Neural Mechanisms of Word Recognition in Different Language Systems

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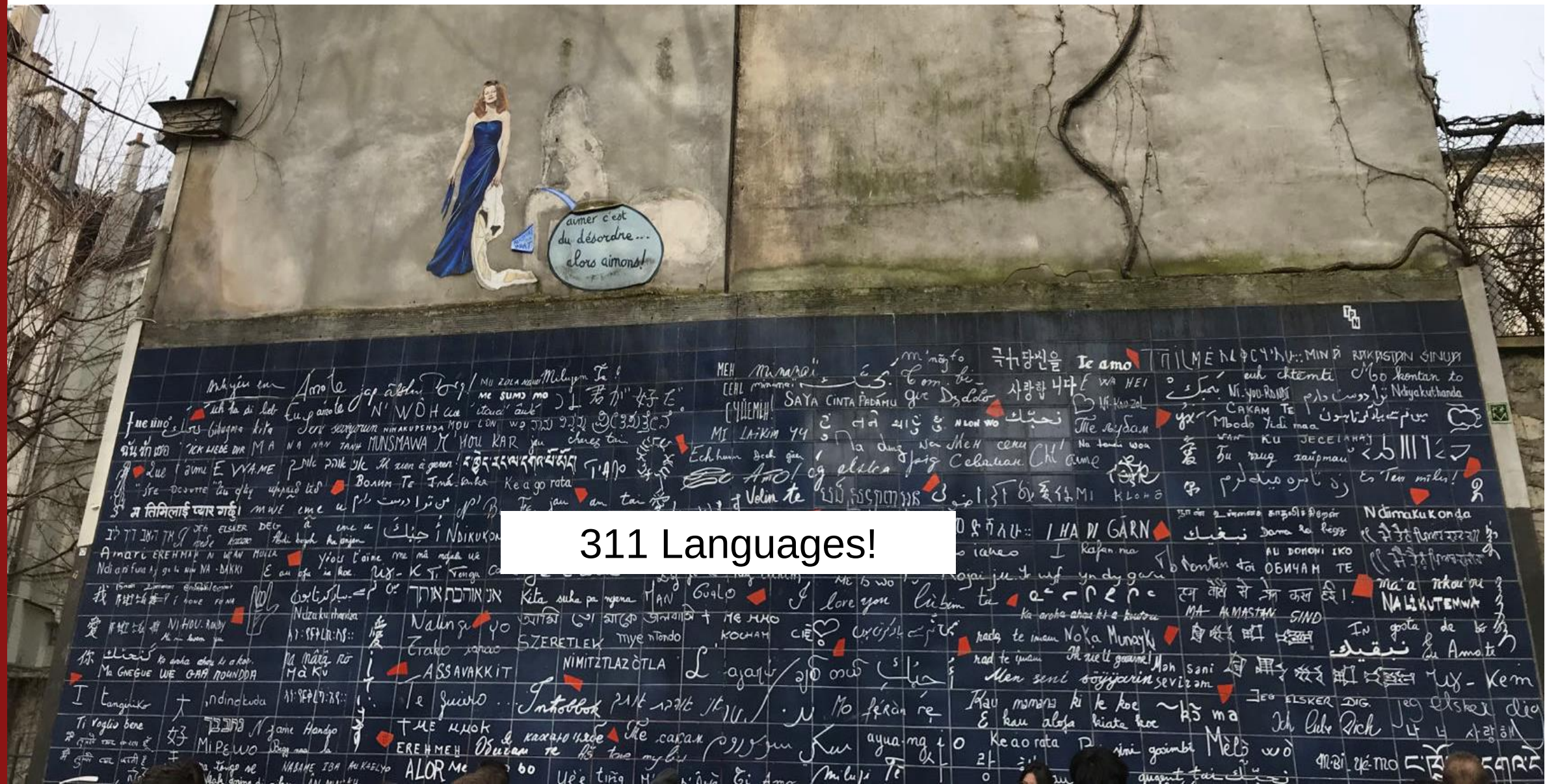
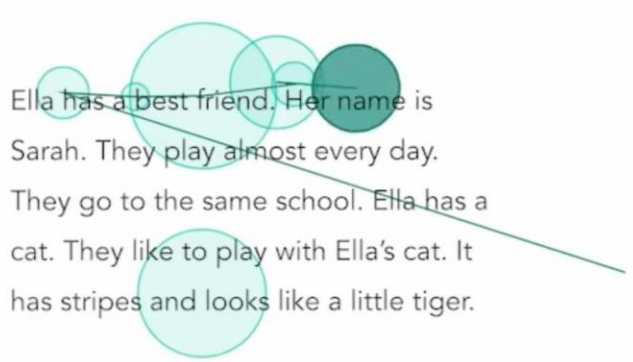
Faculty Interview Seminar for Department of Linguistics & Translation at the City University of Hong Kong

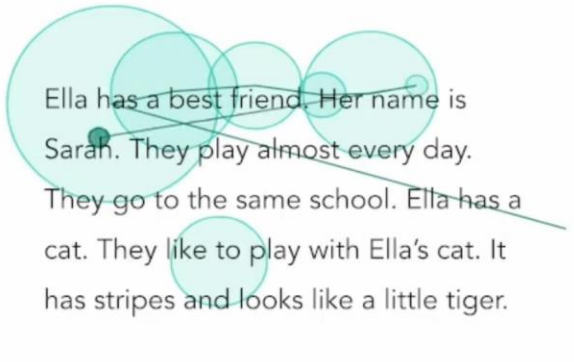
Language is Universal but Unique to Humans



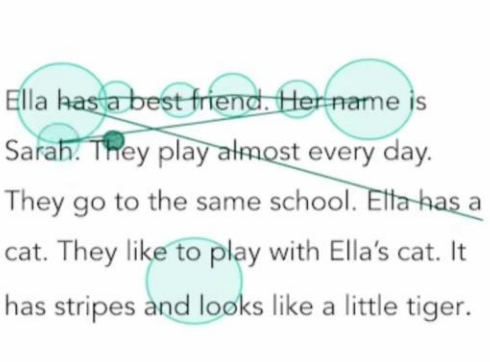
Eyemovements and Lexplores five reading levels



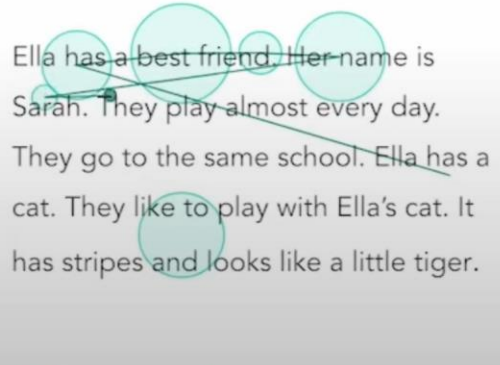
Low



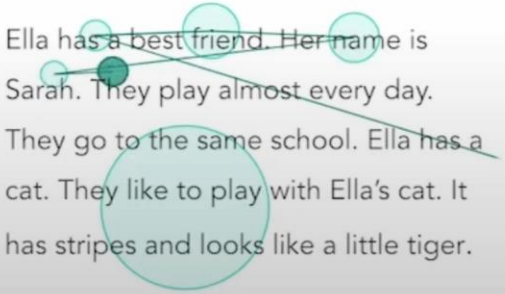
Below Average



Average



Above Average



High

Source Credit: Lexplore - get an overview of the reading ability

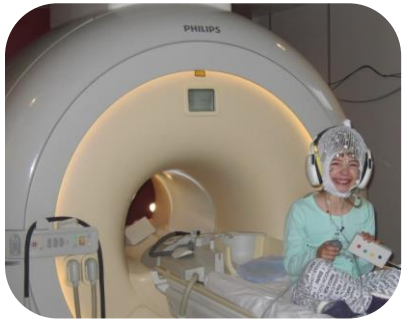
My Main Research Interest

How does word recognition system
get set up in the brain?

