GIVE ME THE GLASS,
AND THEREIN WILL I READ
W. SHAKESPEARE.
RICHARD II. ACT 4, SCENE 1

Brain and Mind - what we know now

T. Chernigovskaya
St. Petersburg
Human brain is a Sphinx.
Self-sufficient, Silent, snobbish.
Shiny surfaces and mirrors were credited in old days with magical powers that could look into the future. Centuries later NASA is relying on them to look into the past: the agency is developing a mirror 21.3 feet across, for use on the new space telescope, to tell us about our beginning in the Universe.
Nature strangely needs a mirror to articulate its own laws, and it develops the human mind for it on the basis of the human brain.
Our mind needs the uniquely human neuronal mirror system for language, communication and social interaction, still more - for learning itself: mirror neurons code actions, sounds, gestures, face and voice qualities to express emotions allowing us to understand intentions of other people, to compose Theory of Mind.
The ability to observe and comment our own behavior in such virtual mirrors is a basis of reflection - probably the only human specific feature left after the years of anthropological and ethological cross-species studies of cognitive faculties (e.g. Tomasello, 2008).
Mirror neurons occur in fiber bundles connecting pre-motor cortex with the parietal cortex. The same mirror neurons fire when you perform an action or you see someone else performing it, even when imagining that you are perceiving or performing an action. Therefore it is not only the basis of social interaction but of the language and creativity forming human specific semiosphere.
What is human specifics?

Computing brain? Others can do it

Specific memory? - Its mechanisms - no

Its structure? Probably (associative) but who knows. Definitely not a library, nothing stable, 'files' rewritten every time over a previous copy. A different 'tapestry' every time we look at it

Human Language!
The human fossil and archaeological records indicate that modern human symbolic consciousness is not the culmination of the long trend that natural selection would predict. Instead, it shows that major change has been episodic and rare and that, as far as can be determined from the archaeological record, the passage from nonsymbolic to symbolic cognition is a recent event as well as an unprecedented one.
It significantly postdates the acquisition of modern human anatomy. It appears that the biological (neural) capacity underwriting the radically new behavioral mode arose as an incident in the same process that produced the new skeletal structure of Homo sapiens, but that it lay unexpressed until it was “discovered” by means of a cultural innovation, plausibly the invention of language.
As in the case of the modern anatomical structure, it appears that the new capacity was initially expressed in Africa and that its various behavioral potentials were sequentially discovered in a drawn-out process that is continuing today.
So, when we ask WHEN and WHERE we should clearly articulate WHAT we are searching for?: bones, genes, behavior, artifacts? We should search for human specific symbolic conventional cognition!

So - archeology, not only physical anthropology and genetics, not larynx and pharynx per se but whether the brain was ready for this type of very complex coding (e.g. like phonemic processing)
It is this leap to conventional symbolic manipulation in the mind that most truly marks us off from other forms of life on Earth.

It appeared in Africa by around 80 kyr ago (and possibly well before that).

The Cro-Magnons, with their art, music, ornamentation, etc. had very clearly crossed the critical threshold.
Mutual features (numerous)...

Specific features: phonology, recursion in syntax, universal features - probably innate (principles vs. parameters), context dependence! Changing meaning following the background of the writer/speaker and the reader/listener. On-line! Every time! No stable fixed meaning of items - just clouds=semantic clusters of some prototypes or concepts, and even their borders are not stable and subjective.

It’s a code!
Designed for what? Communication and THINKING, coping with the world, classifying, categorizing, understanding.

It’s not only science that can do it! Artists (in a wide sense) are not less effective. They managed to dig out the main things thousands of years before science was born! Read sagas, read myths, read Greek and Roman literature. It’s not esthetics per se, it’s decoding the world that is a code and a text to be read by us.

This is what all intellectuals and artists are doing!

