

Why Everything You Know About Language is Wrong

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COVID-19 Weekly Webinars

University College Dublin, School of Medicine (July 16th 2021)

1) The English language is a language.

2) Language is for communication.

3) Words refer to things in the world.

4) The brain's language areas give rise to language.

What is a word?

“A word has a sound with a meaning”.

The concept of a 'word' is an informal abstraction from folk psychology

Linguistics deals with units of computation that may host a constellation of *syntactic*, *semantic* and *phonological* features

Ouch!

Hello

These words have a semantics and a phonology, but no syntax

- **English:**

It is completely dry

'It' has a syntax and a phonology, but no (conceptual) semantics

- **Italian** (a 'pro-drop' language):

È completamente secco

is completely dry

John read Infinite Jest

[What] did John read [] ?

Copies of syntactic objects have a syntax and a semantics, but no phonology

The language system manipulates atoms of computation from the lexicon that may host any number of syntactic, semantic or phonological features

But if 'words' cannot be defined *mind-externally* in terms of acoustic properties or aspects of speech/sign, then how can we go about defining what language is?

I-language vs E-language

Internal, individual, intensional

External(ist)

We skip 30% of words when we read, especially high frequency function words.

We don't actually look at all words, we just see what the language system needs for us to infer a generative meaning.

Old English ('V2' – verb must come as 2nd concept, so permitting SVO)

Middle English (SOV, then some use of VSO, then SVO)

Modern English (SVO)

So we have SVO, then SOV, then back to SVO – is it the same language?

If 'language' is something like Middle English, then there must have been a point when Modern English came about (granted some vagueness).

Humans have a mind-internal generative computational system that maps complexes of features (syntactic, etc.) to a workspace, to merge with other features, and then can recursively call this set again

Basic computational procedure:

$\text{MERGE}(a),(b) = \{a,b\}$

'the man'

$\text{MERGE}\{a,b\},(c) = \{\{a,b\}c\}$

'the man slept'

Restricting this operation to a single element can yield the natural numbers

MERGE the empty set with itself, and again...

$\{\} > \{\{\}\} > \{\{\{\}\}\} \dots$

1, 2, 3 ...

We each have a distinctly set I-language, with varying phonology, and largely overlapping but still distinct syntax and semantics

Most of variation in the 'world's languages' (convenient abstraction) is in **morpho-phonology**, not in syntax-semantics

All languages make use of MERGE and basic, universal semantic features – they differ widely in their use of externalisation (sound)

While two structures might exhibit different linear orders, they may exhibit the same underlying hierarchical order, as in (8) (English) and (9) (Basque), where the Verb-Direct Object dependencies are the opposite but the interpretation is strictly conserved.

(8)	John	has	read	the book
	<i>John</i>	<i>auxiliary</i>	<i>read</i>	<i>the book</i>
(9)	Jonek	liburua	irakurri	du
	<i>Jon</i>	<i>book</i>	<i>read</i>	<i>auxiliary</i>

This suggests that the syntax encodes the Verb and Direct Object as an abstract phrase which omits the subject; roughly [Subj [V DO]]. Different languages externalize these abstract relations in different ways, but the syntax itself does not consider linear order.

Campbell's monkeys

'krak', 'hok', '-oo' (intensifier)

Able to concatenate two objects, but no more

Humans don't just concatenate, we create phrase structures

After MERGE, the resulting set needs to be given a categorial (syntactic) identity which feeds interpretation/semantics

'red boat' – a boat that is red, not a red quality which hosts boat-like features

'John ran' – an event in which John was the agent, not a special kind of John

MERGE generates *hierarchical* structures, not linear strings

The man is happy

[Is] the man [∅] happy?

The man who is tall is happy

*[Is] the man who [∅] tall is happy?

[Is] the man who is tall [∅] happy?

Syntax cares about structural proximity, not linear proximity:

The man _{who is tall} is happy (“who is tall” is embedded deeply)

A number of robust findings from theoretical linguistics can be used to support the image of the brain as a ***constructive organ***, assembling and inferring linguistic representations in the service of surprise minimization and related goals.

Syntactic structures are not mind-external entities, but are rather **actively inferred by the brain**

Substitution of phrase displays understanding of complex syntactic identity:

John went to the old restaurant

John went to [it]

Constraints:

John ate chicken and bread for lunch

[What] did John eat [] for lunch?

*[What] did John eat chicken and [] for lunch?

Entire conjunct [chicken and bread] must be questioned, not discrete parts

Hinders communicative efficiency

Sam [gave a guitar to me] and [loaned a trumpet to you]

What did Sam [give ___ to me] and [loan ___ to you]?

*What did Sam [give ___to me] and [loan a trumpet to you]?

- (1) Mary said [that he_i has a lot of talent] and [that Peter_i should go far]
(2) *[He_i has a lot of talent] and [Peter_i should go far]

Pronoun reference is sensitive to syntactic identity: a Complementizer Phrase in (1), and a Tense Phrase in (2)

Co-reference via Prepositional Phrase fronting is barred, since syntax preserves interpretation across movement:

(3) John_i said he_i is proud of his house

(4) *[In John's_i house] he_i organized a meeting []

Syntax wins over linear precedence (*He_i organized a meeting in John's_i house)

I gave her_i the book that Sarah_i always wanted

*I gave her_i the book that Sarah_i wanted

Moral hierarchy: Agent, Patients, embedded in events



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Review

The Universal Generative Faculty: The source of our expressive power in language, mathematics, morality, and music

Marc D. Hauser ^a ✉, Jeffrey Watumull ^b

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<https://doi.org/10.1016/j.jneuroling.2016.10.005>

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Highlights

- We propose that the expressive power of human thought derives from a computational system we call the *Universal Generative Faculty* or UGF.
- UGF is a suite of contentless generative procedures that interface with different domains of knowledge to create contentful expressions.

Restricting Merge to a single element, X , yields the natural numbers: take the empty set and Merge it with itself

$\{\emptyset\} > \{\{\emptyset\}\} > \{\{\{\emptyset\}\}\}$

We can call $\{\emptyset\}$ 0, $\{\{\emptyset\}\}$ 1, etc...

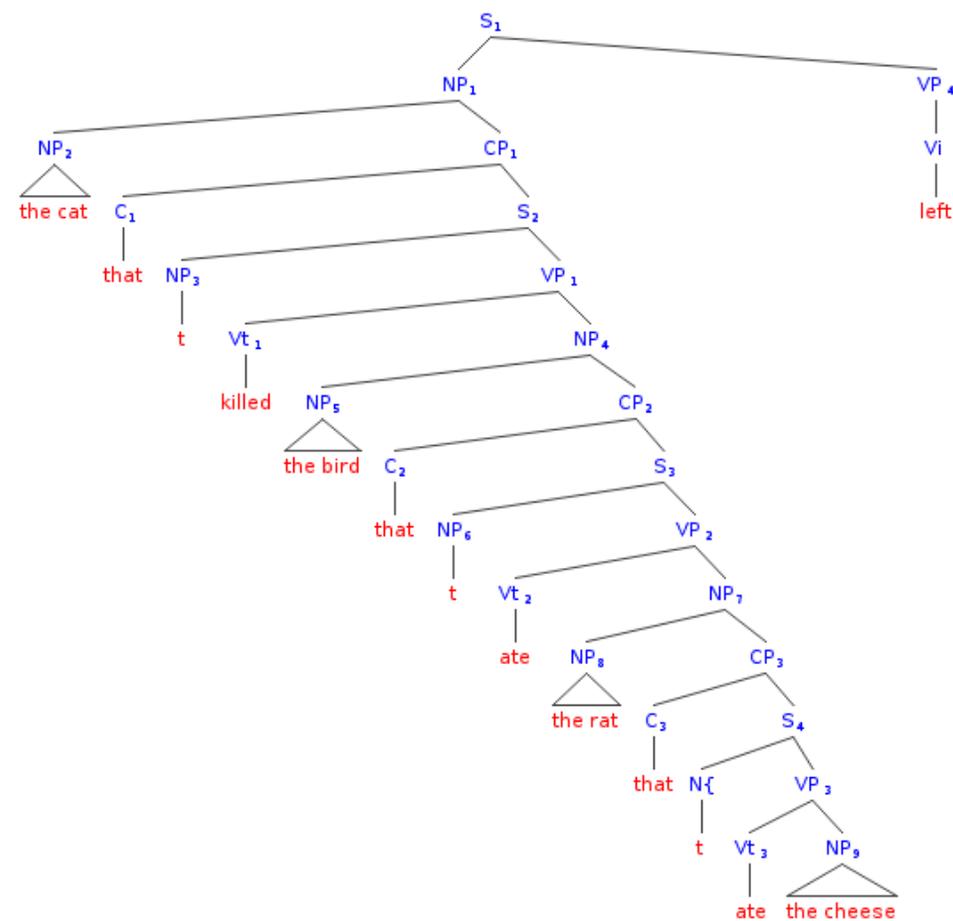
Christus, der ist mein Leben 1st phrase (J.S. Bach)

When UGF interfaces with numeric system of quantification, we get natural numbers

When UGF interfaces with sound system, we get music

When UGF interfaces with theory of mind and moral judgement, we get system of morality

When UGF interfaces with lexicon, we get language. Only language seems to attribute to Merged elements an independent syntactic identity which can be recursively called again



Only humans have language

Unique level of tool complexity involving MERGE (rock + shaft = spear, etc, with added **functional abstraction** for *use* and not just *form*)

Only humans have what Chomsky loosely calls the “**science-forming faculty**” (Peircean abduction, non-deductive complex inference generation abstracted from concrete particulars, etc)

E.g. Some weird event, E, occurs. We know that if A is true, then E would follow naturally. So we assume A.