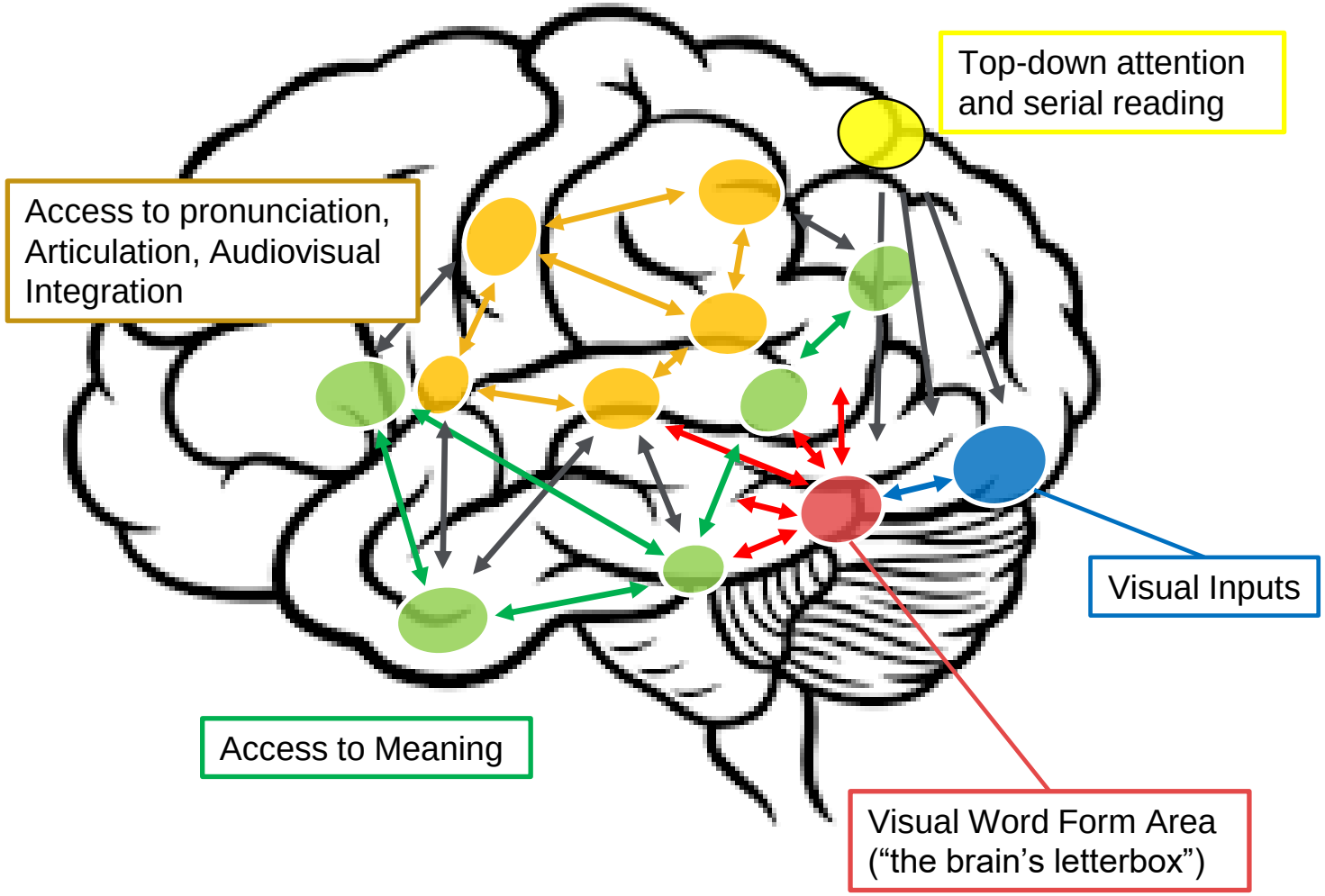
Behavior

Electrophysiology
(EEG)

functional Magnetic Resonance Imaging
(fMRI)

