UNIVERSITÉ DE GENÈVE

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Neurobiology of Concepts Expression

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nccr evolving language

NATIONAL CENTRE OF COMPETENCE IN RESEARCH

Testing Cognitive Theories with Neuroimaging:

Lessons from Primary Progressive Aphasia

Dr. Valentina Borghesani

BSc in Psychology, MSc Neuropsychology, PhD Cognitive Neuroimaging

Assistant Professor at UNIGE/FPSE | NCCR Evolving Language

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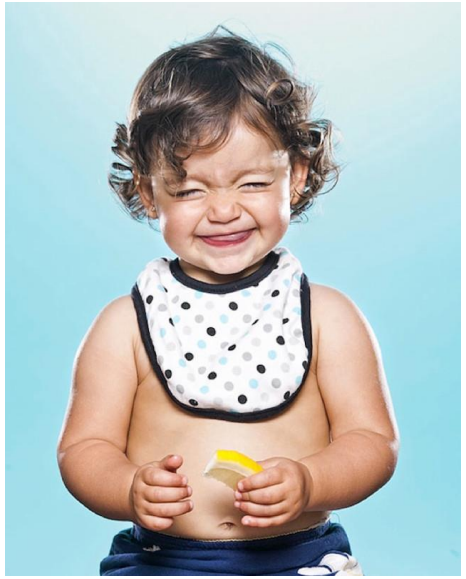
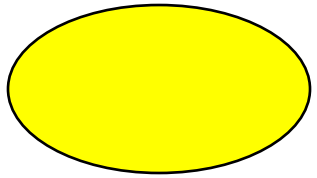
/ˈlɛmən/



l – e – m – o - n

Lemons are native to Asia



/ˈlɛmən/

spoken word

L-shaped wrist mov.

signed word

L E M O N

written word

Concept

taste,
smell

emotion
associations

unlabeled concepts
e.g., learning

ungrounded labels
e.g., patients

n° labels ≠ n° concepts
e.g., bilinguals

Lemons are native to Asia

Channels — **Labels** — **Concept Features**

word *forms* — word *meaning*

/ˈlɛmən/

spoken word

L-shaped wrist mov.

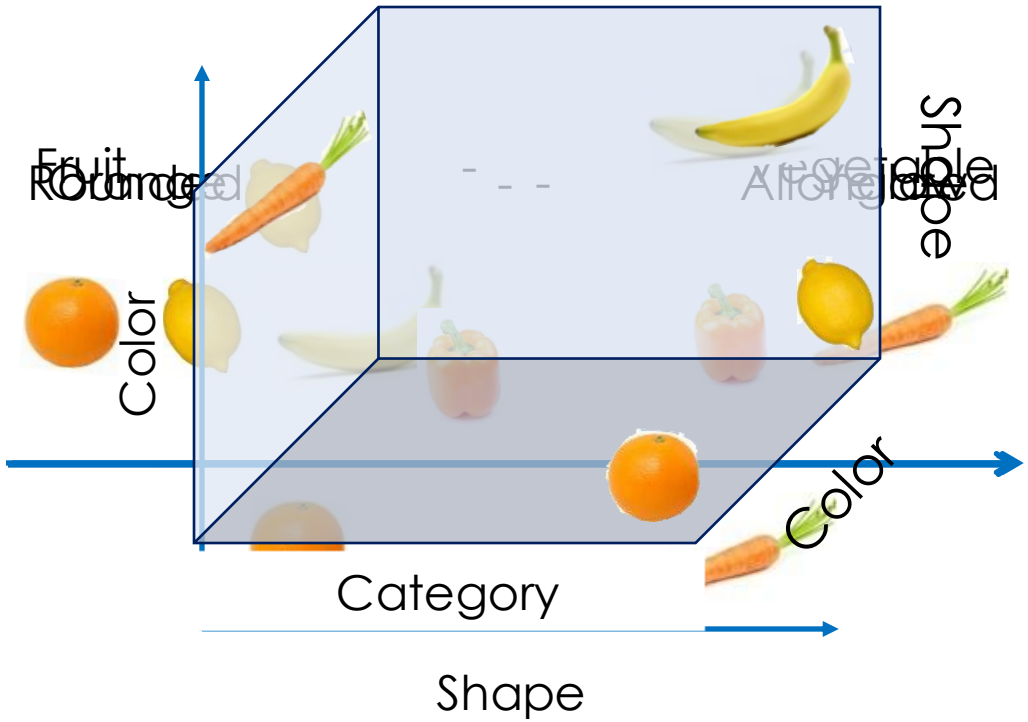
signed word

L E M O N

written word

Conceptual Space(s)