Human language can uniquely distinguish [[un]lockable] from [[unlock]able]

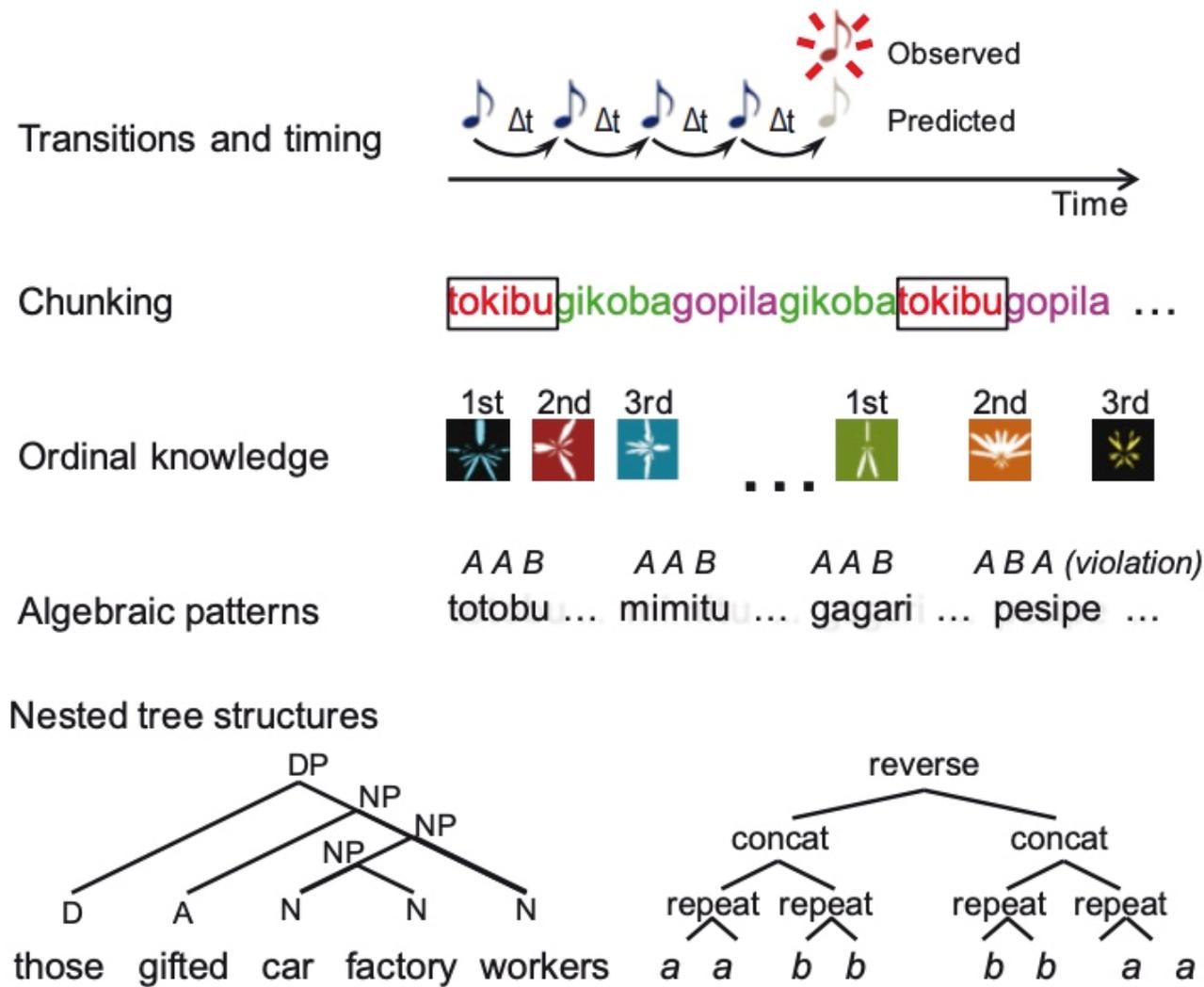


Figure 15.1 A typology of sequence representations. Five types of mental representations of sequences are postulated (for further details, see Dehaene et al. 2015). The first four are present in nonhuman animals, but a capacity to quickly acquire and manipulate nested tree structures may be unique to the human brain. From Dehaene et al. (2015), used with permission.

Natural language syntax complies with the free-energy principle

AUTHORS

Elliot Murphy, Emma Holmes, Karl Friston

AUTHOR ASSERTIONS

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Page: 1 of 74 Automatic Zoom

1 Natural language syntax complies with the free-energy principle

2

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Abstract

Natural language s
We claim that thes
principle (FEP). Wh
attempted to conn

[See more](#)

1) The English language is a language.

2) Language is for communication.

3) Words refer to things in the world.

4) The brain's language areas give rise to language.

OVERVIEW ARTICLE

Language design and communicative competence: The minimalist perspective

Elliot Murphy^{1,2,3}

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Thinking of a problem in your office, writing it down

Talking to yourself

Using cognitive capacities which syntax may have provided
subconscious computational contributions to

Maintaining social bonds ('small talk')

There are close ties between syntax and meaning: If you had a structure that was conceptually empty, it would not be natural language

“The police car sirened up to the accident site”

The meaning does not come from the sound of the siren, but from the syntactic role it is able to play as a particular type of verb

Linguistic computation is optimized for the generation of interpretable syntactic structures, rather than for the generation of maximally communicative messages to conspecifics.

In other words, **whenever there is a conflict between principles of computational efficiency on the one hand, and principles of communicative clarity on the other, the former typically wins.** The normal functioning of syntax leads to instances which reduce communicative efficiency.

(10) You persuaded Saul to sell his car.

The individual ('Saul') and the object ('car') can be questioned, but questioning the more deeply embedded object forces the speaker to produce a more complex circumlocution (below, [] denotes the originally merged position of the *wh*-expression).

- (11) a. *[What] did you persuade who to sell []?
b. [Who] did you persuade [] to sell what?

The structures in (11) involve the same words and the same interpretations, yet the more computationally costly process of moving the more deeply embedded (and more difficult to search for) element cannot be licensed.

Common argument (e.g. from Gregory Hickok):

General intelligence scores are often not impacted in patients that lose core language functions, so therefore language cannot be closely intertwined with cognition, and nor could it have evolved for purely cognitive reasons

The unique contribution of language is not to communication, but rather to cognition

“But language surely evolved (was selected for) because it allowed us to communicate more complex ideas to each other”.

>> These complex ideas were themselves constructed mentally via hierarchical syntactic structures

What is language? “Geometry” was originally the study of “land measurement” but developed a sufficiently rich body of knowledge to abstract away from original object of inquiry and also departed from common-sense intuition. Our common-sense intuitions about what “language” is have no place in science, ditto for our common-sense notions of “mass” and “energy” for physics.

Ev Fedorenko (MIT) recently conducted a Mechanical Turk study asking ordinary people what they thought language’s primary function was: most said “communication” (in line with common-sense) and she used this to attack the generative grammar conception of language as an “instrument of thought”. But a physicist would not conduct a Mechanical Turk study asking people what they thought about the nature of “light”.

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Internalism vs Externalism (with respect to philosophy of language and mind)

Internalism: mental representations are used to make inferences about data acquired through sensory epithelia (meaning is in the head)

Externalism: what is going on in an individual's mind is not (entirely) determined by what is going on inside their brain (meaning is not in the head)

The extent to which properties of language are innate is often overlooked in the literature. Considering the development of the lexicon, words involving polysemy (book, newspaper, city, lunch) involve associating semantically distinct senses for which there is no immediate evidence in the environment (e.g. a lunch can be an abstract event or a physical item of food), and simply associating a sound with a 'thing' in the world will not suffice to generate this knowledge in children.

Escher sentences – illusions that expose the non-referential representational character of language

“More people have been to Russia than I have”

(comparative calculation vs binarity)

Simple lexical items have properties that go beyond the semantic complexity of other atomic representations:

“The large school with large windows next to the river starts at 9am and has a strict headmaster and unruly students”.

There is nothing in the extra-mental world that can simultaneously be a location, an artifact, an event, a social group...

“The average man is concerned about wage cuts because he needs to afford insurance”.

Does language commit us to the belief that the world is made of things like average man and wage cuts and relations of concern?

London can be “fun” and “polluted” and burned down and re-built 10 miles up the river Thames, and still be called “London”.

Consider the Twin Earth thought experiment (Putnam 1975). In some parallel universe, it is said that water is not made of H₂O but rather some other substance, XYZ: Can the inhabitants of this Twin Earth use 'water' to refer to this substance? Putnam says 'No'. The internalist project in semantics says 'Yes', because 'water' seems to be polysemous between some more common, function-based sense, and a more concrete, technical sense.

Indeed, imagine some other parallel universe: Pietroski (2017) offers Fraternal-Earth, where doppelgangers of our scientists discover that what they have all been loosely calling 'mud' in fact has a deep, uniform chemical structure. All forms of 'mud' are of substance XYZ, hence they can use the concept 'mud' to refer successfully to all physical structures of 'mud'. But it does not follow from this that the inhabitants of Fraternal-Earth could not have used 'mud' to refer to our chemically-diverse samples of mud, if they entered a black hole and ended up in the English countryside. The idea that their 'natural kind'-conforming use of 'mud' could not readily be extended to a polysemous (function-informed) sense is not well-supported. Hence, we can use simple words like 'water' and 'mud' to access multiple concepts.

Pietroski (2017: 207), using US government statistics, notes how Diet Coke has a higher percentage of H₂O than “the stuff from my well”. He adds that “Diet Sprite[®] and club soda are even more like H₂O” yet are not deemed *water* for reasons to do purely with “intended purposes”.

Saul Kripke's (2021) response to Chomsky:

You're not saying there aren't extensions, you're just saying the extensions are complicated; maybe words do refer to things in the world, they just refer to extremely complicated things.

However, there's no explanatory advantage to this step, it's just an additional stipulation.