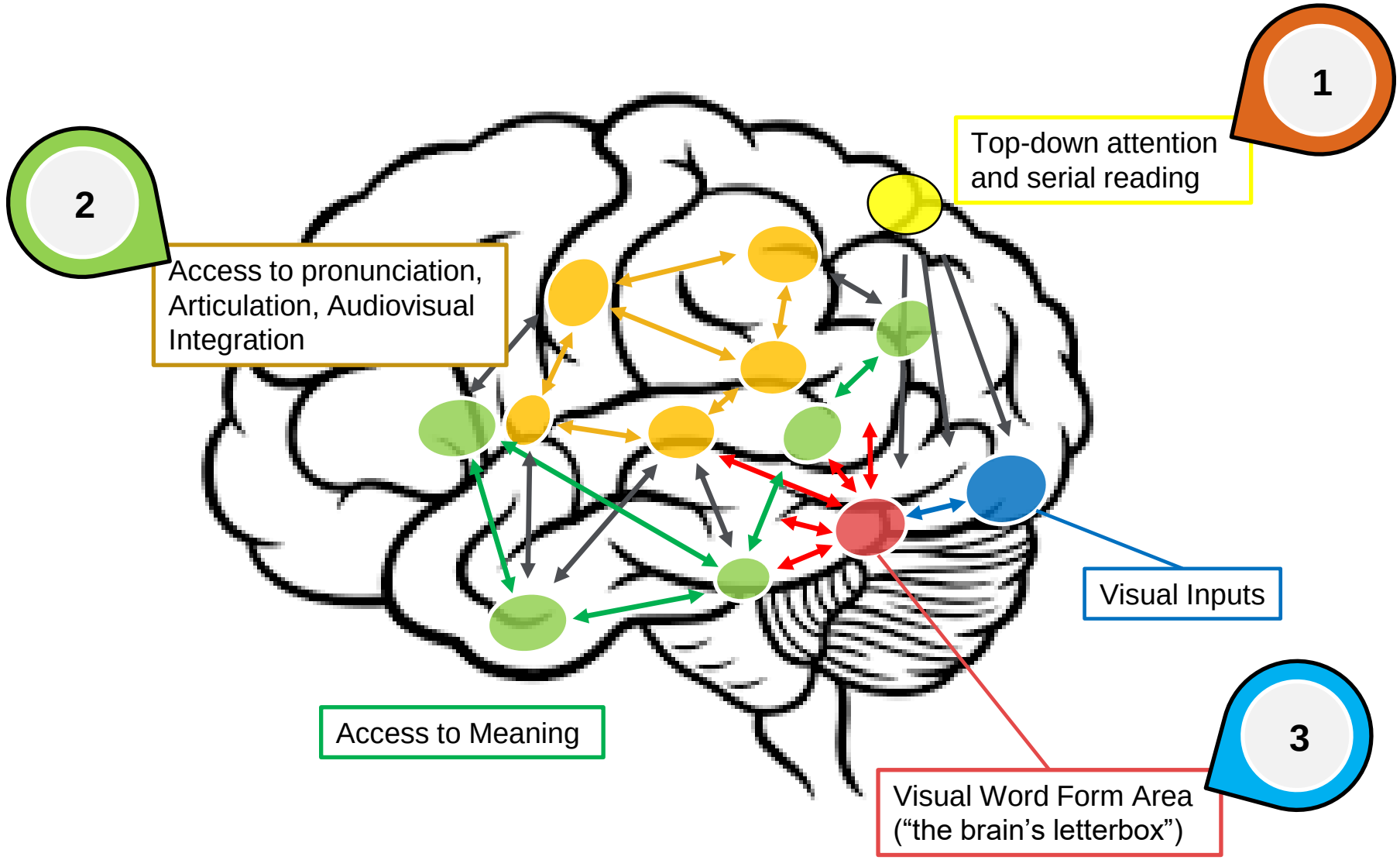


A Modern Vision of the Cortical Networks for Reading

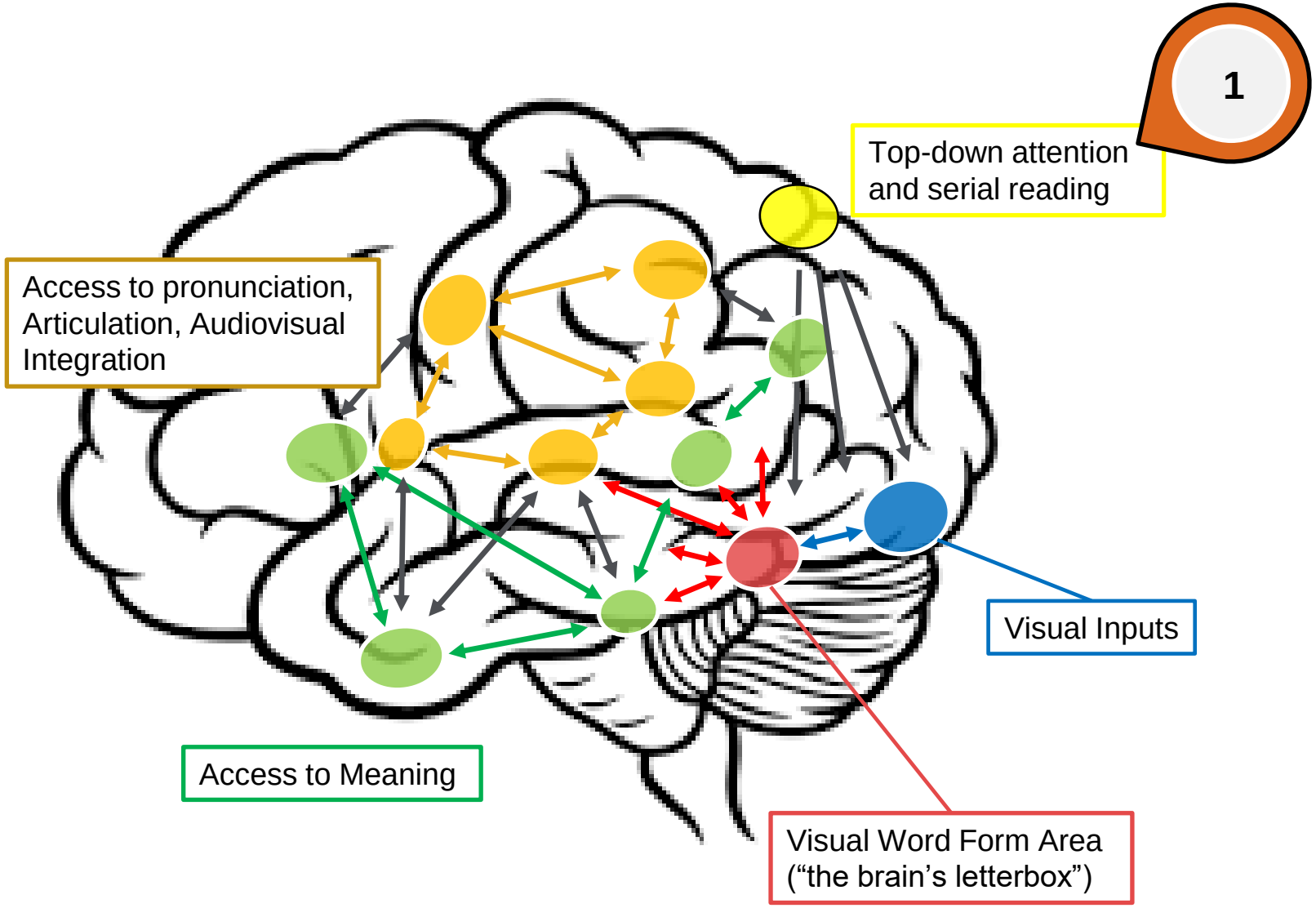


Adapted from Dehaene, Reading in the Brain, 2010

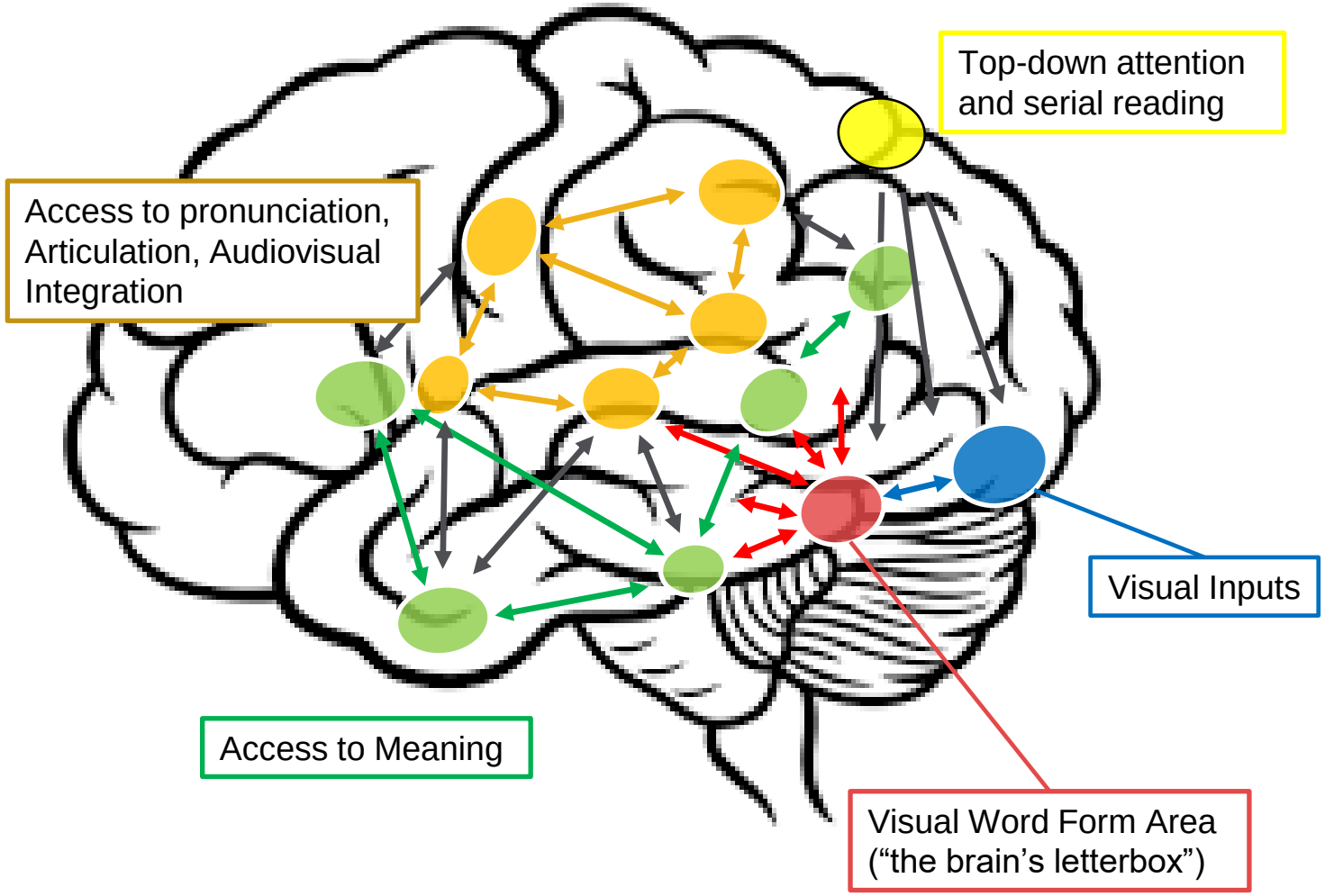
Overview


1
Top-down attention and serial reading
2
Access to pronunciation, Articulation, Audiovisual Integration
Visual Inputs
Access to Meaning
3
Visual Word Form Area ("the brain's letterbox")

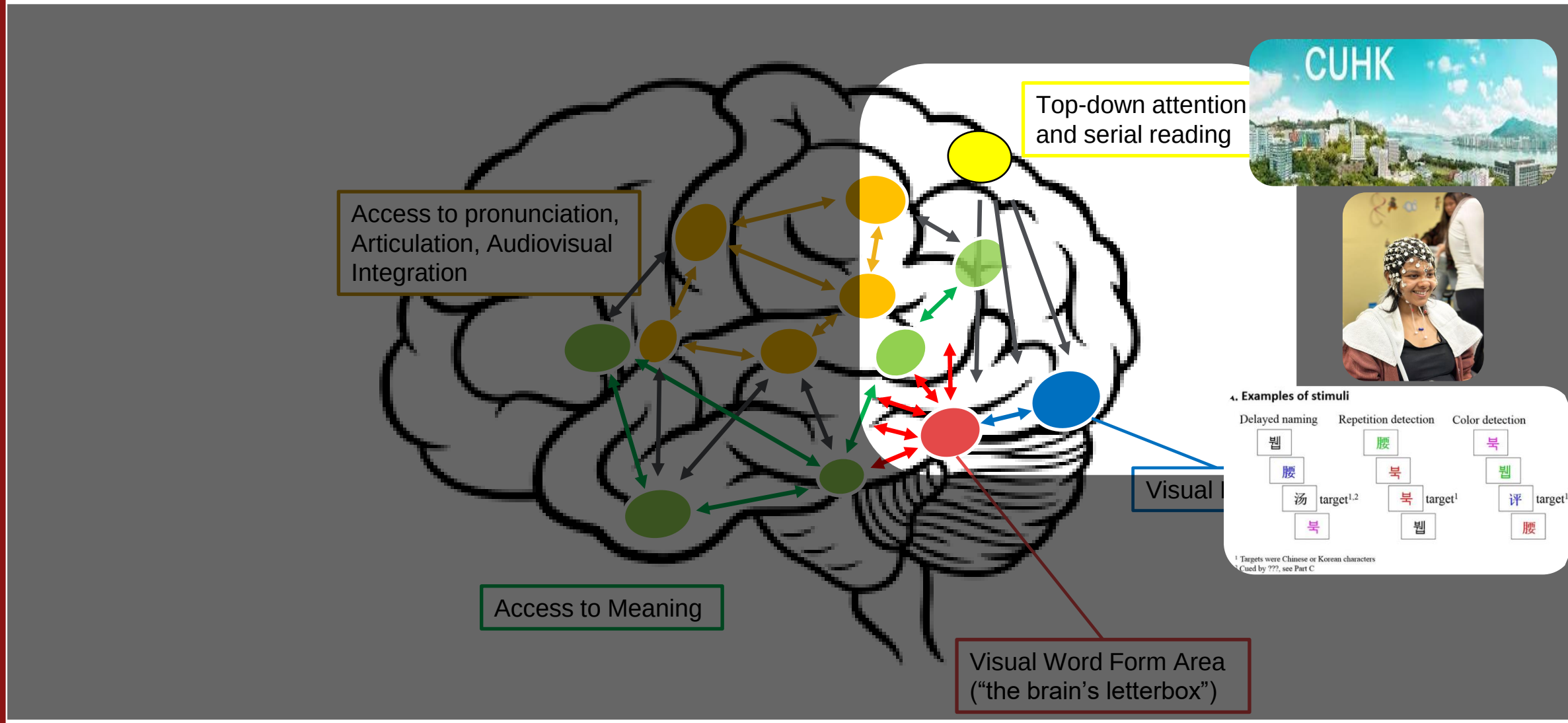
Part 1: Top-Down Modulation in Visual Word Recognition



Research Question: Time Course of the Top-Down Modulation?



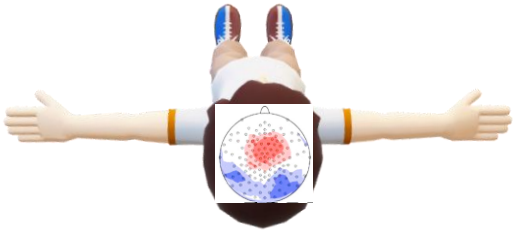
Top-Down Modulation in Visual Word Recognition (Chinese Adults)



The Time Course of Top-Down Modulation (Chinese Adults, *N* = 25)

Wang *et al., Neuropsychologia* (2017, see also 2020)

The Time Course of Top-Down Modulation (Chinese)



Map Difference
(Chinese-Korean)

N1 onset
125~172 ms

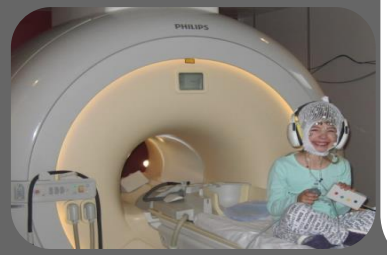
Naming Repetition Color

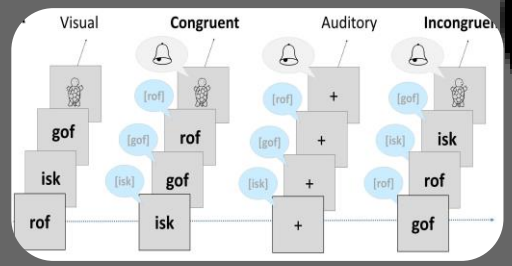
Takeaway: Top-down information (task demands) influences word recognition at around 200 ms.