Representational geometry



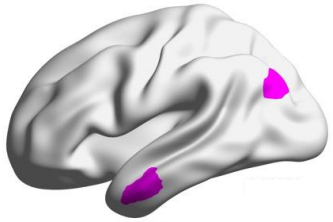
Channels — **Labels** — **Concept Features**

word *forms* — word *meaning*

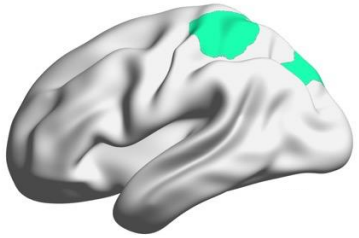
Goal: to **understand**

localization & **dynamics** of neural signatures **causally** linked to semantic representations.

e.g., **BOLD signal** with **fMRI**



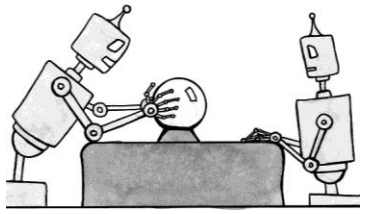
e.g., **spectral power** with **MEG**



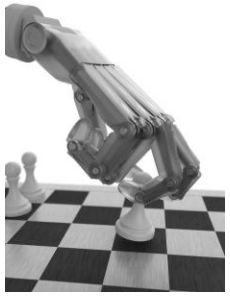
e.g., **volume** with **MRI**

measure / describe

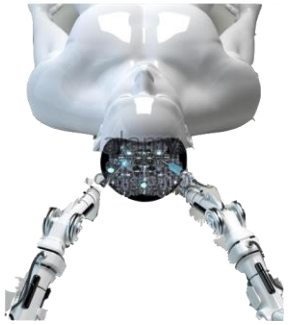
predict



imitate / outperform



fix / change



Introduction to Primary Progressive Aphasia

The synergy of clinical & cognitive neuroscience

Q1: How are semantic representations encoded in the brain?

In distributed yet specialized cortical areas

Rapidly retrieved via symbols

As required by the task and afforded by the stimuli

With the anterior temporal lobe as a critical hub

Borghesani *et al. 2016 NeuroImage*
Borghesani *et al. 2018 Journal of Cognitive Neuroscience*
Borghesani *et al. 2018 Cortex*
Borghesani *et al. 2019 Journal of Cognitive Neuroscience*
Borghesani *et al. 2019 Cortex*
Vonk, ***Borghesani*** *et al. 2019 Aphasiology*
Borghesani *et al. 2020 NeuroImage:Clinical*

Q2: What is the relation with other cognitive functions, namely language?

Critical behavioral dissociations

Preserved percepts, eroded concepts

Can be (partially) compensated by spared functions

Can be (partially) recovered from language use alone

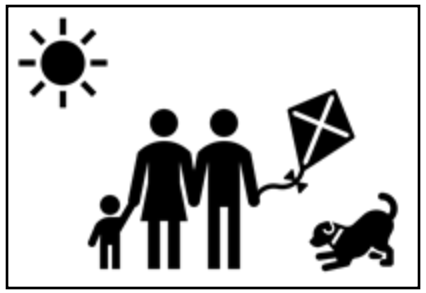
Borghesani *& Gorno-Tempini 2022 HCN*
Borghesani *et al. 2020 Brain*
Lukic, ***Borghesani****, et al. 2021 Cortex*
Borghesani *et al. 2021 eLife*
Younes, ***Borghesani*** *et al. 2022 Brain*
Lukic, Licata,……& ***Borghesani*** *2022 Fr.Psy*
Borghesani *et al. 2023 Scientific Data*

Why are you here today?

*Sometimes I have difficulty **finding** the words.*

Primary Progressive Aphasia (or PPA)

Can you please look at this picture and tell me what you see using full sentences?



