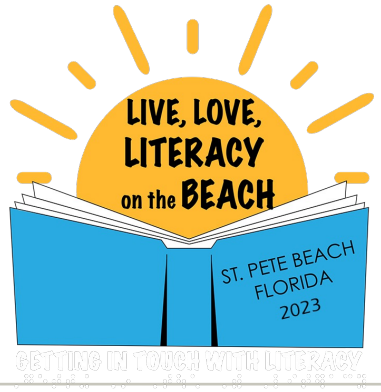
What do we know when we know the spelling of a word?

Simon Fischer-Baum
Department of Psychological Sciences, Rice University
Getting in Touch With Literacy



Literacy is a human right!

- Literacy is key for academic and professional success
- Braille is a means for blind and visually impaired individuals to access information independently
- Federal law is that the default is that all blind and visually impaired children in the United States learn braille

Understanding literacy requires multiple perspectives!

Educational settings

Language experience

As a cognitive scientist, my knowledge contributes here

Sociocultural context

Minds & brains

Understanding literacy requires multiple perspectives!

How I think about literacy…

(in the context of spoken language)

- Goal of this talk is to take the perspective of the child learning to read and write
  - What are they coming to the learning setting knowing?
  - What are their experiences during learning?
  - What do they learn when they learn to read and write?

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  - What are they coming to the learning setting knowing?
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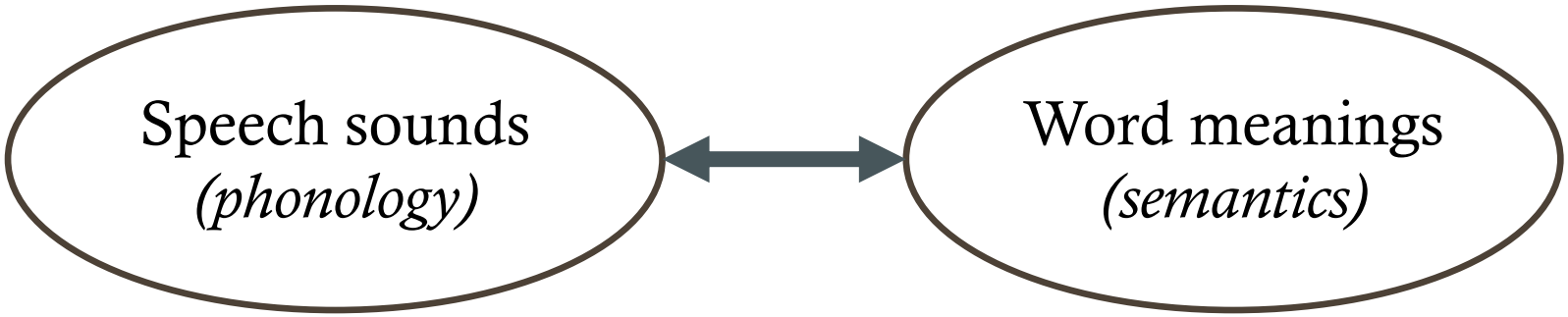
  - What do they learn when they learn to read and write?
  - How do teachers support them in this process?

How I think about literacy…

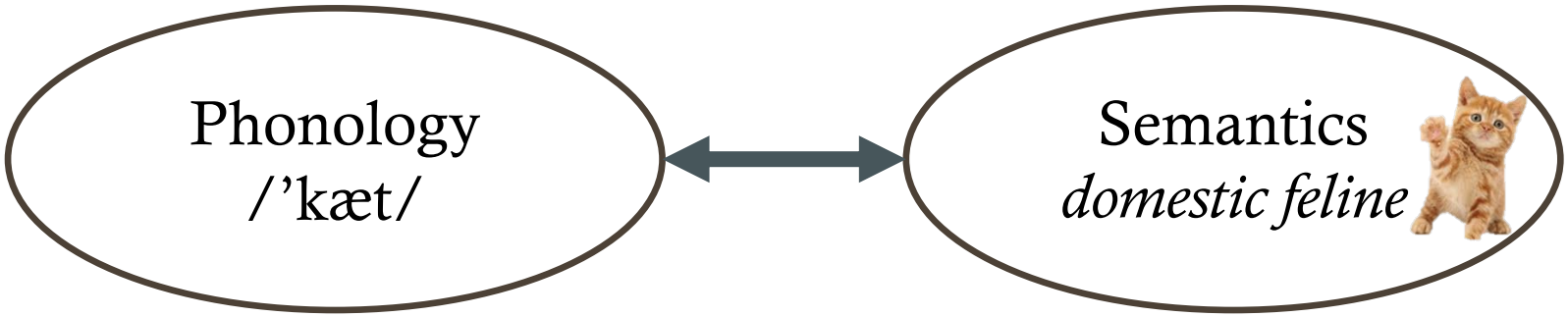
(in the context of spoken language)



Children come into the task of becoming literate having already acquired the mapping between sound and meaning

How I think about literacy…

(in the context of spoken English)



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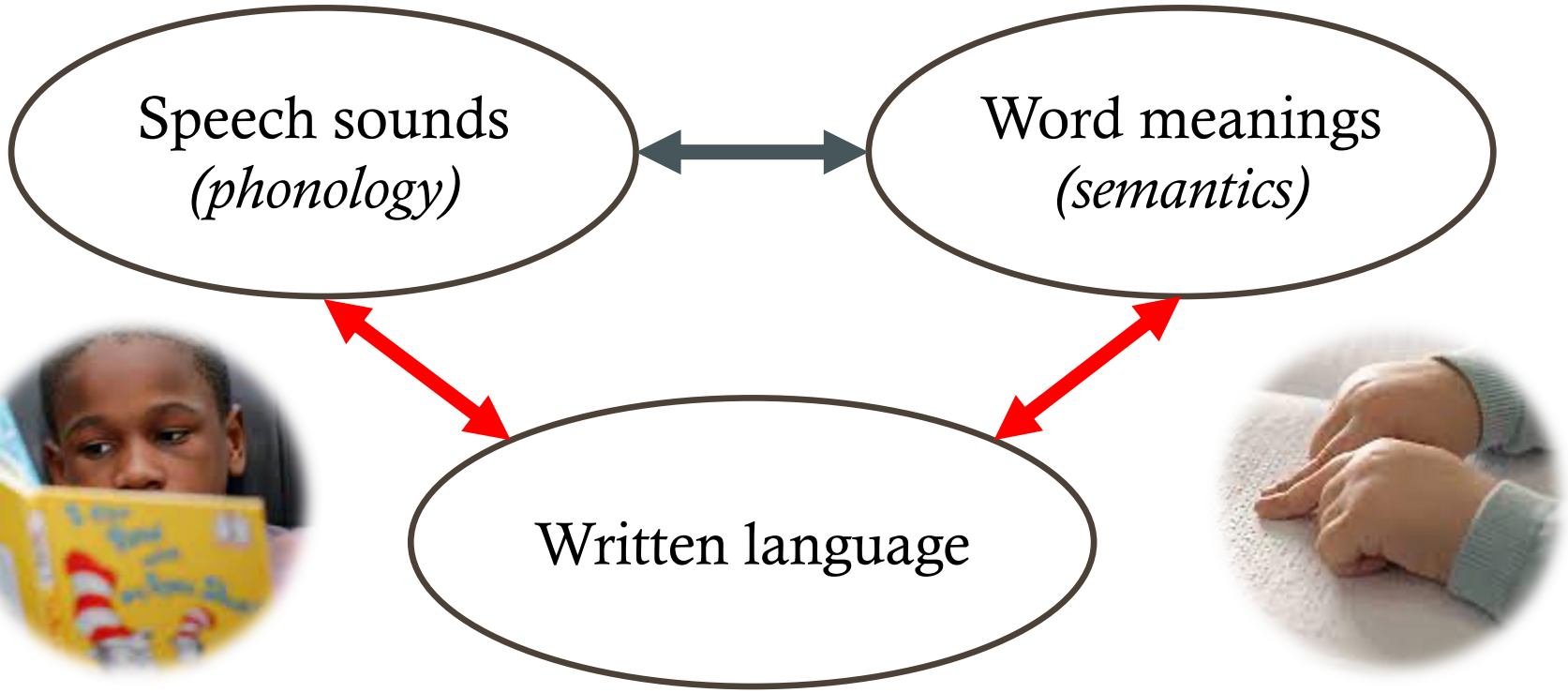
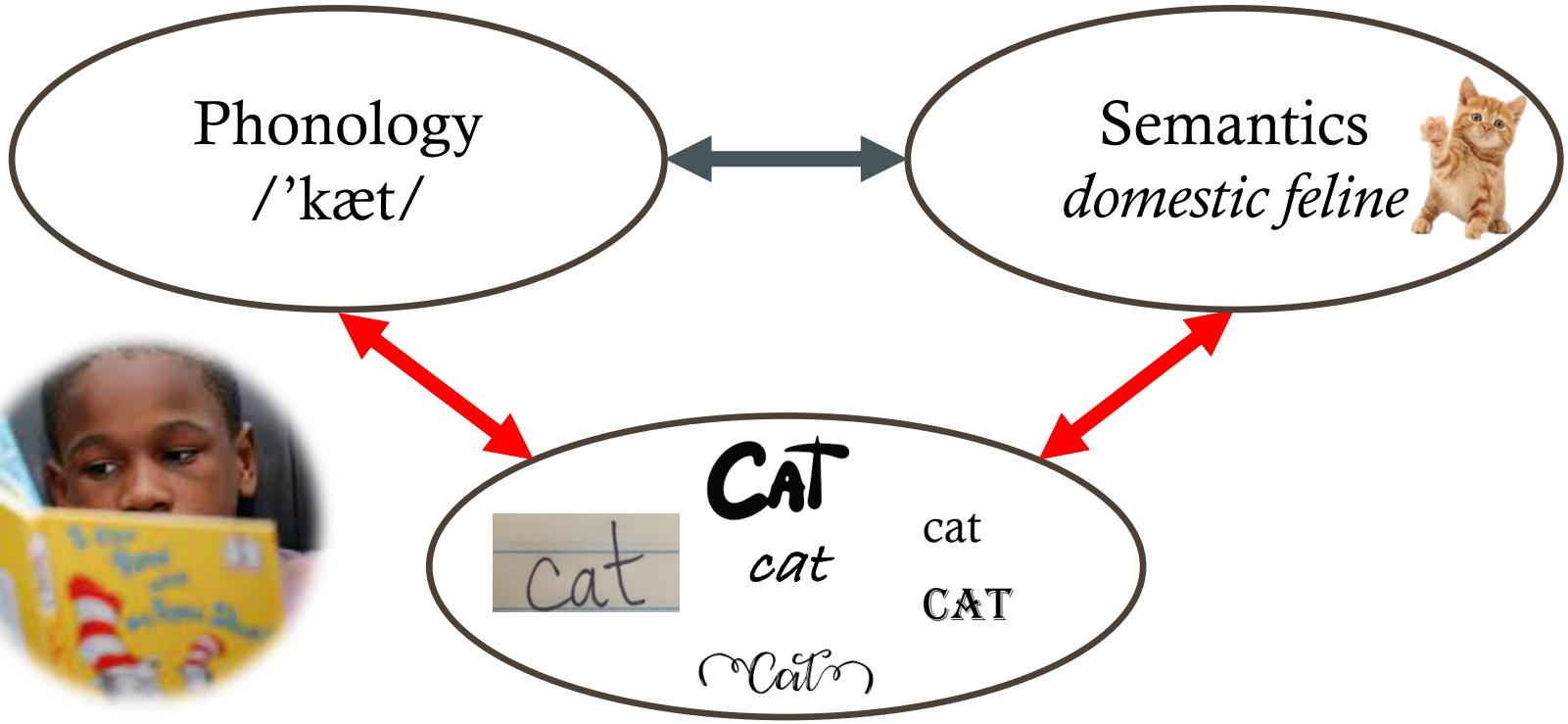


Becoming literate means learning the written language & how to map it to phonology and semantics

How I think about literacy…

(in the context of spoken English & print)

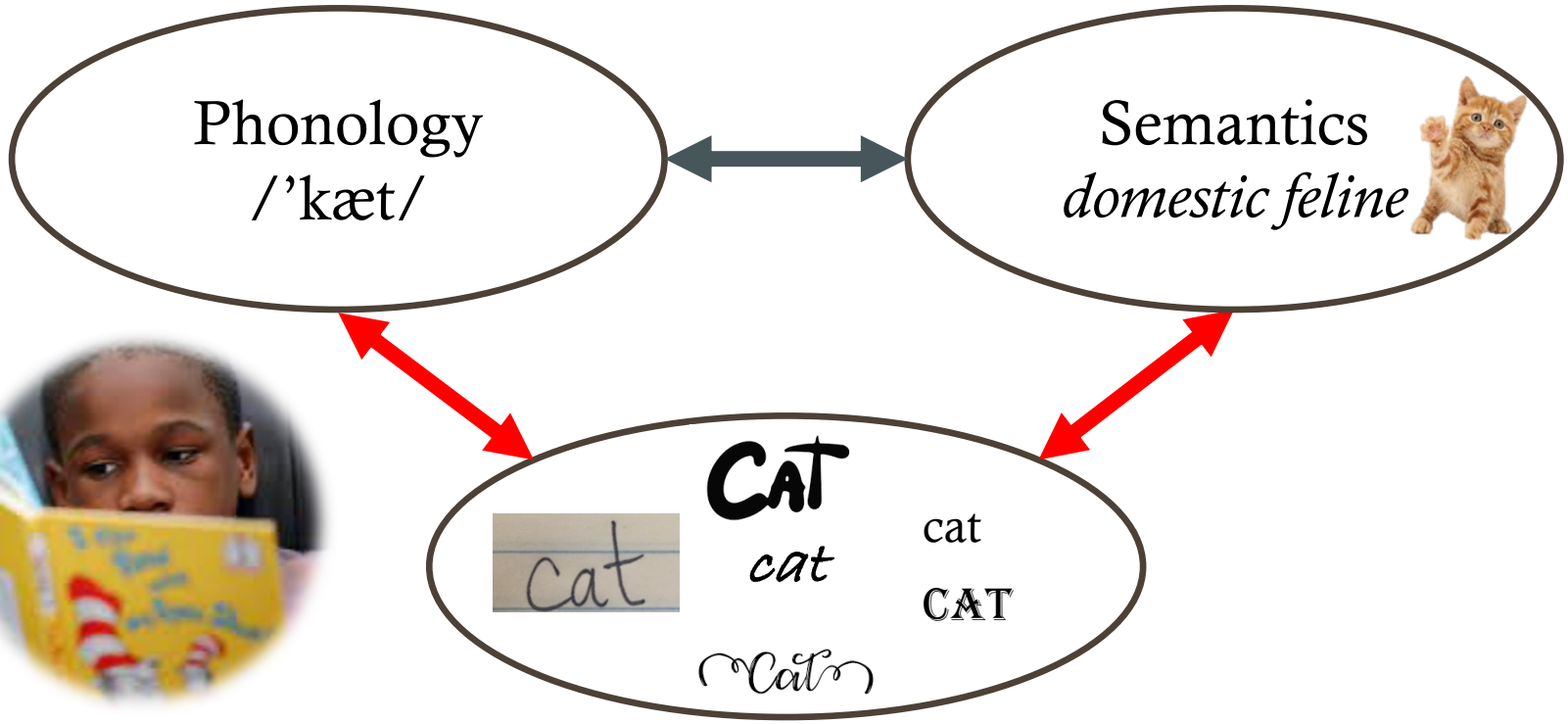


Becoming literate means learning the written language & how to map it to phonology and semantics

What cognitive science knows…

1. Human minds are pattern recognizing machines
2. Natural languages have rich structure with lots of patterns to learn about
3. When you learn a written language, you learn these patterns
   - What you know when you know the spelling of a word

What types of patterns are we learning about?