Wang *et al., Neuropsychologia* (2017, see also 2020)

Research Motivation: AudioVisual Integration in Alphabetic Language

The AV Integration in Children with Risk for Developmental Dyslexia (German)





Access to pronunciation, Articulation, Audiovisual Integration

Top-down attention and serial reading

Visual Inputs

Access to Meaning

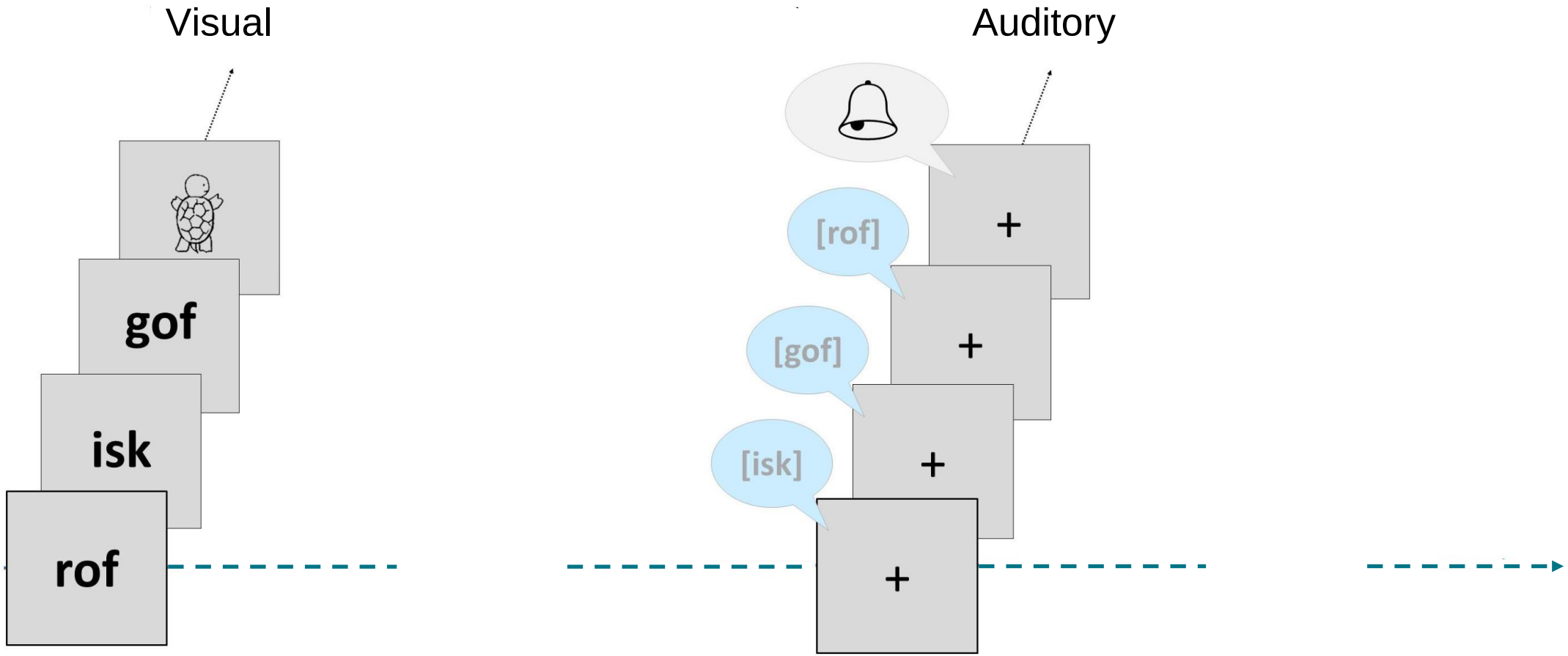
Visual Word Form Area ("the brain's letterbox")


Developmental Disorders
in Children
Dyslexia

Research Question: Visual, Auditory, or AudioVisual Integration Deficit?

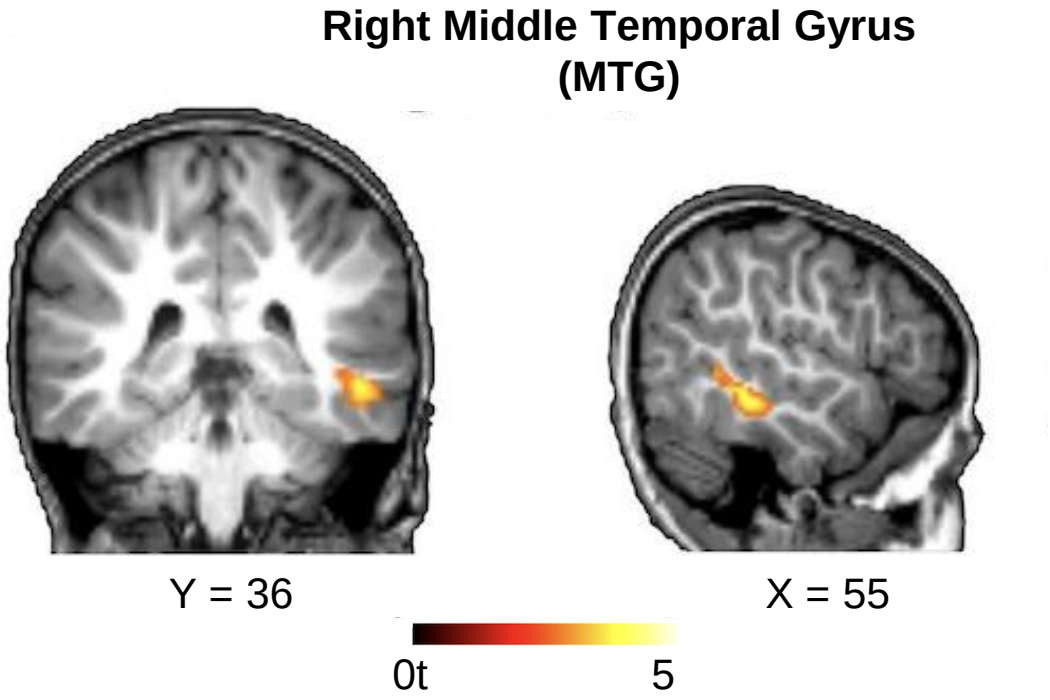
cat

Unimodal Visual/Auditory vs. Audiovisual Integration (German Children, *N* = 41)



Wang *et al., Frontiers in Human Neuroscience,* (2020)

Developmental Trajectory of AV Integration From First to Second Grade



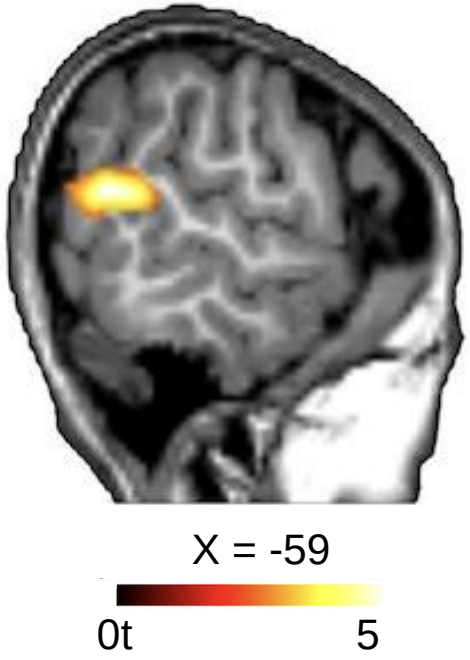
Takeaway: Children are more sensitive to AudioVisual integration at second grade.

Wang *et al., Frontiers in Human Neuroscience,* (2020)

AV Integration in the Temporo-Parietal Cortex Is Related to Reading Outcome

Second – First Grade (T2 – T1)

Left Superior Temporal Gyrus (STG)

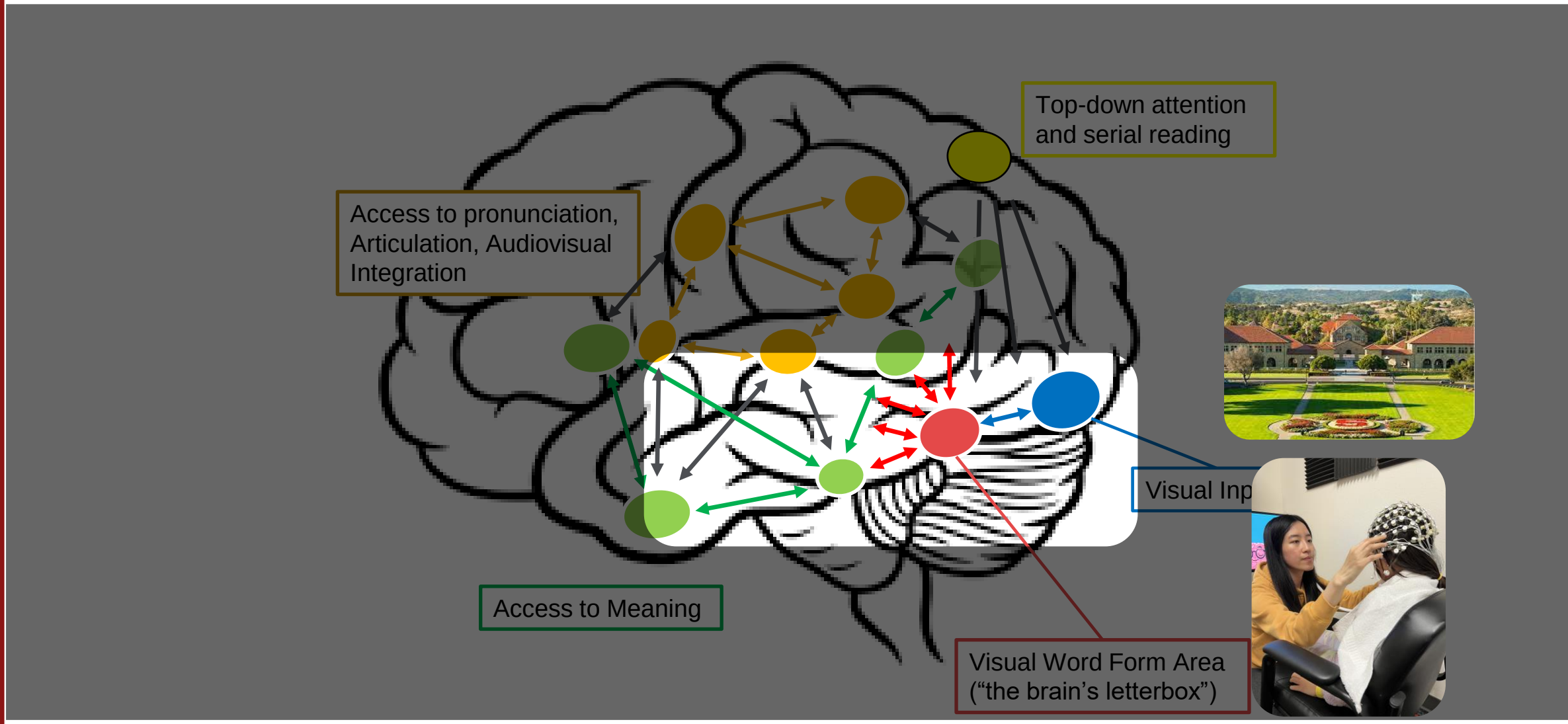


Takeaway: AudioVisual integration is a good predictor for reading fluency growth.