P1. *I s- see a family of three. [pause] Th- the father has a [pause] kite. They have a dog.*

False starts and pauses, but correct grammar and content words.

P2. *Sunny day. Baby. Mother. Fa-d-er. He…kite. Also, a dog.*

Grammatically incorrect and **sounds distortions**, but right content words.

P3. *There are three people and one of them is holding an object. There is also an animal.*

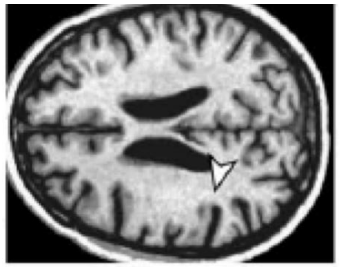
Good fluency and grammar, but **inadequate content words**.

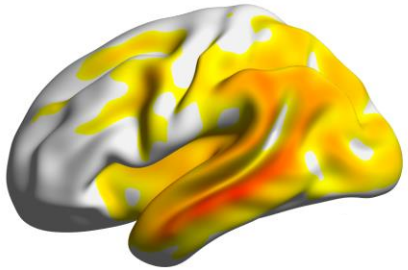
Language Profile

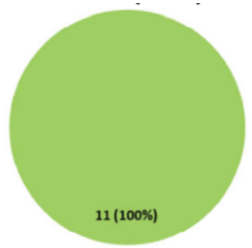
Anatomical Substrate

Pathological Correlates

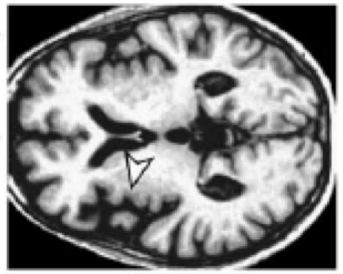
P1. phonology and/or
short term verbal memory deficits
= logopenic variant (**lvPPA**)

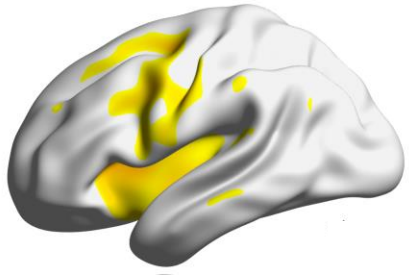


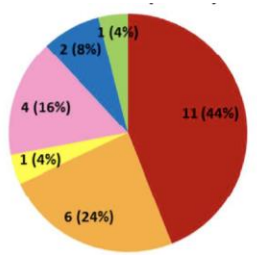


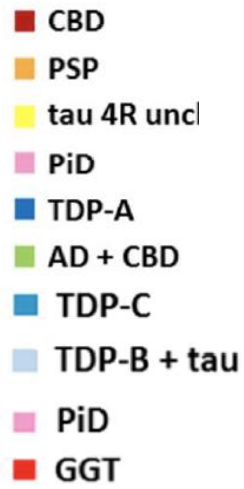


P2. grammar and/or
speech-motor deficits
= nonfluent variant (**nfvPPA**)

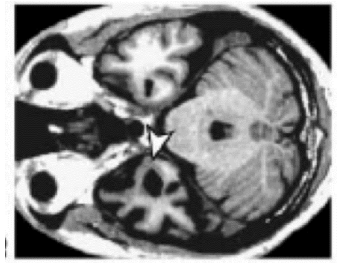


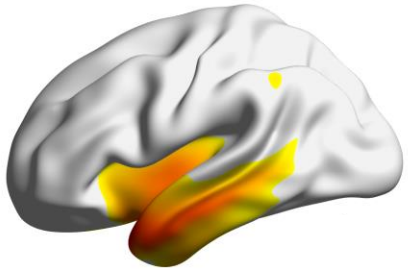


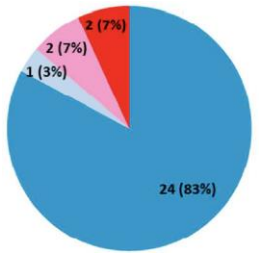




P3. semantic memory deficits
= semantic variant (**svPPA**)







