Boya Linguistic Forum: Language Variation and Change.
Peking University, November 5, 2022.

Language Variation *across the* **Lifespan,**

Forestalling cognitive decline.

WANG Shiyuan & XIE Chenwei.
Research Center for Language, Cognition, & Neuroscience.
Hong Kong Polytechnic University.

We appreciate this opportunity today of joining the BOYA Linguistic Forum, to see many old friends online, & to report on our recent research. The background of our research can be largely traced to two intellectual pioneers. One is the linguist **Edward Sapir**, who always urged us to look beyond the "pretty patterns" of individual languages, & try to connect language to larger aspects of culture & society. An aspect of society that we are particularly concerned with is the explosive growth of the elderly population across the world, & the **cognitive decline** in such populations, especially their **loss of language & the ability to take care of themselves.**

"The status of linguistics as a science". ***LANGUAGE*** 1929.

p.214: "**It is peculiarly important that linguists**, who are often accused, and accused justly, of failure to look beyond pretty patterns of their subject matter, **should become aware of what their science may mean for the interpretation of human conduct in general**."

Photo by Florence M. Hendershot, Chicago, Ill.

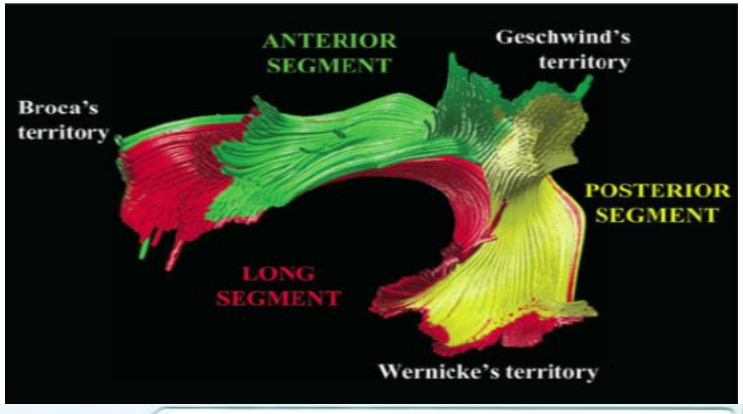
"语言学家时常被指控无法跳脱研究主题的优美模式,这样的指控并不为过,所以这些人必须意识到,他们的语言科学所探讨的结果,应该也适用于对人类一般行为的诠释。"

Edward Sapir
1834-1939

The other intellectual pioneer is the neuroscientist **Norman Geschwind**, who synthesized what was discovered about language & the brain in the 19th century into a holistic system. His influence was so great that an important region of our brain has been named in his honor.

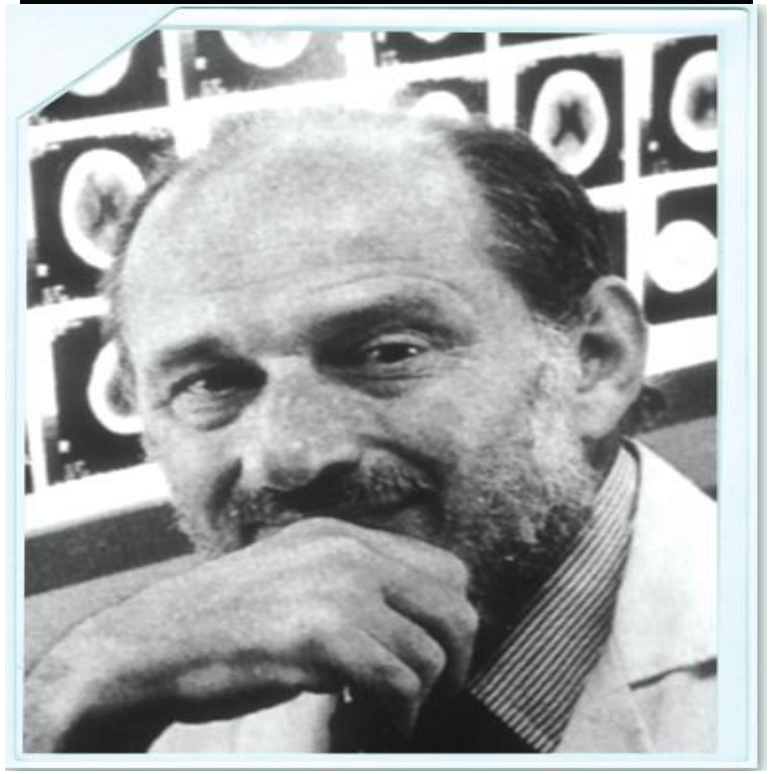
Geschwind strongly advocated that the only way to understand the nature of language is to investigate how **language is enabled by the brain**. He would have been much pleased that many very powerful tools have joined in these investigations, especially EEG, MRI, & many others.

Geschwind, N. 1976. Selected Papers on Language and the Brain.86-104.



'...a real understanding of language will not be achieved until we have a reasonable notion of its neurological mechanisms' .

除非我們對**語言的神經機制**有合理的概念，否則無法真正理解語言。



Norman Geschwind
(1926 – 1984)

Language is enabled by a **broad mosaic of biological and social skills**, including sensory & motor skills for input and output, as well as memory & computational skills for storing, analyzing, & retrieving linguistic constructions. They also include semantic and pragmatic skills to relate these constructions to the social and affective context.

Language begins even when the fetus is in the womb, which then develops along various timelines across the lifespan. At present we know a lot more about this development during the early years of its acquisition than during the **sunset years**, when some of the enabling skills decline & we lose much of our language together with the ability to take care of ourselves. **Cognitive decline** is an urgent challenge across the world, especially in China.

With the remarkable advances in many Life Sciences in recent decades, particularly in **imaging the brain**, we now have a much deeper understanding of the processes of ageing, often with **senescence** caused by illness. Let us hope the day will come soon when the old Chinese saying of Lifespan as 生老病死 (birth, age, illness, death) may change to 生老 病 死, with the 病 removed or at least much reduced.

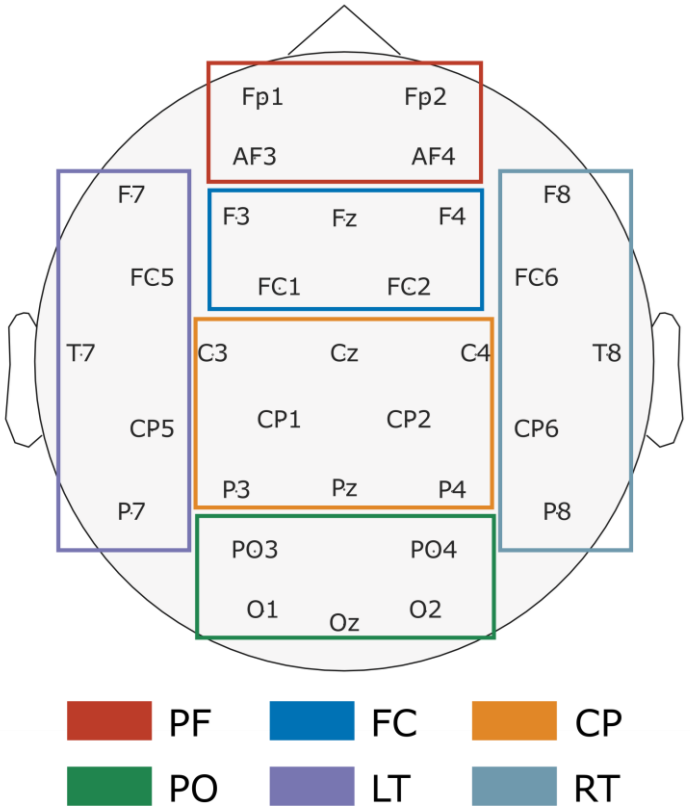
Our team was formed at PolyU several years ago to do research on age-related **cognitive decline**; our report today is a sampling of work that is largely ongoing, or even just starting. While there is an increasing literature in this area on Western (*WEIRD) populations that we can build upon, our focus is on Chinese peoples, where the language has its own distinctive features, such as lexical tones, classifiers, sinographic writing, etc. Our hope is to be able to contribute to the science of neurocognition, as well as to lead to interventions that can reduce the burden of neurodegeneration.