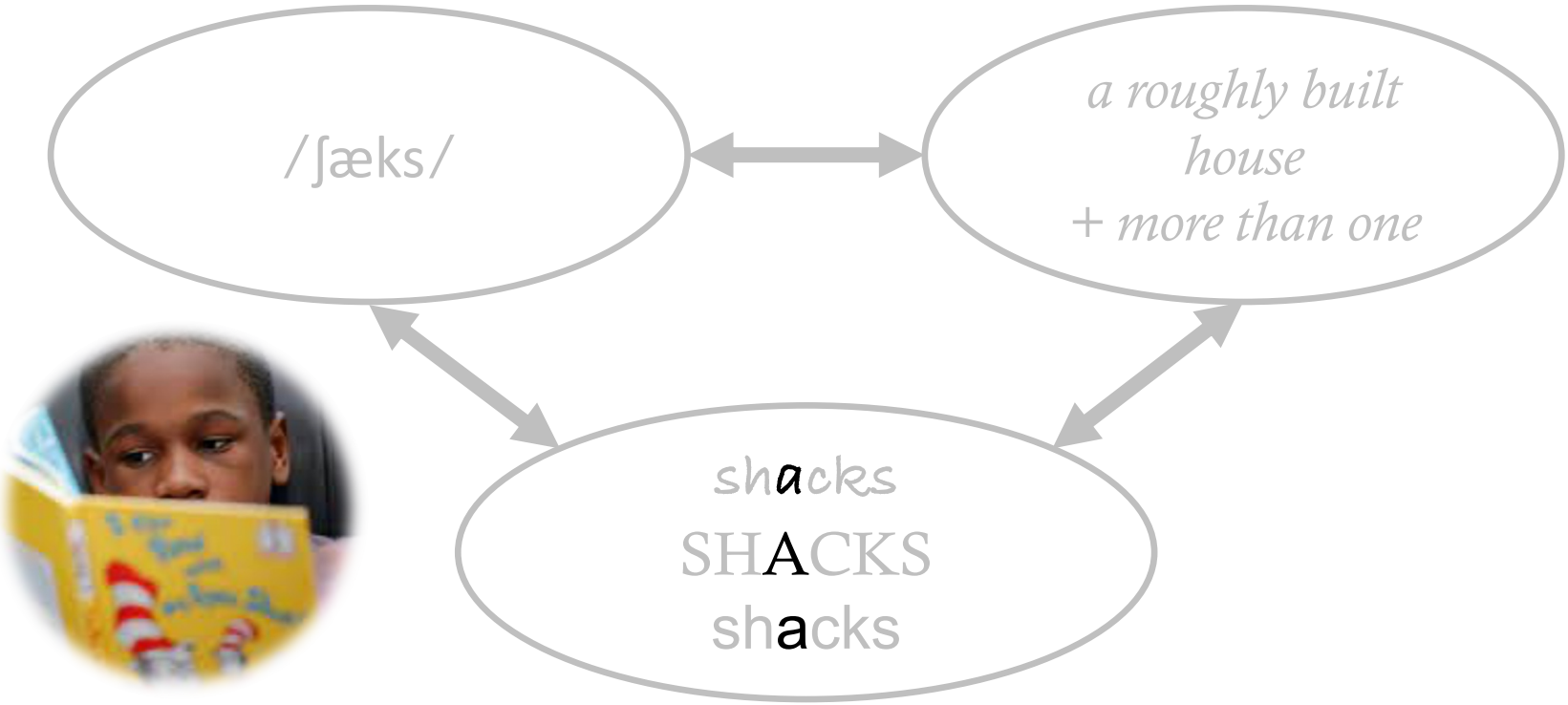
What types of patterns are we learning about?

/ʃæks/

a roughly built house
+ more than one

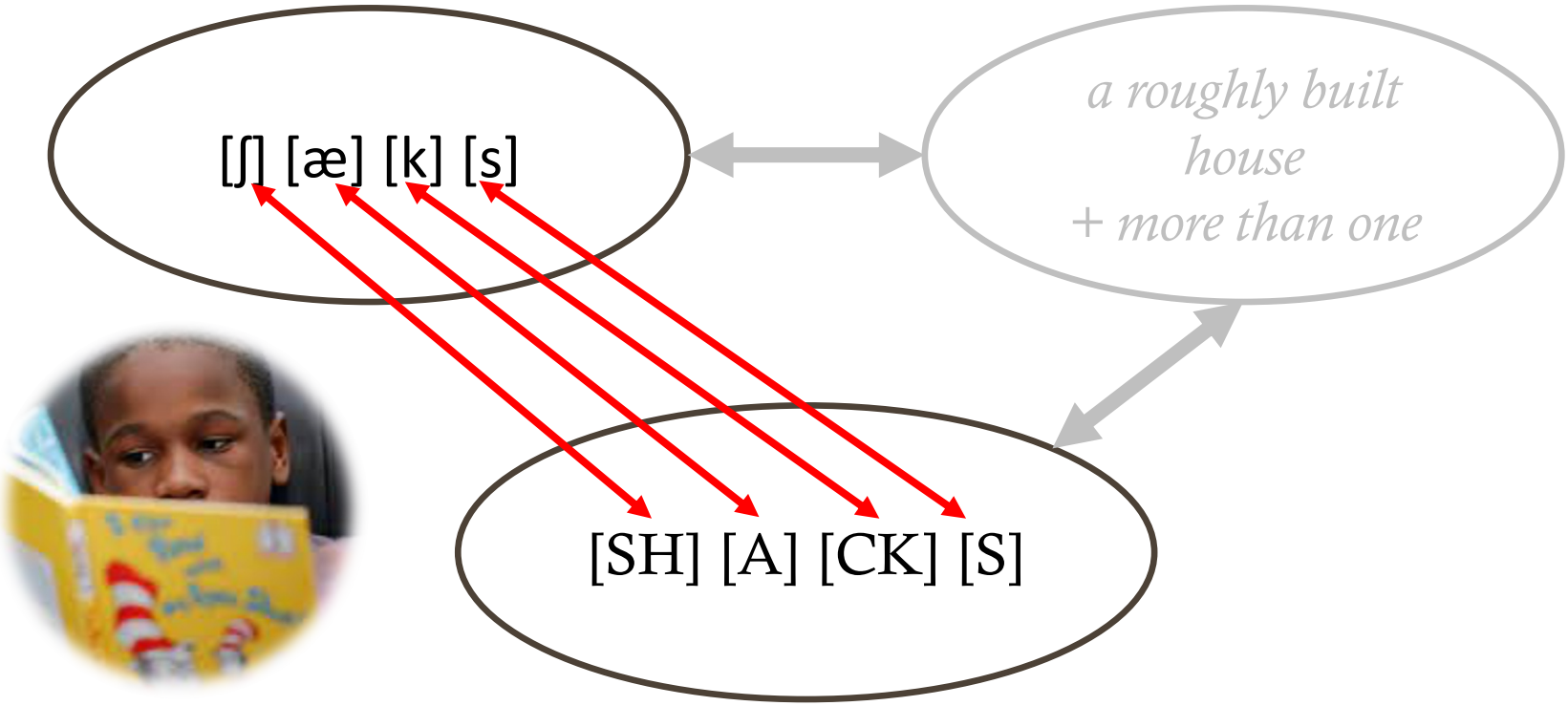
shacks
SHACKS
shacks

Patterns about the script



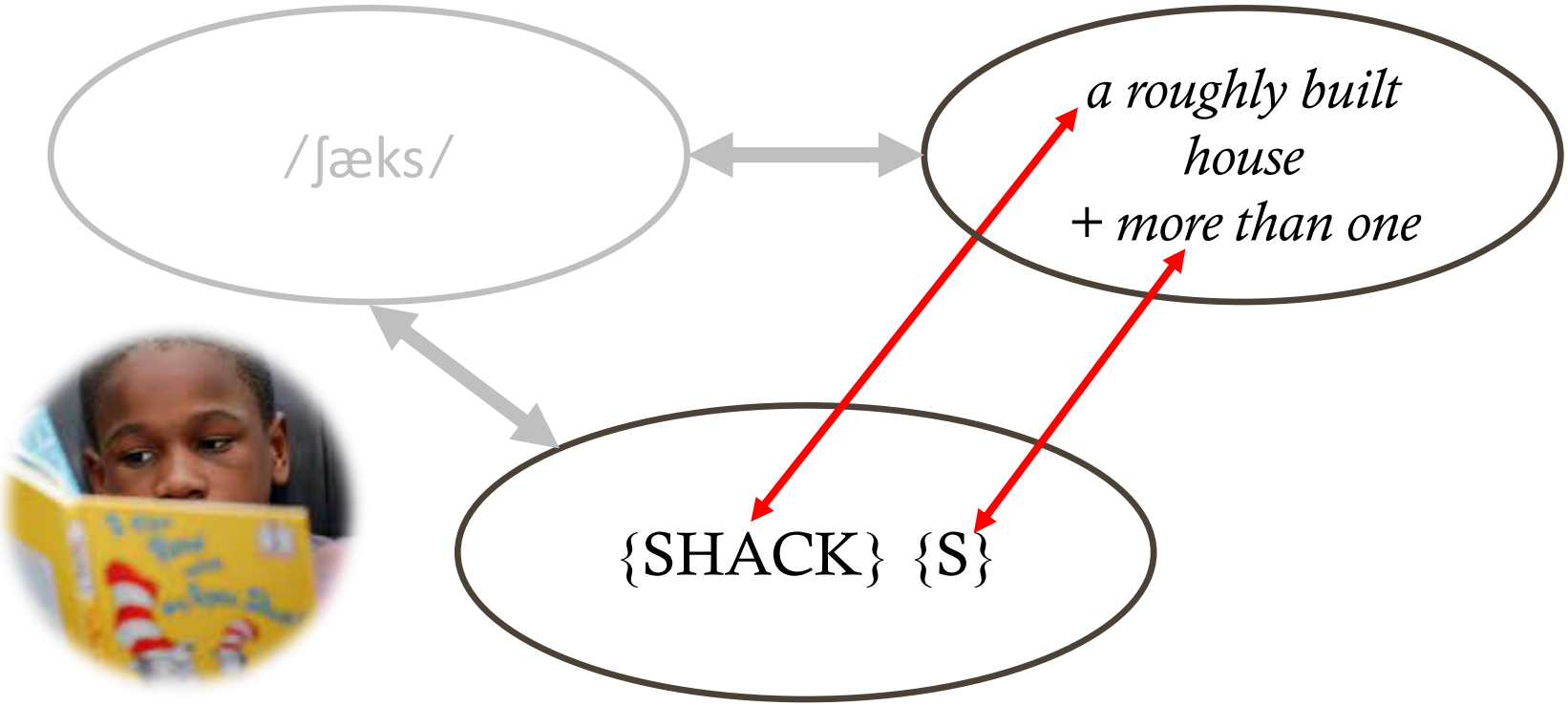
For print English: Different shapes → same letter
"Abstract Letter Identities"

Patterns about spelling sound mapping



Phonics: Mappings between letters and their pronunciations
Digraphs: “Letter teams” that correspond to single sounds

Patterns about spelling to meaning mapping



Morphology: How different word parts map onto different pieces of meaning

Patterns vary across languages

- Languages vary in writing systems, spelling-to-sound transparency, morphological structure
- The patterns that are learned depend on the patterns that are present in the language
- Implicit Knowledge: Learners are not necessarily aware of the patterns that they have learned about

Implicit Knowledge & Explicit Instruction

- Implicit Knowledge: Learners are not necessarily aware of the patterns that they have learned about
- **Still a clear role for teachers & explicit instruction**
- Aligning instruction with the patterns we are learning implicitly improves outcomes

Explicit instruction about the script

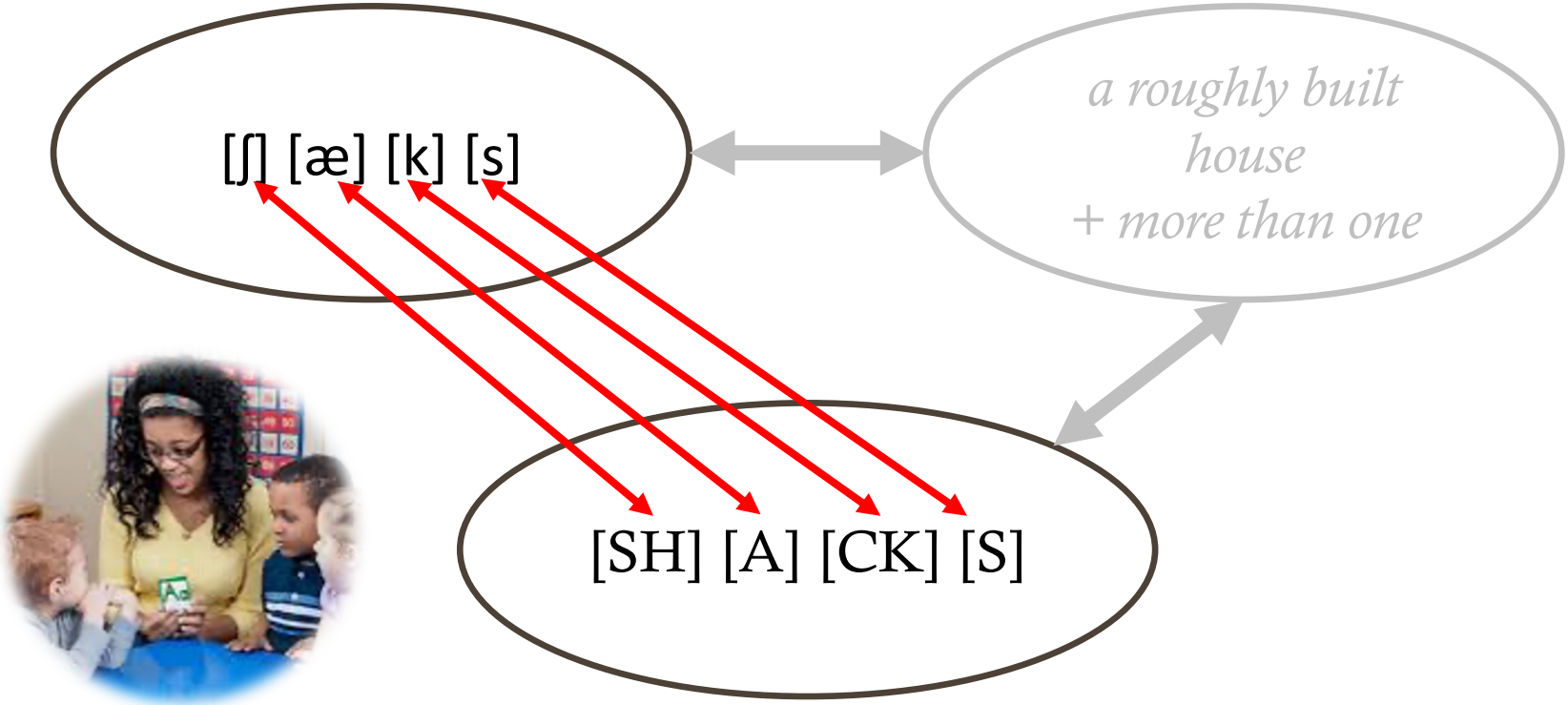
/ʃæks/

a roughly built house + more than one

shacks
SHACKS
shacks

Pre-literacy teaching around alphabet knowledge
Recognize & name upper and lower case letters

Explicit instruction about spelling sound mapping



Phonics curricula → systematically works through learning letter-sound mappings, digraphs, etc.