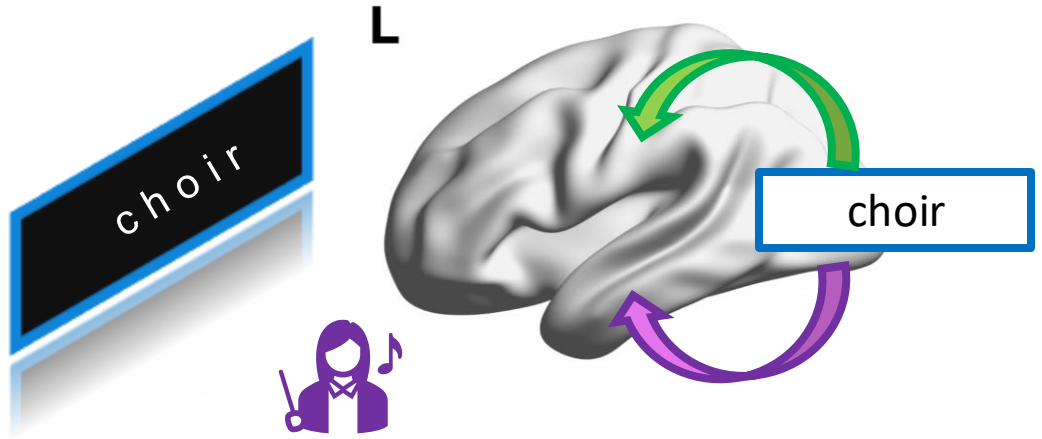
Spinelli et al. 2017 *Ann. Neurology*

Computational Models:
Dual-route cascaded model - *Coltheart et al., 1993*
Triangle model - *Plaut et al., 1996*

Neuropsychology :
Phonological vs. surface dyslexia - *Marshall & Newcombe, 1973*

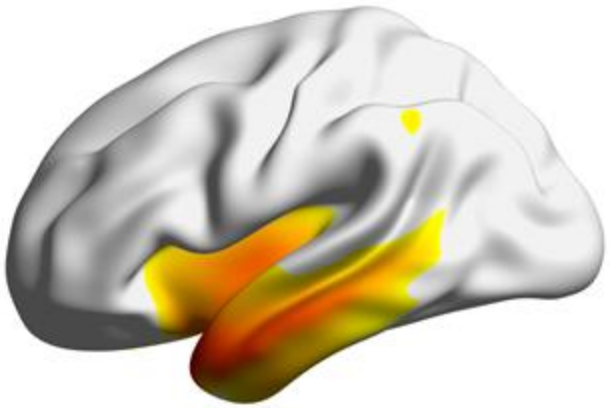
Neuroimaging studies:
Parietal structures activates for pseudowords reading vs.
Temporal structures activates for irregular words reading -
Mechelli et al., 2003; Taylor et al., 2013

