## Speechless

*"Is it conceivable that people should never speak an audible language, but should nevertheless talk to themselves inwardly, in the imagination?"*

(Wittgenstein *Ph. I.* 1953, 344)

## Inner Speech, Merge and the architecture of the Language Faculty.

**Andrea Moro**

**University School For Advanced Study IUSS, Pavia, Italy.**

## A preliminary issue.

## Two distinct paths

*Where* do neurons fire?

*What* do neurons fire?

## Localization

How much can be gained by focusing only on localization by way of imaging?

Not much, at this point - it is the 'homework problem', that is, an important but ultimately uninteresting step from the point of view of *explanation*.

Can we achieve unification by working on localization?

No! We need explicit linking hypotheses between well characterized brain mechanisms and linguistic computation.

Poepple – Embick

**WRONG QUESTION:** **where are syntax/phonology/ semantics mediated?**

**RIGHT QUESTION:** **what kind of computations in the brain form the basis of linguistic representations and operations?**

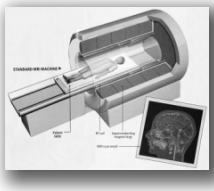
In a theory with linking hypotheses and some notion of what it means for an area to be ***specialized*** computationally, information about location could be potentially extremely important. Without those things, it is not so significant.

## The relevance of the *where*-problem.

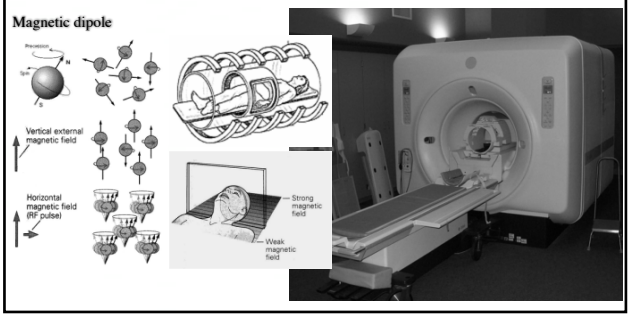
The *where*-problem can still be interesting insofar as the network activation tests a formal theoretical hypothesis which cannot otherwise be founded.

## Beyond pathology: the revolution of neuroimaging

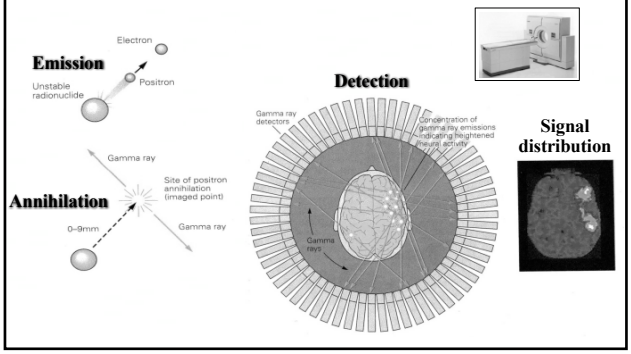
- By measuring blood perfusion (PET) and blood flow (fMRI) one can get information on local metabolism of brain activity of in vivo and healthy subjects.
- This is considered a sign of the underlying neural activity which is proportional to oxygen level carried by the blood (Friston 1996).



## functional Magnetic Resonance Imaging (fMRI)



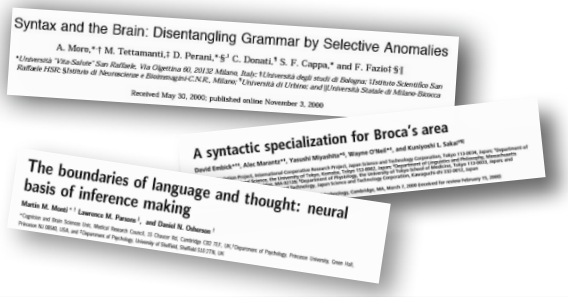

## Positron Emission Tomography (PET)



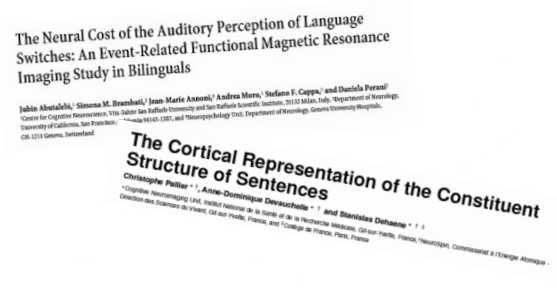

## The dogma of comparison

To study brain activity by measuring blood perfusion we must at least compare two distinct activities (subtraction) or two different moments of the same activity (parametric analysis) (Friston 1996).