Explicit instruction about spelling meaning mappings

/ʃæks/

a roughly built house
+ more than one

{SHACK} {S}

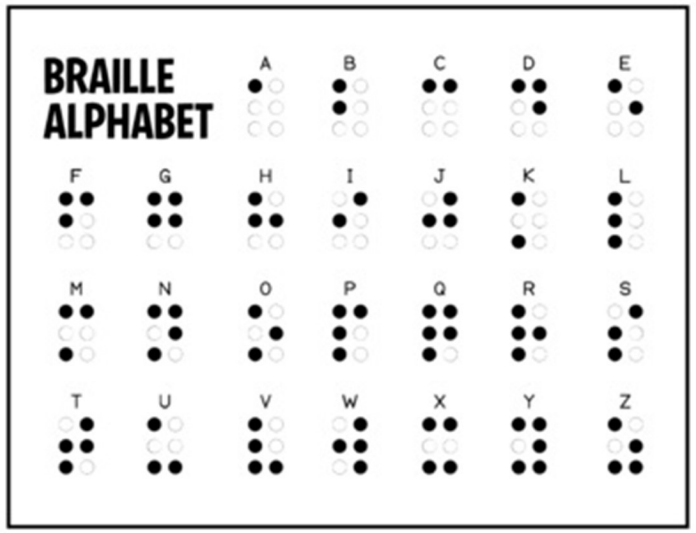
Morphological Awareness Curricula → trains students to recognize the morphological structure of words

Braille in the same framework

- Braille is NOT a language
- Braille and print are **alternative writing systems** for the same spoken language (here, English)
- We learn patterns about the mappings between writing systems and speech sounds/meaning
- Those patterns depend (in part) on the patterns present in the writing system

Print vs braille writing systems

No distinction between upper and lower case

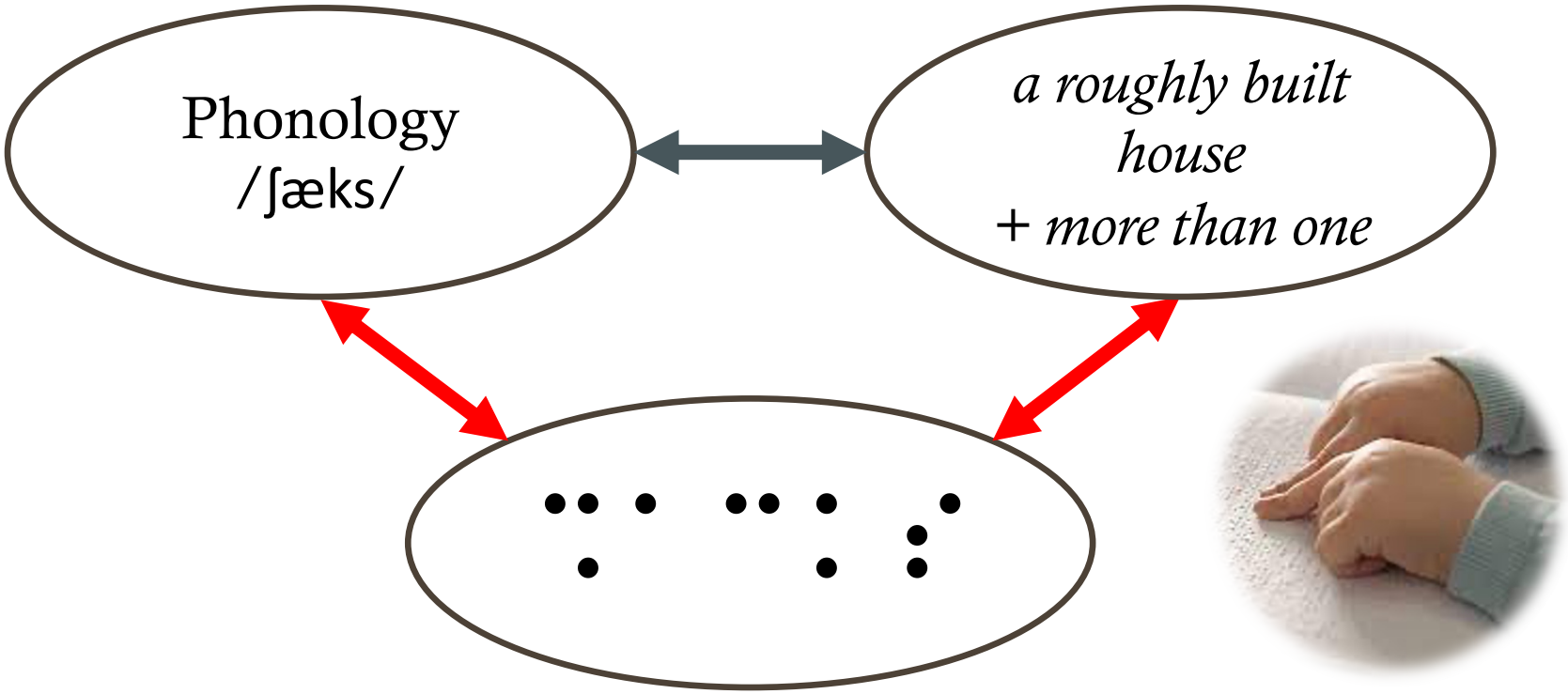


~180 contractions → forms representing groups of letters and/or whole words

⠹ ‘th’ ⠻ ‘er’

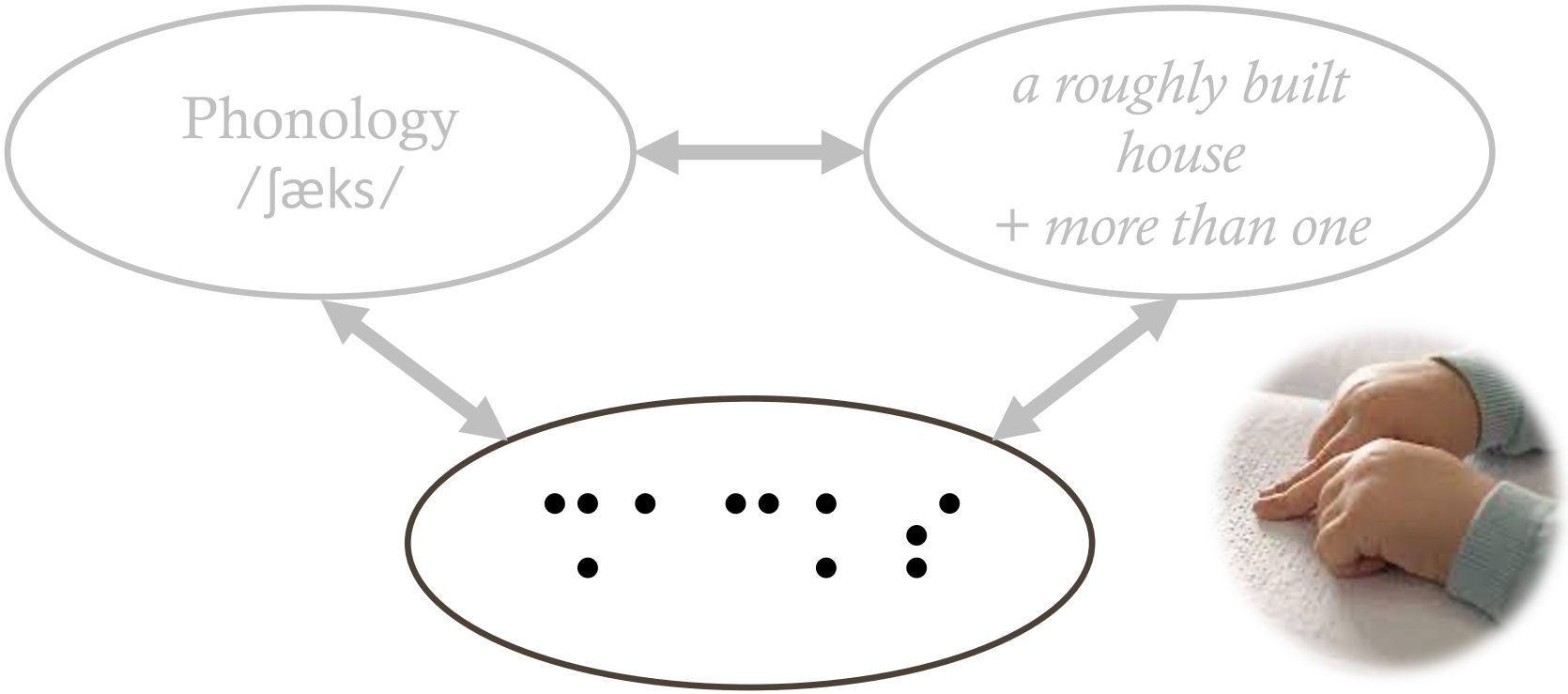
⠢ ‘ea’ ⠢ ‘en’

Braille in the same framework

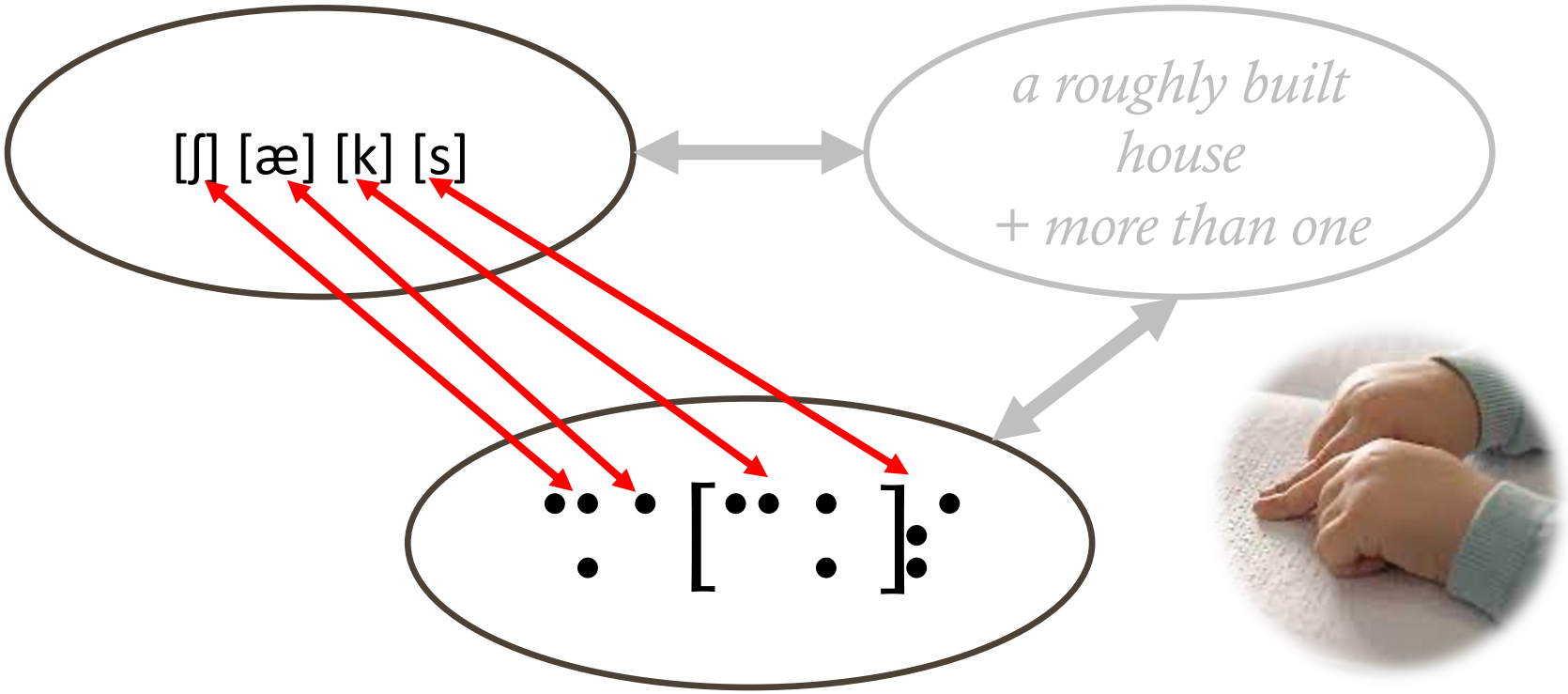


Kids with visual impairments who primarily or exclusively depend on braille

Patterns about the script



Patterns about the spelling to sound mappings



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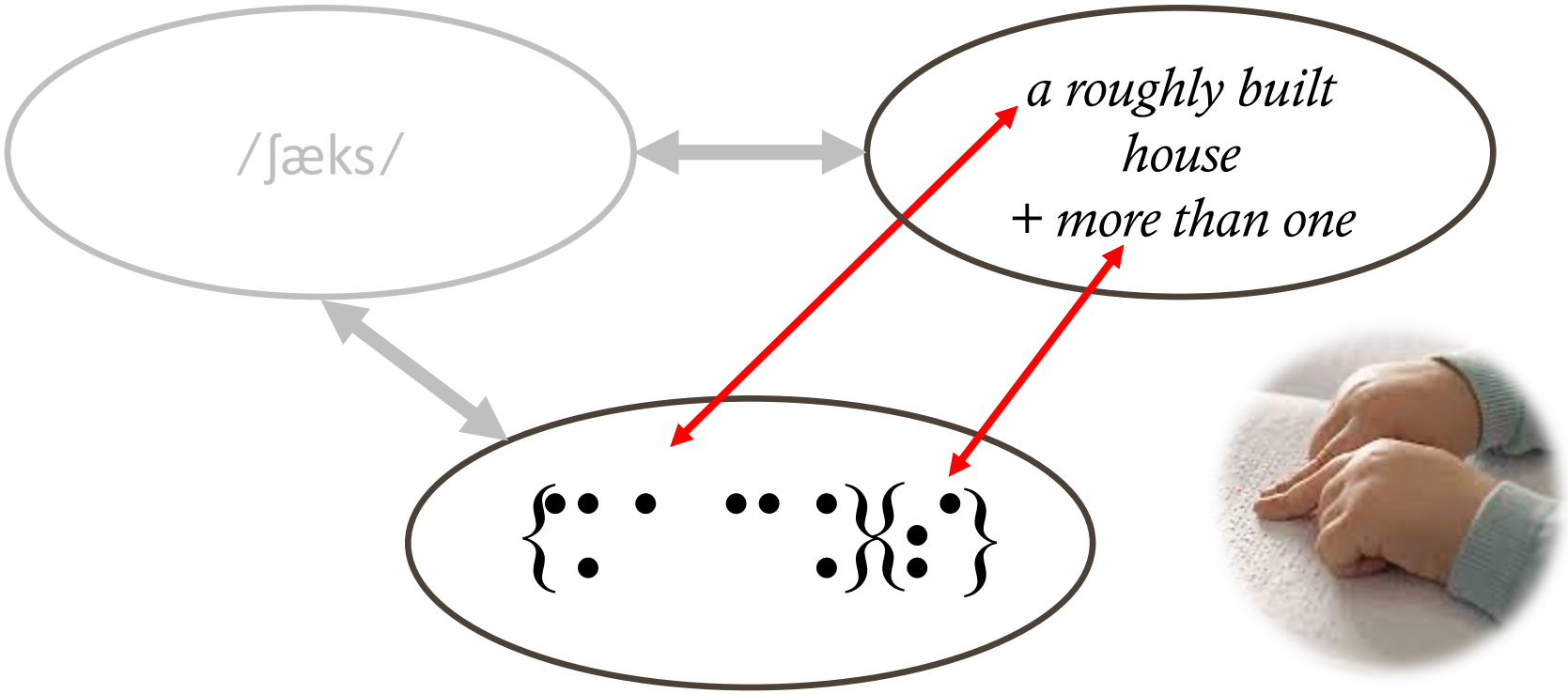

Remainder of today's talk

For each section, I will…

(1) Present research on these written language learning problems in print English

(2) Think about the child learning braille → based on the differences in the braille writing system, how might it be the same? How might it be different?

