Language and Reading Development, Part 1

H-126 Typical and Atypical Neurodevelopment
October 2nd, 2017

"Children are wired for sound, but print is an optional accessory that must be painstakingly bolted on"
Steven Pinker

2

Overview

- Typical language development
- Language in the brain
- Typical reading development
- The dual route cascade model
- The typical reading brain

Elements of language/Terminology

- Phonolgy: refers to the sound of language/system of sounds
- Grammar: refers to the rules used to describe the structure of language (which involves syntax or rules that specify how words are combined to form sentences)
- Semantics: refers to the meaning of a word
- Pragmatics: refers to how people use language to communicate effectively

BOX 1.1 Components of Oral Language Development

COMPONENT	DEFINITION	EXAMPLE
Pragmatics	The transmittal of information to others in socially appropriate ways	Being able to make requests, to comment, to be coherent in conversation and narrative
Phonology	The sound system of the language	Being able to distinguish between /vat/ and /bat/, recognizing that /narg/ could be an English word but that /ngar/ could not
Lexicon	Vocabulary and processes of derivational morphology	Knowing the meaning of words and how to form new words (e.g., if *narg* is a verb, then a *narger* is someone who nargs)
Morphology and syntax	The systems that govern inflectional morphology and word combination	Knowing the difference in meaning between *Man bites dog* and *Dog bites man*, knowing that *Man bite dog* and *Bite man dog* are both ungrammatical

Erika Hoff: Language development

Language development

- Acquiring a language includes

→ learning the sounds and sound patterns of language (phonological development)

→ Learning the vocabulary of the language (lexical development)

→ Learning the structure of the language (grammatical or morphosyntactic development)

→ Learning how to use the language to communicate (pragmatic and sociolinguistic development)

→

Sequence of Language development

5

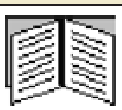
Milestone	Approx. Age
Cooing (vowel like sounds)	2-3 months
Babbling (extended repetition of certain syllables)	5 -7 months
First word	10-14 months
Ten words (Holophrastic stage)	12-18 months
Two-word sentences (Telegraphic stage)	20-24 months
Two hundred words	24 months

Phonemes

6

- Basic Building blocks of language
- Infants can distinguish many of these sounds, even from foreign languages that they have never heard before. Decreases around 6-8 months.

Table 1 Terminology used to describe units of written and spoken language

Item	Examples						
Pictures							
Words	Book			Scarf			
Graphemes	B	OO	K	S	C	AR	F
Phonemes	/b/	/oo/	/k/	/s/	/k/	/ahr/	/f/

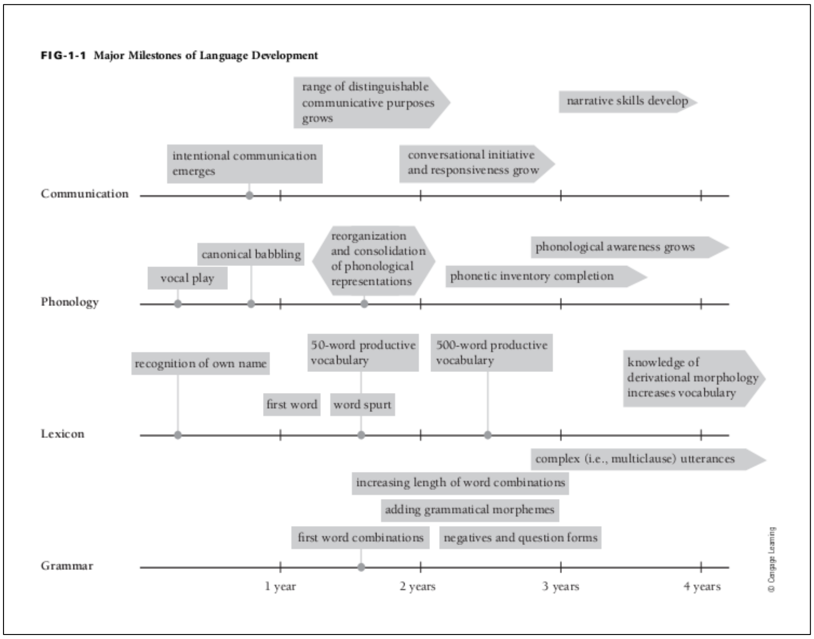
Some examples ….

TABLE 10.7 Important Milestones in Language Development

Age (years)	Phonology	Semantics	Morphology/syntax	Pragmatics	Metalinguistic awareness
0–1	Receptivity to speech and discrimination of speech sounds Babbling begins to resemble the sounds of native language	Some interpretation of intonational cues in others' speech Preverbal gestures appear Vocables appear Little if any understanding of individual words	Preference for phrase structure and stress patterns of native language	Joint attention with caregiver to objects and events Turn-taking in games and vocalizations Appearance of preverbal gestures	None
1–2	Appearance of strategies to simplify word pronunciations	First words appear Rapid expansion of vocabulary after age 18 months Overextensions and underextensions of word meanings	Holophrases give way to two-word telegraphic speech Sentences express distinct semantic relations Acquisition of some grammatical morphemes	Use of gestures and intonational cues to clarify messages Richer understanding of vocal turn-taking rules First signs of etiquette in children's speech	None
3–5	Pronunciations improve	Vocabulary expands Understanding of spatial relations and use of spatial words in speech	Grammatical morphemes added in regular sequence Awareness of most rules of transformational grammar	Beginning understanding of illocutionary intent Some adjustment of speech to different audiences Some attempts at clarifying obviously ambiguous messages	Some phonemic and grammatical awareness
6–adolescence	Pronunciations become adultlike	Dramatic expansion of vocabulary, including abstract words during adolescence Appearance and refinement of semantic integrations	Acquisition of morphological knowledge Correction of earlier grammatical errors Acquisition of complex syntactical rules	Referential communication improves, especially the ability to detect and repair uninformative messages one sends and receives	Metalinguistic awareness blossoms and becomes more extensive with age

Table 10.7 Important Milestones in Language Development.

<u>Developmental Psychology: Childhood & Adolescence: Childhood and Adolescence</u>, by David David Reed Shaffer & Katherine Kipp.