Wang *et al., Frontiers in Human Neuroscience,* (2020)

How A Child's Brain Develops Sensitivity to Different Levels of Word Information?

How A Child's Brain Develops Sensitivity to Different Levels of Word Information?



Research-Practice Partnership

Researchers

Students

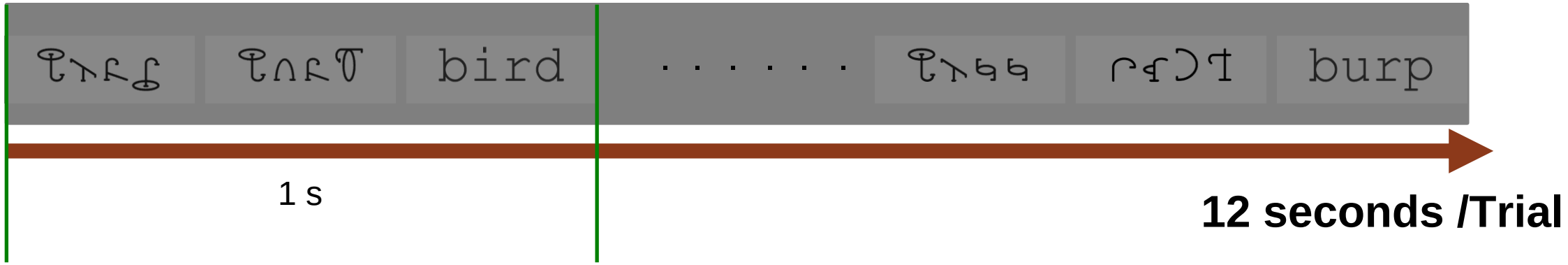
Stanford University

synapse school

Teachers

In-School BrainWave Learning Center and EEG Lab

Steady-State Visual Evoked Potential (SSVEP) Paradigm



Only 2~3 minutes!

10 trials/Condition

Wang *et al., Scientific Reports* (2021)

Benefits of RPP and SSVEP paradigm

Adapted from "From Visual Symbols to Word Recognition", 2019

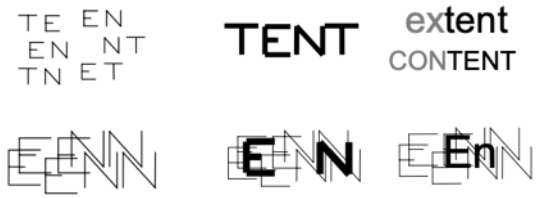
The Brain is Tuned in Layers!

Specific Words

content

Whole Word

Combinations of letters

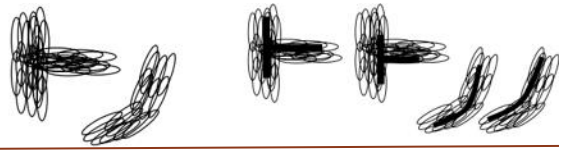


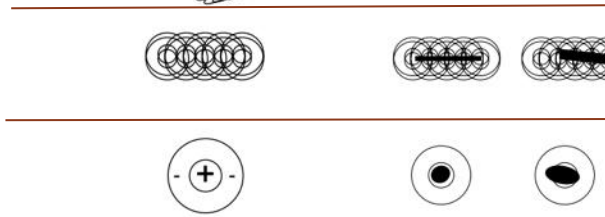
Word Form

Learned Letters

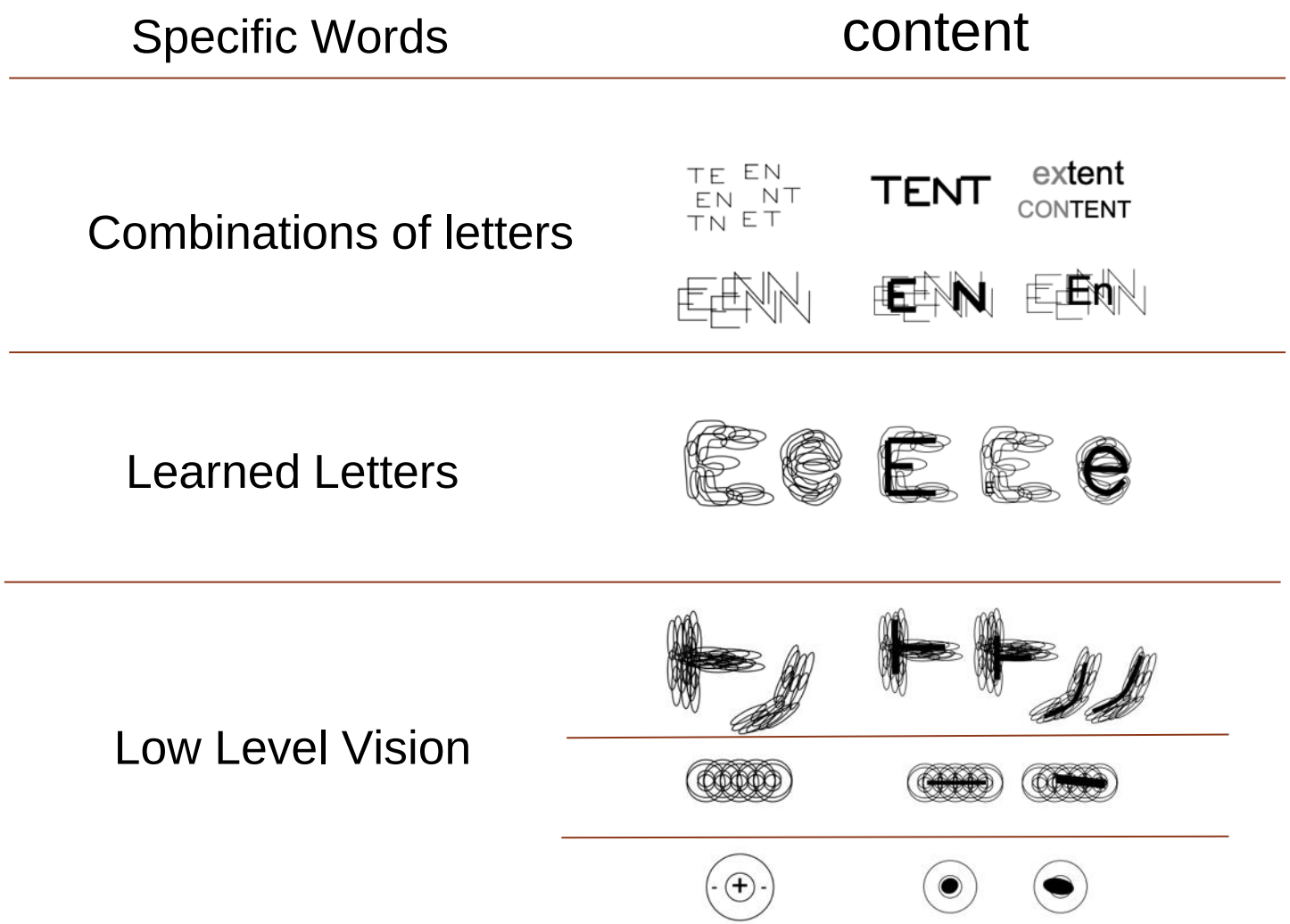
Letter Form

Low Level Vision





The Brain is Tuned in Layers!



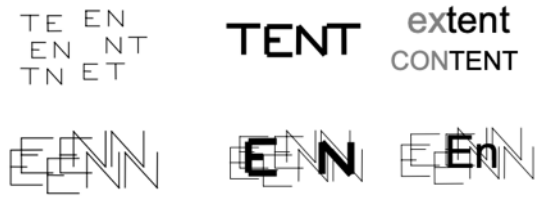
How are we ever going to see each layer gets tuned up and changes over time?