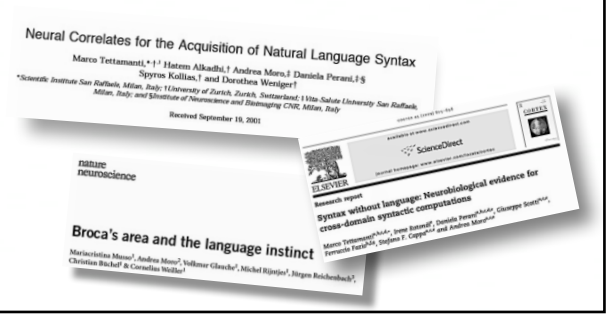
## The *where*-problem and autonomy of syntax.



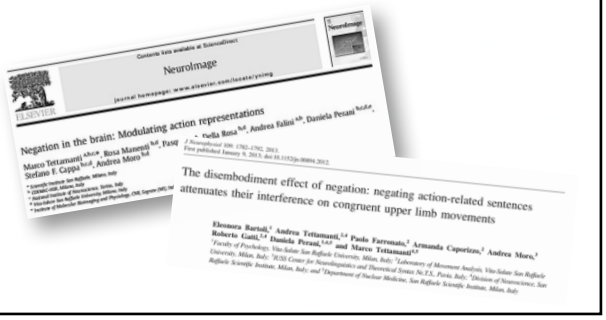

## The *where*-problem and the psychological reality of syntactic trees.



## The *where*-problem and Boundaries of Babel.



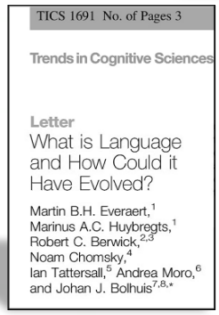

## The *where*-problem and the effect of negation on the brain.




## Against reverse engineering

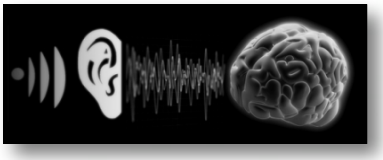
*"There is no denying that language is sometimes used to communicate.*

*However, this should not lead to the apparently common fallacy that the design of language can be inferred reverse-engineering style from this single functional perspective."*




## Part One: Inner speech and the *what*-problem

## Waves are the stuff language is made of

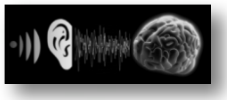


From a physical point of view language consists of waves: air waves (sound) outside us or electric waves (neural activity) inside us.*

* When language is written, it consists of light which is also a wave.

## A simple question.

How much do these two types of waves correlate?

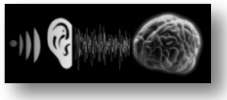


## The "anchoring problem"

To decode the neuronal electric code we must find at least one common phenomenon correlating with that code and the linguistic regularieties we know.

## Perceiving vs. producing language

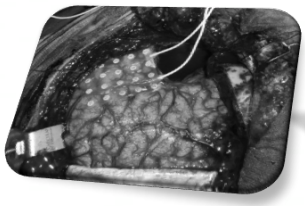
The electric waves generated by perception must contain acoustic information in the acoustic areas but what about non-acoustic areas such as Broca's area or those waves generated by production?

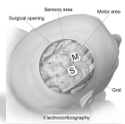


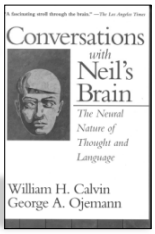
## The "anchoring problem" in non-acoustic areas

To decode the neuronal electric code exploited in higher language areas we must find at least one common phenomenon correlating with that code and the linguistic regularieties we know.

## New frontiers in Neurolinguistics





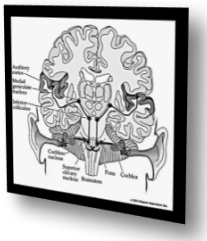




Awake surgery procedures allow to interfere with and to measure the electric cortical activity.

