnosis....

Medical Science needs your help....
**Decoding Thoughts**  
**Brain-Computer Interface (BCI)**

Some scientists want to see inside the brain more figuratively…

BCI systems are designed to acquire electrical signals from the BRAIN and process them into commands for **effector devices** to perform the patient’s desired action.
The functions of a BCI is broken down into three categories: signal acquisition, signal processing, and the function of the effector device. The strength of this technology is that a signal coming from one single neuron may be converted in a complete action.
BCI and its success to provide patient-controlled compensation for the loss of muscle movement and communication

BCIs can now even allow humans with paraplegia (paralysis of all four limbs) to control a robotic arm through thought alone, or allow users to spell out words on a computer screen using just their mind.

At-home devices have huge implications to reduce costs for hospitals and insurance companies, and—if the technology is up to par—results in a more natural set of data for the patient.
The REVOLUTION in the diagnosis of RARE DISEASES

More than 300 million people worldwide are affected by RARE DISEASES
Facial hallmark and dysmorphic feature

Facial signatures of some rare diseases can be subtle and difficult to diagnose, even for a trained professional.
Most of patients with rare diseases often suffer a significant delay in diagnosis. Many diseases are so rare that a general physician is unlikely to see a single case in his career.

The symptoms of rare diseases are often atypical and can point in many different directions. As a result, the correct diagnosis is often delayed for several years.
The latest medical technology that leverages the power of big data to make better diagnoses and more accurate predictions.

Identifying facial phenotypes of genetic disorders using deep learning

Yaron Gurovich1*, Yair Hanani2, Omri Bar1, Guy Nadav3, Nicole Fleischer4, Dekel Gelbman1, Lina Basel-Salmon2,3, Peter M. Krawitz4, Susanne B. Kamphausen5, Martin Zenker5, Lynne M. Bird6,7 and Karen W. Gripp8

Deep learning-based new technology that can help clinicians and geneticists to diagnose rare disease based on patient facial phenotypes

The technology converts a patient photo into de-identified mathematical facial descriptors (facial descriptors)

Facial recognition app Face2Gene is being used by doctors to diagnose rare diseases. Courtesy FORMA

The latest medical technology that leverages the power of big data to make better diagnoses and more accurate predictions.
Face2Gene’s system uses a machine-learning algorithm. It learns from every new face it scans. The more data it acquires through its use, the more accurate should be the diagnoses.

Snapping a quick photo of the child’s face within a matter of seconds, the app generated a list of potential diagnoses.
RARE DISEASES do not have cure
A Startup Using **Artificial Intelligence** To Find Cures For some Rare Diseases

Healx is a tech company from the Cambridge Cluster (UK), focussed on accelerating treatments for rare diseases. It integrates artificial intelligence with deep pharmacology to translate therapies into the clinic within 24 months. Thereby, dramatically reducing the time and cost compared to conventional drug discovery. To achieve this goal, Healx developed the most comprehensive AI-based drug discovery platform for rare diseases: Healnet. With the objective to translate 100 rare disease treatments towards the clinic by 2025.

“Our mission was to apply our technology and approach to identify and validate already approved drugs that may treat some of the most severe symptoms of the disease”
Take home message...

Human Brain is waiting for you to give us all the best it kept hidden up to now....
Thank You For The Attention