Let's Start with the Word Form Layer in K-2 Children's Brain

Specific Words

content

Combinations of letters



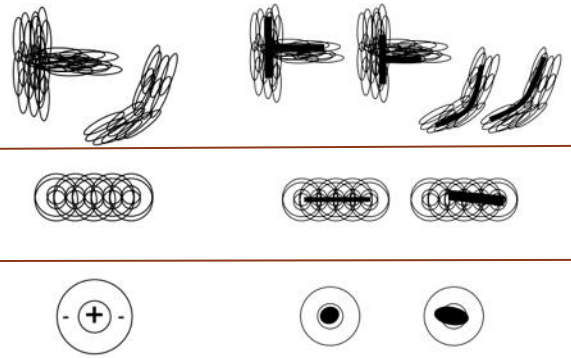
mun

Learned Letters

atn

Word Form

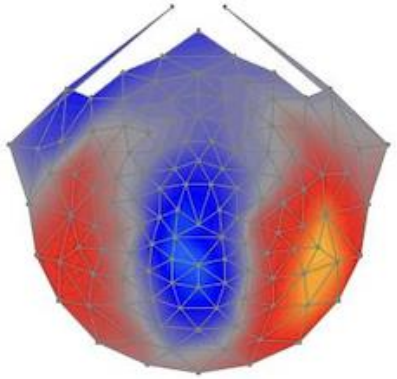
Low Level Vision



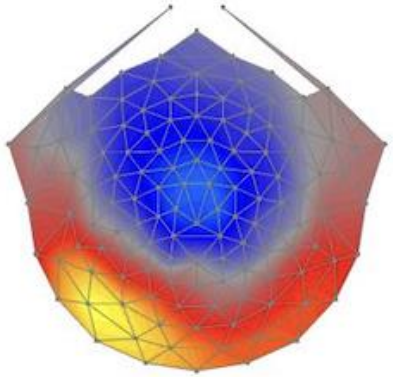
Kindergartners, 1st, and 2nd Graders Respond Differently to Word Form (*N* = 57)

	alternate		***alternate***		***alternate***	
igd	yot	atn	mun	ewb	vad	…

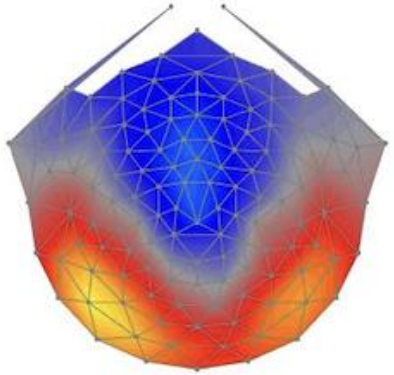
Kindergarten



1st Grade

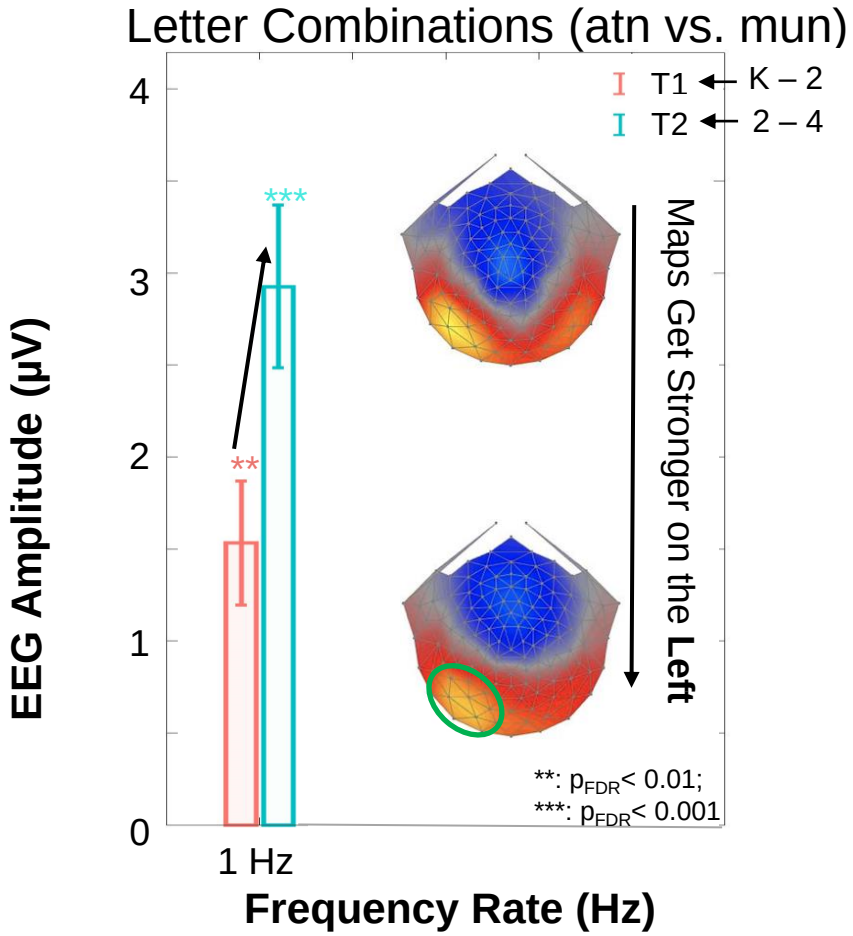


2nd Grade



Wang *et al., Developmental Science* (2022)

Growth in Brain Signals Linked to Fluency Gains within Individual Children



Takeaway: Ability to detect visual word form structure is a crucial factor promoting reading success.

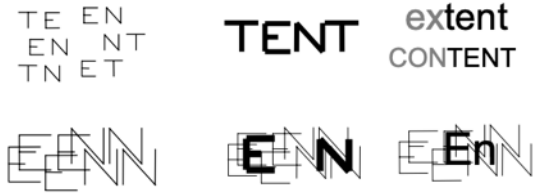
Wang *et al., Developmental Science* (2023)

How Children Learn and Build Whole Word Representations

Specific Words

content

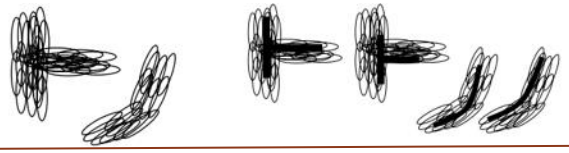
Combinations of letters

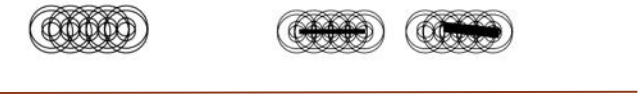


Whole Word

Learned Letters

Low Level Vision





Two Weeks of **Learning Sprint**!

New Vocabulary Words Learning: SSVEP and EEG in School (*N* = 48)

Magic Word List 1 → Class 2

Magic Word List 2 → Class 3

Magic Word List 3 → Class 1

2 Weeks Learning Sprint
15 min / Day

Other Two Classes

deviant ***deviant*** ***deviant***

binge waxen chafe brunt graft shank offal pecan covet ...

Own Class

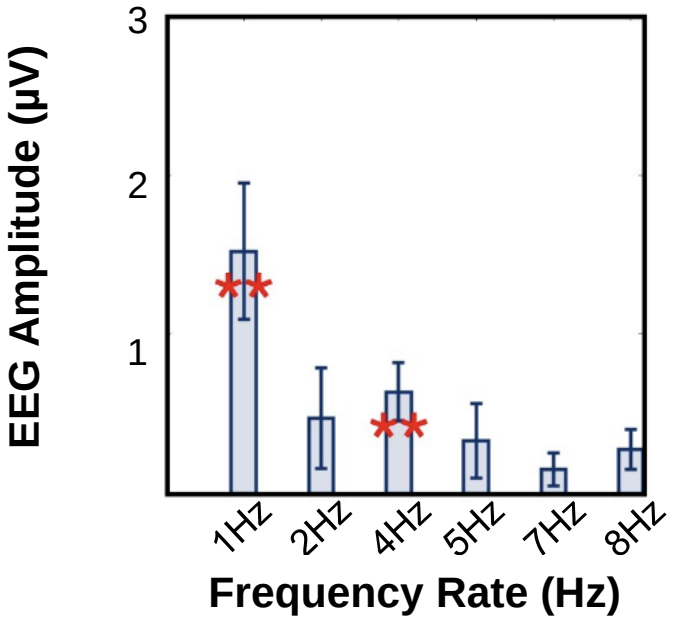
Wang *et al., manuscript under preparation,* (2023)

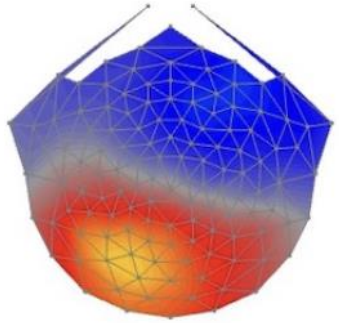
1 2 **3**

Very Similar Responses to New Learned Words and High Frequency Words

water

High Frequency Words
vs.
Pseudowords

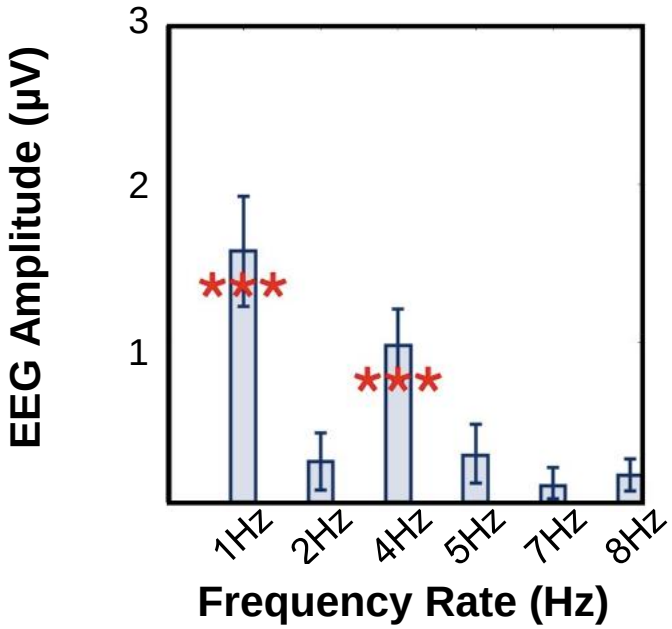




p_{FDR}< 0.01; ***: p_{FDR}< 0.001

crepe

Learned New Words
vs.
Unlearned Words



Individual Differences of New Vocabulary Learning Effect

New words learning effect: Learned New Words vs. Unlearned Words

Takeaway: Children Rely on Phonological Decoding Skills to Learn Novel Words

Wang *et al., manuscript under preparation,* (2023)

Different Teaching Methods for New Vocabulary Words Learning

Wang[#], Hasak[#], *et al., manuscript under preparation,* (2023)