Sub-lexical/phonological route

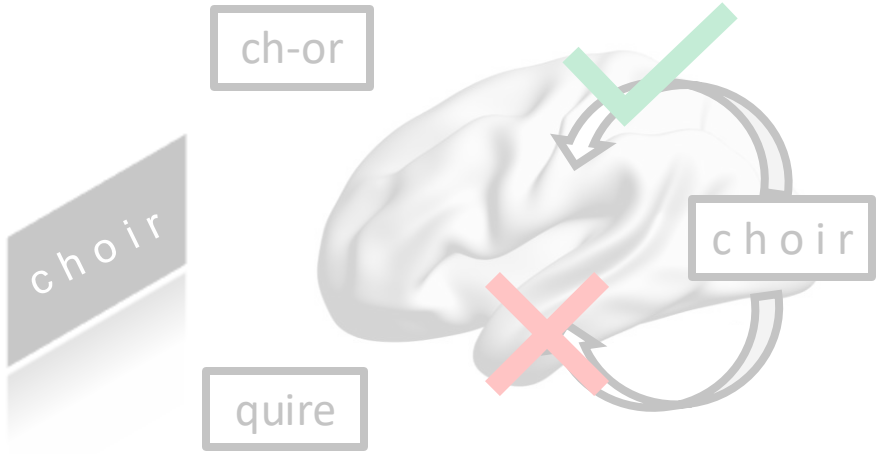


Lexico-semantic route

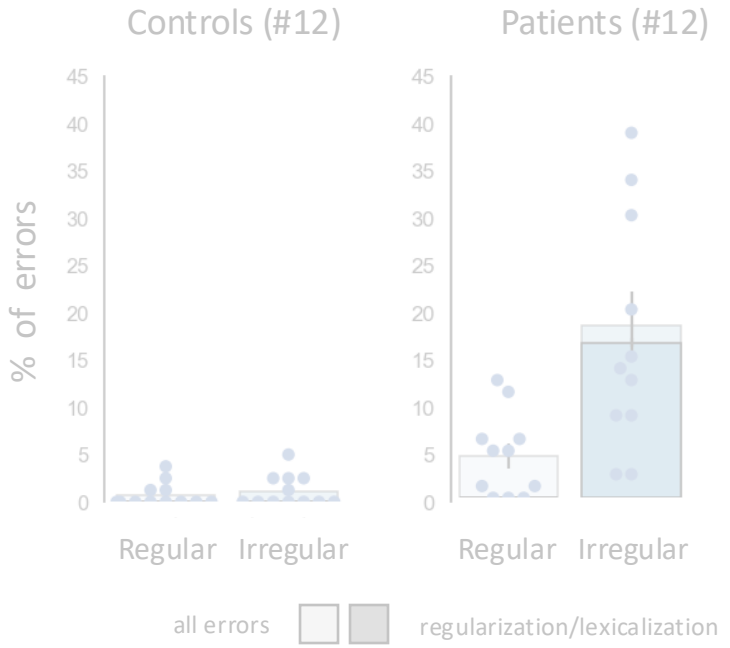
Hypothesis: given the damage to ventral path, **svPPA patients** can only **rely on the dorsal path & phonological information**



Sub-lexical/phonological route



Lexico-semantic route



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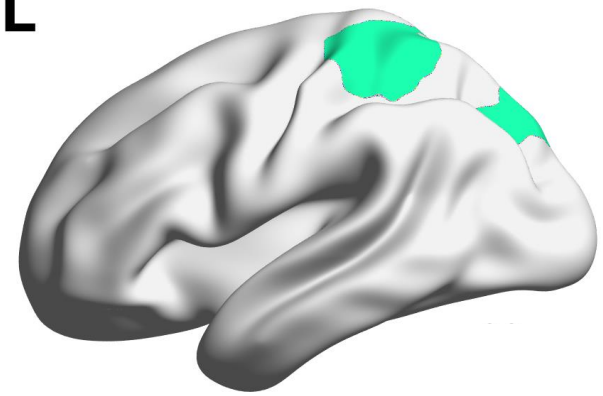


Results: starting **~400 ms** post word onset, patients recruit dorsal areas to read irregular words.

Conclusion: **dorsal structures** can partially **compensate ventral damage.**

Borghesani et al. 2020 *Brain*

Theoretical Models:

Hub-and-spoke model - *Patterson et al. 2007*

Convergence zones - *Damasio et al., 2004*

Dynamic multilevel reactivation framework - *Reilly et al., 2016*

Neuroimaging studies:

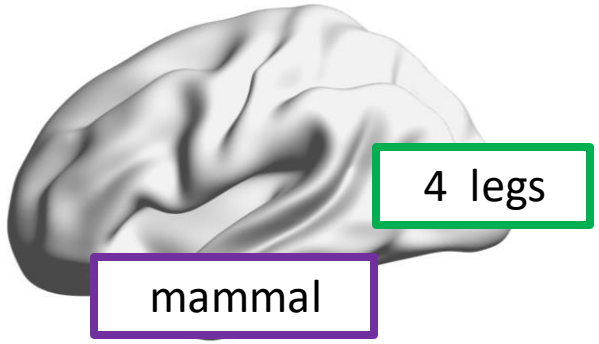
Distributed sematic representations during