Patterns about the script: Abstract letter identities

Patterns about spelling to sound: Digraphs

Patterns about spelling to meaning: Morphology

Cognitive Neuropsychology

- About 1/3 of people who suffer strokes have some kind of language impairment – called aphasia
  - Many of them never fully recover
- People with aphasia can have very different kinds of language problems
  - Research on helping people with aphasia recover language function
  - Research on the brain basis of language
  - Research analyzing patterns of intact and impaired performance/kinds of mistakes→ tells us something about the organization of language

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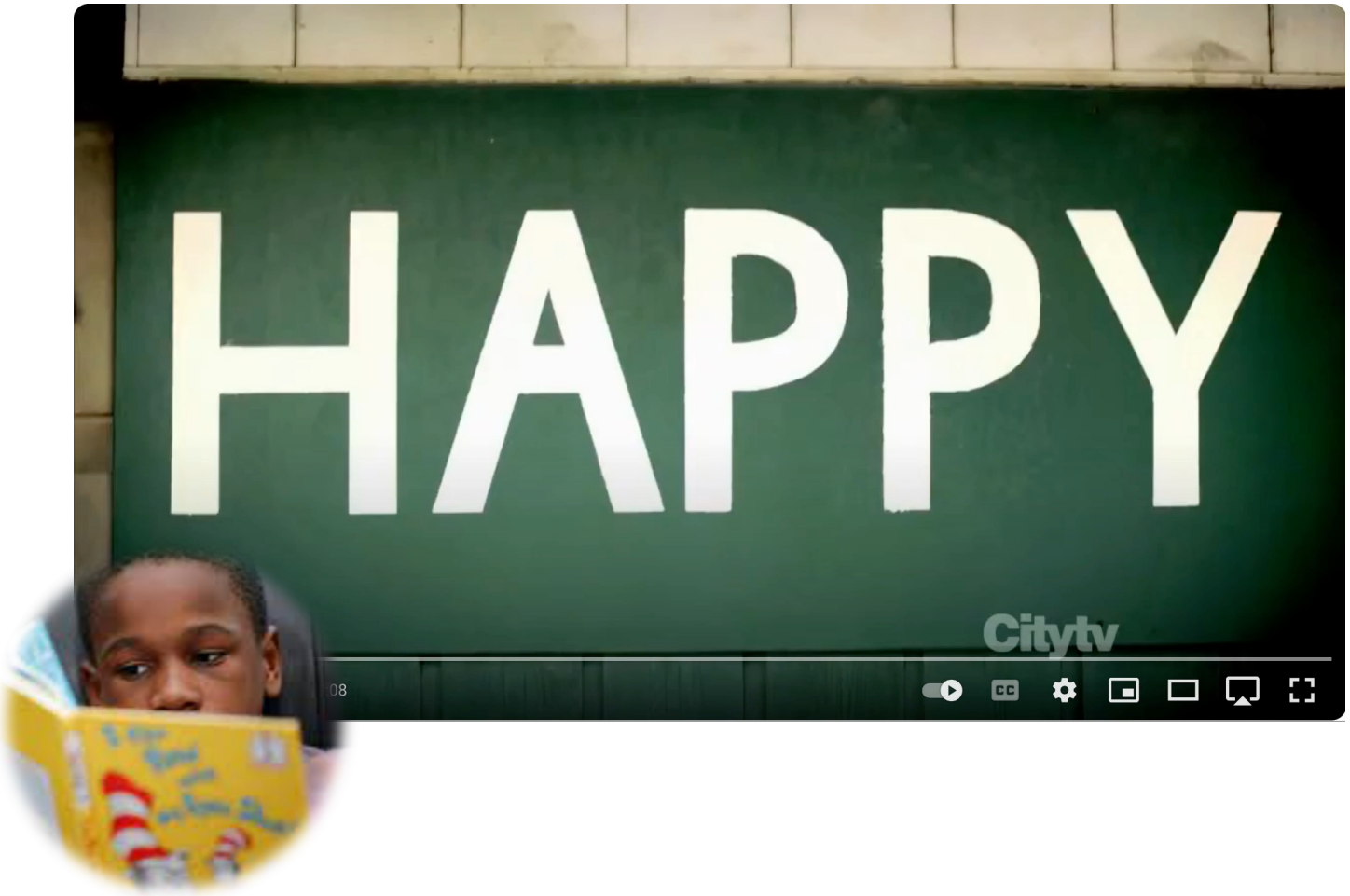
Learning Problem #1: Abstract Letter Identities



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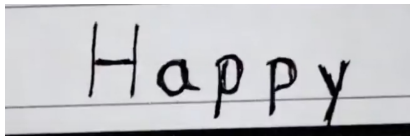
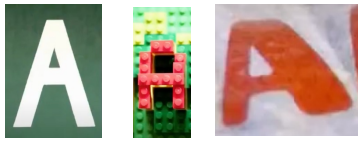


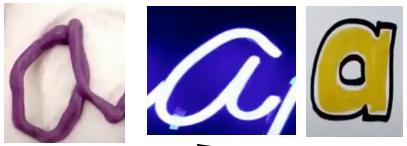
Learning Problem #1: Abstract Letter Identities

Visual Input

Upper Case



Lower Case

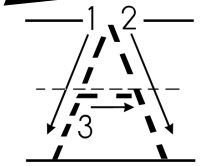


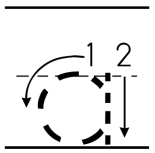
[A]

Abstract Letter Identity

"ay"

Spoken In/Out



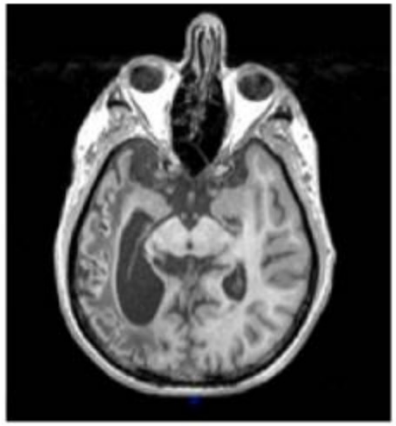


Motor Plan Out

Abstract Letter Identities
Case #1: CH

- Can someone have a specific problem accessing abstract letter identities WITHOUT having a problem in seeing letter shapes?

- CH had a stroke in 2008 at the age of 47
- Masters Degree in Chemical Engineering
- Tested ~5 years post-stroke