## Preliminaries: ascending pathways

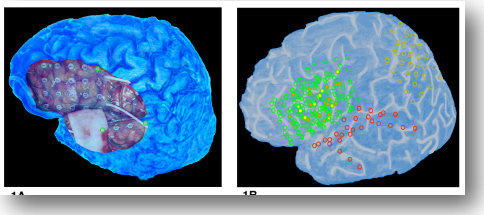
- Sound is mapped onto the auditory cortex (tonotopy) eliciting neuronal electric activity (ECoG) which preserves the shape of sound waves (Giraud – Poeppel 2012, Pulvermueller et al. 2006, Nourski et al. 2009, Pasley et al 2012).

- Electric waves preserving sound shapes are present in Broca's area ECoG activity recorded during language perception (Mesgarani et al. 2014, Kubanek et al. 2013).



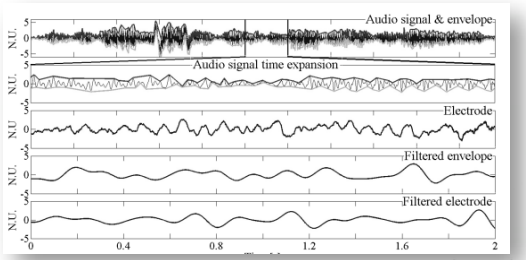
## Sound-waves as code breakers

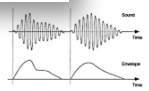
## Awake surgery and the measurement of Electrocortical Waves



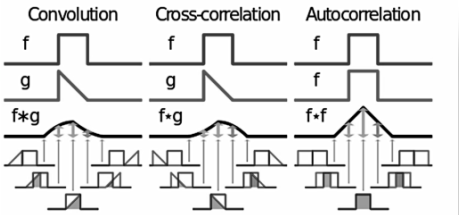
(cf. Ojeman et al. 1989 for the functional identification of Brocas areas)

## Acoustic vs. electric signals

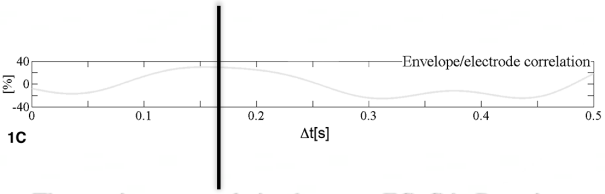


## Comparing non-simultaneous waves

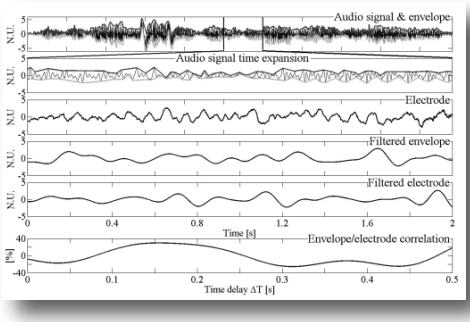



## Correlating sound and neuronal waves




The maximum correlation between ECoG in Broca's area and Sound waves takes place 170 ms before any sound is emitted.

## Summarising




## A simple surprising fact.

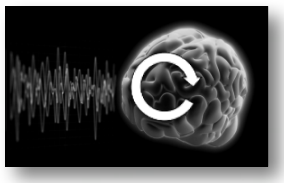
*"When [Ambrose] read, his eyes scanned the page and his heart sought out the meaning, but his voice was silent and his tongue was still."*

(Augustine, Confessions VI)

## The paradigm

Subjects were asked to read the same linguistic expressions given them at the same pace first aloud and then silently.

## The sound of thought

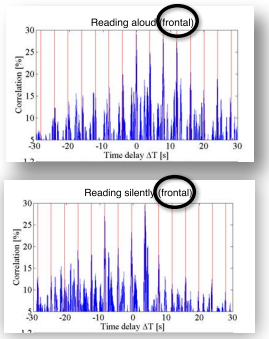


**Comparing the ECoG and sound* correlation in Broca's area during 50 sec of silent and aloud reading yields strong similarity.**

*** Not articulatory or motor planning.**

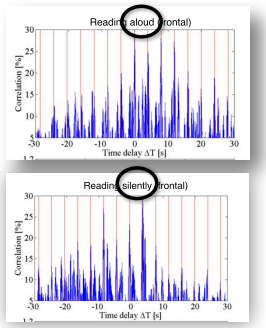
## The sound of thought: the data

**Comparing the ECoG and sound correlation in Broca's area during 50 sec of silent and aloud reading yields strong similarity.**



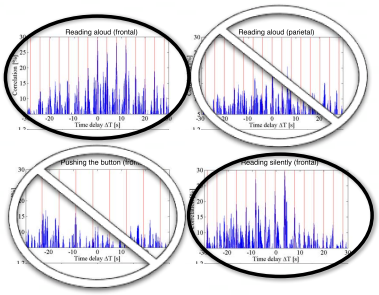

## Comparing inner vs. loud speech.

Comparing the ECoG and sound correlation in Broca's area during 50 sec of silent and aloud reading yields strong similarity.