Scattered entities can be taken to be single physical objects under some conditions: consider a Calder mobile. The latter is a 'thing,' whereas a collection of leaves on a tree is not (unless these leaves are placed for, say, the purposes of an art installation). The reason seems to be that the mobile is created by an act of human will.

Question: How are these human-specific notions of function and intention coded into the lexicon?



Sorites paradox, Ship of Theseus...



“John burned every book in the library”



**“London burned down and was re-
built 50 miles up the Thames...”**

Bertrand Russell's claim that objecthood is based on spatiotemporal contiguity cannot be sufficient: The four legs of a dog could be seen as a single object under many conceivable contexts, such as if they were cut off, tied together and used as a doorstop, still being understood by its user to be part of a dog. Abstract objects do not bear causal relationships and are not spatiotemporally located (an 'object' is also usually understood to be a concrete thing, hence the confusion when some are denied spatiotemporal relations).

A psycholinguistic lens is also needed:

- a. Batman fights more mobsters than Bruce Wayne.
- b. Batman fights more mobsters than Batman.

There is a constraints on discourse interpretation in language through which whenever there are two referential expressions in a single clause, they are default interpreted as non-identical (redundant computation), and as such reference is obviative. The sentence in (b) forces us to search for different referents.

Another psycholinguistic lens is needed:

The city has 500,000 inhabitants and outlawed smoking in bars last year

*The city outlawed smoking in bars last year and has 500,000 inhabitants

The effects of predicate ordering appear to be anchored around *semantic complexity*, such that “copredications” with semantically Simple-Complex predicate orderings are more acceptable than the reverse



University College London

PhD Thesis

*Linguistic Representation and
Processing of Copredication*

Author: Elliot Murphy

First Supervisor: Wing-Yee Chow

Second Supervisor: Andrew Nevins

Any object is much more than its (i) *material constitution* and its (ii) *function* (as Aristotle assumed): we can also use its (iii) *origin* (Hobbes) or derive a sense of (iv) *continuity* (Locke's view of personhood, which can be shown to generalize far beyond humans) to individuate entities. In addition, we also have (v) *extra-linguistic biases* for shaping objecthood, pertaining to default marking of object surfaces ("John painted the house brown" implies he painted the external surface).

At least these 5 components, likely more, are encoded somehow via language.

What is language?

*Love, like Matter, is much
Odder than we thought.*

W.H. Auden

- 1) The English language is a language.
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- 4) The brain's language areas give rise to language.**

The “language network” extends to substantial parts of superior and middle temporal cortex, inferior parietal cortex, but also subcortical areas such as the basal ganglia, the hippocampus and the thalamus.

The image shows a screenshot of a preprint page. At the top, the title "Subcortical syntax: Reconsidering the neural dynamics of language" is displayed in white text on a dark background. Below the title, the authors "Elliot Murphy, Koji Hoshi, Antonio Benítez-Burraco" are listed. Underneath, there are three dropdown menus for "Conflict of Interest: No", "Public Data: No", and "Preregistration: No". The main content area is framed by a dark border and contains the title, authors, and a list of three affiliations. On the right side, there is a sidebar with a "Download preprint" button, a "plaudit" logo, and an "Abstract" section with a "See more" link. The bottom of the page shows a "Preprint DOI" section.

Subcortical syntax: Reconsidering the neural dynamics of language

AUTHORS
Elliot Murphy, Koji Hoshi, Antonio Benítez-Burraco

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Page: 1 of 34 Automatic Zoom

Subcortical syntax: Reconsidering the neural dynamics of language

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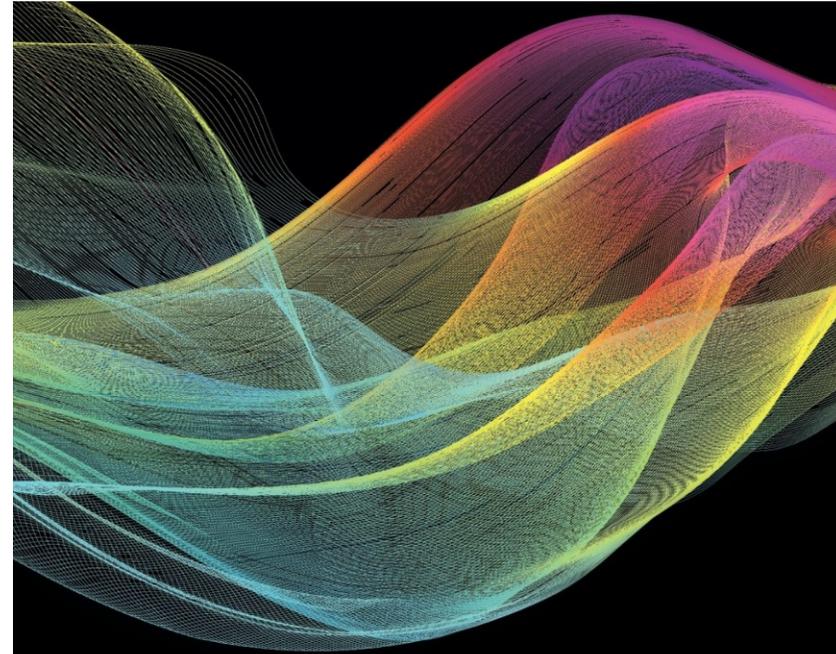
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Abstract

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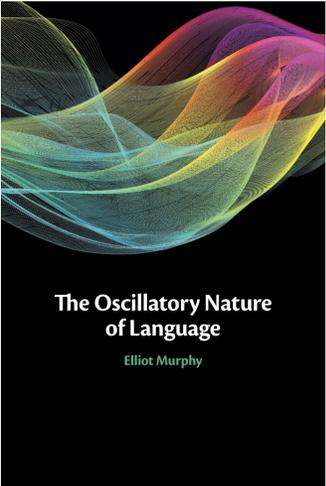
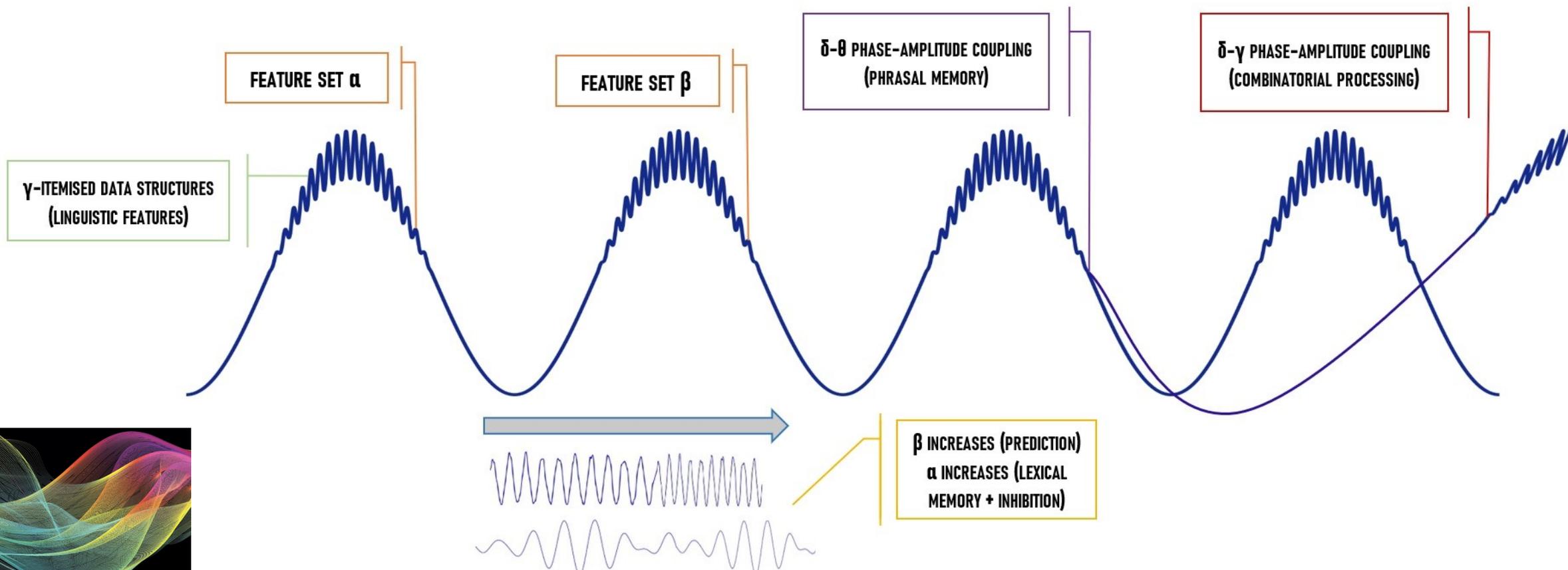
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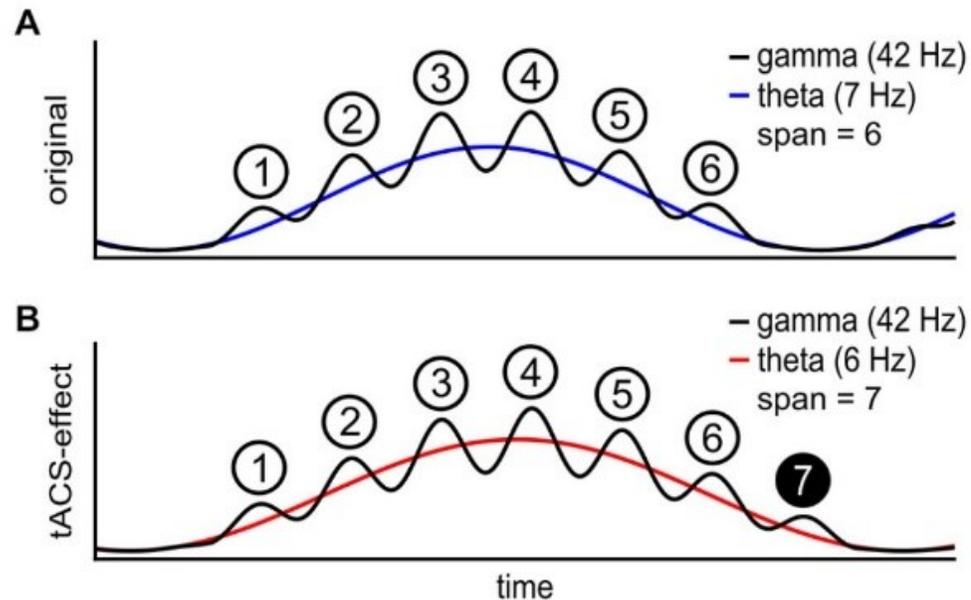
The Oscillatory Nature of Language

Elliot Murphy



Reasons to believe that the θ - γ code is causally implicated in memory retrieval and maintenance come from Vosskuhl et al. (2015):

- 1) Transcranial alternating current stimulation (tACS) decreased participant's θ .
- 2) The θ : γ ratio changed and an abnormally large number of γ cycles could be nested within θ .
- 3) Enhanced short-term memory performance.