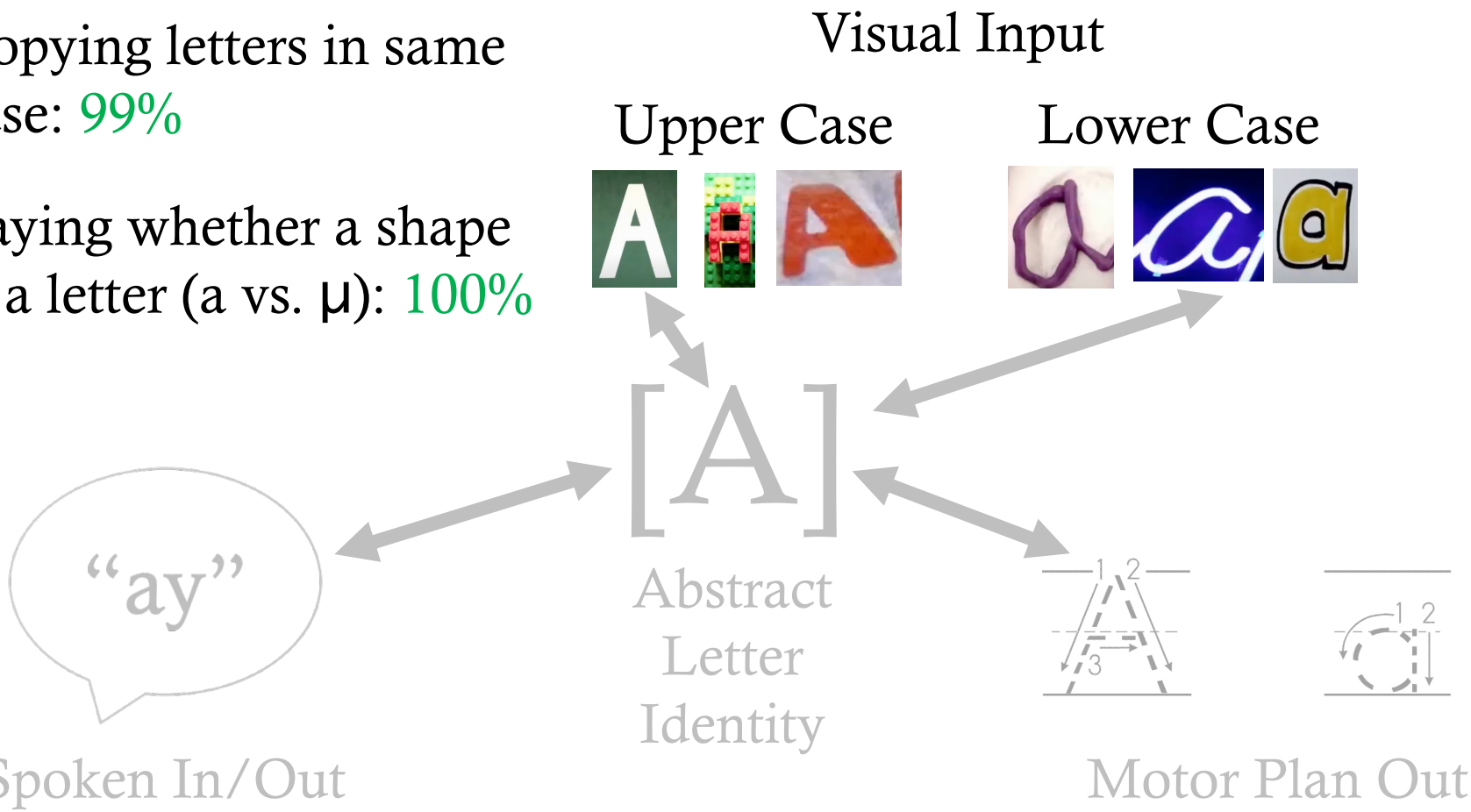


Fischer-Baum, Jang & Kajander, 2017, *Neuroplasticity*

CH can see letter shapes & and knows which shapes are letters

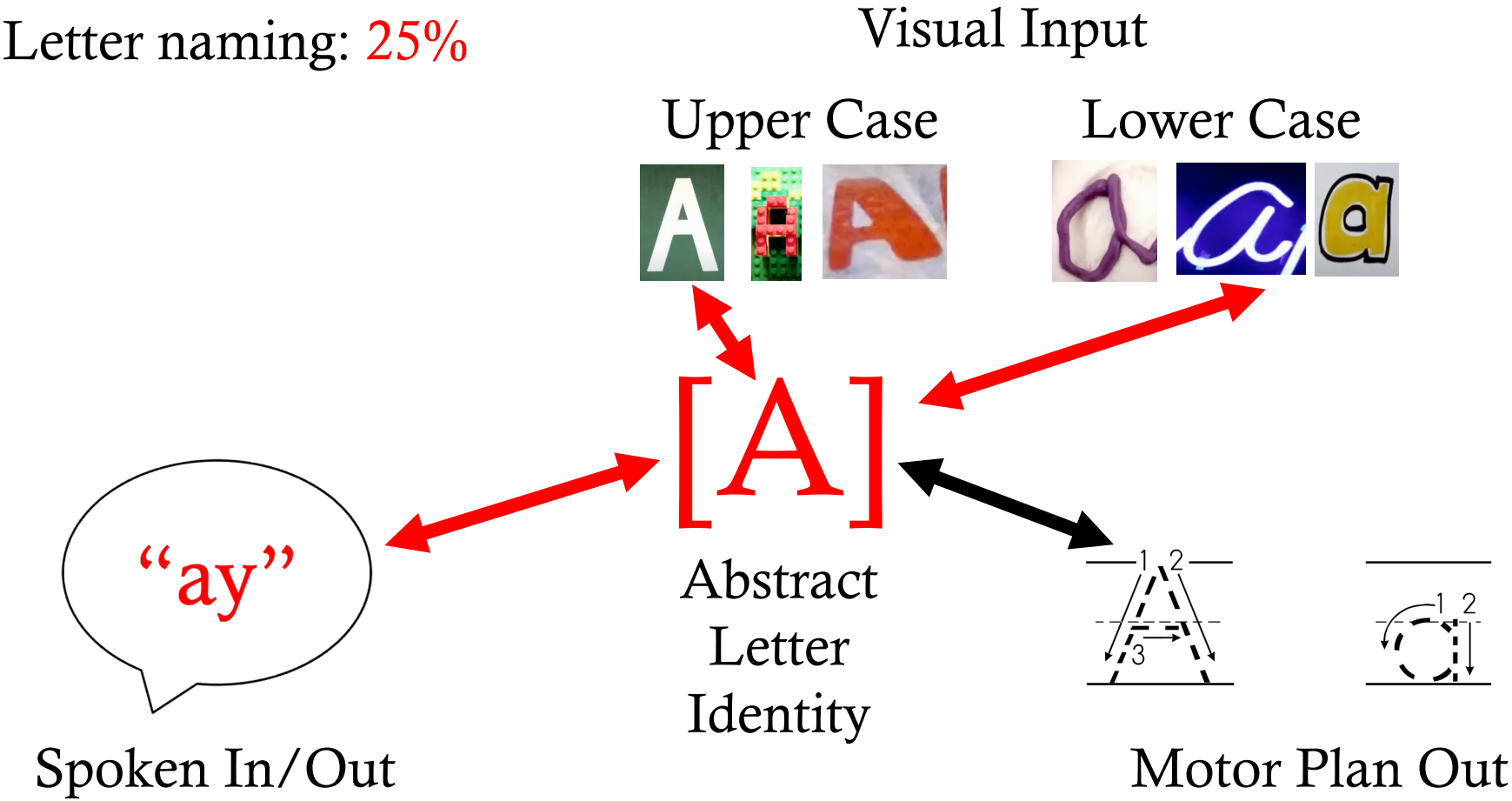
Copying letters in same case: 99%

Saying whether a shape is a letter (a vs. μ): 100%



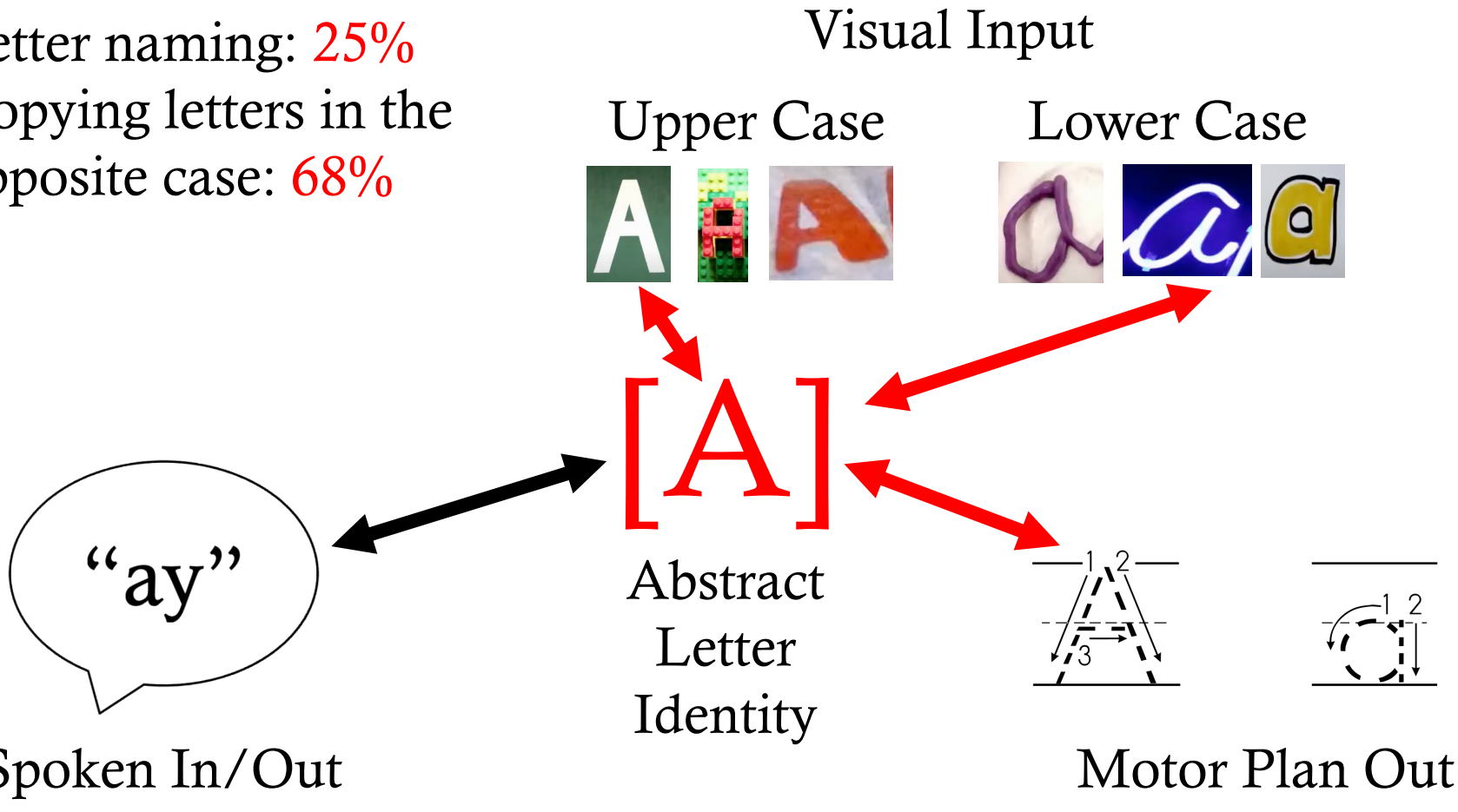
But on other tasks, CH struggles

Letter naming: 25%



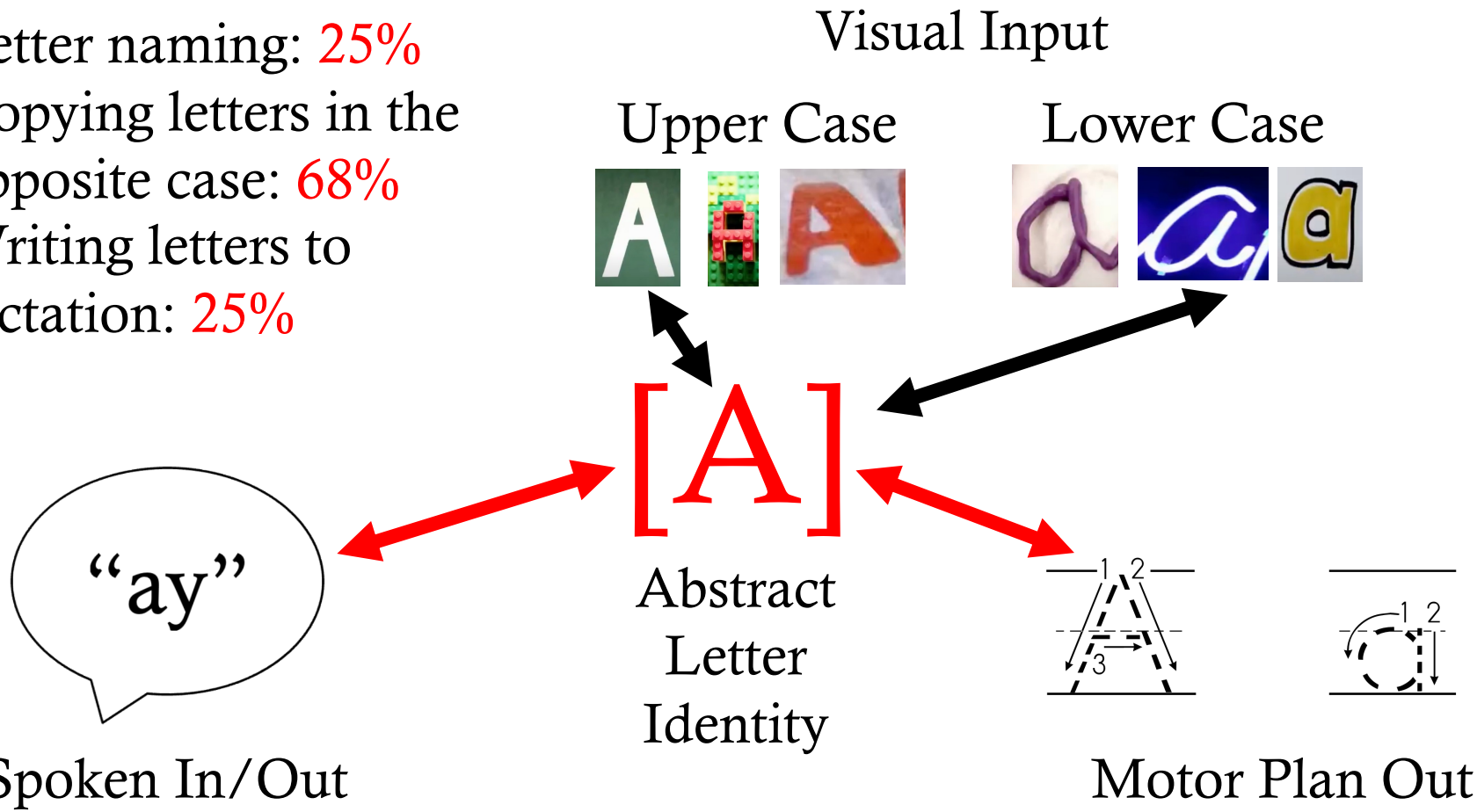
But on other tasks, CH struggles

Letter naming: 25%
Copying letters in the opposite case: 68%



But on other tasks, CH struggles

Letter naming: 25%
Copying letters in the opposite case: 68%
Writing letters to dictation: 25%

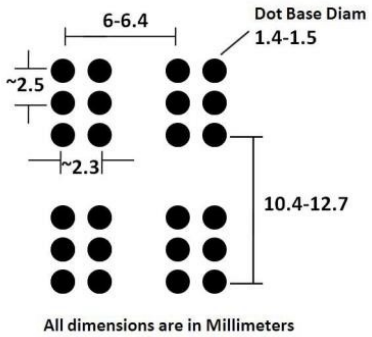


Summary of CH/Abstract Letter Identities

Tasks that…	CH
… rely only on letter shape	✓
… rely on abstract letter identities	X
… involve reading words aloud	X
… involve understanding written word meaning	X

CH's stroke damaged his ability to access abstract letter identities
As a result, he cannot read words for sound or meaning

Braille and abstract letter identities



Print:
Letters in different cases/fonts/sizes

Braille:
Cells are standardized, difficult to read when cell size is altered

Abstract Letter Identities:
Way of dealing with variation

With no variability – no need for abstract letter identities?

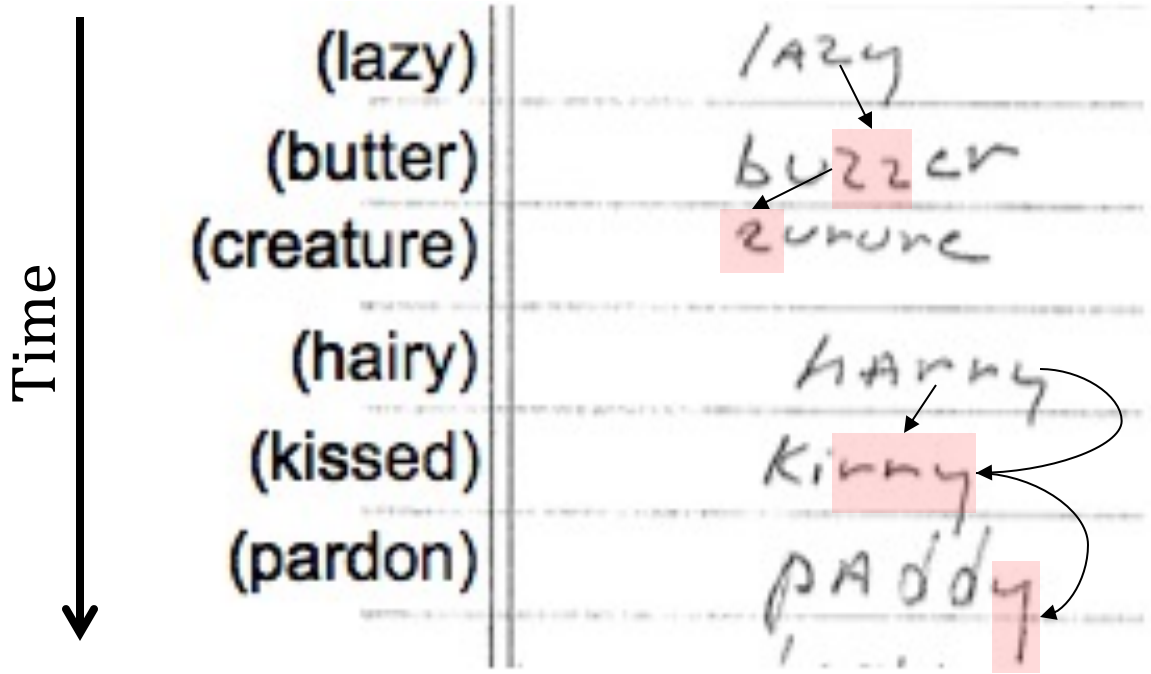
Baciero et al. (2023): Visual reading abstracts away for letter shape, but braille does not → difference between what it means to know how to read braille and print?

Learning Problem #2: Digraphs as units?

- Decoding → mapping from letters to sounds
- **Singleton**: 1 letter → 1 sound
  - T → /t/, B → /b/
- **Digraphs:** 2 letters → 1 sound
  - SH → /ʃ/, TH→ /**θ**/, PH → /f/
- **Blends:** 2 letters → 2 sounds
  - ST → /st/, ND→ /nd/

Are letter combinations that map to one sounds learned as **units** when we read and write?

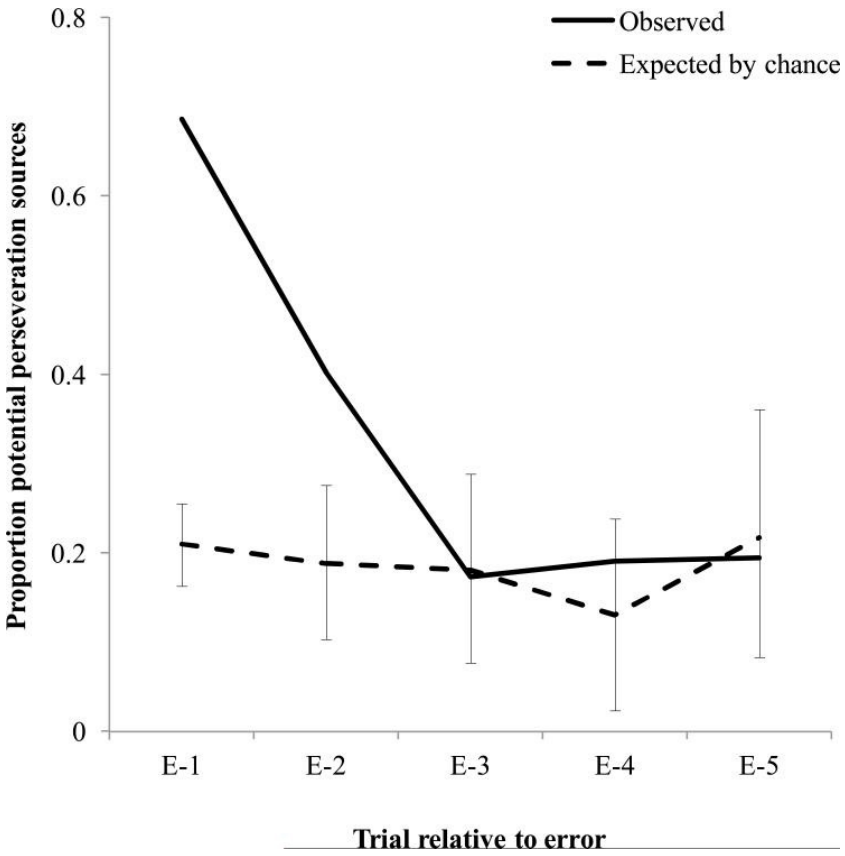
Digraphs as units
Case #2: LSS



These are called letter perseveration errors → intrusion of a letter into a current response because it was just produced

Fischer-Baum & Rapp, 2014, *Cognitive Neuropsychology*

A bit more about perseveration



- When LSS intrudes a letter, it is very likely to appear in the previous response
- If not in E-1, then E-2
- Taken together, and taking into account chance - ~70% of the time letter intrusions appear in either E-1 or E-2 or both

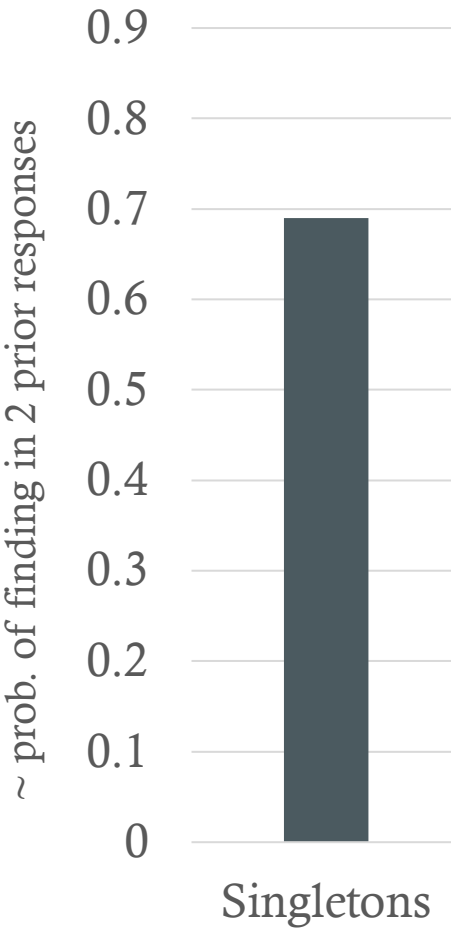
Digraphs as units
Case #2: LSS

Singleton intrusions: UNDER → UNDE**L**
Digraph intrusions: SOUL → SOU**CK**
Blend intrusions: JUNK → JU**MP**

Q1. Did L appear in a response just before UNDE**L**?
Did CK appear in a response just before SOU**CK**?
Did MP appear in a response just before JU**MP**?

Q2. When a singleton appears in an earlier response…
… is it a part of a digraph?
… is it a part of a blend?

Question 1:
Do digraphs travel together?