Symbolic species (Deacon) - semiotic animals. Not the only ones, however (Biosemiotics)
poetry is not a form of entertainment, and in a certain sense not even a form of art, but our anthropological, genetic goal, our linguistic, evolutionary beacon. ...It is also a highly economical form of mental acceleration...As a tool of cognition, poetry beats any existing form of analysis. In other words, what a poem, or more accurately the language itself, tells you is "be like me."

(Joseph Brodsky)
The oldest evidence of people using numbers dates back about 30,000 years: bones and antlers scored with notches that are considered by archaeologists to be tallying marks. More sophisticated uses of numbers arose only much later, coincident with the rise of other simple technologies. The Mesopotamians developed basic arithmetic about 5,000 years ago. Zero made its debut in A.D. 876. Arab scholars laid the foundations of algebra in the ninth century; calculus did not emerge in full flower until the late 1600s.
Huge computational capacities are needed to subserve higher functions.
Talmy (2000): spatial relations in human languages preserve topology (i.e. containers remain containers no matter of their boundaries’ shapes). Possibly it is based on Fodor’s universal inborn concepts, or primary metaphors, as Lakoff et al. call it - meaning that neurons that fire together wire together according to the Hebbian principle, and as a result of it neural mapping circuits linking the two domains are learned. This is the basis for language acquisition as well as for social adaptation to the Umvelt (Uexküll, 1928).
The discussion on **Nature vs. Nurture** is becoming more productive when we use a 'genetic mirror'. Mutation and The Event of Grammatik Explosion vs. evolution and a spontaneously evolved unprecedented adaptation, leading to language the structure of which does not derive from either innate or social instruction but rather self-organization and selection; its quasi-universal features emerge from the interactions among semiotic constraints, neural processing limitations, and social transmission dynamics (Deacon, 2009)
J. Feldman, one of the founders of the theory of neural computation, developed together with G. Lakoff *Neural Theory of Language* (1988, 2009). Among other issues the theory argues that all mental simulation is embodied (cf. Damasio 1994), since it uses the same neural substrate used for action, perception, emotion.
Where is my mind?

'J. Fodor's' Robot vacuum cleaner
David Chalmers: My new iPhone is part of my mind

Jerry Fodor’s AI vacuum cleaner ‘All that it literally has inside is rug dust and cat hair: I know because I’ve looked’ (no place for representations!), even very clever tools like iPhones – aren’t parts of minds. That’s not, however, because iPhones are ‘external’, it’s because iPhones don’t, literally and unmetaphorically, have contents.

Externalism needs internalism; but not vice versa.

The world can’t be its own best representation because the world doesn’t represent anything; least of all itself. The world doesn’t mean anything and it isn’t about anything; it just is.
Jerry FODOR: There is a gap between the mind and the world, and (as far as anybody knows) you need to posit internal representations if you are to have a hope of getting across it. Mind the gap. You’ll regret it if you don’t.

Andy Clark: The machinery that makes minds can outrun the bounds of skin and skull.
Cognition is not inside the skull of an individual, and cognitive processes involve external structures and may be distributed across several subjects and even social groups (Hutchins, 1995; Rogers, 1997). For each signal, the speaker and the addressee try to create a joint construal of what the speaker is to be taken to mean by it (Clark, 1996). Such interaction abilities can collapse in pathology as *broken mirrors* are not good anymore, and social metacognition is irrelevant.
Such a capacity needs a number of activated cortical regions: the left medial prefrontal cortex, the orbito-frontal cortex and the left temporal cortex (Baron-Cohen et al 1994; Goel et al 1995; Fletcher et al 1995; Levine et al 1999; Vogeley et al 2001), the anterior cingulate cortex (Gallagher et al 2000; Gusnard et al 2001; Calder et al 2002; Castelli et al 2000; Brunet et al 2000).

In schizophrenia and other autistic spectrum disorders these regions and the mirror systems are malfunctioning leading to specific inability to represent one's own and other subject's mental states.
Deficient meta-level of activity in pathology and in young children

- Deficit of explicit planning and coordination
- Deficit of metacommunicative utterances (e.g., clarification requests, repairs, repair initiations...)
- Lack of metalinguistic utterances
- Lack of checking phases in interaction
Disruptive antisocial behavior is a hallmark of frontotemporal dementia. These profound changes in personality have been predominantly ascribed to degeneration of the right PFC & the temporal poles.