The number of γ cycles able to be embedded within a θ cycle may be a major constraint of working memory limits

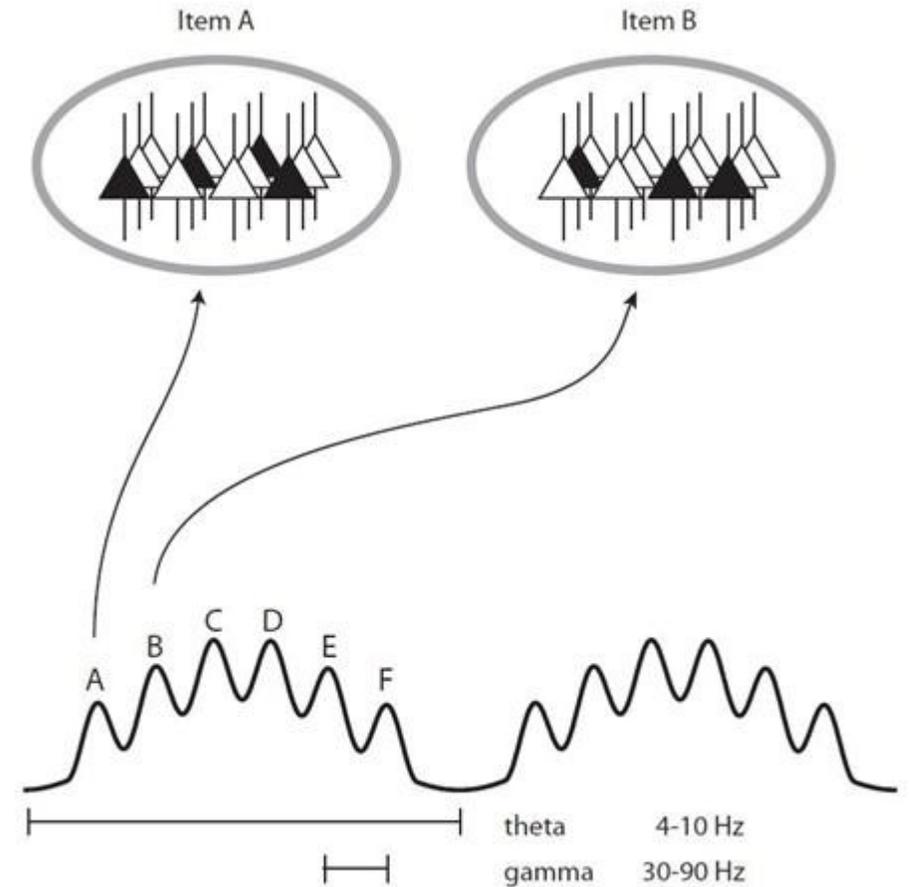
Nested γ cycles could act as multiplexing mechanisms for sustaining working memory representations by sending multiple representations as a single complex message to be recovered and 'unpacked' downstream, such that information encoded by the faster rhythm would be integrated over the time scales of the slower rhythm – precisely what is needed for syntactic structures.

e.g. the cell assembly that fires during a given γ cycle forms a topographic pattern representing a particular item from memory.

Slower θ waves would presumably improve the fidelity of the representations accessed, given the greater number of γ bursts nested.

However, a certain trade-off is also at play: There would be a slower rate of memory re-activation for a sequence of items if the θ waves are long, since slower waves would need more time before all memory items are represented.

>>> careful balancing act: the brain selects an appropriate representational fidelity whilst also trying to maximize reactivation speeds





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Review article

Language deficits in schizophrenia and autism as related oscillatory connectomopathies: An evolutionary account

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The Oscillopathic Nature of Language Deficits in Autism: From Genes to Language Evolution

Antonio Benítez-Burraco¹ and Elliot Murphy^{2}*

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Problems with syntax in ASD are suggestive of an impairment of the procedural memory.

Language impairment in ASD also involves problems with binding, relative clauses, *wh*-questions, raising and passives.

Frequency band	Role in the present model of language computation	Observed and predicted differences in Autism Spectrum Disorder
Delta (~0.5-4Hz)	Involved in phrasal processing and possibly labeling.	Increased in eyes-closed resting state exam; predicted to be disrupted in processing phrases involving raising and passives.
Theta (~4-10Hz)	Hippocampal source; embeds γ to generate cyclic transfer of syntactic objects; involved more generally in memory retrieval.	Reduced coherence in children; does not synergistically engage with γ during speech; predicted to be disrupted in certain memory retrieval processes.
Alpha (~8-12Hz)	Synchronizes distant cortical regions; embeds γ generated cross-cortically to yield inter-modular set-formation; involved in lexical decision making.	Reduced cross-cortically; reduced resting-state α - γ phase amplitude coupling; increased in resting state; predicted to be disrupted during certain lexicalisations.
Beta (~10-30Hz)	When γ is slowed to β and coupled with α via a basal ganglia-thalamic-cortical loop, syntactic objects are labeled; holds objects in memory.	Reduced cross-frequency coupling with γ ; predicted to be disrupted in the maintenance of syntactic objects in raising, passives and <i>wh</i> -questions.
Gamma (~30-100Hz)	Generates syntactic objects before β holds them in memory; central role in a number of linguistic operations; involved in lexical processing.	Over-connectivity gives rise to increased γ ; reduced in rSTG and IIFG during picture naming; predicted to be disrupted quite generally in linguistic cognition.



Why Brain Oscillations Are Improving Our Understanding of Language

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Murphy and Benítez-Burraco (2016, 2017) and Benítez-Burraco and Murphy (2016) suggest that language deficits in schizophrenia and autism spectrum disorders can be explained by assuming that their abnormal cross-frequency coupling profiles impair (among other things) the domain-general ability to extract particular items from memory.

Kessler et al. (2016) conducted an extensive literature review and hypothesised that “especially low delta-theta frequency long-range phase coupling should be affected in ASD in conjunction with reduced local PAC and possibly inter-trial phase coherence during high-level social cognition that requires complex signal integration over time”.

A highly important application of interventionist strategies to brain stimulation can be found in network stimulations to treat mental diseases (see Salimpour & Anderson 2019, Wilkinson & Murphy 2016), with cross-frequency coupling in particular being a potential therapeutic target in disease states.

Similar approaches have already been taken to improve performance on visual tasks in patients with schizophrenia (Farzan, Barr, Sun, Fitzgerald, & Daskalakis, 2012; Barr, Farzan, Rajji, Voineskos, Blumberger, & Arenovich, 2013).

Overall, these ideas are commensurable with recent moves in neuroscience to view psychiatric illnesses as oscillatory connectomopathies (Vinogradov & Herman 2016; Cao et al. 2016), and are also compatible with the more general (and plausible) claim that autism and schizophrenia were the ‘price’ that humans paid for acquiring language (Sikela & Searles Quick 2018), since the arrival of such a complex system brings with it the risk of malfunction, with many of the core traits of these disorders arguably being linguistic in nature.



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bioRxiv posts many COVID19-related papers. A reminder: they have not been formally peer-reviewed and should not guide health-related behavior or be reported in the press as conclusive.

New Results

Minimal phrase composition revealed by intracranial recordings

 Elliot Murphy,  Oscar Woolnough,  Patrick S. Rollo, Zachary Roccaforte,  Katrien Segaert,  Peter Hagoort,  Nitin Tandon