Today I will begin by very briefly illustrating two instruments our team uses in our work for imaging the brain: EEG (Matthew MA) & MRI (Manson Fong). XIE Chenwei will follow me by discussing two related issues he is studying: production/comprehension asymmetry & the retrogenesis hypothesis in language acquisition and atrophy.

**WEIRD stands for Western, Educated, Industrialized, Rich, Democratic. It is a term coined by scientists who warn against the generalizability to humans in general of results exclusively achieved by WEIRD experimenters on WEIRD subjects.*

Longitudinal changes of EEG spectral characteristics

- Several of our lab members have been recording their EEG longitudinally (approximately **200 weekly sessions from me from 2016 till now**).
- Unfortunately, many sessions are missing due to pandemic…



PF: Prefrontal

FC: Frontocentral

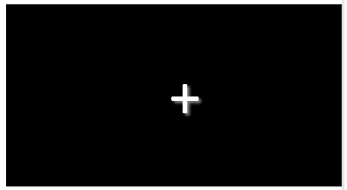
CP: Centroparietal

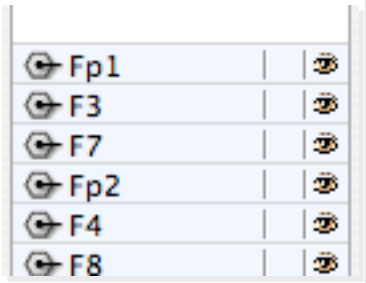
PO: Parieto-occipital

LT: Left temporal

RT: Right temporal

BioSemi 32 channel. 20160414 @ GH146 HKPolyU




Fp1
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F8

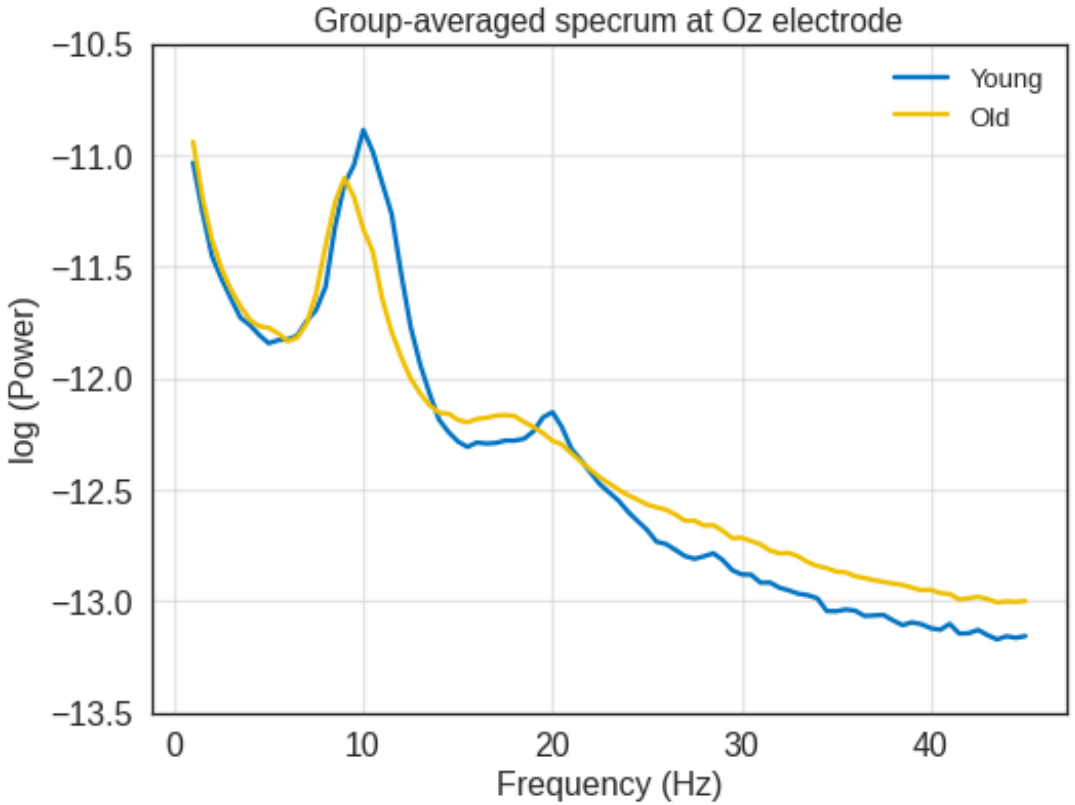
Age-related changes in EEG spectral characteristics *(Matthew Ma)*

Age-related spectral changes in resting-state EEG has been investigated since 1940s.

- Five traditionally defined EEG bands:

Delta (2-4 Hz)	Beta (13-30 Hz)
Theta (4-8 Hz)	Gamma (30-45 Hz)
Alpha (8-13 Hz)	