Deep-Sea Spellers --- Different Teaching Methods

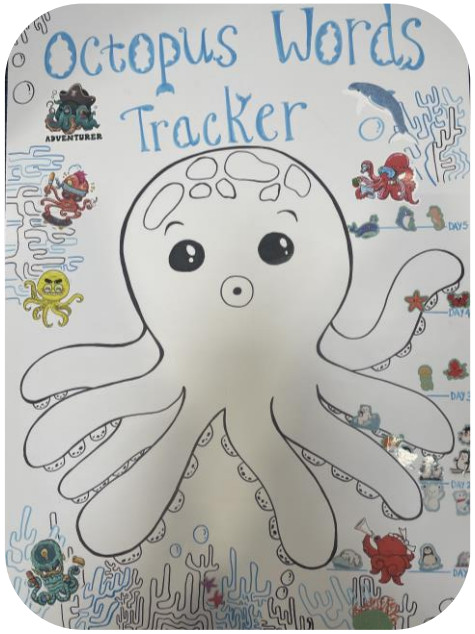
Sublexical Focus 

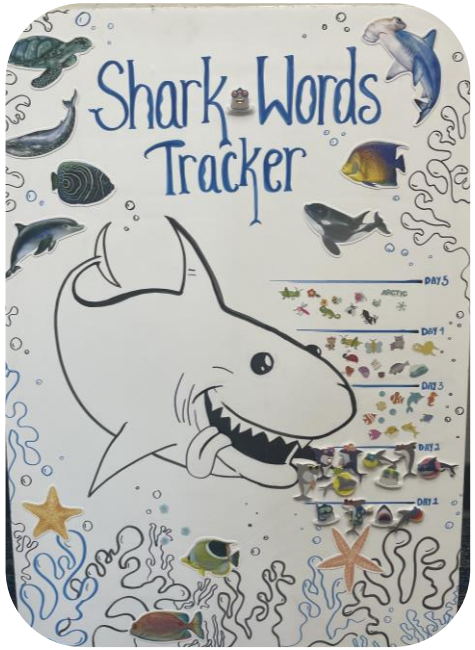
Lexical Focus 

Onset-Rime		Whole-Word
thr		snail
b		trail
g	**oat**	tail
fl		mail

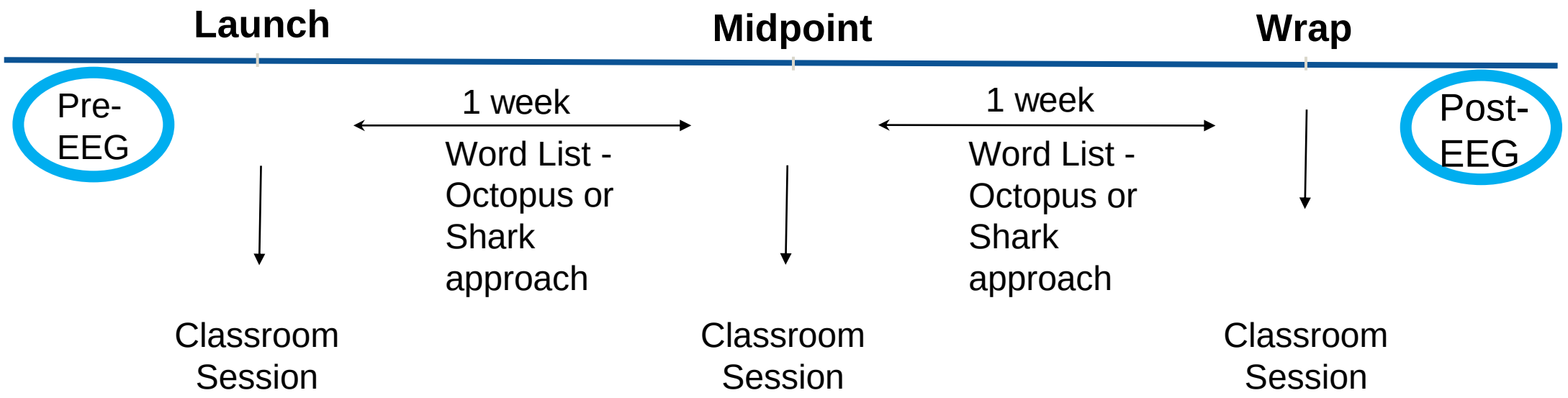
Activities


ight
erve
eet
awl
ail


Octopus Words
Tracker


Shark Words
Tracker

Logistics

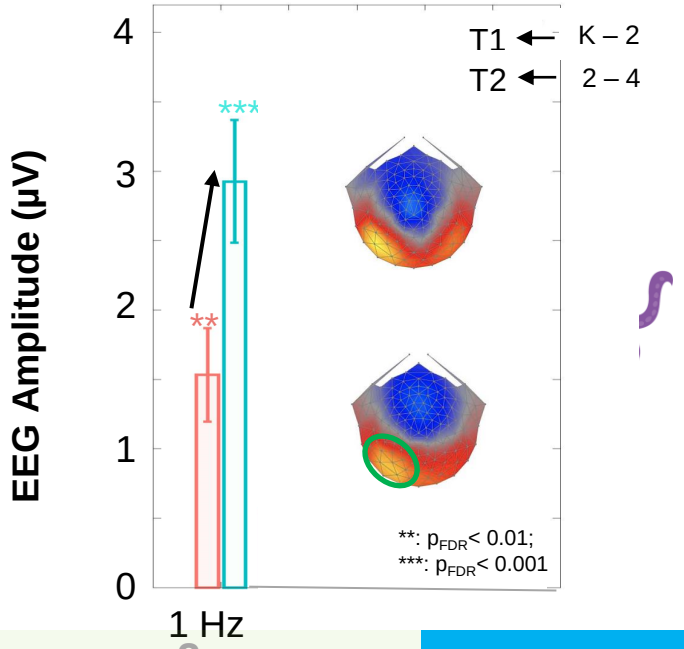

Launch
Midpoint
Wrap
Pre-EEG
1 week
Word List - Octopus or Shark approach
1 week
Word List - Octopus or Shark approach
Post-EEG
Classroom Session
Classroom Session
Classroom Session

Hypotheses

1. Sublexical Focus throat  > Control

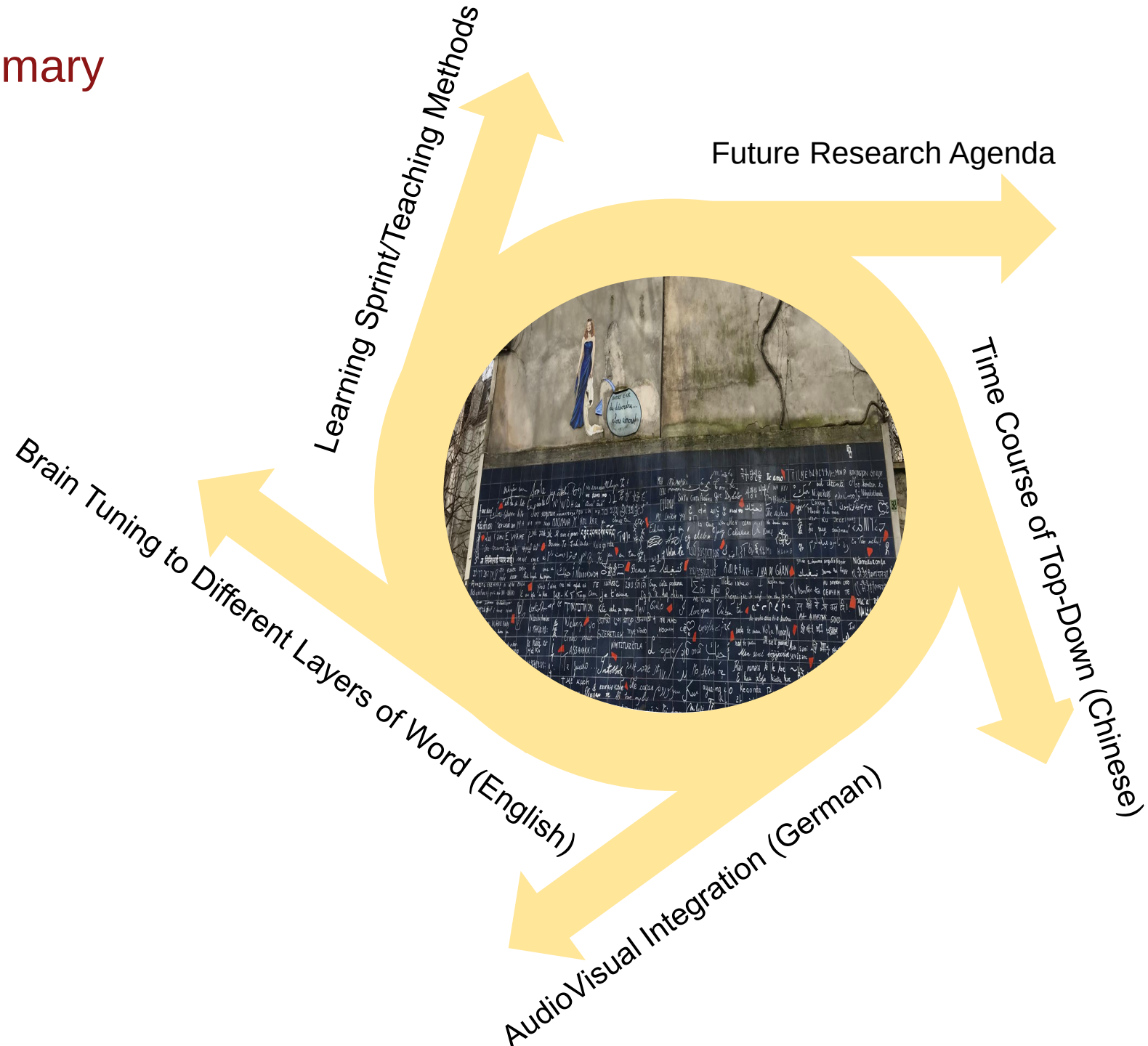
Lexical Focus throat 

2. Letter Combinations (atn vs. mun)



> Lexical Focus throat 

Summary


Learning Sprint/Teaching Methods
Future Research Agenda
Time Course of Top-Down (Chinese)
AudioVisual Integration (German)
Brain Tuning to Different Layers of Word (English)