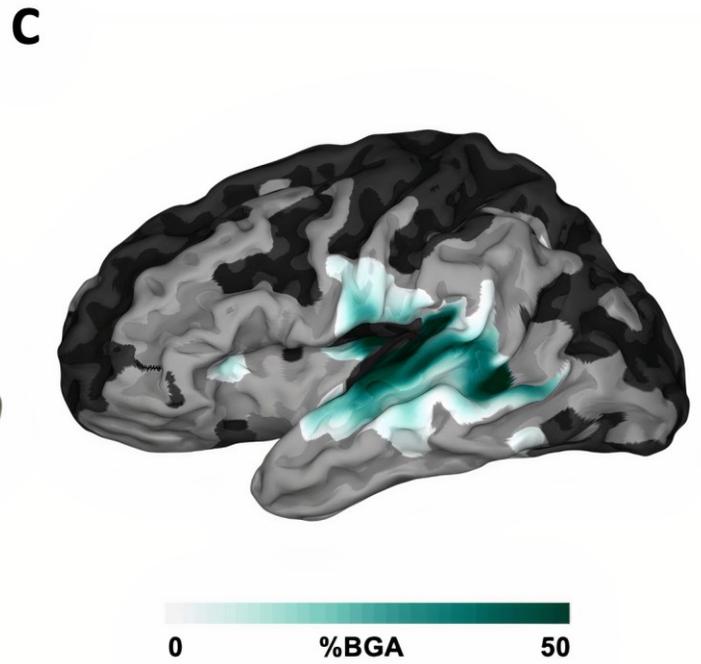
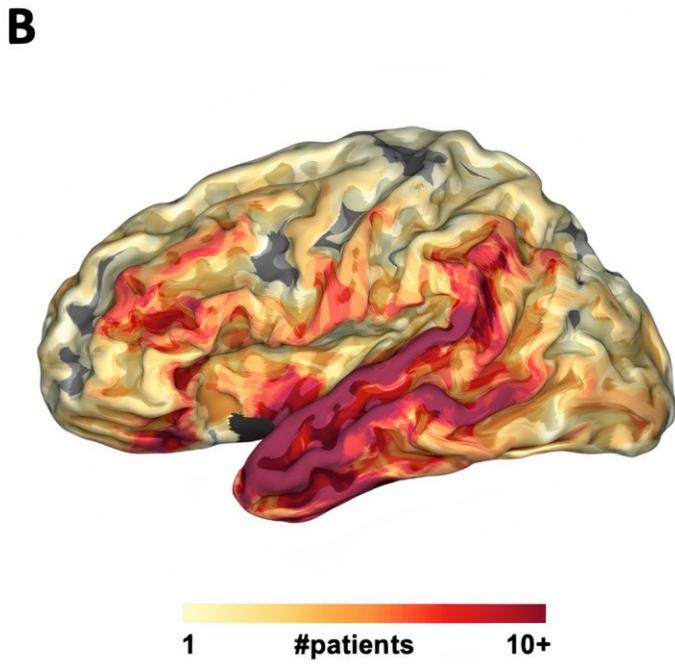
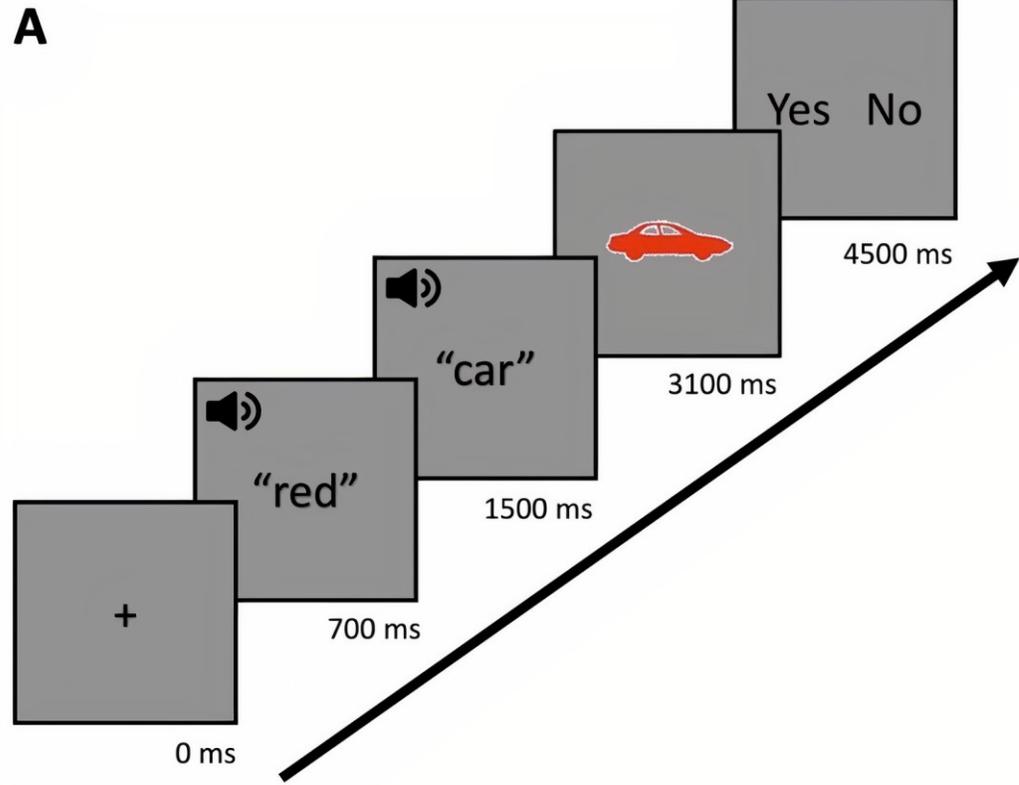
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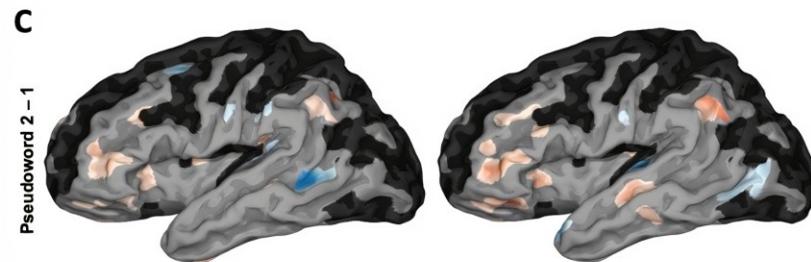
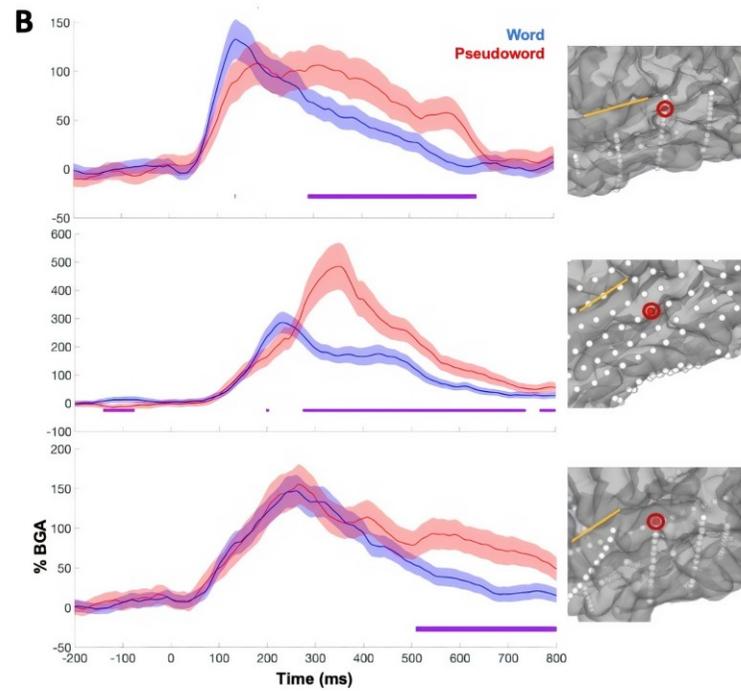
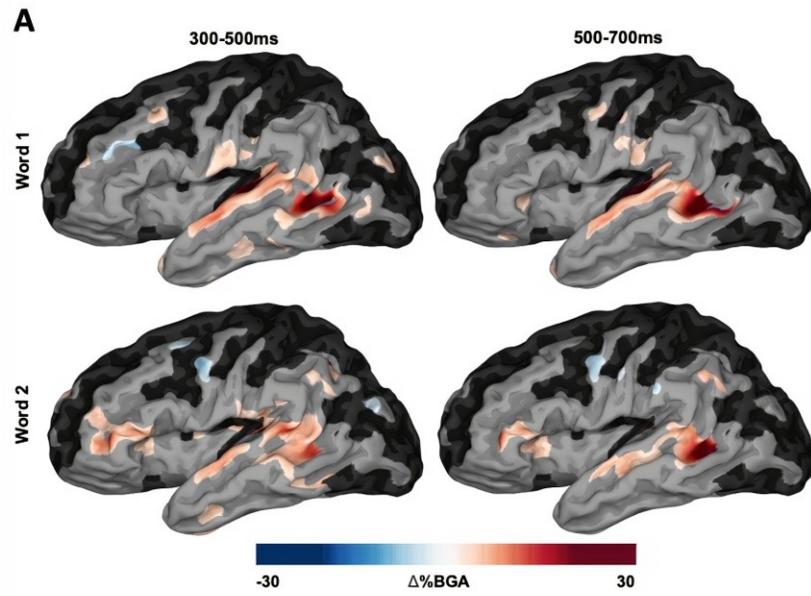
19 epilepsy patients (Memorial Hermann Hospital, Houston, Texas)

Data were acquired from either subdural grid electrodes (SDEs; 6 patients) or stereotactically placed depth electrodes (sEEGs; 13 patients)

3,458 electrodes implanted

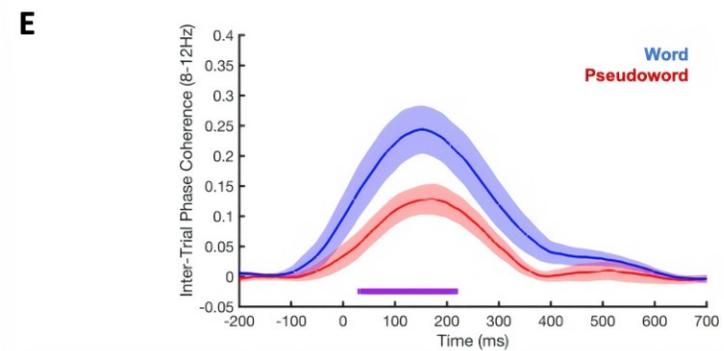
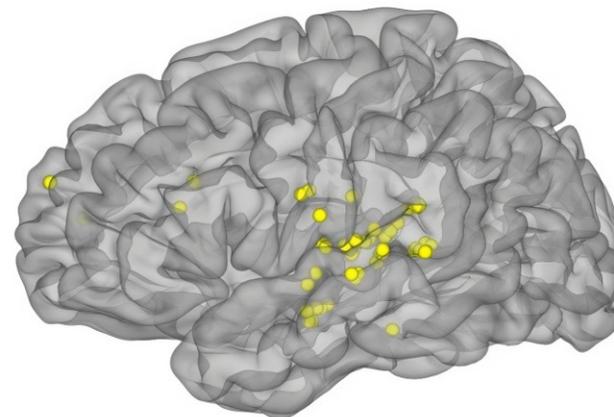
Analyzing broadband high gamma (70-150Hz), which correlates strongly with local cortical neural activity, and low frequency power, which is implicated in synchronizing broad portions of tissue and non-local cortical sites