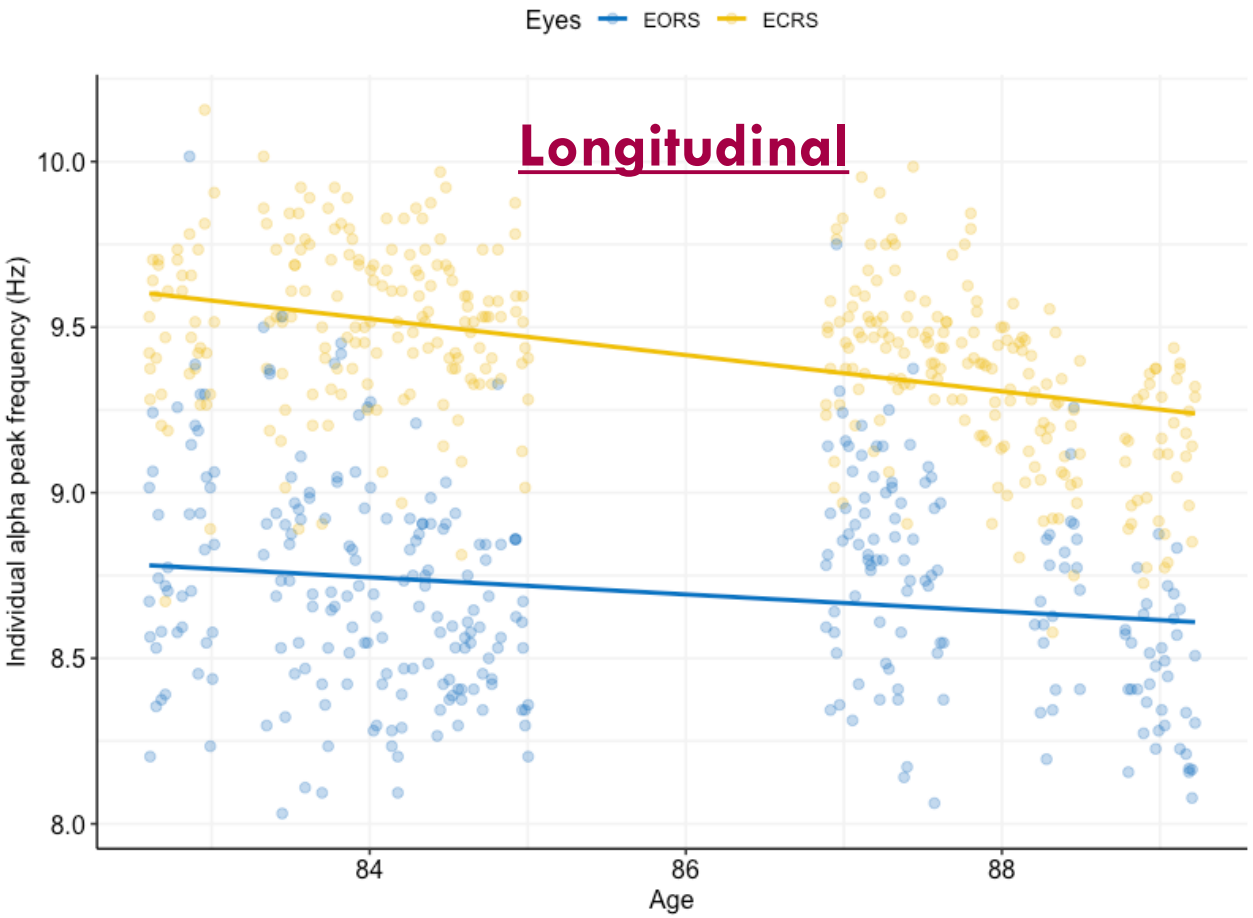
- The most consistent findings were the (1) **slowing of the dominant frequency** and (2) **decreasing alpha amplitude** (Celesia, 1986; Scally et al., 2018).
- Findings about other bands (delta, theta) in normal ageing have been inconsistent (Babiloni et al., 2006; Rossini et al., 2007; Vlahou et al., 2015).

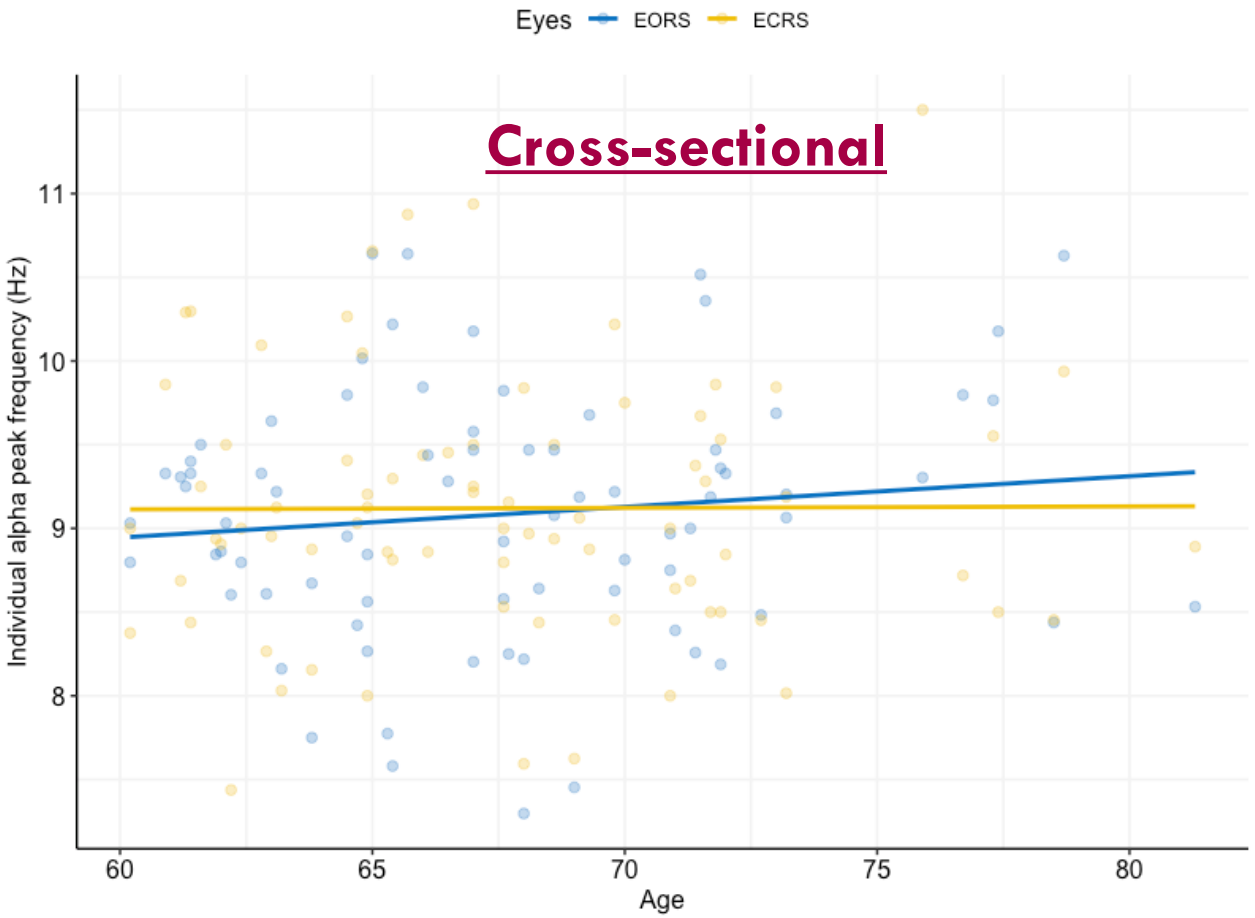


- A sample power spectrum from **young** (n=27, age 19 - 26 (2.23)) and the **old** (n=68, age 60.2 – 81.3 (4.59)) participants **collected by our team**.
- Showed both slowing and decreased alpha amplitude.