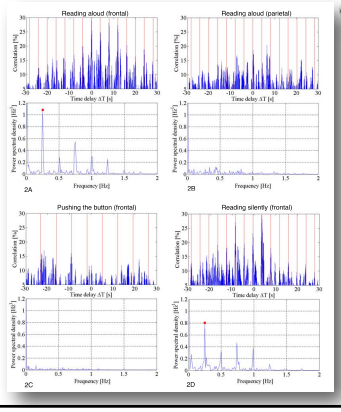



## Further Contrasts.

**Comparing sound ECoG correlations with non-linguistic areas and non-linguistic stimuli**




## Summarising and including periodograms



## On the presence of grammatical information.

The different response ensures that this is not just an acoustic area/process.

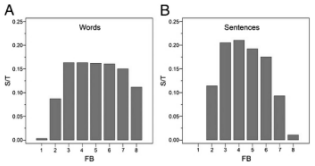



**Fig. 4.** The cross-correlation of the envelope of the speech sounds with the ECoG above background is differentially distributed in the frequency bands according to the presence of specific morphosyntactic structures (words vs. sentences) contained in the text read by the patients. (*A*) Histogram showing the number of electrodes with suprathreshold correlation in each ECoG frequency band (FB) when patients were reading words. *S/T*: Ratio between electrodes showing suprathreshold correlation in each ECoG frequency band and the total number of electrodes in all ECoG frequency bands. (*B*) Same as above, but values referred to patients reading sentences.

## Future applications

It can be used to help patients with language impairment.

It can be used to acces thoughts people do not want to reveal.


## Summary: on the *what*-problem

The electric-waves generated by neurons to communicate with each other when exchanging linguistic information correlates with the sound-waves of the corresponding words and sentences, independently from the presence of sound.

## Open questions

- Why are phonetic representations present during inner speech?
- Why are phonetic representations present in non-acoustic areas?
- What does a born-deaf person's brain network generates during inner speech?
- Is there late insertion?

## Part Two: Generalized Merge

## On "Generalized Merge"

What is Suppletive Allomorphy? On *went* and on **goed* in English*

Richard S. Kayne
New York University

December 11, 2016

# $GM_1$
# The empirical problem

1. Introduction.
Embick and Marantz (2005, 244) allude to "blocking effects, such as *went* blocking *goed*". This specific blocking effect is illustrated in:
(1) They went/*goed to the movies last night.
However, **goed* is also impossible as a past participle:
(2) They have gone/*goed to the movies several times this month.
This second fact about **goed* could also be stated as a blocking effect. **Goed* would then be blocked as a past tense form by *went* and, separately, as a past participle, by *gone*.[1] Such an approach to (1) and (2) would fail, though, to give a unified account of the impossibility of **goed* in both (1) and (2).

# $GM_2$
# Morphological minimality

We are now in a position to understand a striking fact, namely that *-ed* forms never show a stem alternation, i.e. adding *-ed* never changes the bare form of the verb, the reason now being formulable as follows:[9]
(16) The English theme vowel *-e-* protects the stem from being affected by *-d*.
An exemplary minimal pair is *tell* vs. *spell*:
(17) tell, told
(18) spell, spelled
By (16), the theme vowel *-e-* in *spelled* ensures that the stem remains *spell* in *spelled*. In *told*, on the other hand (and similarly for *sold*), there is no theme vowel. Therefore a stem alternation is possible and we have *told* rather than **telled*. In the spirit of Chomsky and Halle (1968, 69, 184n), the orthography here seems to be telling us something about abstract representations. The orthographic presence of *-e-* before *-d* in *spelled* is a clue to the morphosyntactic presence of a theme vowel that is missing in *told* and *sold*, even though that *-e-* in *spelled* is not pronounced.[10]