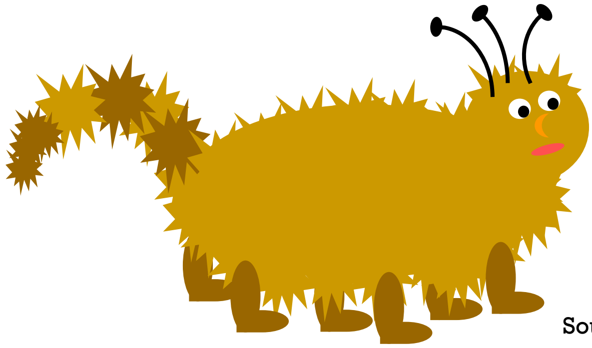
Erica Hoff: Language Development

10

Fast mapping ….

is the process of rapidly learning a new word simply from the contrastive use of a familiar word and an unfamiliar word

let's try an example….



Source: Unknown

1. This is a snurk. It walks on its flaxes. How many flaxes does a snurk have?
2. Snurks have twice as many flaxes as ampolinks. Where are the amopolinks?
3. Snurks are covered with garslim. Garslim is like __________?
4. Like dogs, snurks can wag their pangeers. Where is the pangeer?
5. Do you think snurks can bispooche? Why or why not?

12

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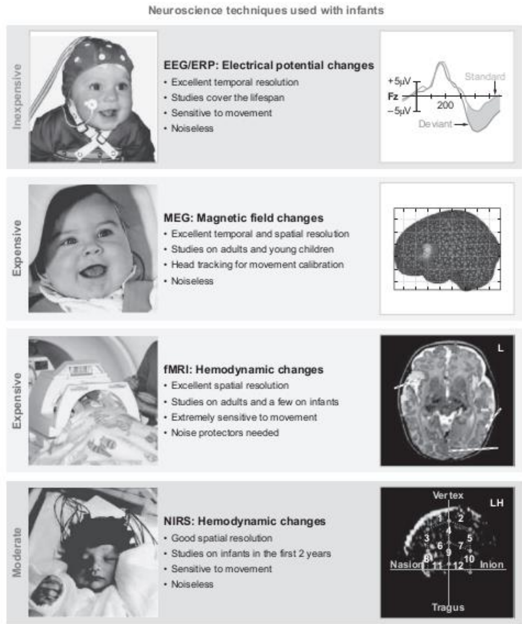
Neuroscience techniques used with infants & young children

(Hoff: Language Development)



Source: Kuhl & Rivera-Gaxiola (2008), Institute for Learning & Brain Sciences, University of Washington

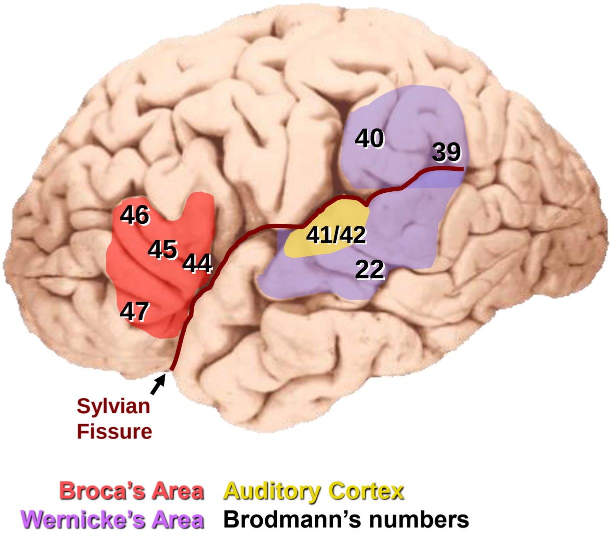
Early left lateralization for language

Studies using both ERP (and even fMRI) have suggested that infants show increased activation in the left hemisphere when presented with a variety of acoustic signals (not only speech) and the lateralization for speech becomes stronger as children's language skills develop (e.g., Dehaene-Lambertz et al., 2006).

Studies using NIRS with newborns have observed that speech elicits greater activation in the left hemisphere than does the same signal played in reverse (e.g., Pena et al., 2003). However, the specific properties of the speech signal that cause this effect are highly debated.

Hoff: Language Development

Neurobiology of Language



- Language is uniquely human. As such, it has been difficult to apply the majority of 'systems neuroscience techniques' to the study of human language.
- Traditionally, what we know about the neural basis of language has been derived primarily from observing the effects of lesions to specific areas of the brain.
- The advent of functional neuroimaging technologies has revolutionized our ability to study brain activation patterns generated by language tasks.

Broca and Wernicke Aphasia

In 1861 Broca reports "Mr. Tan" (Leborgne)
Patient can only produce "tantan"
but understands language
→ Broca aphasia

In 1874 Wernicke presents
10 patients who cannot understand language
but can still produce it
→ Wernicke aphasia

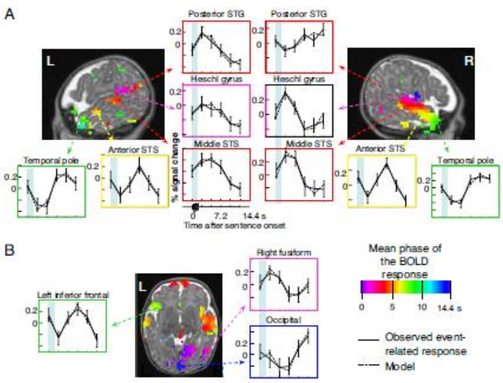
- Wernicke proposes that there are 2 language areas: one for production (Broca's area) & one for meaning (Wernicke's area) & that these are connected
- Disruption of the 'meaning area' or 'motor area' or it's connections would result in different disruptions.