Age-related changes of IAPF *(Matthew Ma)*

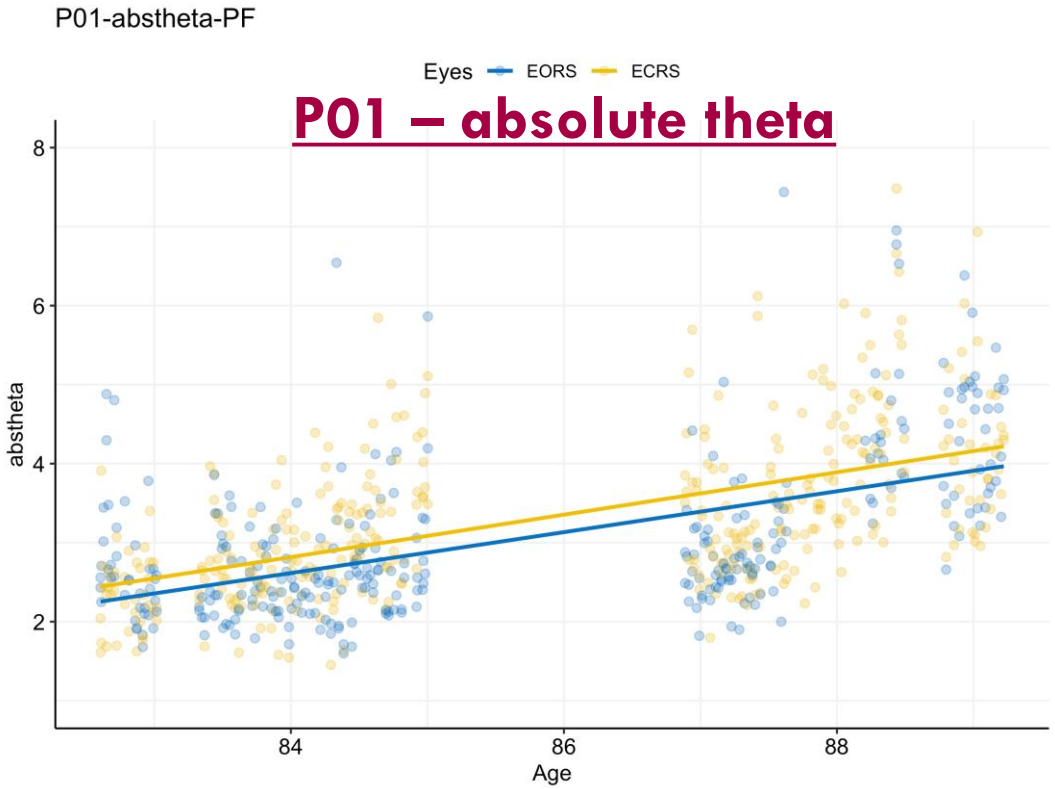
- The **longitudinal** data is able to show the **decreasing individual alpha peak frequency (IAPF)** with increasing age.
- But, the **cross-sectional** data **fails to reveal a decreasing trend** (or maybe even slightly increasing!).