# $GM_3$
# The empirical problem solved

(57) *beed, *haved, *doed, *goed, *comed, *taked, *bringed, *putted, *getted, *gived, *maked, *letted, *sayed, *canned, *willed, *shalled, *mayed, *musted
Thus the blocking approach to *went* and **goed* mentioned at the beginning of the paper not only misses the generalization that **goed* is unacceptable both as a past tense form and as a participle form, it also misses the generalization that **goed* is part of the broader fact about English illustrated in (56)/(57).[52]

# $GM_4$
# Implications

Assume that the case of *went* and **goed* is representative of suppletive allomorphy. If so, then the language faculty will not need to allow recourse to blocking in such cases. This in turn leads to the possibility that the language faculty turns its back on blocking in a general way. But rather than address the general status of blocking, let me instead turn to the related notion of late insertion, as clearly discussed in Embick (2015). The question is whether late insertion (whether limited to non-roots or not[48]) is available to the language faculty. (Certainly, it has not been required anywhere in the preceding discussion of *went* and **goed*.) More specifically, we can wonder:[49]
(76) Why would the language faculty have turned its back on late insertion (if it has)?

# $GM_5$
# Restricting bundling

(78) UG imposes a maximum of one interpretable syntactic feature per lexical item.
If we strengthen (78) by dropping the word 'interpretable', as in:[50]
(79) UG imposes a maximum of one syntactic feature per lexical item.
then we have a decompositionality principle that in effect says that there is no bundling of syntactic features into a single head.[51] But if that is the case, the question is, why not? That is, what would lead the language faculty to have the property expressed in (79)?

# $GM_6$
# Unifying compositional mechanisms

The answer that I would like to propose runs as follows. Taking a cue from discussions with Chris Collins and thinking of Agbayani and Ochi (2014) and references cited there, bundling must be an instance of Merge.[52] Now let me add to this an idea from Kayne (2011, sect. 4), to the effect that every instance of Merge must be associated with a precedence relation. If so, then bundling (= merging) two syntactic features together must result in one preceding the other, in a way that wouldn't fit with the usual interpretation of the term lexical item.[53]

## $GM_7$
## Morphemes and segments

What is important in the preceding section for the idea that syntactic structure cannot in principle be built up in a phonologically-free way is the assimilation of bundling to merge, insofar as that kind of assimilation can be extended to phonology. Consider the fact that morphemes are not atomic, insofar as they are composed of (a syntactic feature associated with) phonological segments,[54] in turn composed of phonological features. Assume now that composition, in this sense, is also not distinct from merge.

## $GM_8$
## Unifying Merge (Bundling) and composition

fact that morphemes are not atomic, insofar as they are composed of (a syntactic feature associated with) phonological segments,[54] in turn composed of phonological features. Assume now that composition, in this sense, is also not distinct from merge.

If so, then the language faculty will have phonological features merging to form segments, and segments merging to give the phonological form of a morpheme, which

## $GM_9$
## Generalized Merge

sufficient for our purposes. We need to assume further and more specifically that there (is and can be just one single "merge engine", i.e. that bottom-to-top bare phrase (structure-type derivations (as in Chomsky (1995, 249)), must in fact start with (phonological features, continue on up through the phonology and only then reach the syntax.

## $GM_{10}$
## Excluding late insertion and the externalization problem

phonological features, continue on up through the phonology and only then reach the syntax.

A resolutely bottom-to-top derivation of this sort that starts with the phonology would by definition preclude late insertion[57] and would thereby eliminate as a matter of principle the redundancy in (77) that late insertion leads to.

If the language faculty has a single merge engine in the preceding sense, then that constitutes a straightforward solution to the externalization problem discussed by Chomsky (2009, 386).

## $Gm_{final}$
## Explaining Inner Speech ECoG

20. Conclusion.

I have proposed analyses of English *went* and of English **goed* that revolve around the notion of verbal theme vowel. These analyses do not invoke late insertion. It may be that late insertion is systematically unavailable. That may be due to the fact that merge-based bottom-to-top derivations start with the phonology, merging phonological features and then segments, before moving up to syntactic features; if so, phonology feeds syntax and should not be factored out of it.

## A retrospective prediction.

If the formal hypothesis of a Generalized Merge and the electrophysiological findings on Inner Speech are correct, then we would see not just the confirmation of an empirical finding by a later theory but by one which was motivated by independent empirical data and completely different goals.