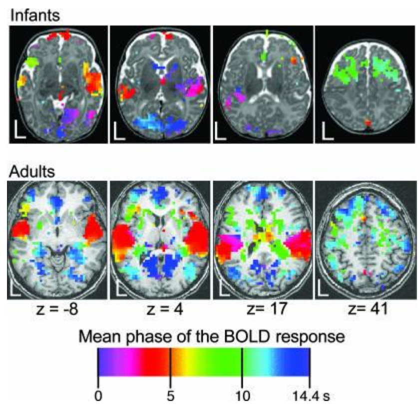
16

17

Functional organization of perisylvian activation during presentation of sentences in preverbal infants

Ghislaine Dehaene-Lambertz[*,†,‡,§], Lucie Hertz-Pannier[‡,¶,‖,**], Jessica Dubois[‡,‖], Sébastien Mériaux[‡,‖], Alexis Roche[‡,‖], Mariano Sigman[*,‡], and Stanislas Dehaene[*,‡,††]





18

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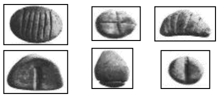
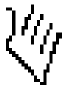
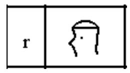
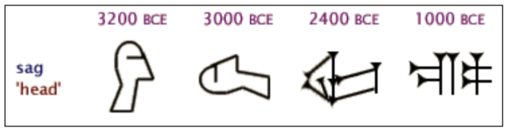
Development of our writing system









It took us roughly 2000 years to make the major breakthrough to learn to read an alphabet. We ask a child to learn to read an alphabet in roughly 2000 days….

GHOTI

- "FISH"

- gh as in *TOUGH*
- o as in *WOMEN*
- ti as in *NATION*

George Bernard Shaw

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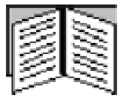
Pictures							
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Graphemes	B	OO	K	S	C	AR	F
Phonemes	/b/	/oo/	/k/	/s/	/k/	/ahr/	/f/

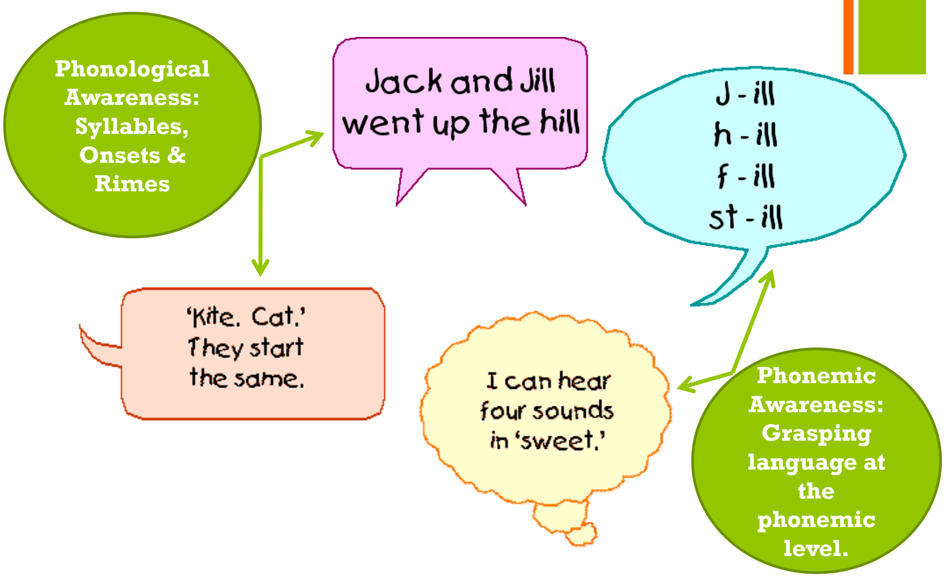
Phoneme: the smallest unit of sound that you can hear within a word; the word phoneme refers to the sound, not the letter(s) which represent the sound in writing (approx. 44 phonemes in English; 24 in Spanish)

Grapheme: a 'symbol' of a phoneme – it's a letter or group of letters representing a sound and we use the letter names for this (approx. 200 graphemes in English).

Letters: Character representing one or more phonemes (26 in English)

e.g. Paracchini et al., Annu. Rev. Geonmics Hum. Genet., 2007

Phonological vs. Phonemic Awareness



Irregularly Spelled Words

- Typical spelling-to-sound correspondence

  HAT /H/, /A/, /T/

- Atypical spelling-to-sound correspondence

  yacht, straight, friend

  15% of words in text

Why learning to read is so difficult:

- Learning to read **in English** is particularly difficult. Some language systems are based on a system where each syllable represented a symbol (learn the symbols and you have mastered the system) or where the number of phonemes and graphemes are similar (e.g. Italian).

Examples:
- College
- Collegial
- Colleague
- **Gh**ost versus nei**gh**borhood

Table 1. Hypothetical classification of participating languages relative to the dimensions of syllabic complexity (simple, complex) and orthographic depth (shallow to deep)

		Orthographic depth				
		Shallow				Deep
Syllabic structure	Simple	Finnish	Greek Italian Spanish	Portuguese	French	
	Complex		German Norwegian Icelandic	Dutch Swedish	Danish	English

Seymour et al., 2003

Syllable structure = combination of allowable segments and typical sound sequences

Spelling system Highly regular <———————————————> Irregular				
Finnish	Spanish, Portuguese, Italian, Hungarian, Slovenian	German, Dutch, Greek Swedish, Norwegian, Icelandic	Danish, French	English

Stein & Curatolo, 2006

Timeline of typical reading development

Sound and Language Processing Visual Processing	Phonological Processing Letter Recognition	Grapheme-phoneme Mapping Reading of single words Reading sentences and connected text	Reading complex text Reading Fluency Reading Comprehension

Milestones of reading development

27

- Early coordination and recruitment of auditory and visual systems → integration of two systems: phonology and orthography; decoding
- Decoding forms basis for deciphering single letters, morphemes, words → fluency
- Fluent reading: ability to read text quickly, accurately, and with appropriate prosody; facilitated by attention, working memory, executive functioning.
- Reading comprehension requires cascade of cognitive and linguistic processes and is strongly related to semantic knowledge, vocabulary, and language comprehension.
- Fundamental processes are very similar across orthographies (e.g. such as Arabic, or Japanese), but developmental trajectories and relative importance for the development and maintenance of reading skills differ.

→ Logosyllabic languages rely primarily on visual memory and morphologic and visual processing, whereas phonological processing is of greater importance in alphabetic orthographies.