Dissociation between the impairment in ToM mechanisms and normal executive performance (including IQ)
What matters most is how you see yourself.
We know a lot about neurons as units. We are starting to know how they work together, we can even see it. Functional blocks, no modules, some localization and spread activity.
Occam’s razor: If one system can explain everything, why do we need to look for others?

The existing theories are rather contradictive (even interpreting the same experimental data)

Quantity of neurons

$10^{12}$ - **TRILLION** NEURONS IN THE HUMAN BRAIN

$10^{15}$ **QUADRILLION** SYNAPTIC CONNECTIONS
Forgotten 90 percent of the brain: **glial cells**, which outnumber our neurons ten to one. And no one really knows what they do.
Glia
Tanacytes and glia cells constitute a net around neurons
Neurons and glia
In spite of all the complexity there are still some mirrors we have now to persuade that Sphinx to tell us something: we have brain imaging technique (PET, fMRI, MEG, optical...) to see this film about what is going on, where and when. We also have a set of non-invasive techniques like lexical decision or eye-tracking to look into on-line processing and functioning attention
fMCi is a functional imaging technique with multicell loading of calcium fluorophores, it has unique advantages, including: i) recording *en masse* from hundreds of neurons in a wide area, ii) single-cell resolution, iii) identifiable location of neurons, and iv) detection of non-active neurons. In hippocampal area - 2000 frames per second

- Yuji IKEGAYA, Laboratory of Chemical Pharmacology, Graduate School of Pharmaceutical Sciences, The University of Tokyo.

raw movie

ΔF/F movie
Lateral views of the brains of Leborgne (left) and Lelong (right).

Paul Broca's historic cases: high resolution MR imaging of the brains of his patients - Leborgne and Lelong
What we know now: Modularity vs. Connectionism

- The cortex is a network - no modules or blocks
  - So, the cortical representation of language is a network
  - The cortical representation of knowledge in general is a network
  - The representation of memory is a network
  - Language uses the same cortical structures and processes as other cognitive skills
  - Except for phonetics, which has specialization
The Hunting of the Gene…
Evolution? Mutation? Creation?

FoxP2, FoxB1. HARF1.....
What we know is that a specific gene-group has been found - HAR - that caused acceleration of the frontal regions of the cortex in our ancestors and it developed 70! times as quick as the other parts of the brain. So, what did it give us? Quick computation! Giving us recursion rules.

But recursion is acting not only in linguistic processes subserving mental lexicon and grammar (morphosyntax), but in subserving social behavior.
Candidate gene loci for Reading Disability (RD) on chromosomes 1p36, 3p12-q13, 6p22, and 15q21, and the speech-language candidate region on 7q31 in a sample of 322 participants ascertained for Specific Language Impairment (SLI).
The experience of conscious will is a marvelous trick of the mind, one that yields useful intuitions about our authorship - but it is not the foundation for an explanatory system that stands outside the paths of deterministic causation.
Our brains are supposedly able to make a decision 7-20 seconds faster than our minds (Hugdahl et.al. 2008)

What about free will then?

What ethical and epistemological consequences can be faced by our culture in the context of neuro- and genetic data?
Our genetic storage is still unfolding today with technological and artistic innovations coming and changing so quickly.
J. Craig Venter has successfully created a living organism with a completely synthetic genome.

May 20, 2010
Eve, please meet Synthia!

It's life, but not as we know it
Daily Telegraph
21 May 2010
Not to ruin the world we should develop Responsibility and Morals.

Rembrandt  Conus_marmoreus
The soul may be a mere pretence, 
the mind makes very little sense. 
So let us value the appeal of that 
which we can taste and feel

Piet Hein

You are always welcome, Inger!
Thank you!