Movie watching - *Huth et al., 2012*

Story listening - *De Heer et al., 2017*

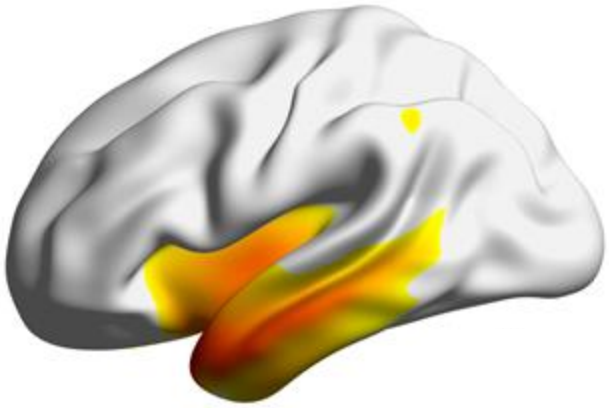
Single words processing - *Fernandino et al., 2016*

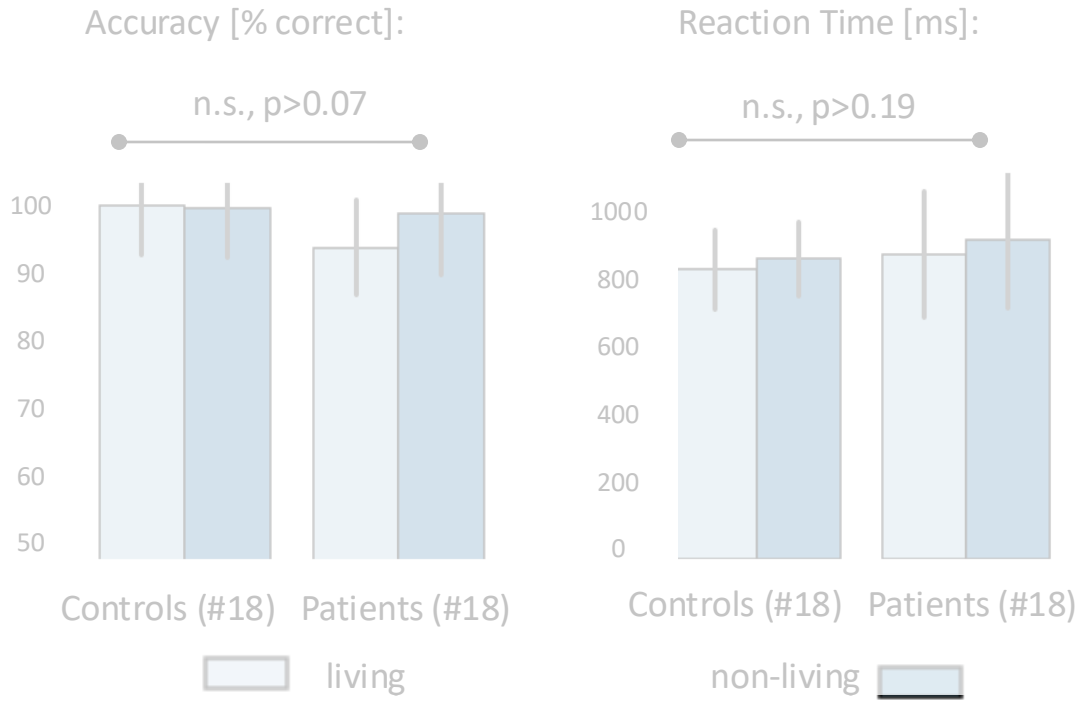
Perceptual information

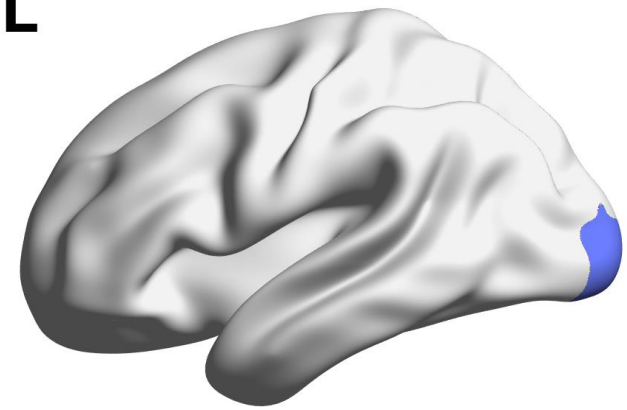


Conceptual information

Hypothesis: given the damage to the anterior regions, **svPPA patients** can only **rely on the posterior regions & perceptual information**