Stages of Reading development

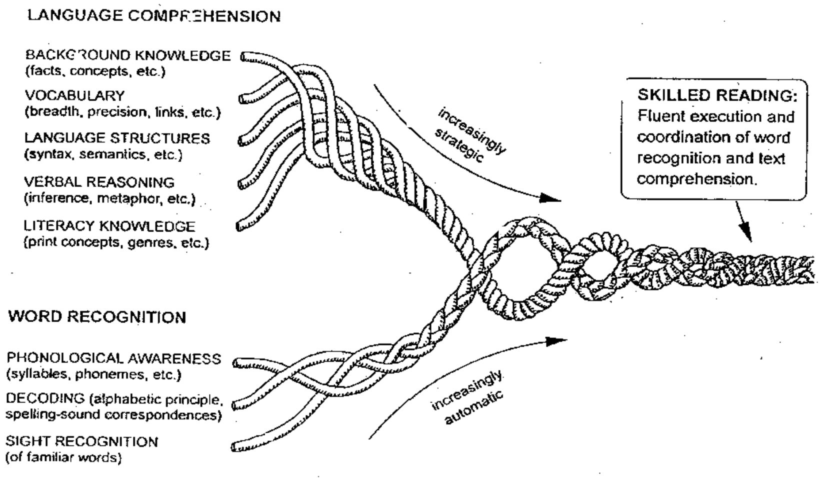
28

Exhibit 3. Stages of Reading Development

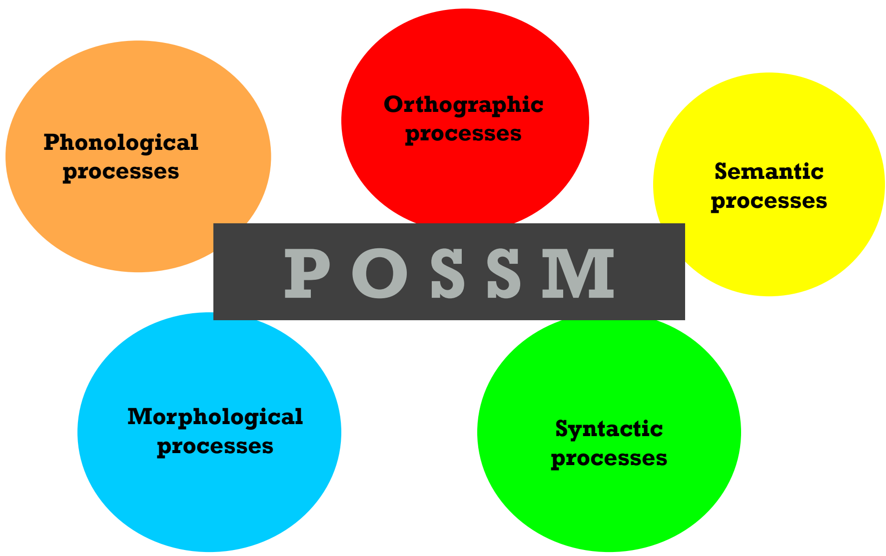
Stage	Name	The Learner
Stage 0: Birth to Grade 1	Emergent Literacy	Gains control of oral language; relies heavily on pictures in text; pretends to read; recognizes rhyme
Stage 1: Beginning Grade 1	Decoding	Grows aware of sound/symbol relationships; focuses on printed symbols; attempts to break code of print; uses decoding to figure out words
Stage 2: End of Grade 1 to End of Grade 3	Confirmation and Fluency	Develops fluency in reading; recognizes patterns in words; checks for meaning and sense; knows a stock of sight words
Stage 3: Grade 4 to Grade 8	Learning the New (Single Viewpoint)	Uses reading as a tool for learning; applies reading strategies; expands reading vocabulary; comprehends from a singular point of view
Stage 4: Secondary and Early Higher Education	Multiple Viewpoints	Analyzes what is read; reacts critically to texts; deals with layers of facts and concepts; comprehends from multiple points of view
Stage 5: Late Higher Education and Graduate School	A Worldview	Develops a well-rounded view of the world through reading

Source: Roskos et al., 2009.

The Many Strands that are Woven into Skilled Reading
(Scarborough, 2001)



Processes involved in Reading



(M. Wolf)

31

Key predictors of reading ability before reading instruction starts:

- Phonological processing/Phonological awareness
- Oral comprehension
- Speech perception
- Syntax production and comprehension
- Receptive/expressive vocabulary
- Rapid automatized naming abilities
- Letter name knowledge
- Verbal short-term memory

32

Home literacy environment

Aspects of HLE that are most predictive of future language and literacy skills include:

- Age of onset of shared reading
- Frequency and quality of book reading
- Library visits
- Parent's knowledge of storybook titles
- Maternal mediating style during shared reading
- Child's perceived interest in reading

33

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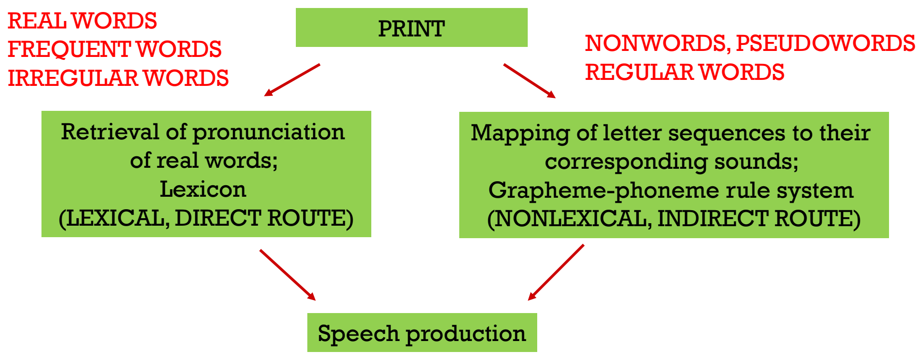
Let's read some words out loud together. Just say them out loud as they come up on the screen…

Dual Route Cascade model of visual word recognition and reading aloud (Coltheart, 2001)



Some findings that support the model:

- High frequency words are read aloud faster than low frequency words
- Real words are read aloud faster than nonwords
- The more letters in a nonword there are the slower it is read aloud; but number of letters has little or no effect on reading aloud for real words.

