Could we Read Thoughts Directly from the Brain?
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1. The origin of electrical activity in the brain (neurons, spikes, synapses)

2. Coding the world with “spikes” - examples

3. Attempts/successes? of “thought reading” (EEG, fMRI, Intracranial, single spikes)

1. Summary of present understanding
Bibliography

1. Reconstructing Speech from Human Auditory Cortex
   Brian N. Pasley et al., PloS Biology 2012


http://en.wikipedia.org/wiki/Brain-reading
The origin of electrical activity in the brain (the spike)

\[ I = C_m \frac{dV}{dt} + g_{Na} h m^3 (V - V_{Na}) + g_K n^4 (V - V_{K}) + g_L (V - V_{L}) \]  

(1)

\[ \frac{d}{dt} m = \alpha_m (V) (1 - m) - \beta_m (V) m \]  

(2)

\[ \frac{d}{dt} n = \alpha_n (V) (1 - n) - \beta_n (V) n \]  

(3)

\[ \frac{d}{dt} h = \alpha_h (V) (1 - h) - \beta_h (V) h \]  

(4)

The H&H model; (1) Biophysical, (2) Compact, (3) Predictive
The synapse: Plastic Communicating Device

Input spike

response

~1 mV
~100 mV

Axon

dendrite
The neural code (spikes in large neuronal networks)

FIGURE 53.3 The neuronal correlates of consciousness (NCC) are the minimal set of neural events and structures—here synchronized action potentials in neocortical pyramidal neurons—sufficient for a specific conscious percept or memory. From Koch (2004).
Parkinson - a wrong electrical code in the brain
A point to note – subjective (conscious) perception with fixed input

**WHAT'S ON A MAN'S MIND**
A voyage into the brain
(“reading” the brain with fMRI)
Functional Magnetic Resonance Imaging (fMRI)
Detecting blood flow to active brain regions
Probing the brain with fMRI for: Lie-detection
“Accessing brain activity goes to the very source of the lie”

No Lie MRI (Philadelphia)
*Cephos*, (Peppel Mass)

Mind reading: functional MRI scans reveal brain regions that light up only during a lie.

Cards related to money; students try to conceal which card they held
When lying - particular spots at the prefrontal cortex become more active
Detecting thoughts and feelings while interacting with someone of a different race.

Regions showing greater activity to black faces than to white faces for people with racial bias.
Interacting with the brain in vegetative states
Brain activity in a vegetative state

A patient in a persistent vegetative state showed activity in the same brain areas as healthy volunteers in response to spoken commands to visualize herself playing tennis or moving through her house.
Communication with people in vegetative state

Willful Modulation of Brain Activity in Disorders of Consciousness

A. "Is your father's name Alexander?" "Yes" response with the use of motor imagery

B. "Do you have any brothers?" "Yes" response with the use of motor imagery

C. "Is your father's name Thomas?" "No" response with the use of spatial imagery

D. "Do you have any sisters?" "No" response with the use of spatial imagery
Reconstructing Visual Experiences From Brain Activity Evoked by Natural Movies
fMRI Measures of Conscious Access (using masking)

A  Visible word

B  Detected sound

Non-detected sound
A voyage into the brain
(“Reading thoughts” with EEG)
The EEG (Electroencephalography)

Recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain.
EEG during different stages of sleep (a diagnostic tool)
Epileptic seizure (EEG recording)
Free Will and the Brain

1916 - 2007
Benjamin Libet’s experiment


The “readiness potential” – Libet experiments
Brain Fingerprinting lab.

(L. Farwell, Seattle)

- using P300 (EEG) for detecting input that has a special significance ("hidden knowledge") for the subject

Lies, damned lies, and technology: the accuracy of the polygraph lie detector (facing page) has been attacked. Lawrence Farwell (above, right) thinks measuring the burst of brain activity that occurs when a person recognizes something (left) could provide a reliable alternative. Others fear the technique works better in the lab than in the field.
A voyage into the brain intracranial recordings
Reconstructing speech from human auditory cortex intracranial recordings from superior temporal gyrus (epileptic patients)

Pasley BN, David SV, Mesgarani N, Flinker A, Shamma SA, Crone NE, Knight RT, Chang EF. 2012.
Word identification (auditory example)
“The results provide insights into higher order neural speech processing and suggest it may be possible to readout intended speech directly from brain activity”.
A voyage into the brain
“Single unit” (single neuron) recordings
Recording Single Neurons in the Human Medial Temporal Lobe

G. Kreiman, C. Koch and I. Fried‡

‡Division of Neurosurgery. University of California at Los Angeles, School of Medicine
Technique pioneered by Crandell & Engel, UCLA

Surgery carried out by I. Fried

Entorhinal Cortex Neuron

![Graphs showing neural activity for different categories: Emotional faces (100), Object (51), Spatial (105), Animal (46), Car (17), Face drawings (134), Famous (100), Patterns (54).]
Imagery Neurons in the Human Brain
Same cell active for same feature when you actually see and when you imagine

Kreiman, Koch and Fried (2000b)
Summary

Some thought about thought-reading with available techniques (fMRI, EEG, intracranial, single unit)

A training (calibration) session is required first, to be later use on new data.

There is a significant difference between people in their brain signaling (and in brain location) representing the encoded data.

The brain representation of an item (a familiar face) changes with learning and thus the coding/encoding changes.

Refined recording techniques (e.g., single units vs. fMRI) improves “thoughts reading”.

It is unlikely that in the foreseeable future we will see “brain polygraphs”.
HBP Interaction with Society

1. Bring society on a scientific journey
2. Inspire the youth
3. Demystify the brain and mind
4. Humanize brain diseases
5. Understand yourself and others
6. Manage your brain
A proposal for a brain corner in all 3000 Science museums worldwide
Features of Brain Exhibits

• **Visual Displays**
  – 3D voyage into the brain – experience its structure and activity
  – Trace and understand perceptions, emotions, creativity, intelligence
  – Understand brain diseases
  – Learn about future computing, robots, technologies inspired by the brain

• **Interaction (in science centres)**
  – Power screens – self-navigation through the brain
  – Challenges & games
    • find the pattern to activate a neuron
    • Neuron beats (activate excitatory and inhibitory neurons to change the beat of the music)
  – Synapsing (museums as synapses – world view)

• **Participate (beyond science centres)**
  – Citizen science
  – **Frontiers for young minds**
  – Questions & answers
  – Ethical implications (opportunities to input on / track & report responses)
  – Feed back
Frontiers for the young minds

Frontiers for Young Minds is a web-based scientific journal with an editorial board of kids.

Learn how you can participate »
Seeing with your ear

Seeing with your ears: a wondrous journey across the senses
Figure 2 - Neuroimaging (fMRI) results demonstrating a relationship between the nucleus accumbens response to discovering one has a good reputation and Facebook.
Welcome to

“The century of the Brain”

Toda Rabba
To all of you