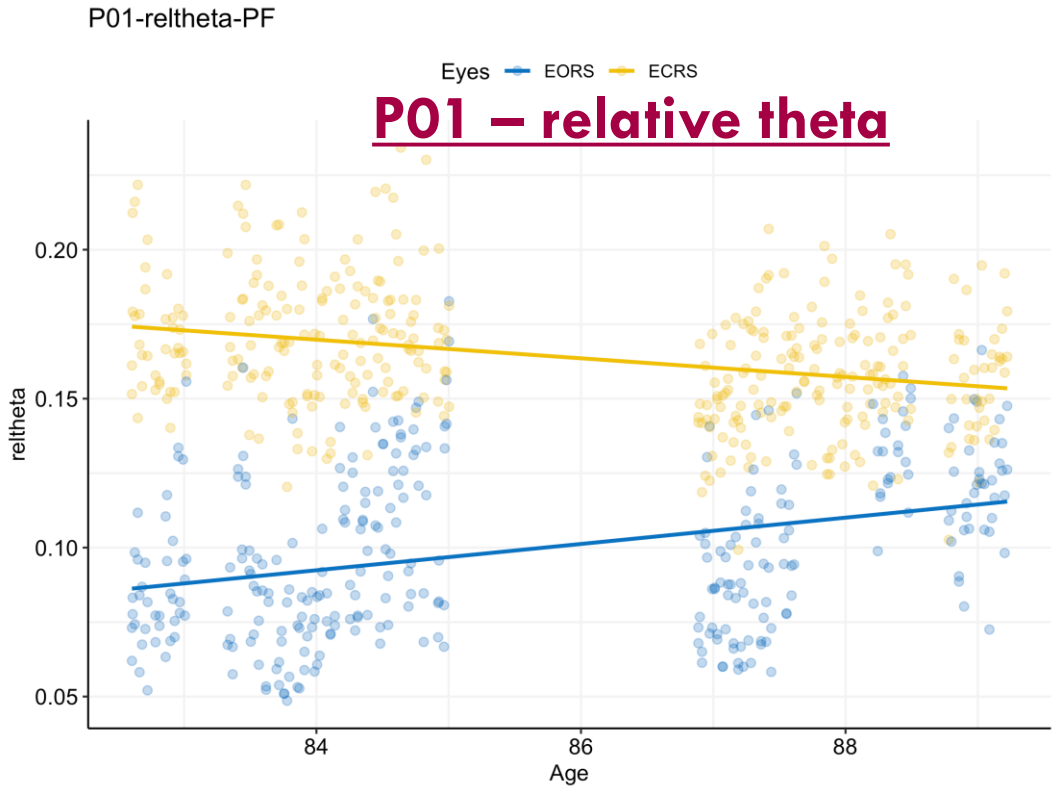


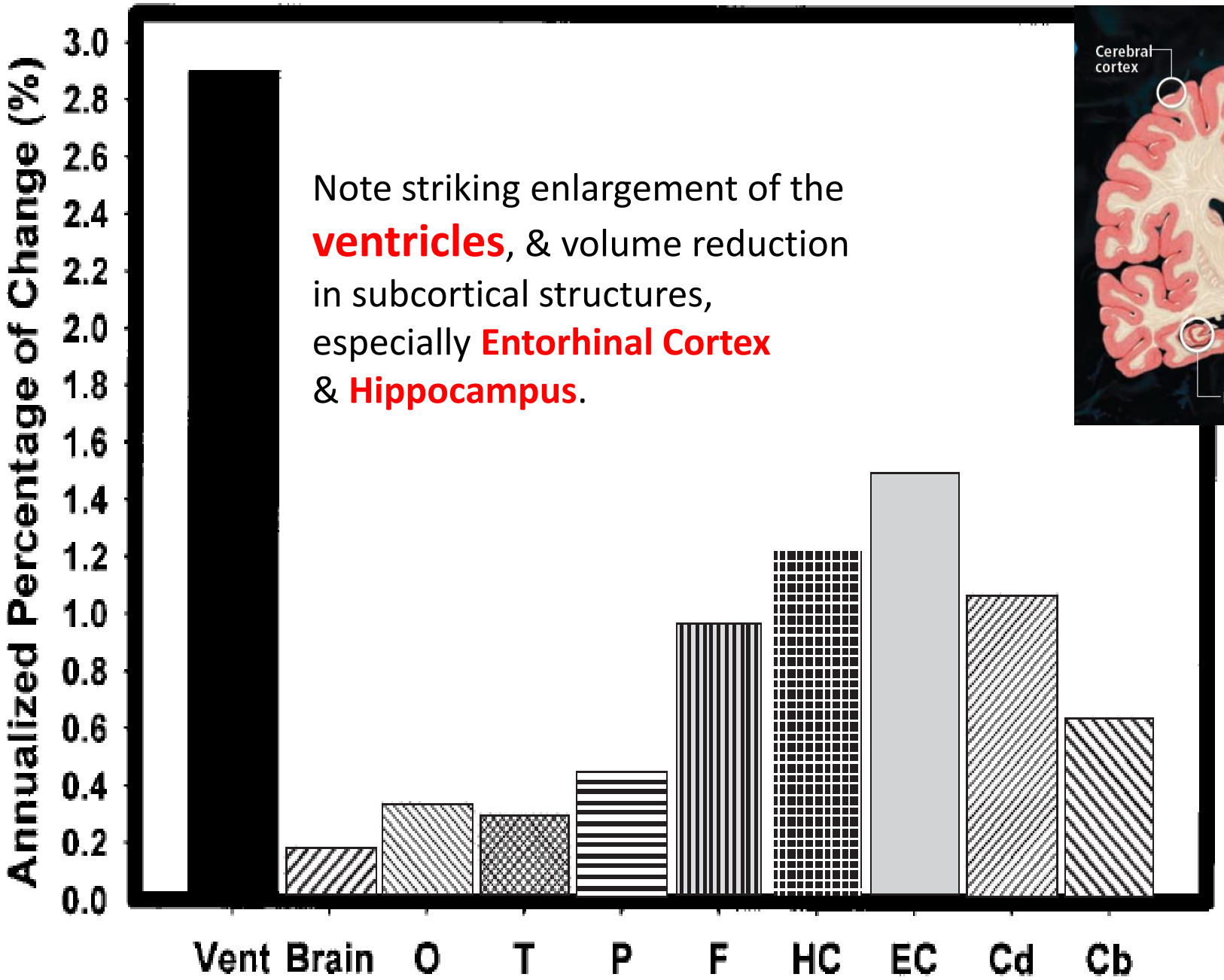


Individual-specific changes in longitudinal data *(Matthew Ma)*

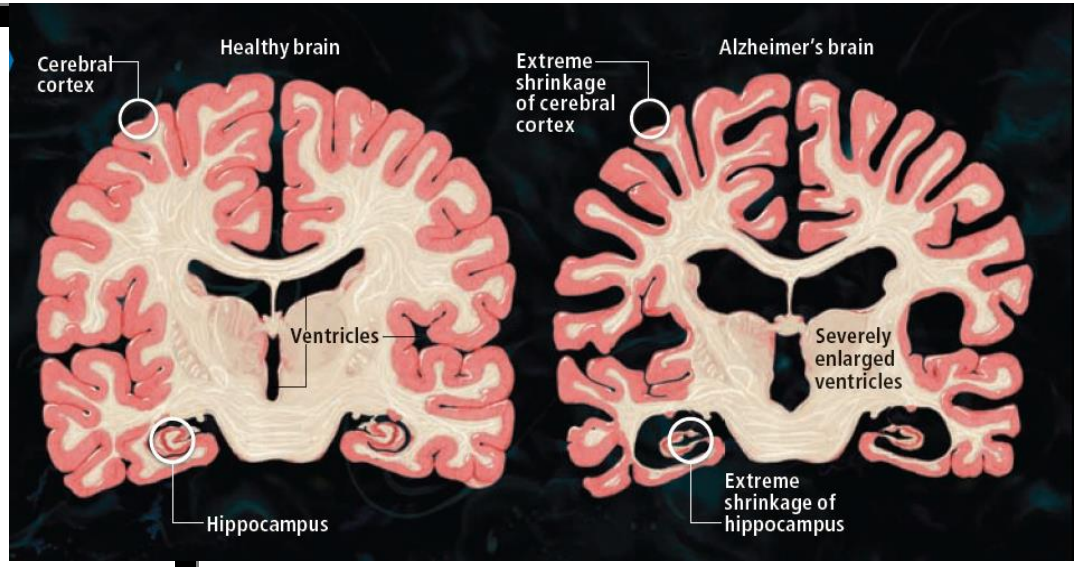
- One of the most interesting findings about individual-specific changes is on the **theta band**. While the absolute theta (and also other band) power increased with age, the relative theta showed **divergent patterns** in the two eyes conditions.
- Cross-sectional studies have shown both positive (Vlahou et al., 2015; Finnigan and Robertson, 2011) and negative relationships (Prichep et al., 2006) between theta power and cognitive abilities.







Note striking enlargement of the **ventricles**, & volume reduction in subcortical structures, especially **Entorhinal Cortex** & **Hippocampus**.



Cabeza, R.et al. eds. 2005:41. *Cognitive Neuroscience of Aging Linking Cognitive and Cerebral Aging*: Oxford University Press.

Stix, G. 2010. Alzheimer's: Forestalling the darkness. *Scientific American* 50-7.

T1 MP-RAGE

TE = 2.29 ms TR = 2000 ms TI = 900 ms

Video produced by Manson Fong, 2017.

Young

Old

Changes in **Total Ventricular Volume** across Time

Analyses by Manson Fong.

		Session 1 (SIAT) 17.10.10	**Session 2** (HKU) 20.09.16	**Session 3** (PolyU) 21.11.22	**Session 4** (PolyU) 22.09.07
Subject 1	Age (year)	84.2	87.1	88.3	89.1
	Ventricular volume (cm^3)	**73.853**	**84.258**	**84.797**	**86.068**
Subject 2	Age (year)	33.1	36.1	37.3	37.9
	Ventricular volume (cm^3)	**14.806**	**16.346**	**16.132**	**15.586**

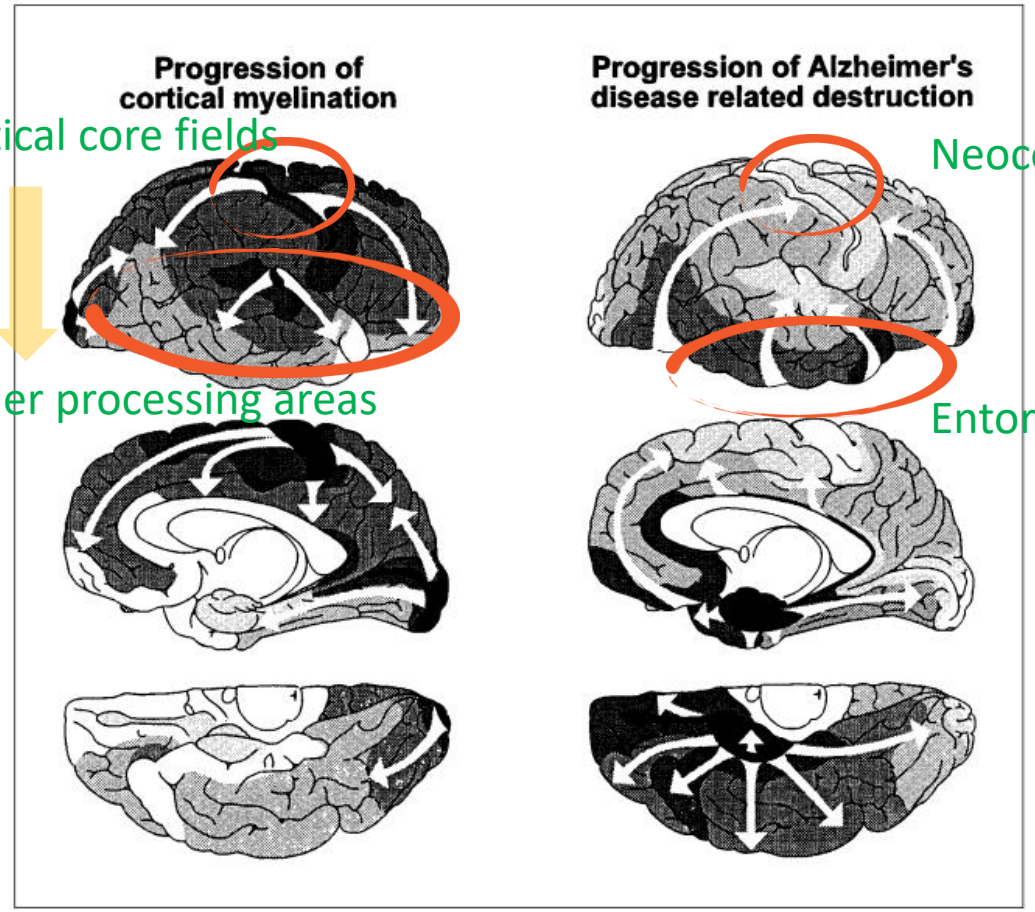
Cognitive decline is an immense area of research because the brain is so incredibly complex & so little understood so far, especially within a Chinese context. Yet the challenges of ageing are pressing & urgent at all levels of society – personal, familial, community, & government.