Results: starting **~200 ms** post onset, patients recruit posterior areas to classify items

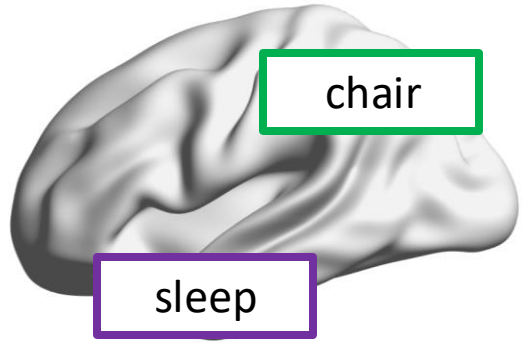
Conclusion: **posterior structures** can partially **compensate anterior damage.**

Borghesani et al. 2021 *eLife*

Reviews:

Neuropsychology - *Mätzig et al. 2009*
Neuroimaging - *Vigliocco et al. 2011*
Neurodegenerative patients - *Lukic et al., 2021*

Grammatical error

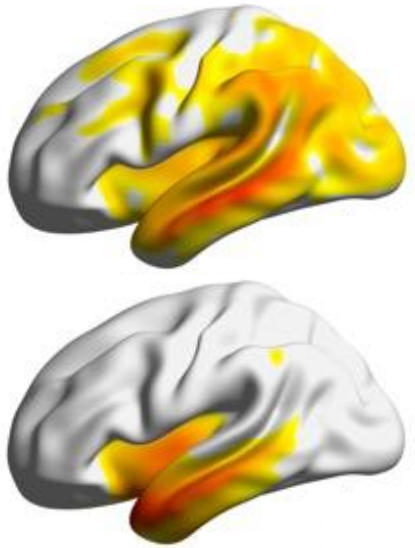


Conceptual error

Hypotheses:

given the damage to the posterior temporal regions,
lvPPA patients will show **verb-related deficits**

given the damage to the anterior temporal regions,
svPPA patients will show **conceptual deficits**



lvPPA
(n=19)

nfvPPA
(n=24)

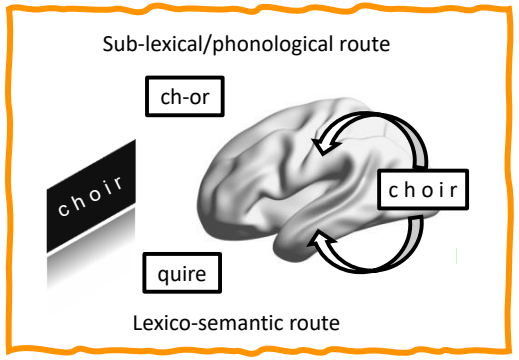
svPPA
(n=28)

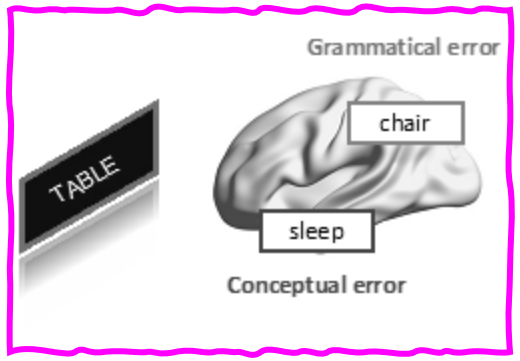
Results: **lvPPA** produce many semantically **related nouns**, while **svPPA** semantically **unrelated verbs**

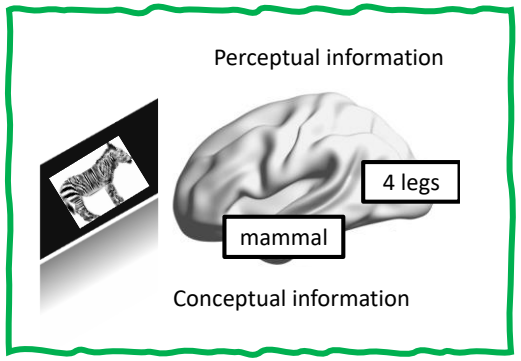
Conclusion: temporo-parietal regions & lexical processing, anterior temporal lobe & semantic processes.