D

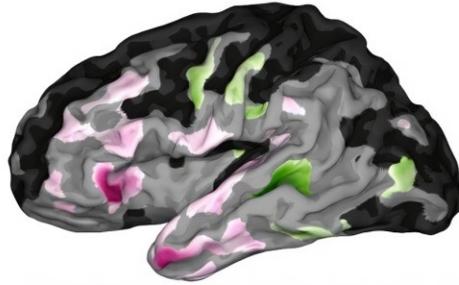
Lexicality ITC differences (8–12 Hz)



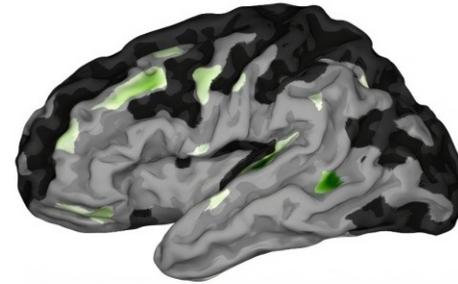
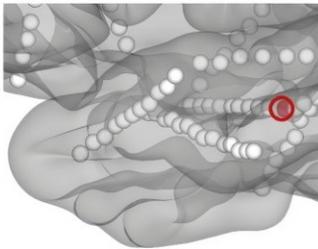
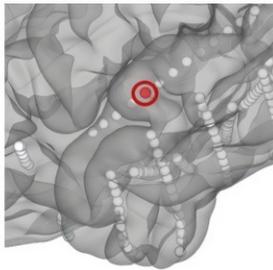
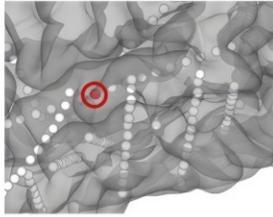
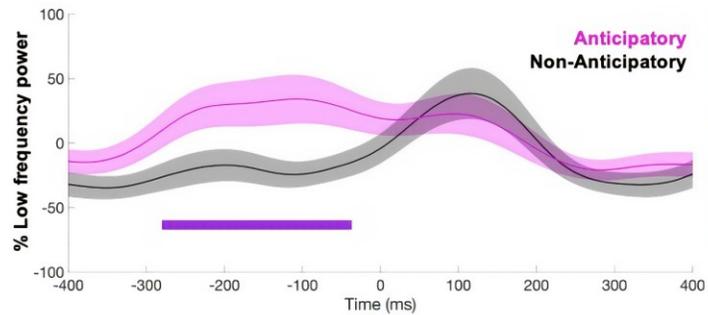
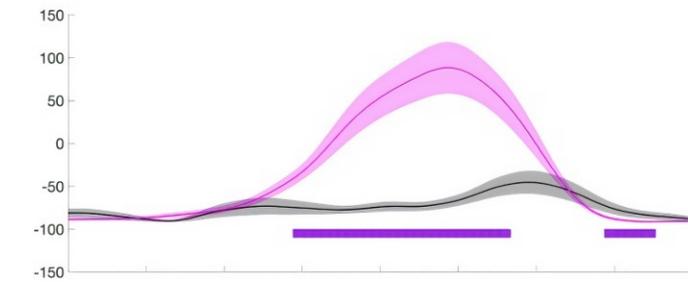
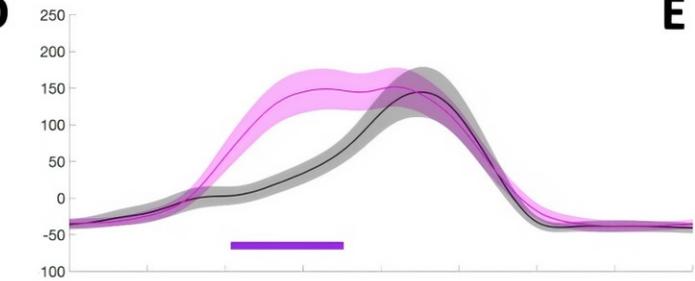
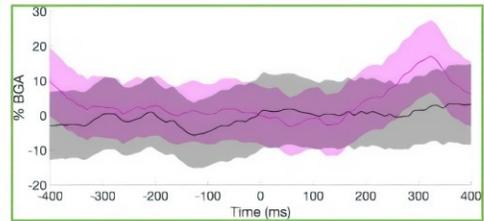
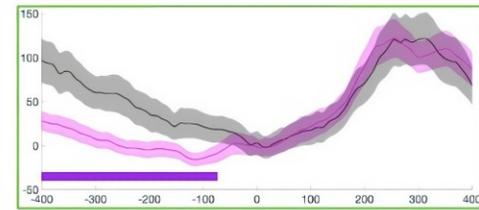
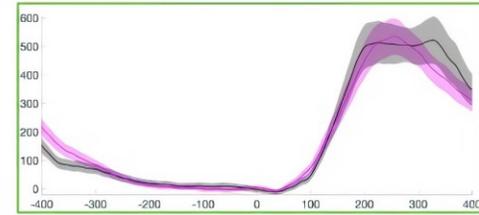
A

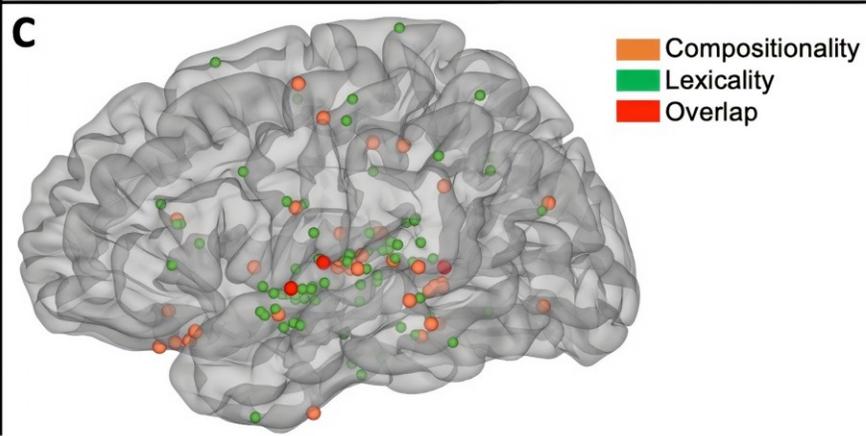
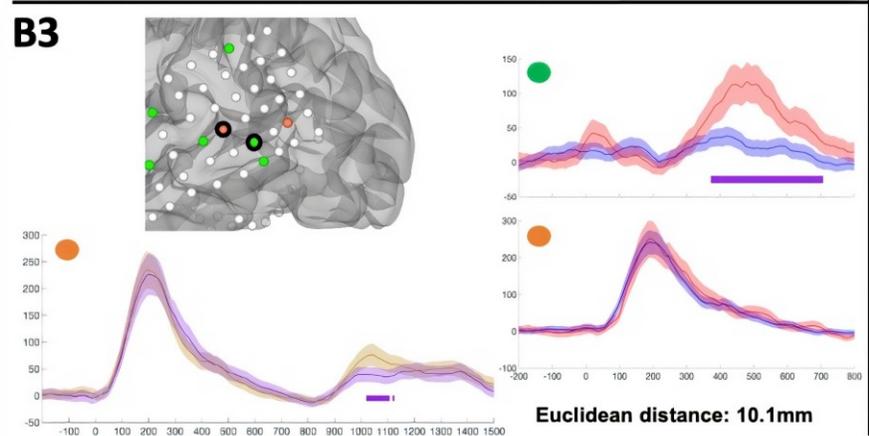
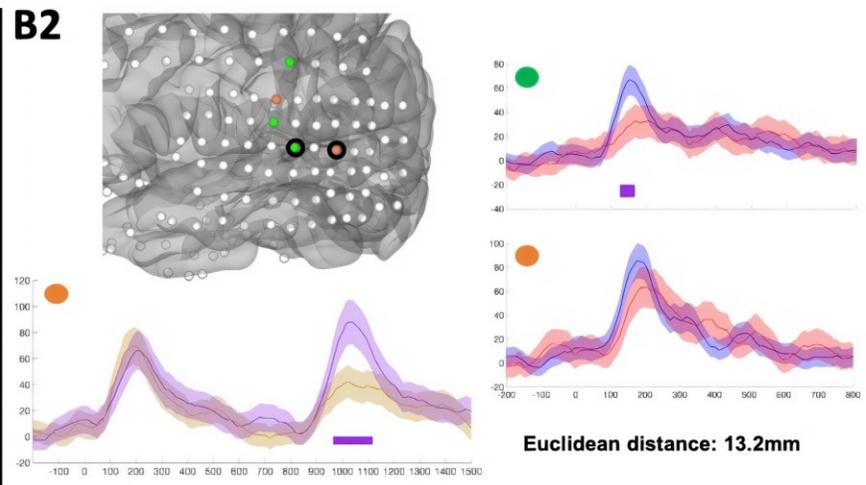
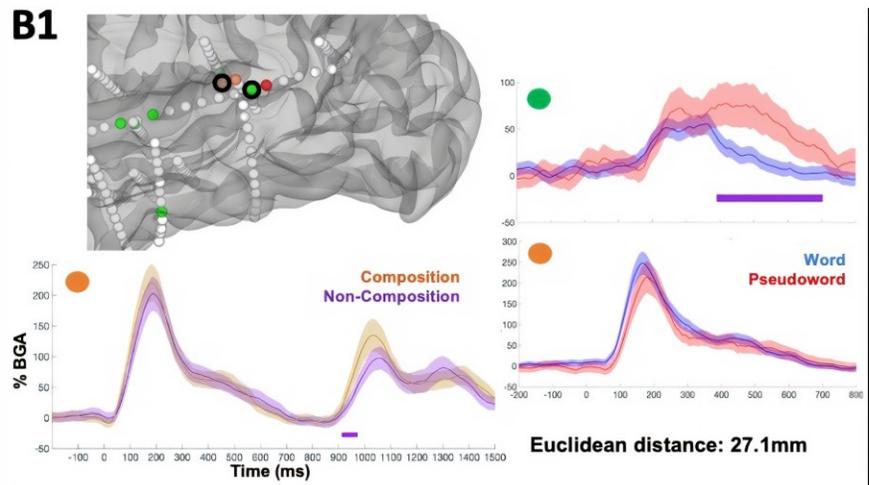
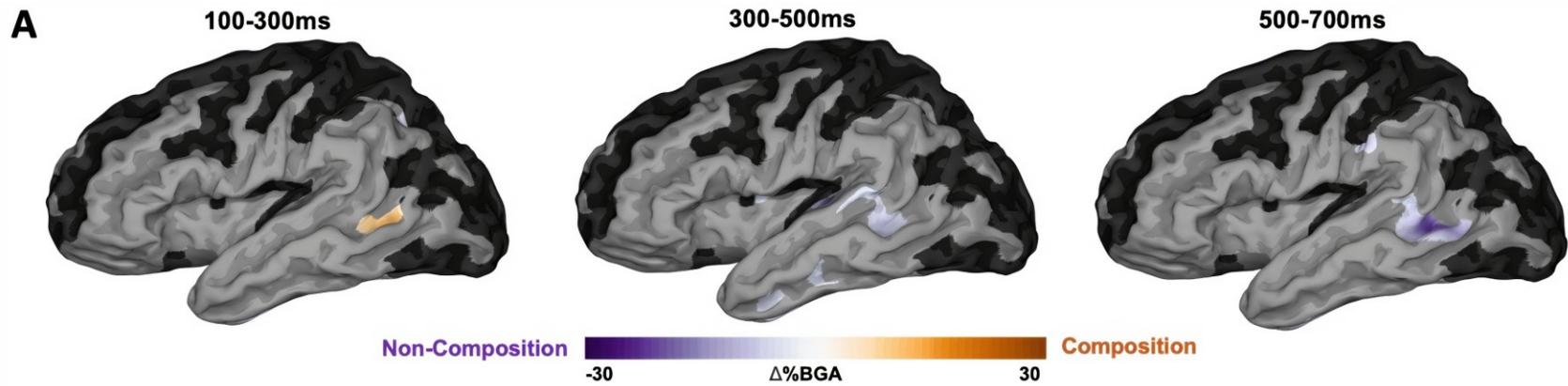
Low frequency power
(8-30 Hz)