# Part Three:
# De Saussure revisited

## The prevalence of sound.

The structure of the signifier may be more deeply entangled in the actual neurobiological process constituting linguistic computation then previously thought. This poses new computational, neurobiological and evolutionary questions which call for a revision of the current models.

*Le signifiant, étant de nature auditive, se déroule dans le temps seul et a les caractères qu'il emprunte au temps: a) il représente une étendue, et b) cette étendue est mesurable dans une seule dimension; c'est une ligne. Ce principe est évident, mais il semble qu'on ait toujours négligé de l'énoncer, sans doute parce qu'on l'a trouvé trop simple; cependant il est fondamental et les conséquences en sont incalculables; . . . Tout le mécanisme de la langue en dépend.*

Ferdinand de Saussure

## Syntax and linearization: a Dynamic Antisymmetry perspective.

In a DA framework, movement can be either related to the impossibility to linearize a Point of Symmetry (Moro 1997, 2000) or to label the constituent resulting from Merge (Moro 2009): these findings suggest that linearization must be set before spell-out and thus cannot be used to decide which interpretation of the DA principle is correct (if there is only one).

## Movement and feature-checking.

The Generalized Merge approach is not immediately compatible with the feature-checking theory of movement for the features may not be accessible to computation. If the EPP and wh-movement can be reduced to DA, still other types of A'-movement may constitute a problem.

## Sources of instability in syntax: on symmetry breaking phenomena

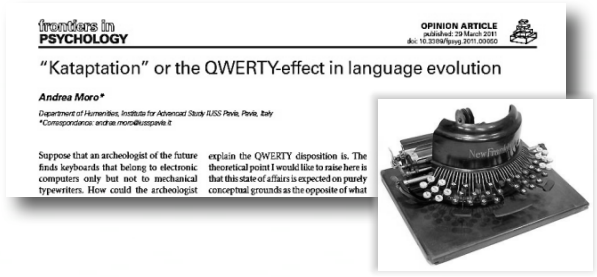
Syntax appears to require asymmetric structure for computation or linarization reasons. One example of unstable structures is Copular Constructions constituting the base for Dynamic Antisymmetry approaches to movement (Moro 1997, 2000, Chomsky 2013).

## Complexity, instability, morphogenesis.

*"It is suggested that a system although it may originally be quite homogeneous, may later develop a pattern or structure due to an instability of the homogeneous equilibrium, which is triggered off by random disturbances. It is found that there are six essentially different forms which this may take"*

(Turing 1952, adapted)

## Kataptation or the lost reasons of Babel.



frontiers in PSYCHOLOGY

OPINION ARTICLE
published: 29 March 2011
doi: 10.3389/fpsyg.2011.00050

"Kataptation" or the QWERTY-effect in language evolution

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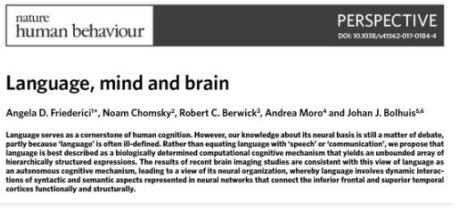
Suppose that an archeologist of the future finds keyboards that belong to electronic computers only but not to mechanical typewriters. How could the archeologist explain the QWERTY disposition is. The theoretical point I would like to raise here is that this state of affairs is expected on purely conceptual grounds as the opposite of what

## A unified perspective



nature human behaviour

PERSPECTIVE

DOI: 10.1038/s41562-017-0184-4

**Language, mind and brain**

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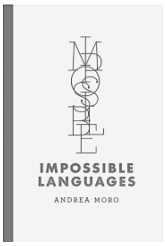
Language serves as a cornerstone of human cognition. However, our knowledge about its neural basis is still a matter of debate, partly because 'language' is often ill-defined. Rather than equating language with 'speech' or 'communication', we propose that language is best described as a biologically determined computational cognitive mechanism that yields an unbounded array of hierarchically structured expressions. The results of recent brain imaging studies are consistent with this view of language as an autonomous cognitive mechanism, leading to a view of its neural organization, whereby language involves dynamic interactions of syntactic and semantic aspects represented in neural networks that connect the inferior frontal and superior temporal cortices functionally and structurally.

*Language appears to be the "constant scandal" of nature but it seems we have never been so close to see the hidden connections behind it.*

## Thank you




## Thank you