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36

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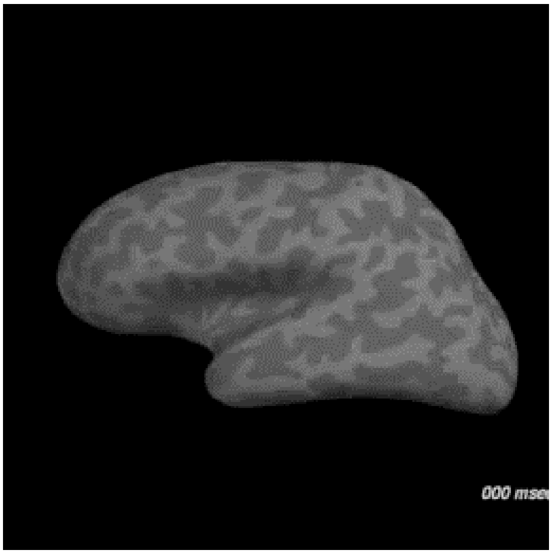
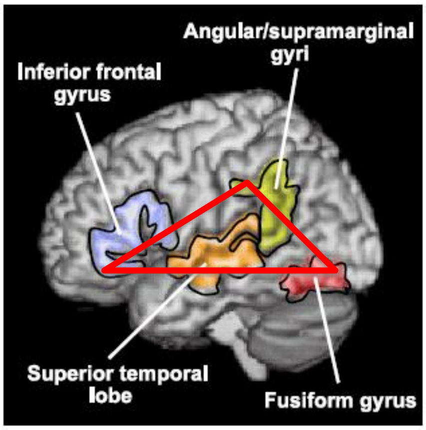
Reading words…



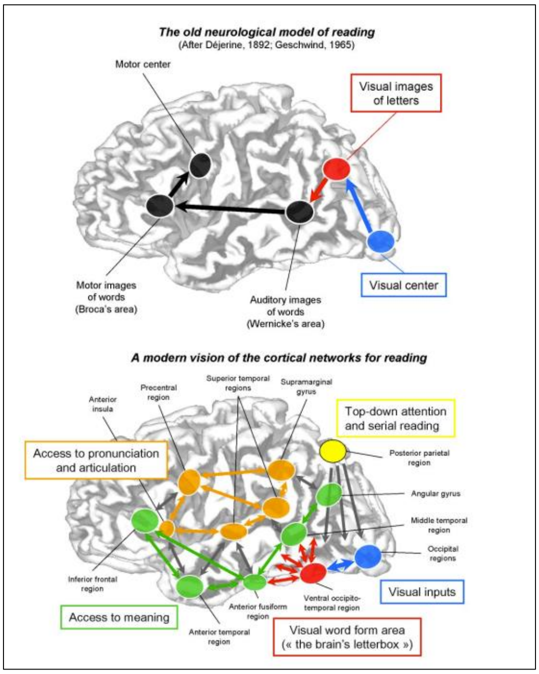
(Dale et al., 2000)

The typical reading network with its key components



Mature reading is performed by a left hemispheric network. It maps visual (orthographical) information onto 'auditory' (phonological) and conceptual (semantic) representations.

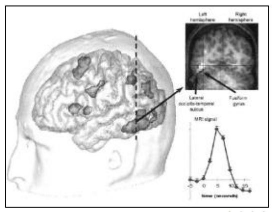
Some of these functional areas seem to be fully developed in elementary school and some develop through adolescence [e.g.; Turkeltaub, *et al.*, 2003].



39

[Dehaene, 2009]

The 'Visual Word Form Area'



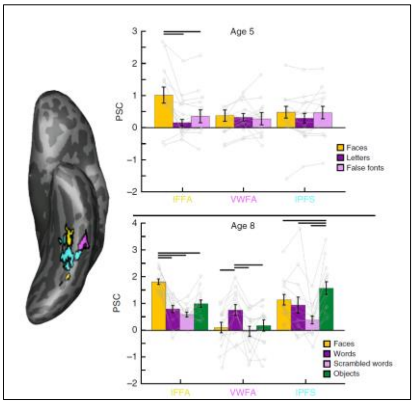
[Dehaene, 2009]

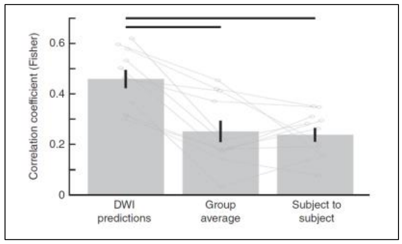
- Preferentially, but not exclusive, processing of prelexical representations of letter patterns within visual words.
- Seems to be independent of writing script.
- All purpose-area or is the VWFA specialized for reading? The VWFA is one of the most intriguing structure-function debate in cognitive neuroscience.
- Left occipito-temporal region centered on the mid-fusiform gyrus.

41

Connectivity precedes function in the development of the visual word form area (2016)

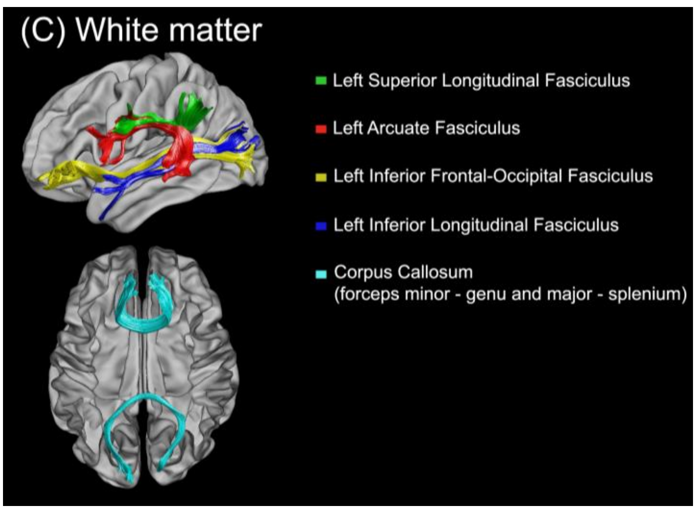
Zeynep M Saygin[1,2], David E Osher[3], Elizabeth S Norton[4], Deanna A Youssoufian[5], Sara D Beach[1,2], Jenelle Feather[1], Nadine Gaab[6], John D E Gabrieli[1,2] & Nancy Kanwisher[1,2]