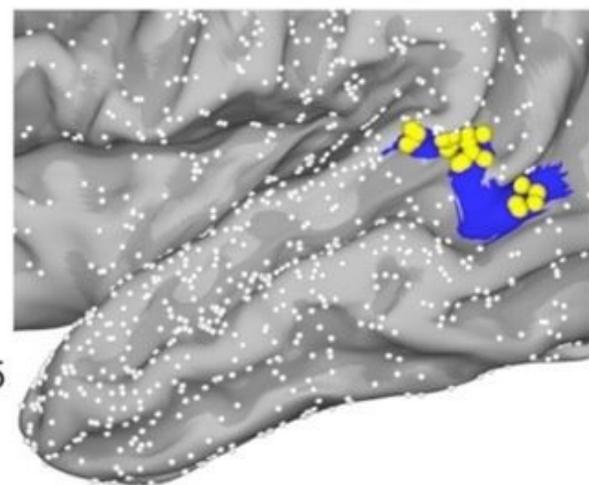
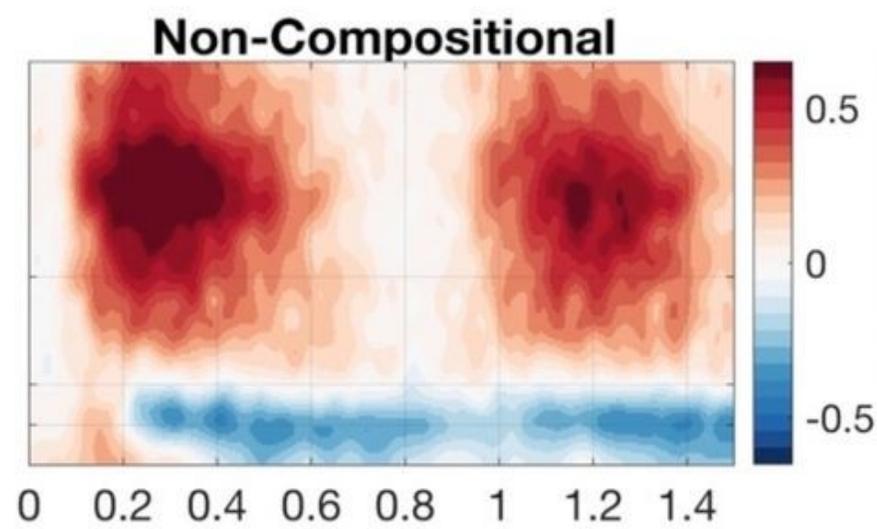
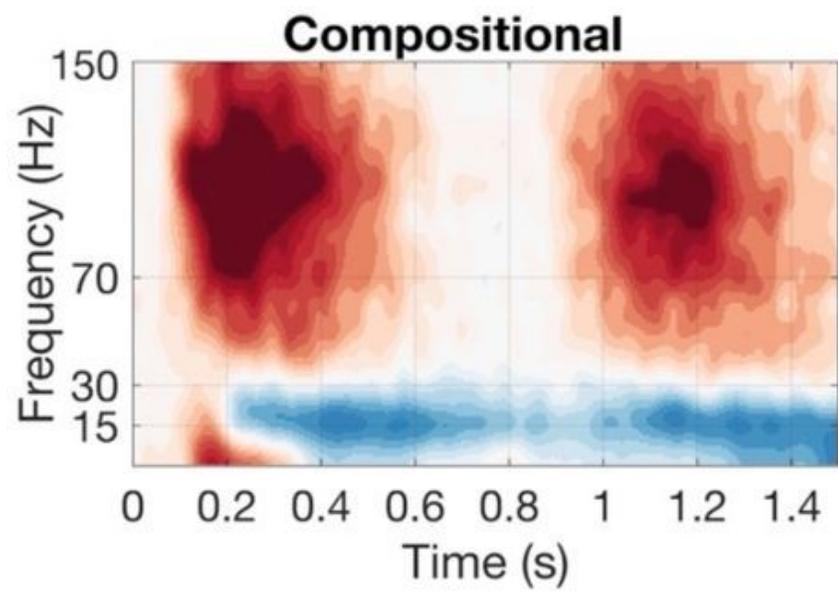
-200-0ms