Summary

Future Research Agenda

Learning Sprint/Teaching Methods

Time Course of Top-Down (Chinese)

AudioVisual Integration (German)

Brain Tuning to Different Layers of Word (English)

Visual impairments in English speaking children with developmental dyslexia

Literacy development in Chinese-English bilingual children

Developmental profiles of visual word sensitivity in children

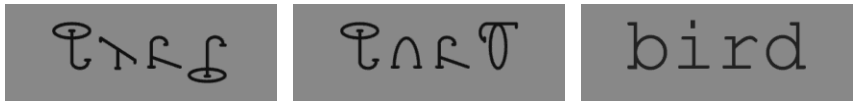
Visual impairments in English speaking children with developmental dyslexia

Literacy development in Chinese-English bilingual children

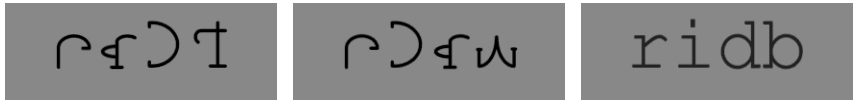
Developmental profiles of visual word sensitivity in children

Project #1: Visual impairments in English speaking children with DD

Cond 1: Pseudofont vs. Word



Cond 2: Pseudofont vs. NonWord



Cond 3: NonWord vs. Word

Project #1: Visual impairments in English speaking children with DD

Age Matched Controls	Dyslexics	Reading Matched Controls

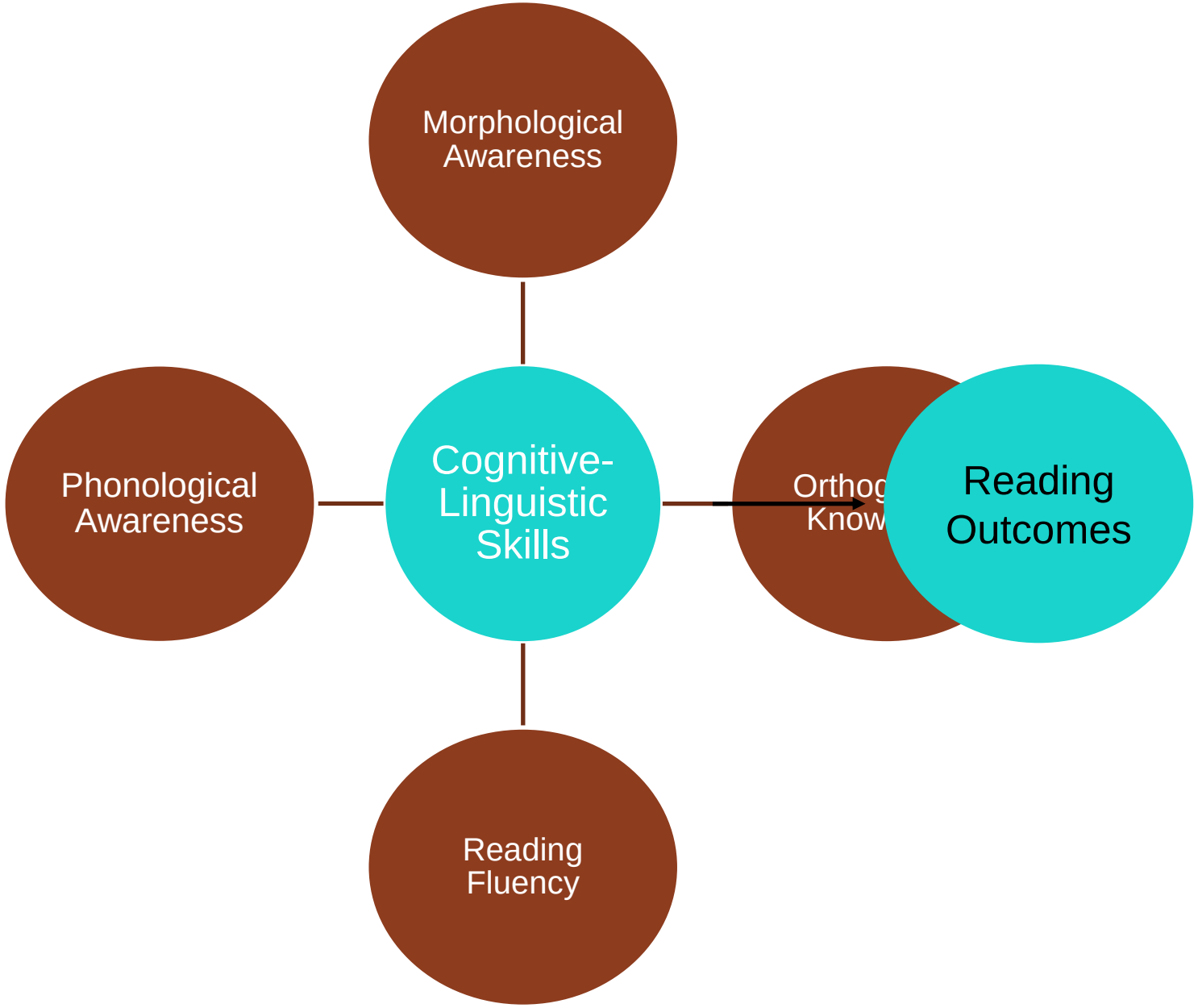
Age

Visual impairments in developmental dyslexia (DD)

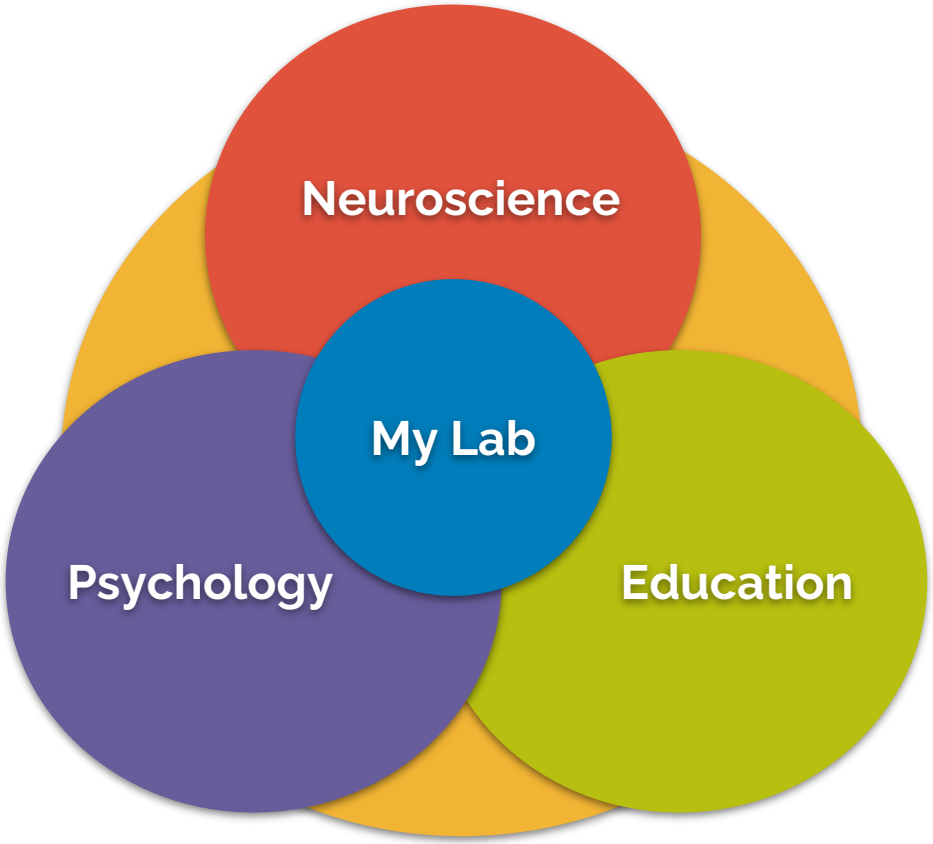
Literacy development in Chinese-English bilingual children

Developmental profiles of visual word sensitivity in children

Project #2: Literacy development in Chinese-English bilingual children with DD



Interdisciplinary Lab Environment



Acknowledgement

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Gorka Fraga-González, PhD
David Willinger, PhD

Families and all participants in these studies!

рахмат
danke
謝謝
ngiyabonga
شكراً جزيلاً
spas
teşekkür ederim
Баярлалаа
mersi
kia ora
barka
welalin
tack
mahalo
tapadh leat
спасибо
faafetai lava
vinaka
blagodaram
dank je
misaotra
matondo
paldies
grazzi
спасибі
kiitos
dankie
nanni
nandri
dhanyavad
mauruuru
köszönöm
thank you
gracias
хвала
asante
manana
obrigada
tenki
bedankt
bayarlalaa
gràçie
hvala
aciu
dankon
akun
murakoze
enkosi
djiere dieuf
tau
mochchakkeram
дякую
mamnun
dziękuję
chnorakaloutioun
gratias ago
gràcies
sulpáy
go raibh maith agat
chokrane
sobodi
dēkuji
sagolun
sukriya
kop khun krap
taiku
obrigado
mèsi
didi madloba
najis tuke
ありがとう
tanemirt
grazie
arigatô
takk
dakujem
trugarez
kam sah hamnida
rahmat
terima kasih
rahmet
ευχαριστώ
diolch
dhanyavadagalu
shukriya
merce
мерси
তোমাকে ধন্যবাদ
감사합니다
xièxie
merci