There is about a 70% chance that the intruded singleton L in UNDE**L** appears in one of the two prior responses

Question 1:
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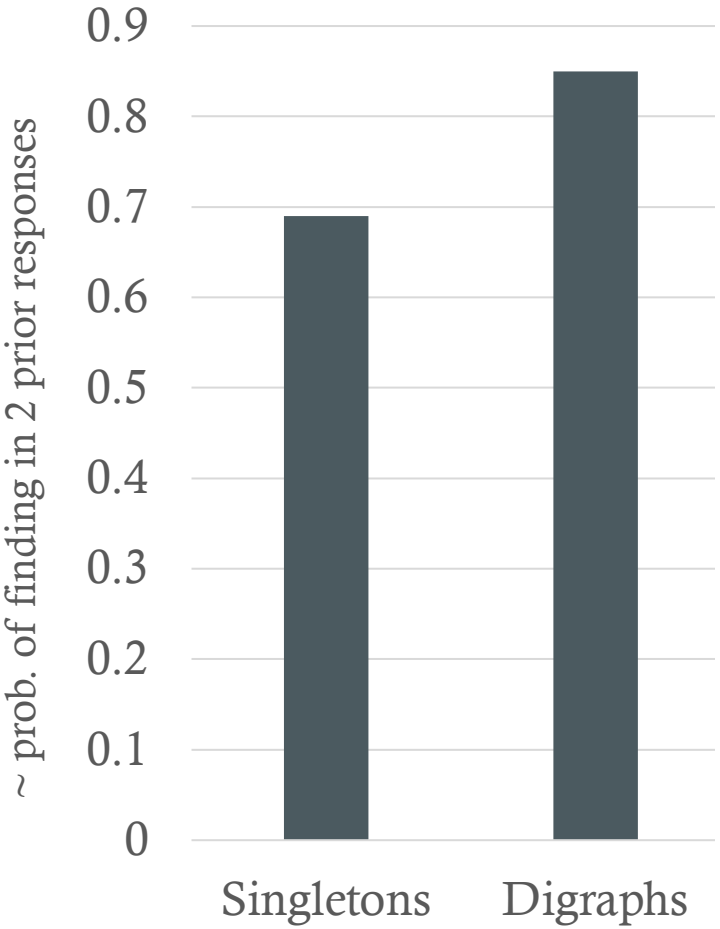
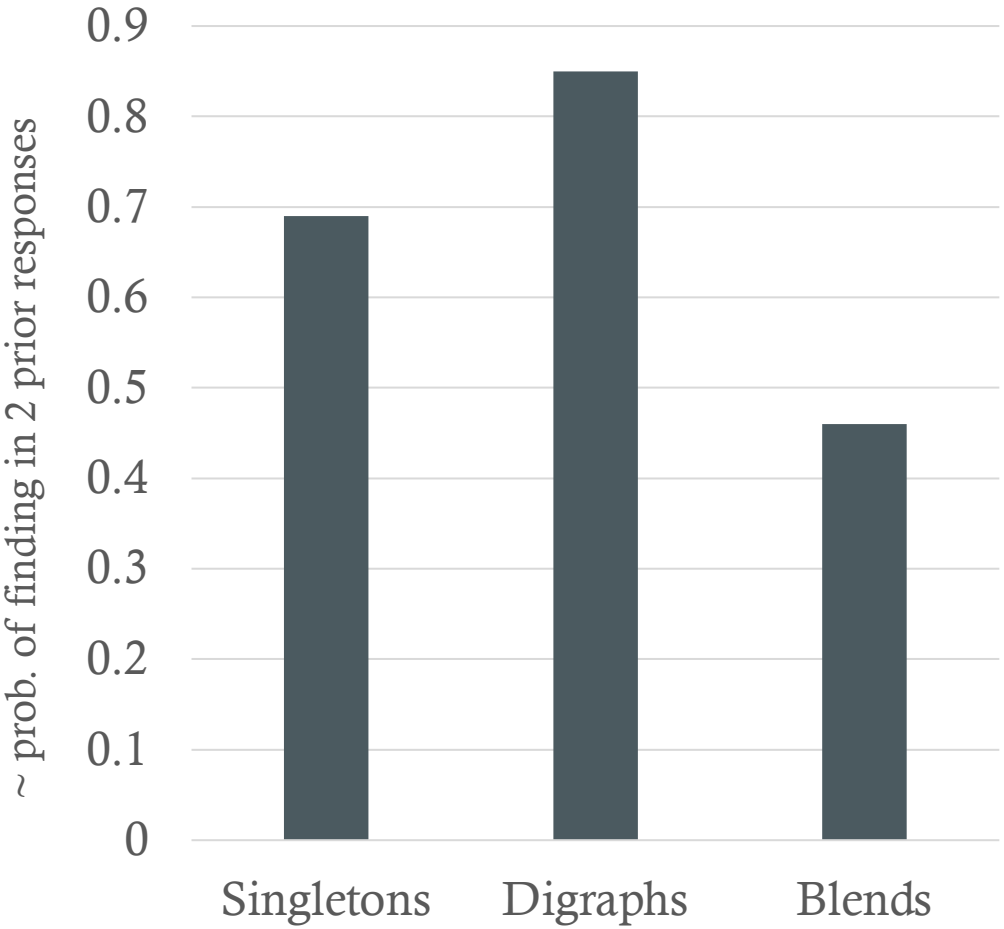


There is about an 85% chance that the intruded digraph CK in SOU**CK** appear together in one of the two prior responses

Numerically higher – but not significantly different from singletons

Question 1:
Do digraphs travel together?



Only about a 45% chance that the intruded blend MP in JU**MP** appear together in one of the two prior responses

Less likely than both singletons and digraphs

Digraphs perseverate together like they are a single unit and different from blends

Question 2:
Do digraphs split up?

Singleton intrusions: CAT → CA**S**
… in a digraph in a previous response (e.g. FI**S**H)?
… in a blend in a previous response (e.g. DU**S**K)?

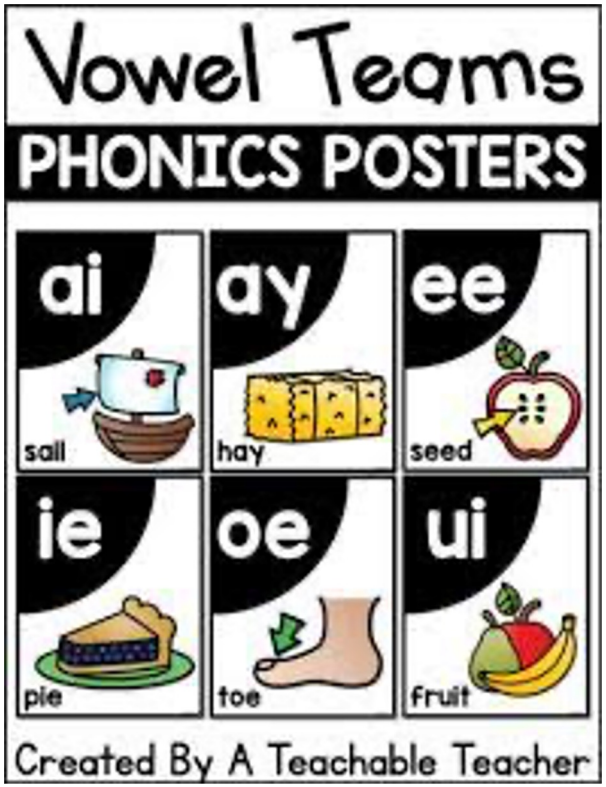
	Observed	**Chance**	**p-value**
From Digraphs	.03	.03	ns
From Blends	.19	.10	*<.0001*

Individual letters of digraphs do not perseverate separately, but individual letters of blends do

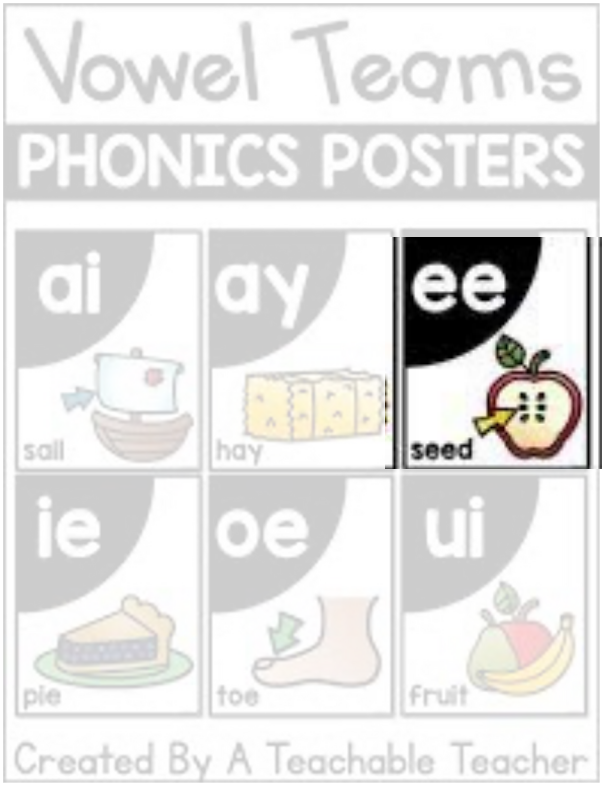
Digraphs as units

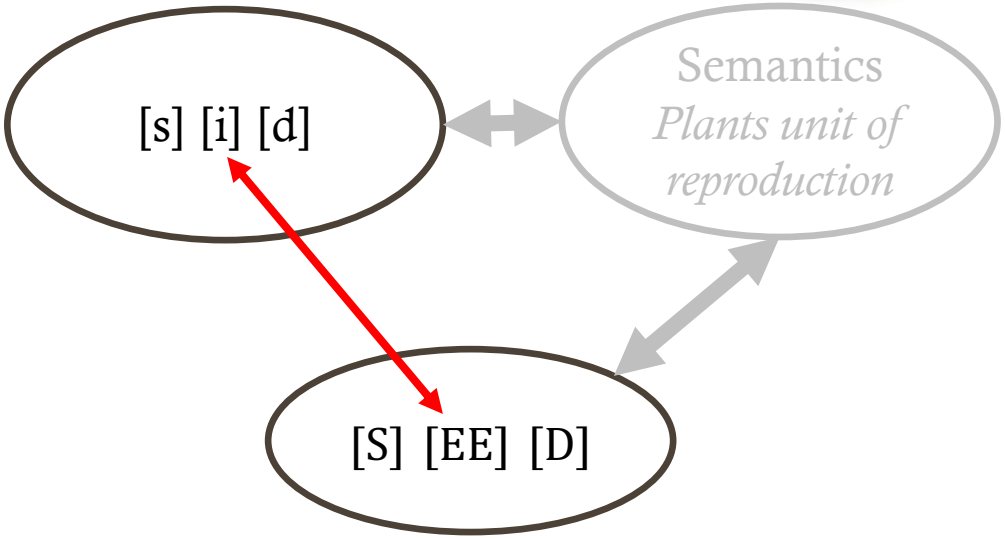
- LSS perseverates when he writes
- He perseverates digraphs like single letters but other blends like two separate letters

Contracted braille and digraphs

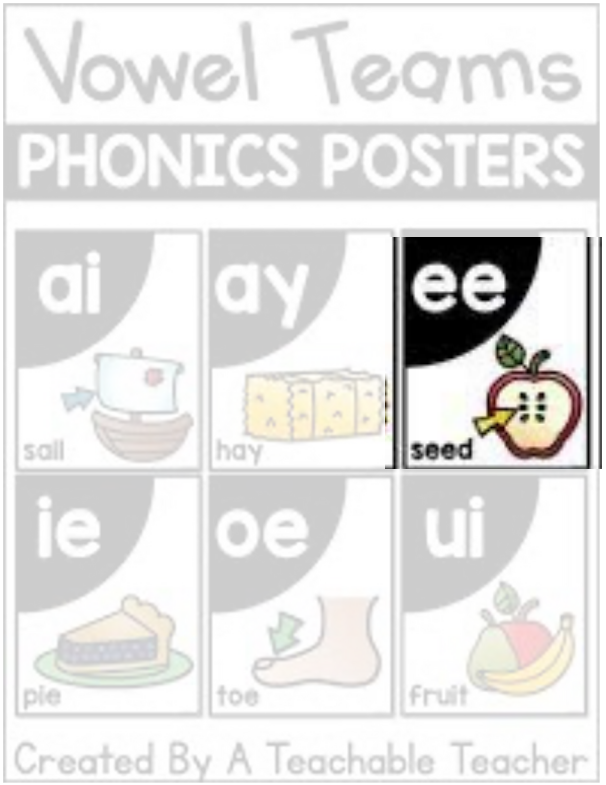


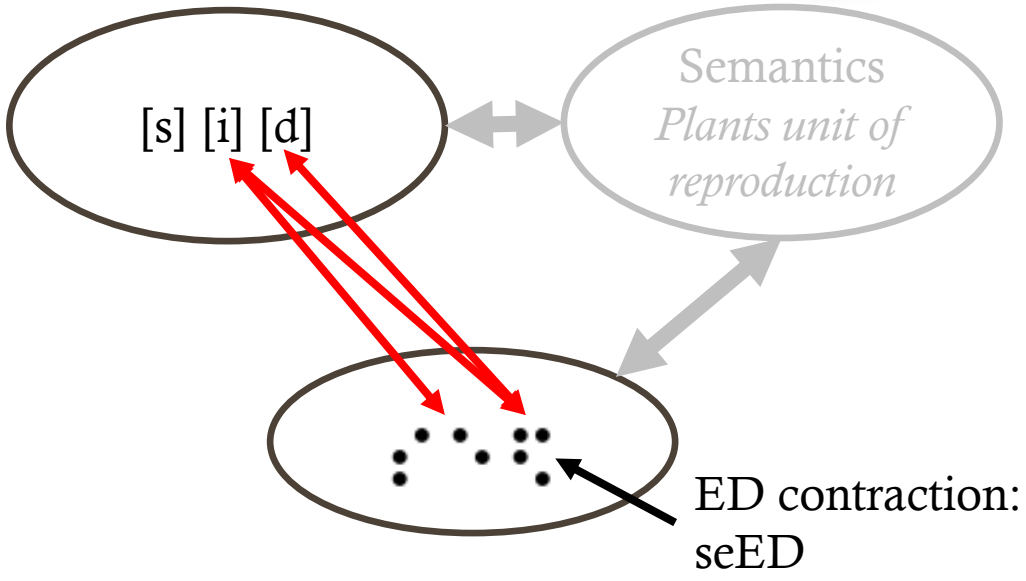
Our print readers:
Vowel teams make sense





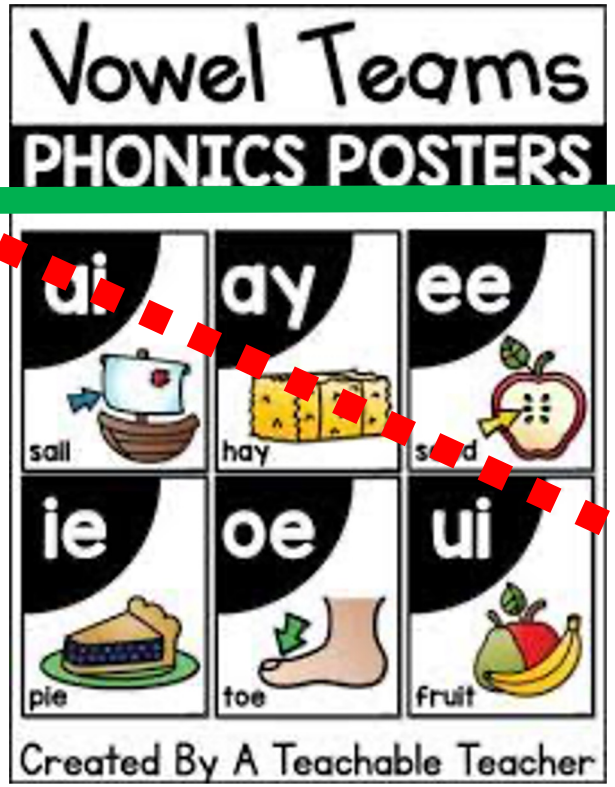
Our braille reader: Contraction breaks the vowel team