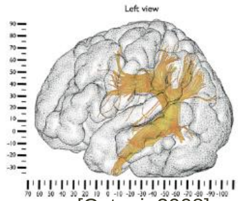


42

White matter reading circuitry



(Ozernov-Palchik et al., 2016)

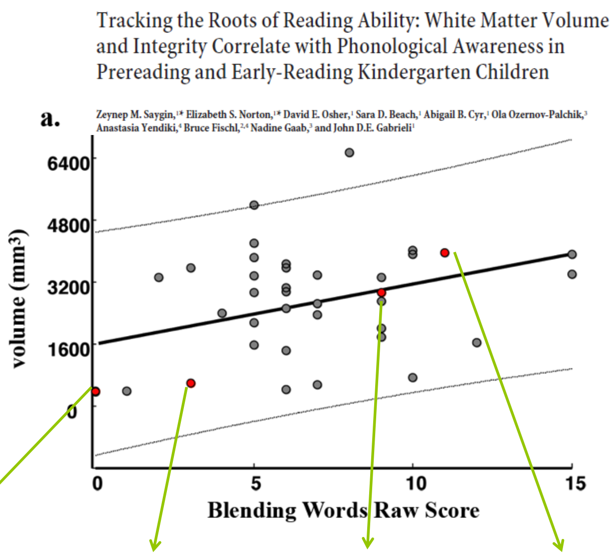


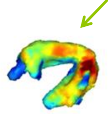
[Catani, 2008]

Arcuate faciculus

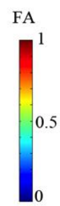
Arcuate Fasciculus, a neural pathway connecting the posterior part of the temporoparietal junction with the frontal cortex.

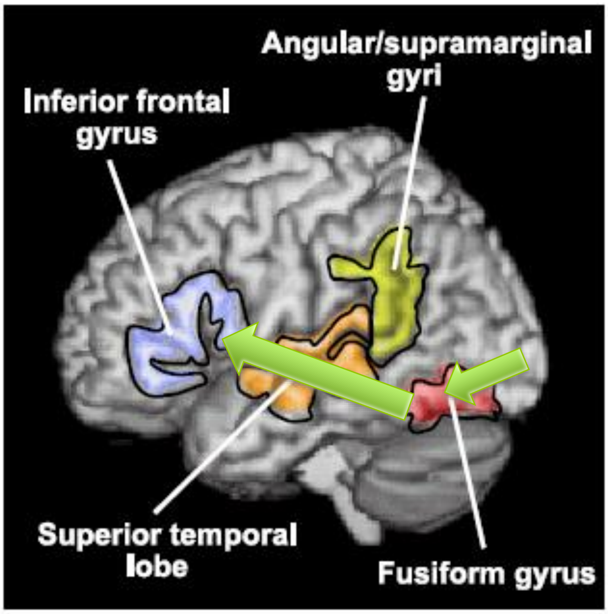
- Patients with lesions in the left AF exhibit profound deficits in phonological processing, reading fluency, speech production, language comprehension, and speech repetition (e.g. Fridrikson et al., 2013; Rauschecker et al., 2009).
- Acquisition of literacy in previously illiterate adults is accompanied by increased integrity of the left AF (Thiebaut de Schotten et al., 2014), and microstructural properties of the left arcuate predict artificial word-learning ability (Wong et al., 2011).
- Integrity of the left AF (as e.g. measured by fractional anisotropy) in children correlates positively with phonological awareness (Yeatman et al., 2011)and predicts later reading outcome in beginning readers (Myers et al., 2014).



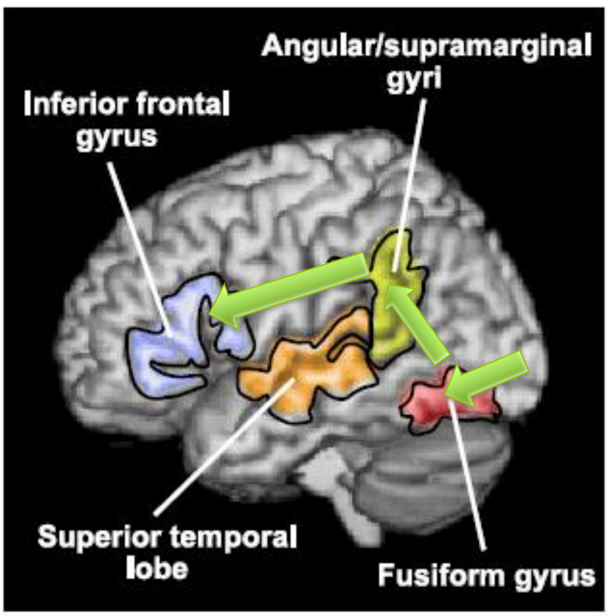


BW score=0





Lexical Route



Nonlexical Route

Evidence from Lesion studies

Left inferior -temporal Lesions → Poor at reading irregular words/ability to read pseudowords unimpaired → Acquired Surface Alexia/Semantic dementia

DIRECT ROUTE IMPAIRED

Left inferior –parietal & frontal Lesions → Poor at reading pseudowords but irregular words unimpaired → Acquired Phonological Alexia

INDIRECT ROUTE IMPAIRED

Evaluation of the dual route theory of reading: a metanalysis of 35 neuroimaging studies