Language is a natural window for research on cognition & its decline. The efforts of our team are no more than 沧海一粟. We need many more talented & dedicated **researchers** to join in, as well as much more support in various **resources** for its early success.

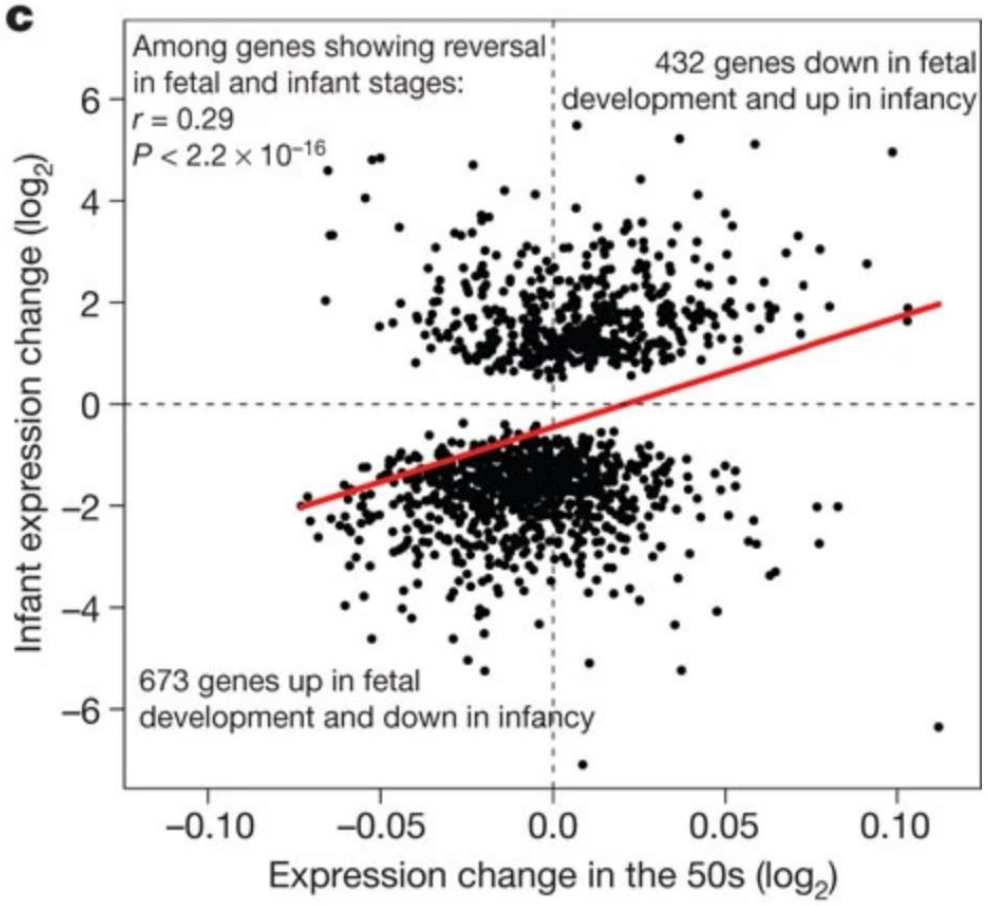
Retrogenesis

- Language is not invariable, rather it shows ontogenetic and phylogenetic variance.
- Furthermore, in contrast to being random, the change of language is guided by principles.
- We suggest that the language acquisition and dissolution follow the **retrogenesis theory** (Ribot, 1881/2012; Jakobson, 1941/1968; Reisberg et al., 1999), or "first-in-last-out" principle, namely, the first one acquired in the language system is the last one dissolved from the system.

Neural and genetic retrogenesis



"Regressive changes of the cortex frequently repeat the process of maturation in reverse order." (p. 200)
(Braak, H., & Braak, E., 1996)

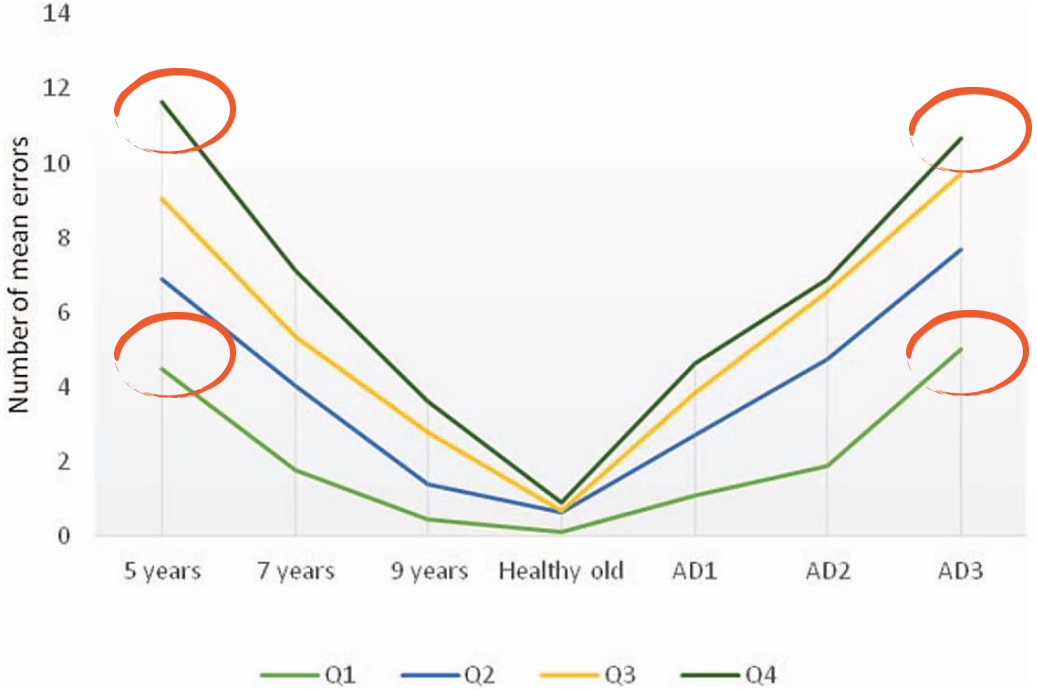


"the specific reversal of fetal expression trajectories seen in infancy is mirrored within changes in ageing." (p.521)
(Colantuoni et al., 2011)

Acquisition and dissolution in language

Semantic processing

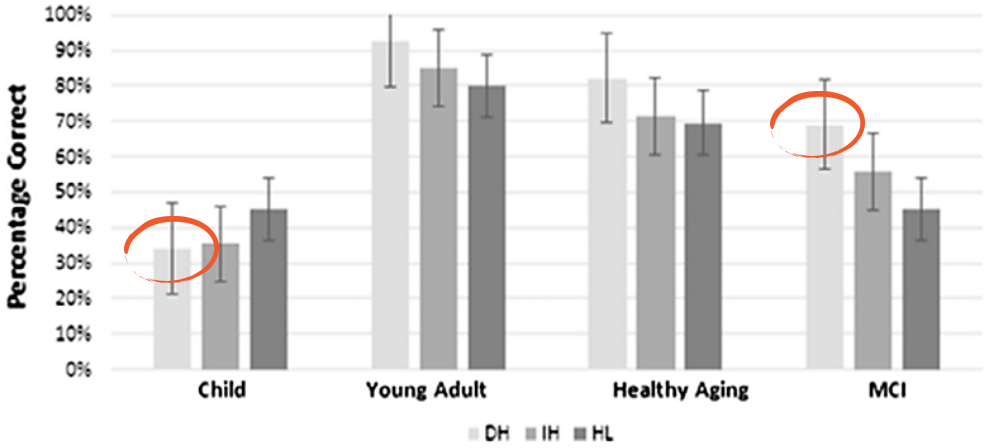
Simoes Loureiro, I., & Lefebvre, L. (2016)



Q1: is the ostrich an animal, a plant, or an object?
Q2: is the ostrich a four-legged animal, a bird, or an insect?
Q3: is an ostrich's neck longer than a rooster's?
Q4: does the ostrich run, walk, or swim?