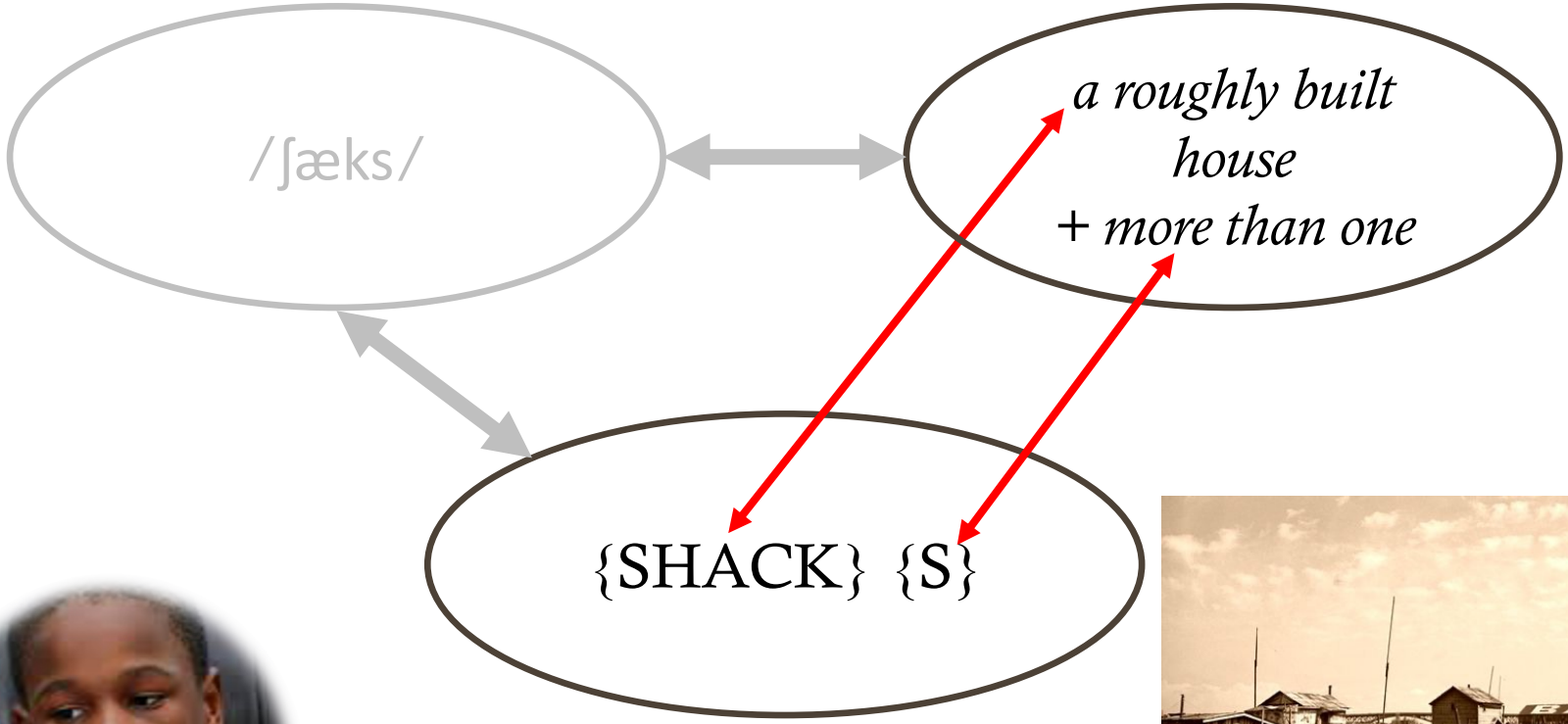
Different spelling to sound mappings learned with contracted braille

Contracted braille and digraphs

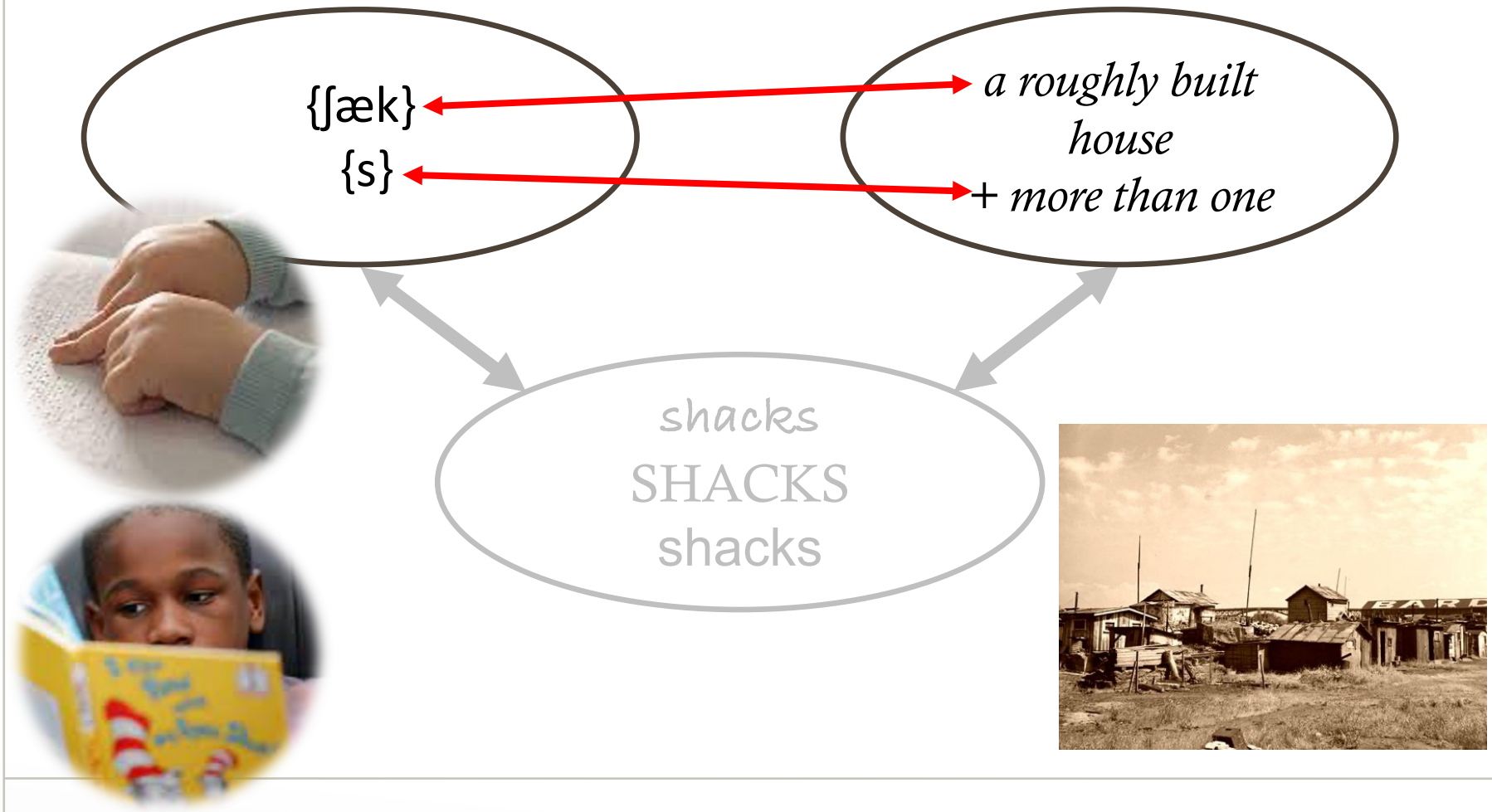


Role for TVI?

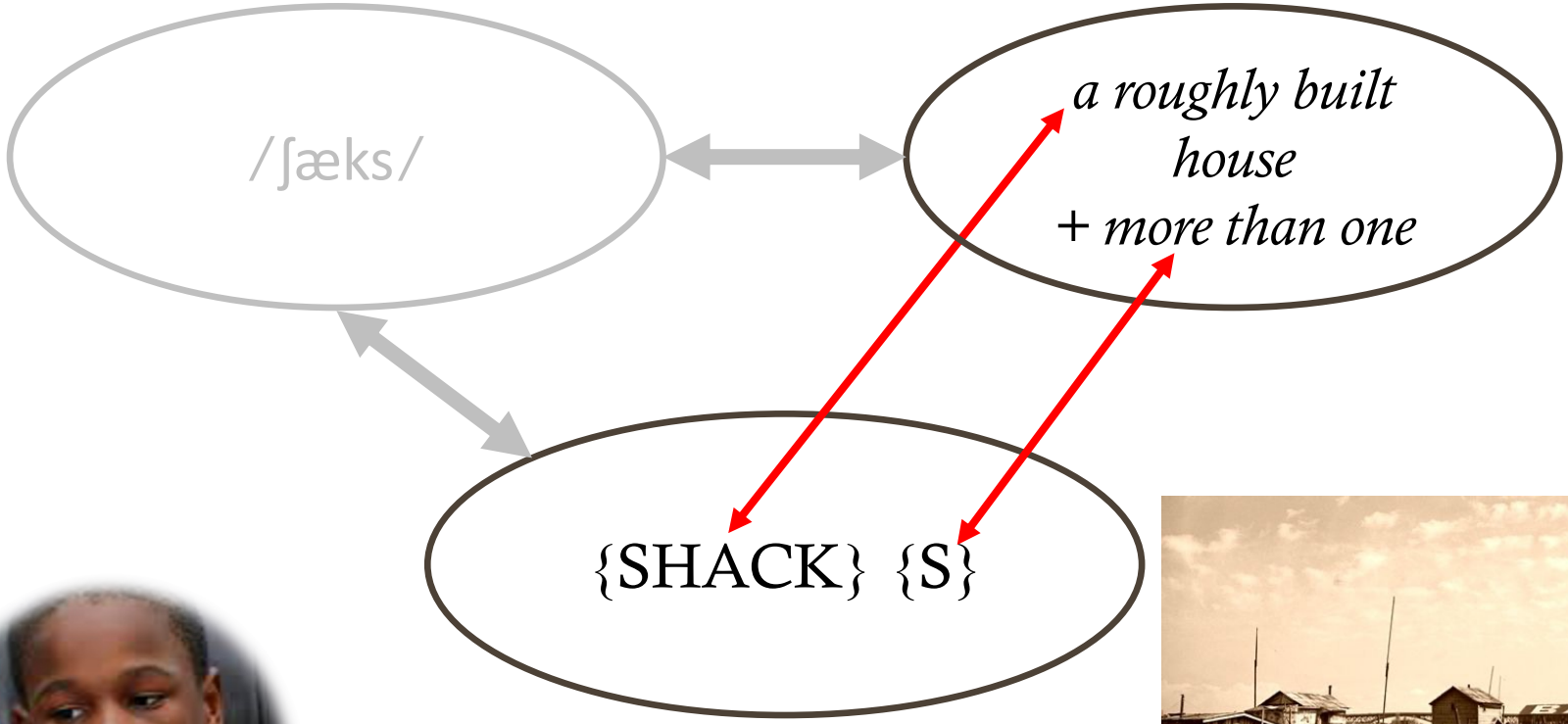
Learning Problem #3: Morphology in writing



Learning Problem #3: Also in spoken language

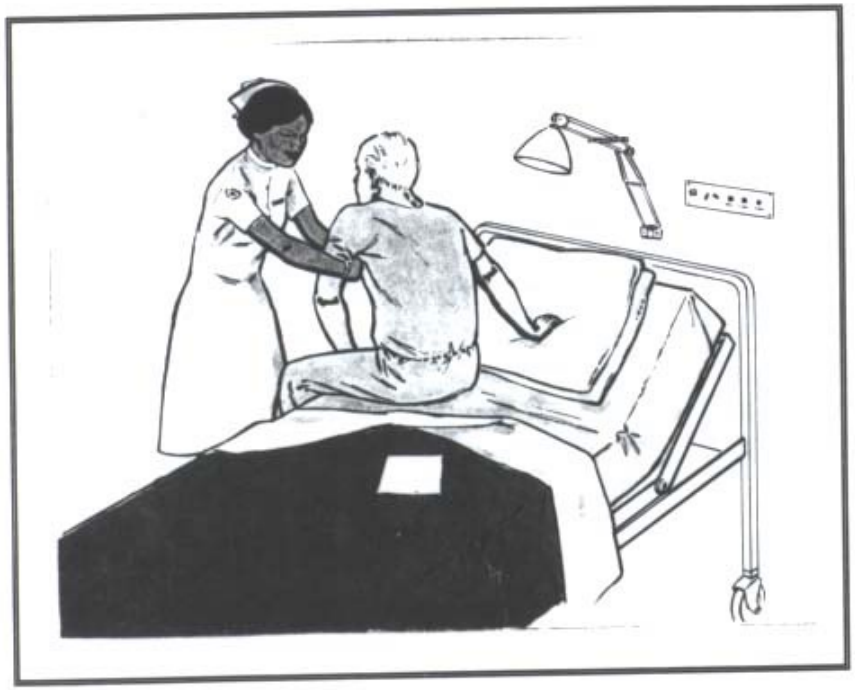


Learning Problem #3: Morphology in writing



Evidence for morphology in spelling-meaning mappings?

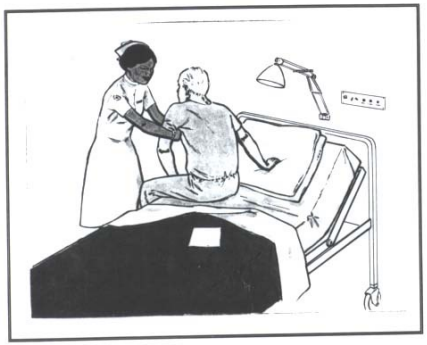
Morphology in writing: Case #3: AES



"Say a sentence, write the sentence"

A variety of tasks tapping into writing and speaking

1. Description of line drawings representing simple events.
   - "Say a sentence, write the sentence"



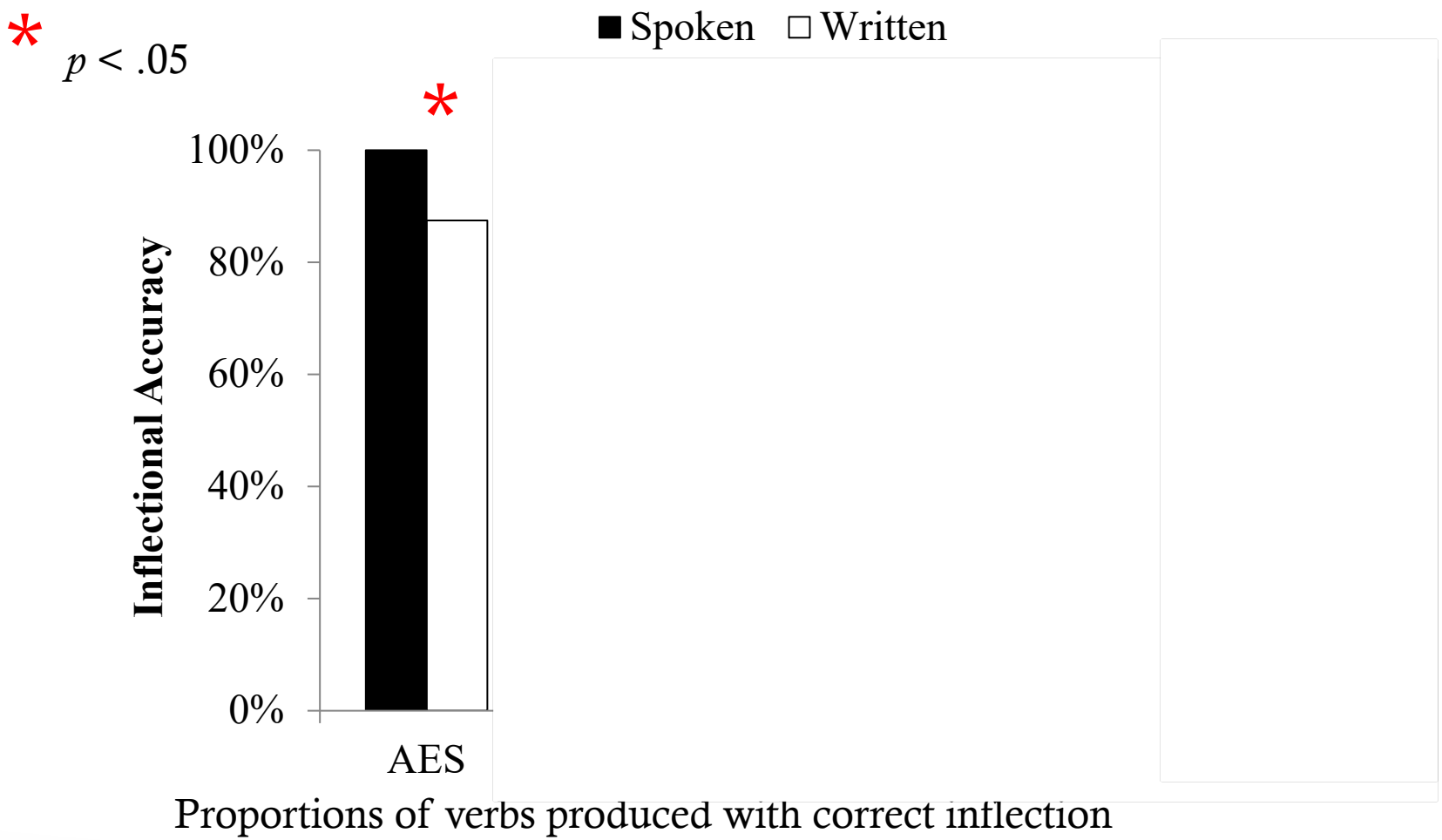
2. Written and spoken plural/singular picture naming

vs.