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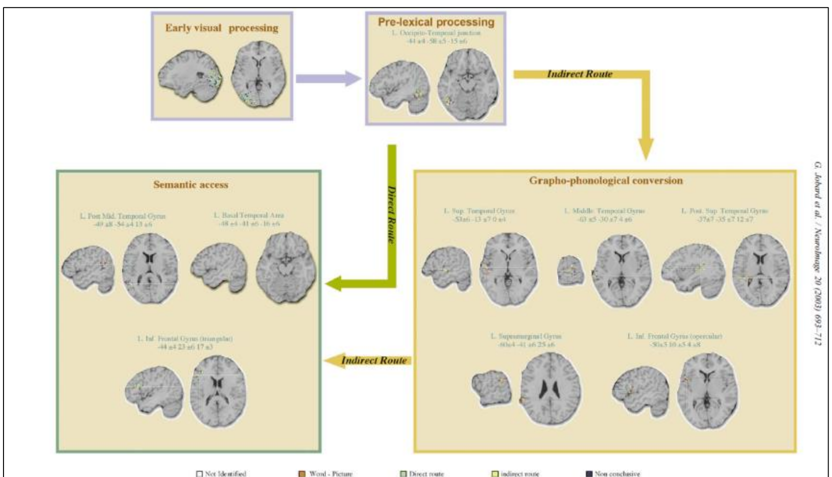

Fig. 5. Dual route model of reading as suggested by the metanalysis of results published in neuroimaging studies.

49

Reading in the Brain of Children and Adults: A Meta-Analysis of 40 Functional Magnetic Resonance Imaging Studies

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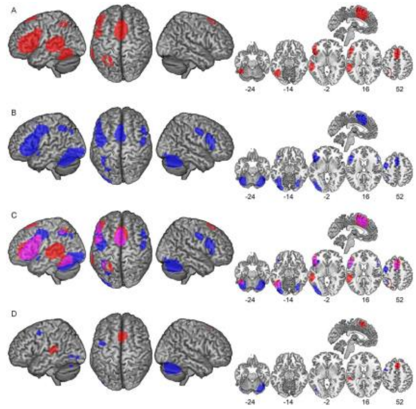

Figure 1.

(**A**) Surface rendering and selected slices of the separate meta-analytic map of reading-related activation in children (red). (**B**) Surface rendering and selected slices of the separate meta-analytic map of reading-related activation in adults (blue). (**C**) Surface rendering and selected slices of both separate meta-analytic maps. Overlapping regions are shown in violet. (**D**) Surface rendering and selected slices of the meta-analytic difference map for the direct comparison between children (red) and adults (blue).

50

Mapping numerical processing, reading, and executive functions in the developing brain: an fMRI meta-analysis of 52 studies including 842 children

Olivier Houdé,†[1,2] Sandrine Rossi,†[1] Amélie Lubin[1] and Marc Joliot[1]

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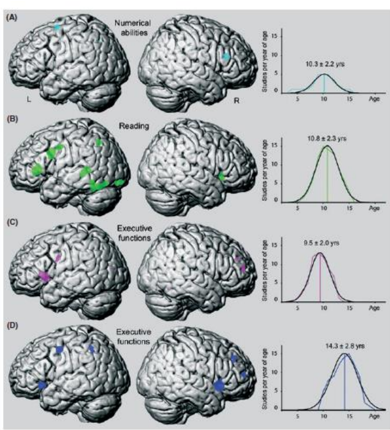
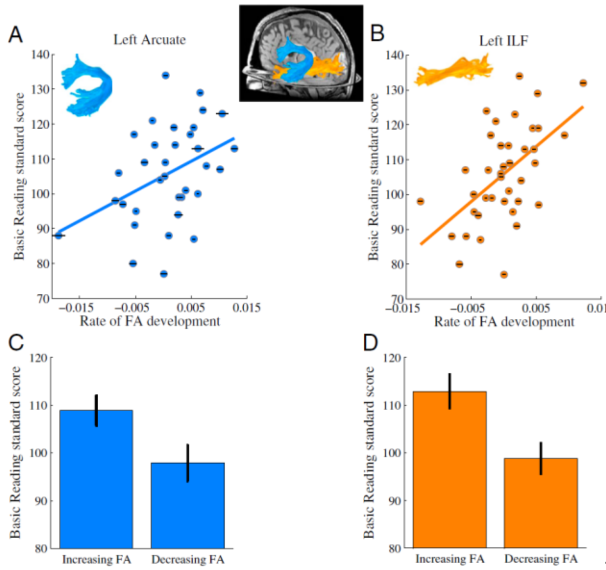


White matter development and reading skills

51

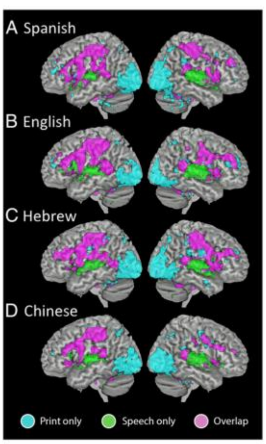


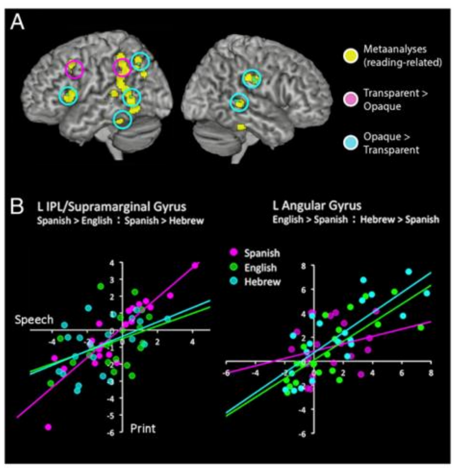
Yeatman et al., 2012)

Universal brain signature of proficient reading: Evidence from four contrasting languages

52

Jay G. Rueckl[a,b], Pedro M. Paz-Alonso[c], Peter J. Molfese[a,b], Wen-Jui Kuo[d], Atira Bick[e], Stephen J. Frost[a,1], Roeland Hancock[f], Denise H. Wu[g], William Einar Mencl[a], Jon Andoni Duñabeitia[c], Jun-Ren Lee[h], Myriam Oliver[c], Jason D. Zevin[a,i,j], Fumiko Hoeft[a,f], Manuel Carreiras[c,k], Ovid J. L. Tzeng[l,m,n], Kenneth R. Pugh[a,b,o], and Ram Frost[a,c,e]





53

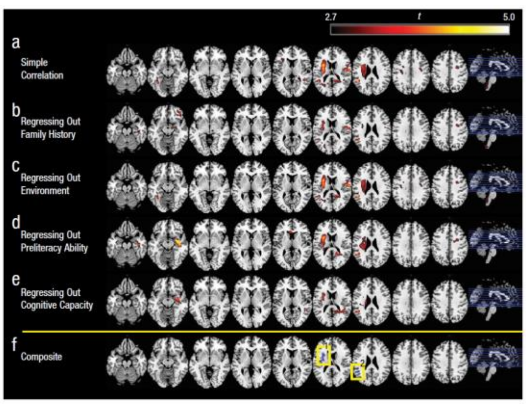
Could neuroimaging help to predict the variance in reading outcome?