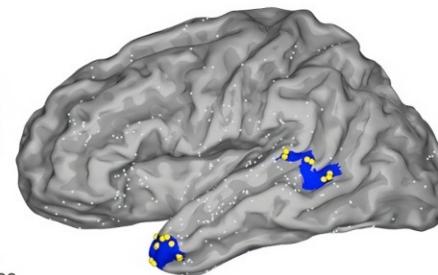
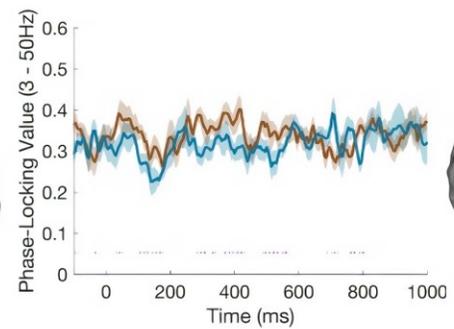
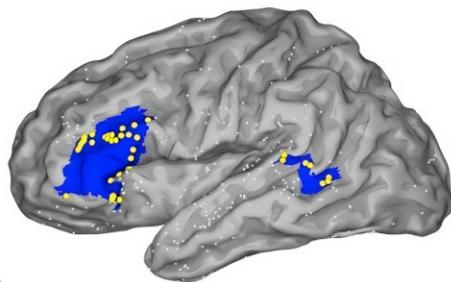
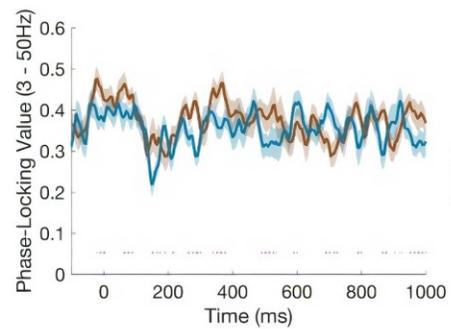
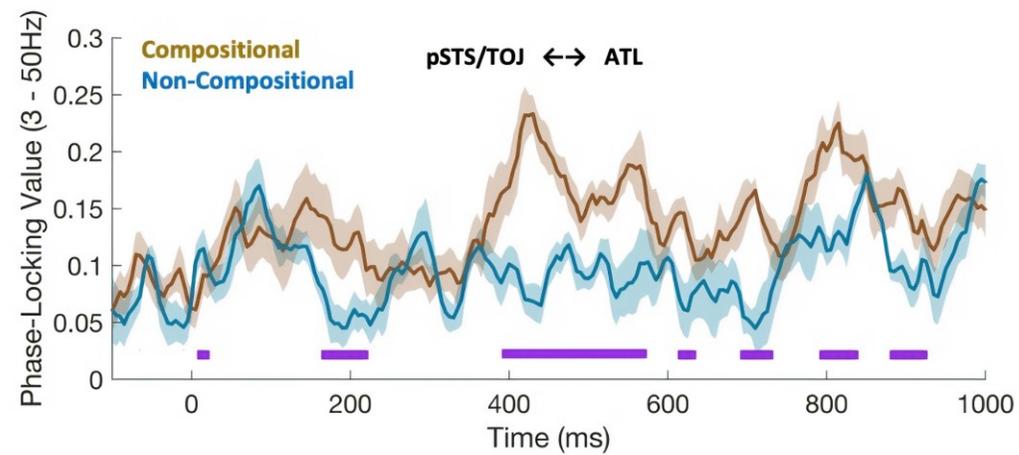
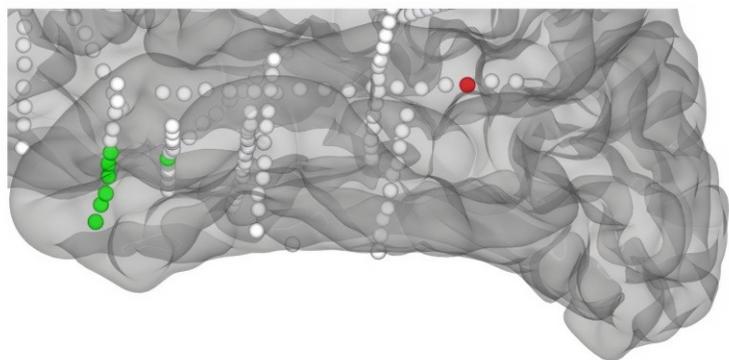
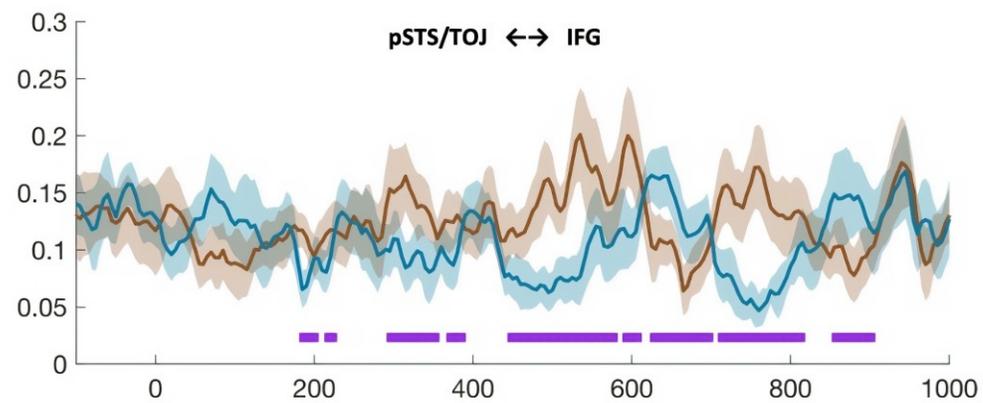
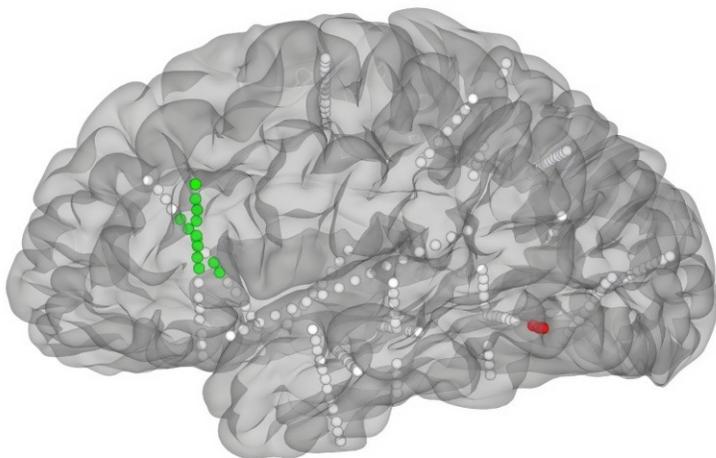
**B**

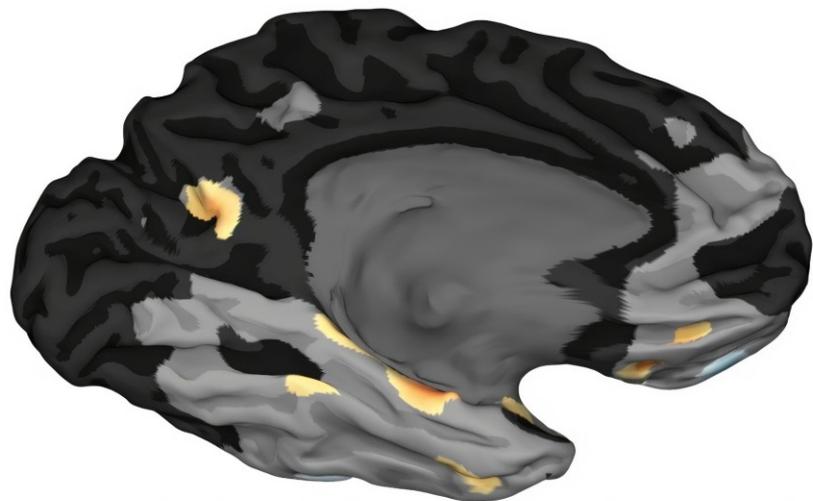
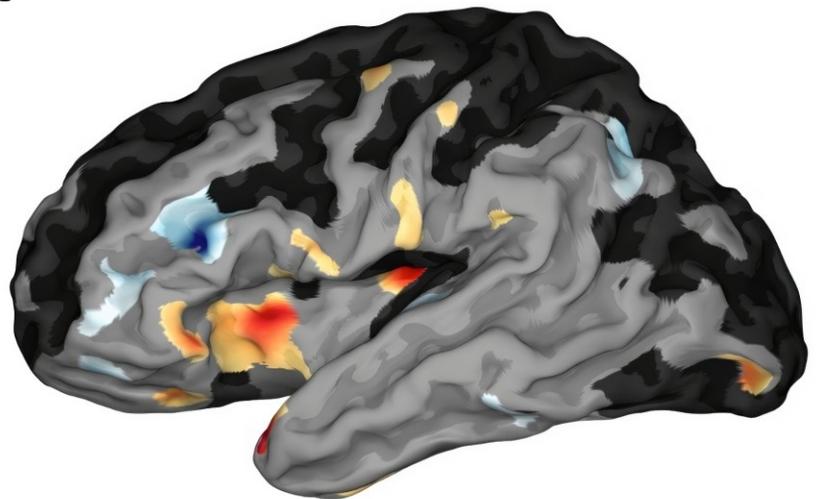
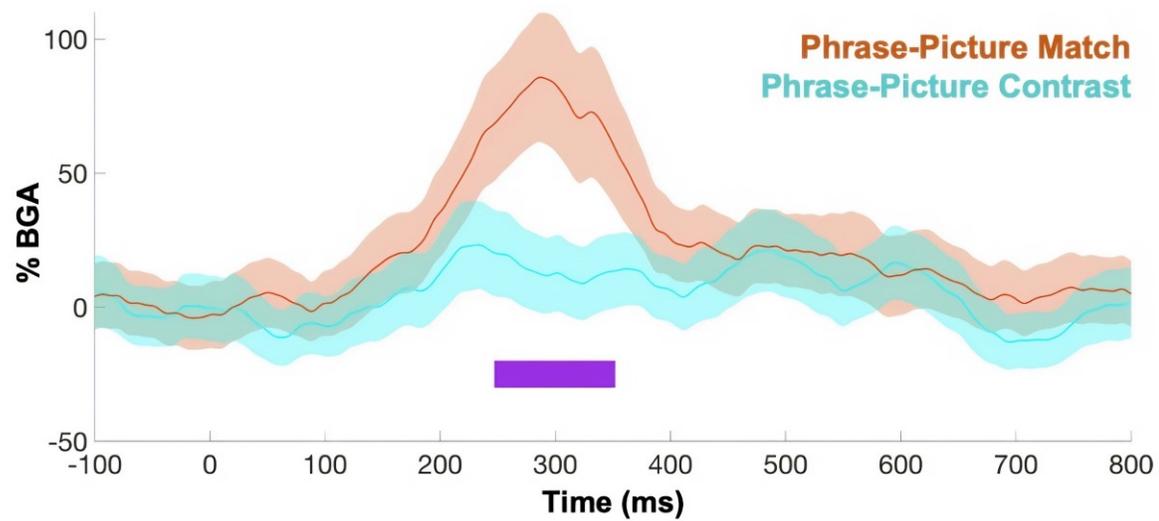
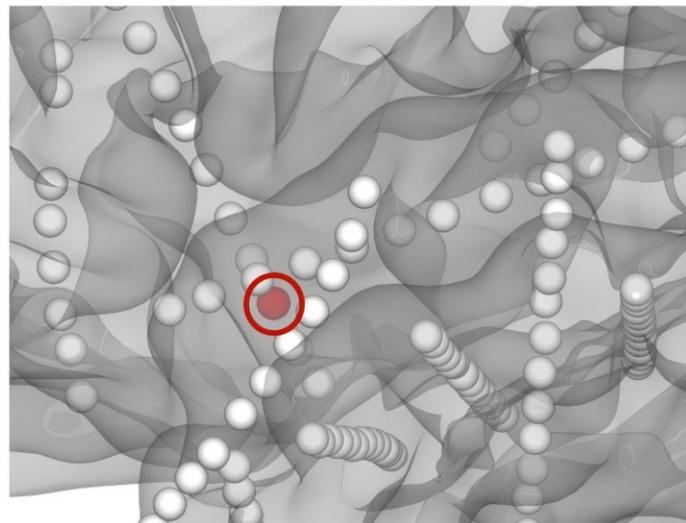
-100-0ms

**C****D****E**





A**B**

A**250-500ms****B**

Thank you for listening 😊