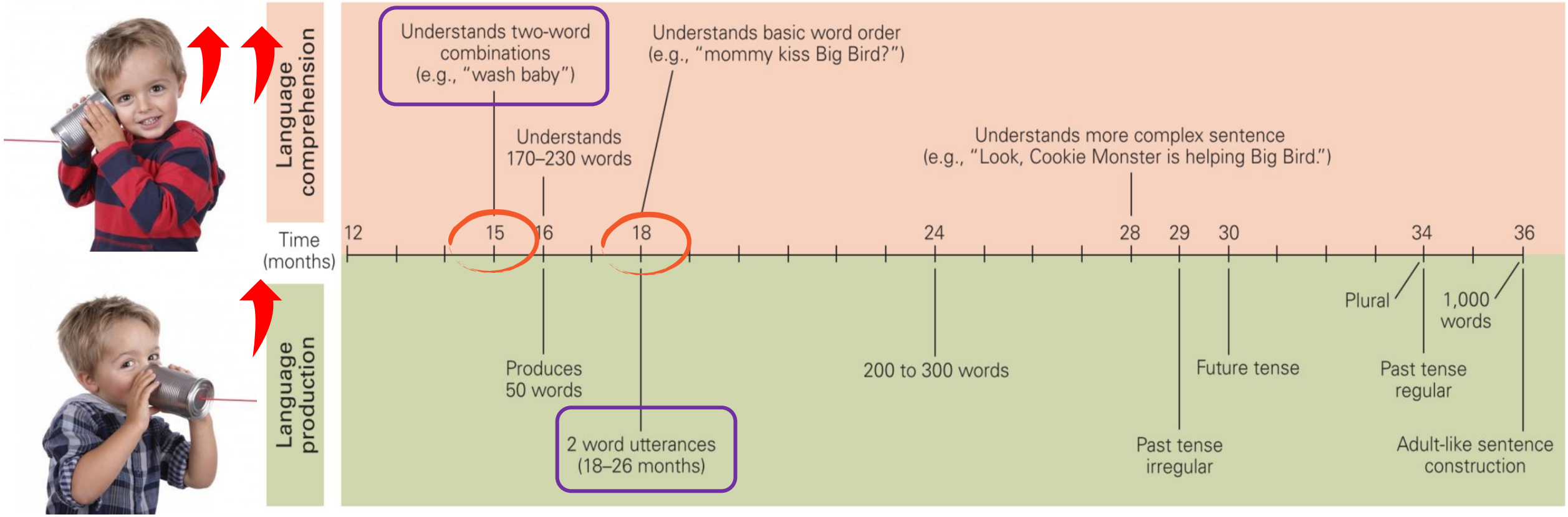
Syntactic processing

Lust, B., et al., (2015)



DH: The physician formulated **the therapy** which ___ cured the patient.
IH: The custodian removed **the thing** which ___ annoyed the librarian.
HL: The office manager corrected what ___ bothered the summer intern.

Production/comprehension asymmetry (PCA)



Kuhl, P. K., & Damasio, A. R. (2013). In E. R. Kandel, et al. (Eds.)

https://www.friendshipcircle.org/blog/2015/01/08/5-ways-to-encourage-auditory-processing-and-listening-skills/

Methods

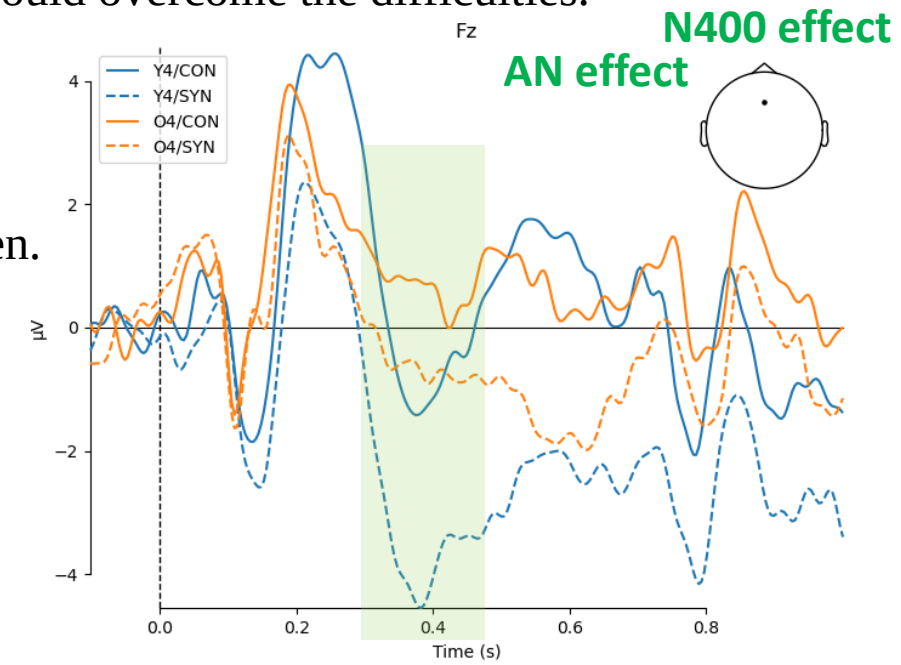
- 1. Constrained production task
  - E.g., 班主任(mentor) 把(Ba) 哭泣(cry) 资金（fund)

    班主任把大家募、募集的资金交给了正在哭泣的小明同学并嘱咐他一定要闯过难关(Y_1-1_21)

    The mentor gave the funds raised to crying Ming and told him he would overcome the difficulties.
- 2. Semantic correctness judgement task
  - E.g., *园丁整理花园，把杂草**宰/*拔**了。

    *The gardener killed/*pulled the weeds when trimming the garden.
- 3. Syntactic correctness judgement task
  - E.g., *管家把**整理**房间了。

    *The steward the room has tidied.