54

White Matter Morphometric Changes Uniquely Predict Children's Reading Acquisition

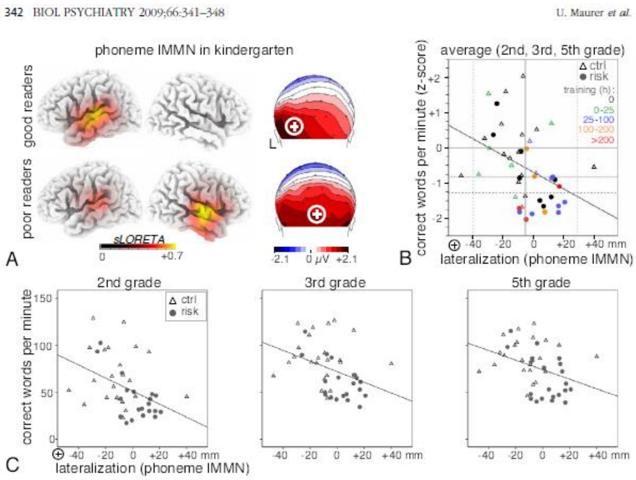
Chelsea A. Myers[1], Maaike Vandermosten[2], Emily A. Farris[1,3], Roeland Hancock[1], Paul Gimenez[1], Jessica M. Black[1,4], Brandi Casto[1,5], Miroslav Drahos[1], Mandeep Tumber[1,5], Robert L. Hendren[1], Charles Hulme[6], and Fumiko Hoeft[1,7,8]

[1]Division of Child and Adolescent Psychiatry, Department of Psychiatry, University of California, San Francisco; [2]Parenting and Special Education Research Unit, KU Leuven; [3]Department of Psychology, University of Texas of the Permian Basin; [4]Graduate School of Social Work, Boston College; [5]Pacific Graduate School of Psychology, Palo Alto University; [6]Division of Psychology and Language Sciences, University College London; [7]Haskins Laboratories, Yale University; and [8]Department of Neuropsychiatry, Keio University School of Medicine



White matter volume changes in temporo-parietal white matter, together with preliteracy measures, predicted 56% of the variance in reading outcomes.

- Brain measures in kindergarten not only improved prediction of reading ability in grade 2 over behavioral measures alone, but only brain measures significantly predicted reading success in grade 5 (Maurer et al., 2009). **(T*he brain measure was better than any behavioral measure used in that study*).**



Growth of decoding skills in 8-12 year olds at risk (Hoeft et al., 2007); beginning to end of school year:

- Prediction with behavioral scores: 65%
- Prediction with brain imaging: 57%
-Prediction with behavioral scores and imaging: 81%

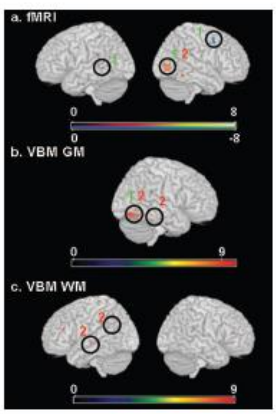
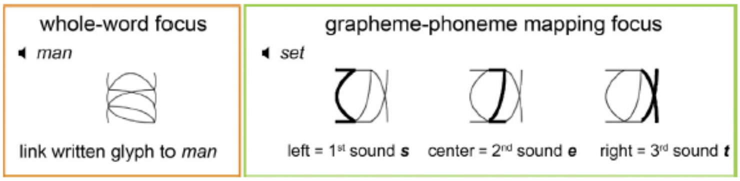


Figure 3. Neuroimaging redictors of future decoding skill. (a) I

57

Can an instructional approach change brain circuitry?



Y.N. Yoncheva et al. / Brain & Language 145–146 (2015) 23–33 29

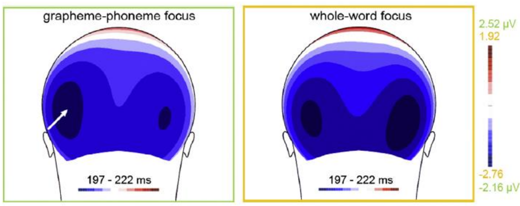
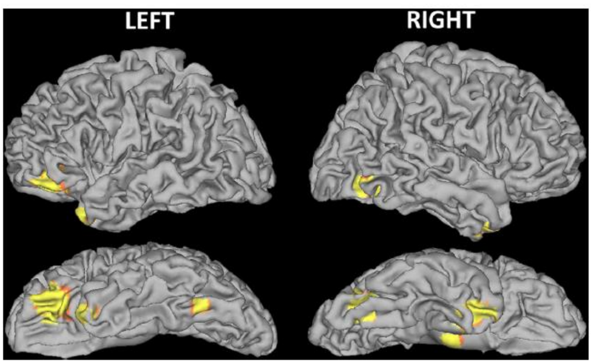


Fig. 5. Training focus modulates N170 lateralization during subsequent reading. Reading words trained under GP focus elicits a significantly more left-lateralized N170 topography relative to words trained under WW focus as evident over the 197 – 222 ms N170 interval in the grand-average voltage maps for each training condition.

Yoncheva et al., 2015

58

The influence of home literacy on reading development



Positive correlation between the 'home literacy environment' and activation during a Phonological processing task.

Powers et al., (2016)

Language and Reading Development, Part 1

H-126 Typical and Atypical Neurodevelopment
October 2nd, 2017

"Children are wired for sound, but print is an optional accessory that must be painstakingly bolted on"
Steven Pinker