Lukic*, Licata*, **.....** et **Borghesani**. 2022 *FP*

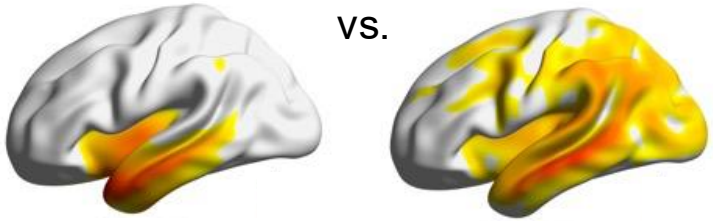
Theories on the neurocognitive correlates of **language (e.g., reading, syntax)** and its interplay with **semantic** can be empirically tested combining **neuroimaging & neuropsychology**





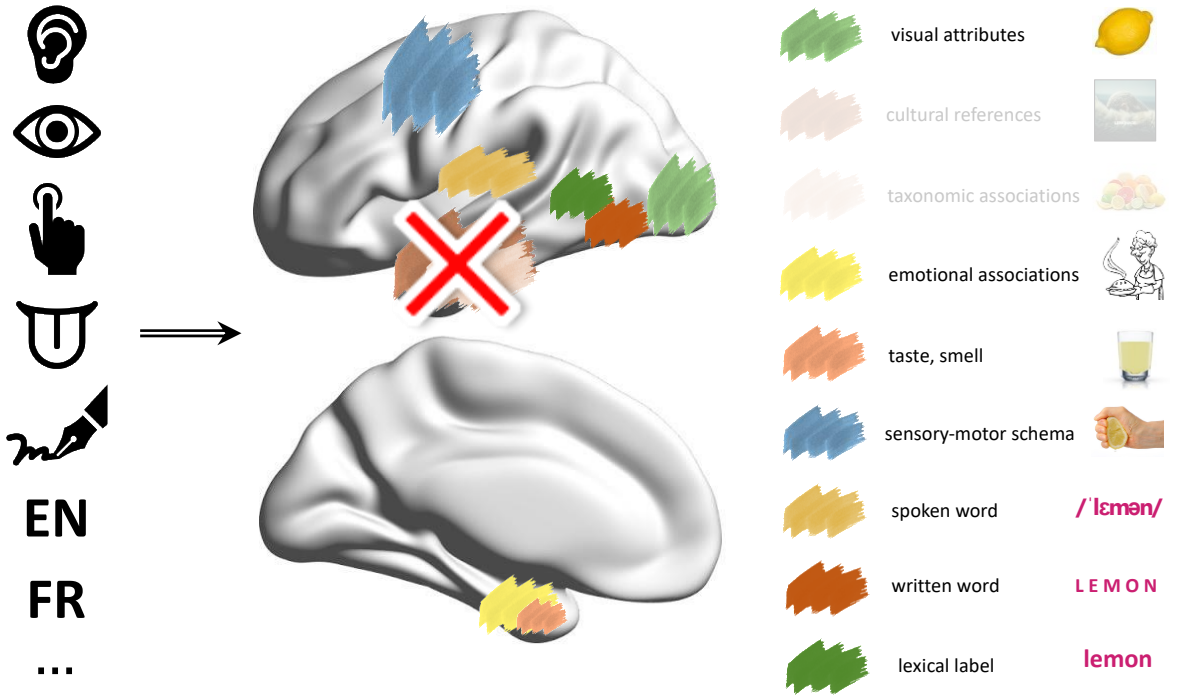


Damage to the anterior temporal lobe (and following semantic loss) can be compensated relying on **dorsal** (phonological) or **posterior** (perceptual) processes, and the analysis of **error patters** can **improve syndromic diagnosis**



Neurodiversity: can we model how **language** (i.e., input/output system) interfaces with **semantic** (i.e., multidimensional concepts) **across modalities, tasks, languages, level of expertise, lifespan,** etc.. ?

Can we improve the description of the **neural topography & dynamics** of the interplay between language & semantic?



Translational neuroscience: can alterations in language & semantic can be used as **neuro-cognitive biomarkers** for **neuro-psychiatric conditions**? Can we leverage what we learn for **interventions**?

Thanks to colleagues, funding agencies, and to you for your attention!



















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