PCA results

Syntactic performance

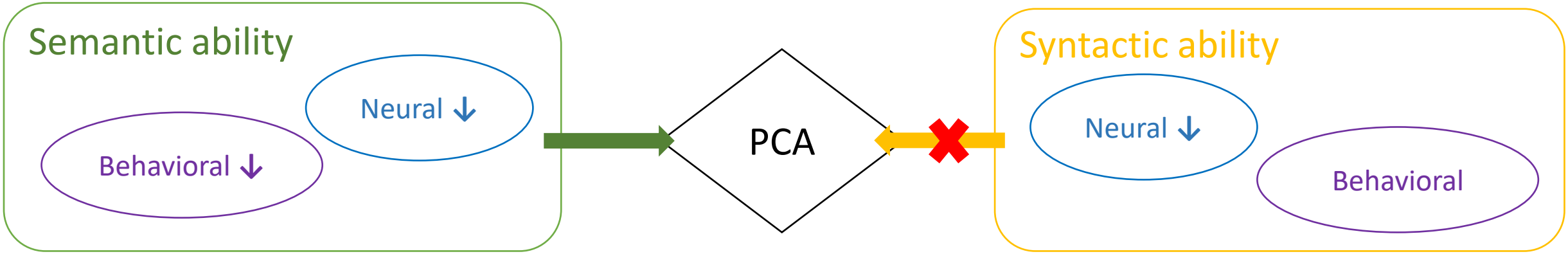
Variable			Median	IQR	V	*p*	r
Behavioral	Young	RT of production	0.80	0.22	153	0.20	0.28
		ACC of comprehension	0.88	0.13			
	Old	RT of production	0.76	0.24	120	0.33	0.23
		ACC of comprehension	0.90	0.31			
Neural	Young	Syntactic complexity	0.57	0.46	153	0.20	0.28
		Amplitude of AN component	0.40	0.29			
	Old	Syntactic complexity	0.23	0.37	90	0.86	0.05
		Amplitude of AN component	0.26	0.41			

Semantic performance

Variable			Median	IQR	V	*p*	r
Behavioral	Young	RT of production	0.80	0.35	114	0.97	0.01
		ACC of comprehension	0.72	0.32			
	Old	RT of production	0.77	0.51	93	0.95	0.02
		ACC of comprehension	0.70	0.18			
Neural	Young	Semantic complexity	0.53	0.45	156	0.17	0.31
		Amplitude of N400	0.72	0.31			
	Old	Semantic complexity	0.20	0.20	158	0.009	0.58
		Amplitude of N400	0.49	0.21			

Paired Wilcoxon signed rank test on the min-max normalized expressive and receptive data.

Semantic PCA



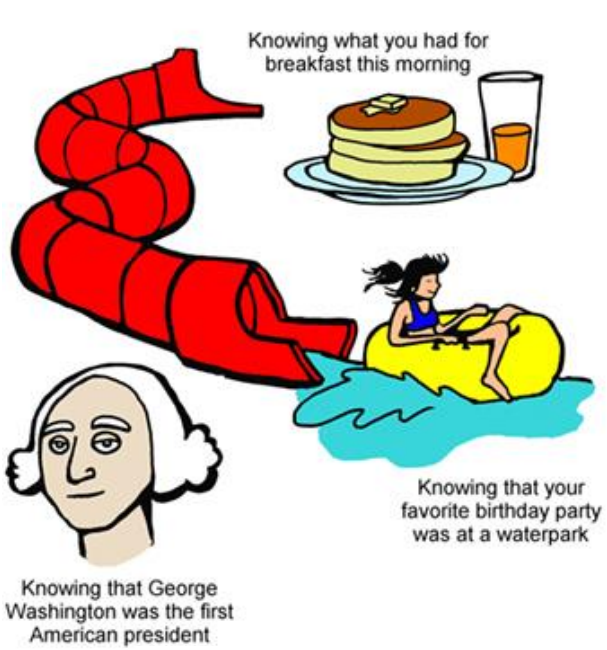
Language & Memory

Mosaic Theory

"language is regarded as a kind of 'interface' that makes a whole host of preexisting component abilities" (p. 17)

(Wang, 1982)

Declarative/Procedural model



DECLARATIVE MEMORY

Memory for facts and events

Mental lexicon

The declearn task

PROCEDURAL MEMORY

Memory for sequences and rules

Serial reaction time task

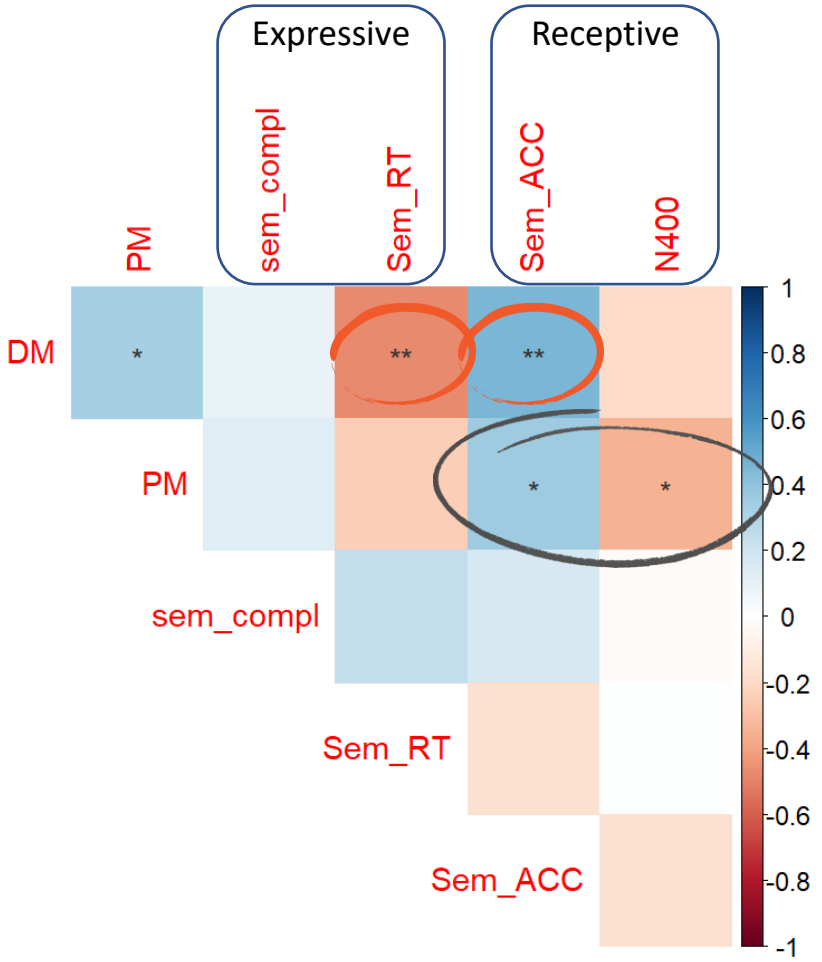
Mental grammar

https://images.app.goo.gl/gCxeW6uGcPvvfyGx9
https://stock.adobe.com/sk/search/images?k=brain+mosaic&asset_id=80637687

Ullman. (2001a); Ullman. (2001b); Ullman. (2014); Reifegerste et al., (2020); Lum, J. A. G., Conti-Ramsden, G., et al. (2012)

Semantic PCA and memory

- Pearson correlation coefficients were computed on the original data of all participants.
- DM was related to semantic ability in both modalities.
- PM was also related to semantic ability but solely in the receptive modality.
- It is plausible that semantic PCA is related to the accumulation of lifelong divergent support from PM.



Take-home message

- EEG & MRI are useful tools for age-related language variation study and personalized health monitoring.
  - The longitudinal data revealed **subject-specific changes** in addition to the commonly observed group level age-related changes.
  - **Within-subject variability** is two to three folds less than that **between-subject variability**
- In accordance with the retrogenesis theory, older adults show the same production/comprehending asymmetry (PCA) as children do.
  - The **PCA emerges** after the corresponding receptive ability declines at both behavioral and neural levels.
  - **Differential contributions** from DM and PM have a significant effect on PCA in older adults.

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Thank you!

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3q!

For PDF file, email:

wsywang@polyu.edu.hk

chenwei7.xie@connect.polyu.hk

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