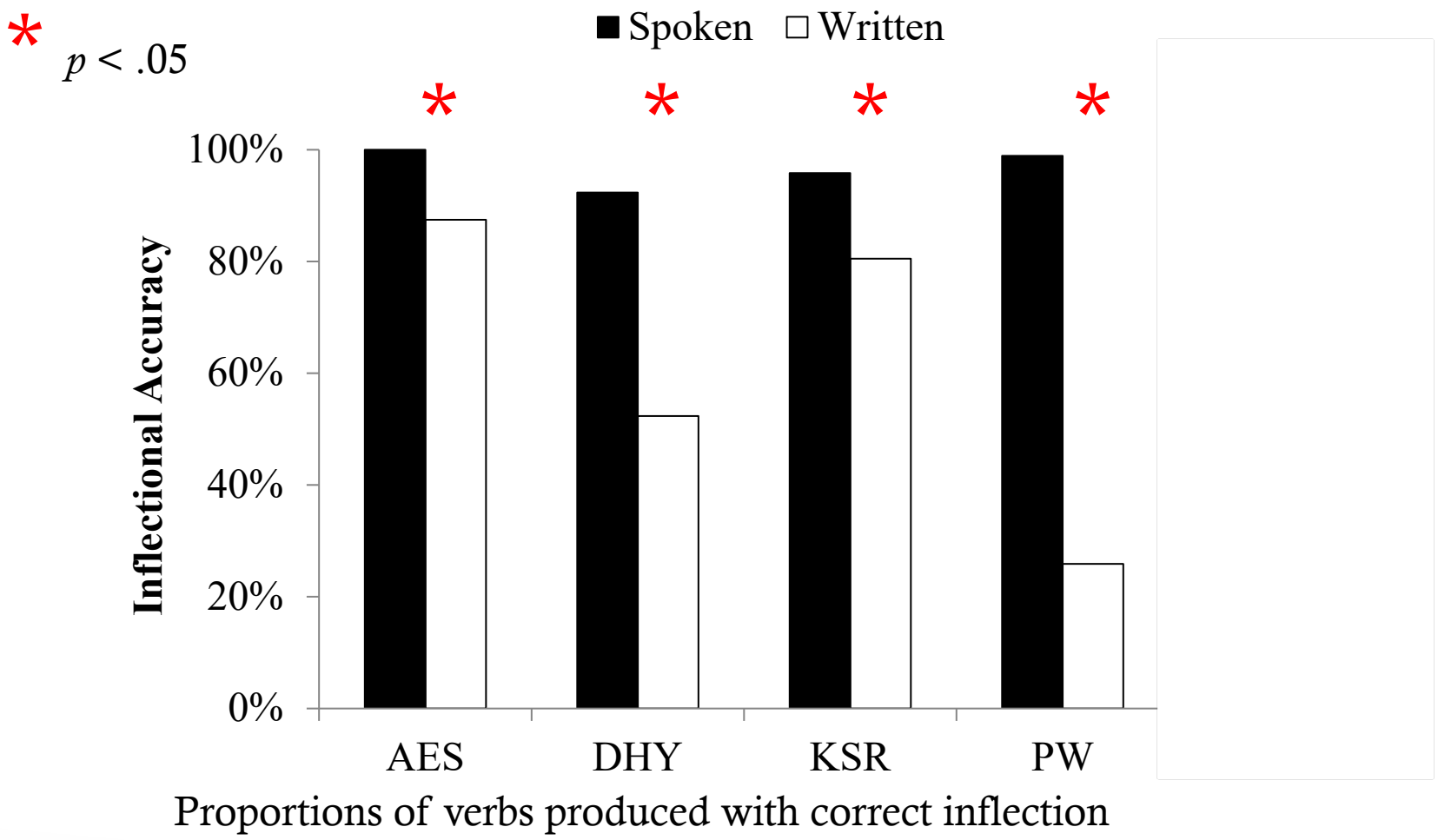
3. Fill in the blank
   - "Today I walk, yesterday I ___ "

Rapp, Fischer-Baum & Miozzo, 2015

Results: Morphology on Verbs



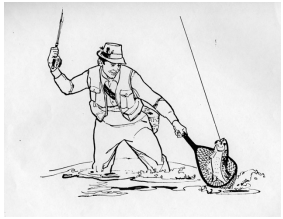
Results: Morphology on Verbs



Morphological errors in writing but not in speaking

KSR-speech: "*Dave is eating an apple*"
KSR-writing: Dave is eats an apple

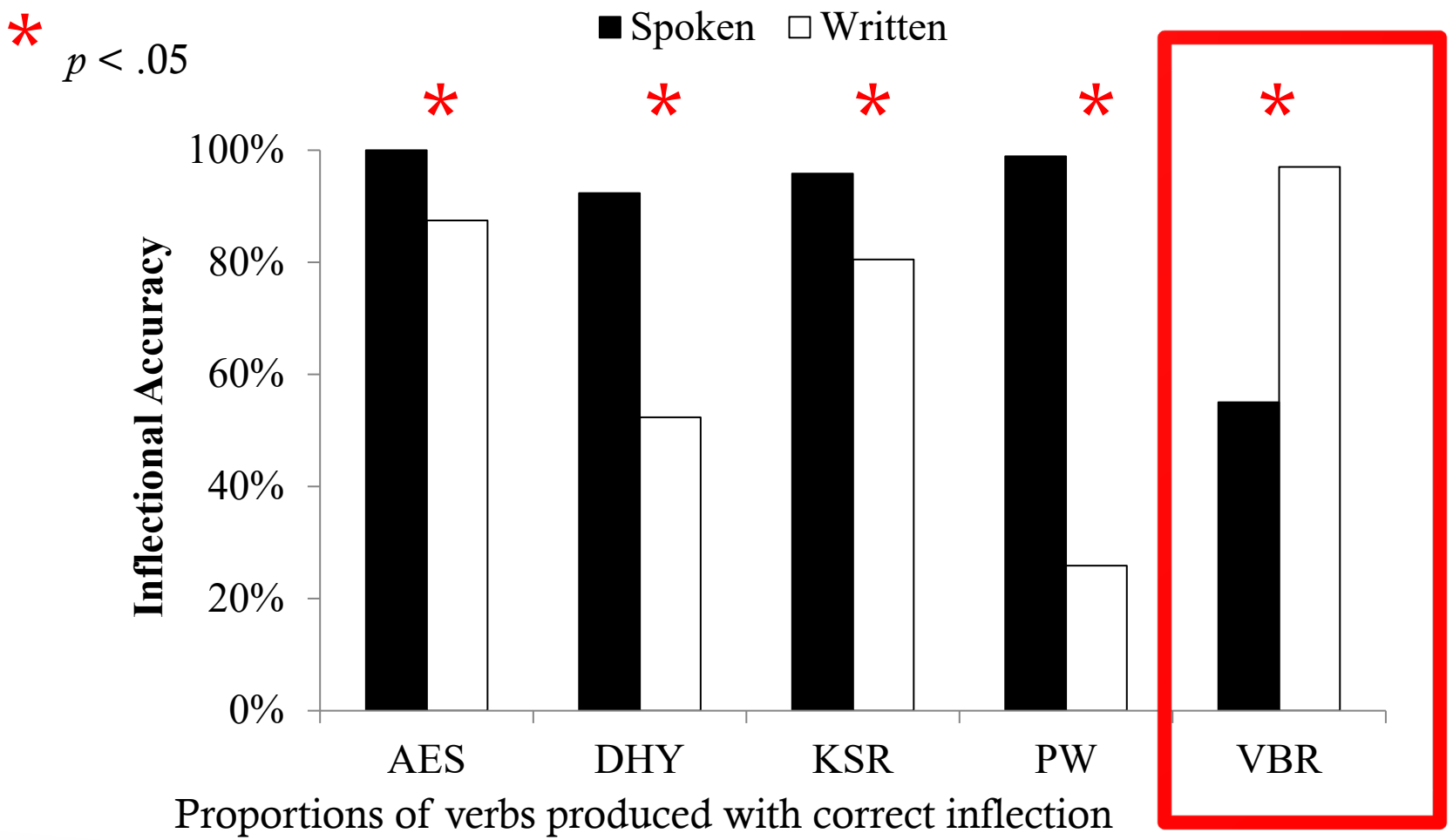
AES- speech: "*The man is catching a fish*"
AES- writing: The men is catches a fish



PW-speech: "*The man sitting on the bench*"
PW-writing: The man sit on the bench

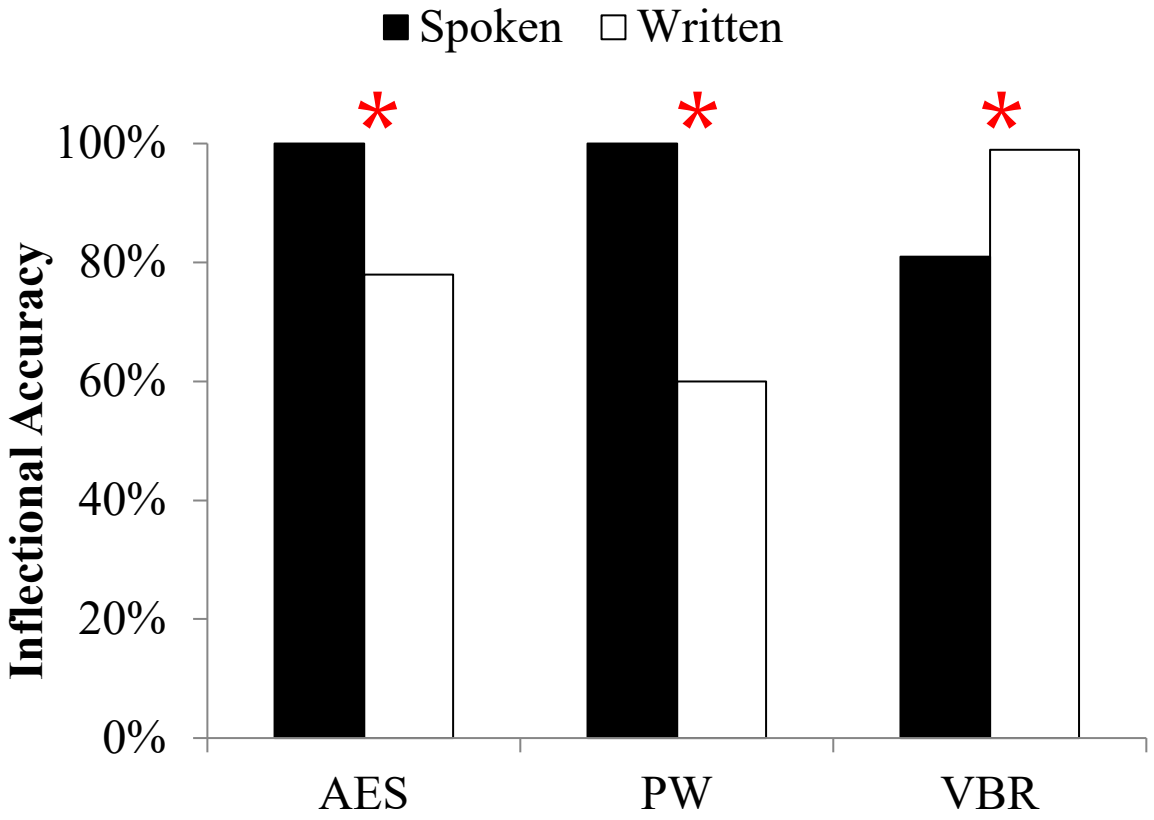
Rapp, Fischer-Baum & Miozzo, 2015

VBR→ Opposite pattern: Morphology on Verbs



Morphology on Nouns

* $p < .05$

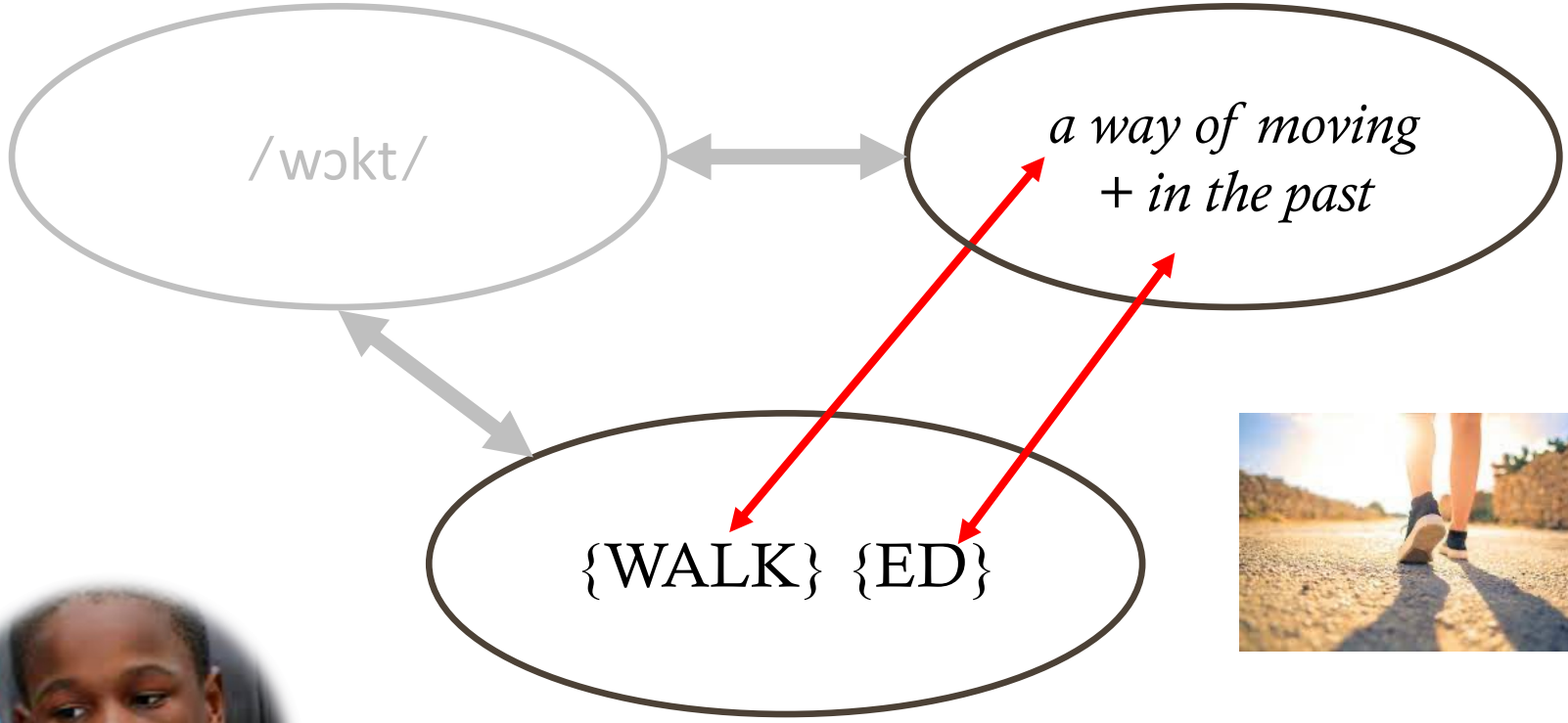


Proportions of plural nouns produced with correct inflection

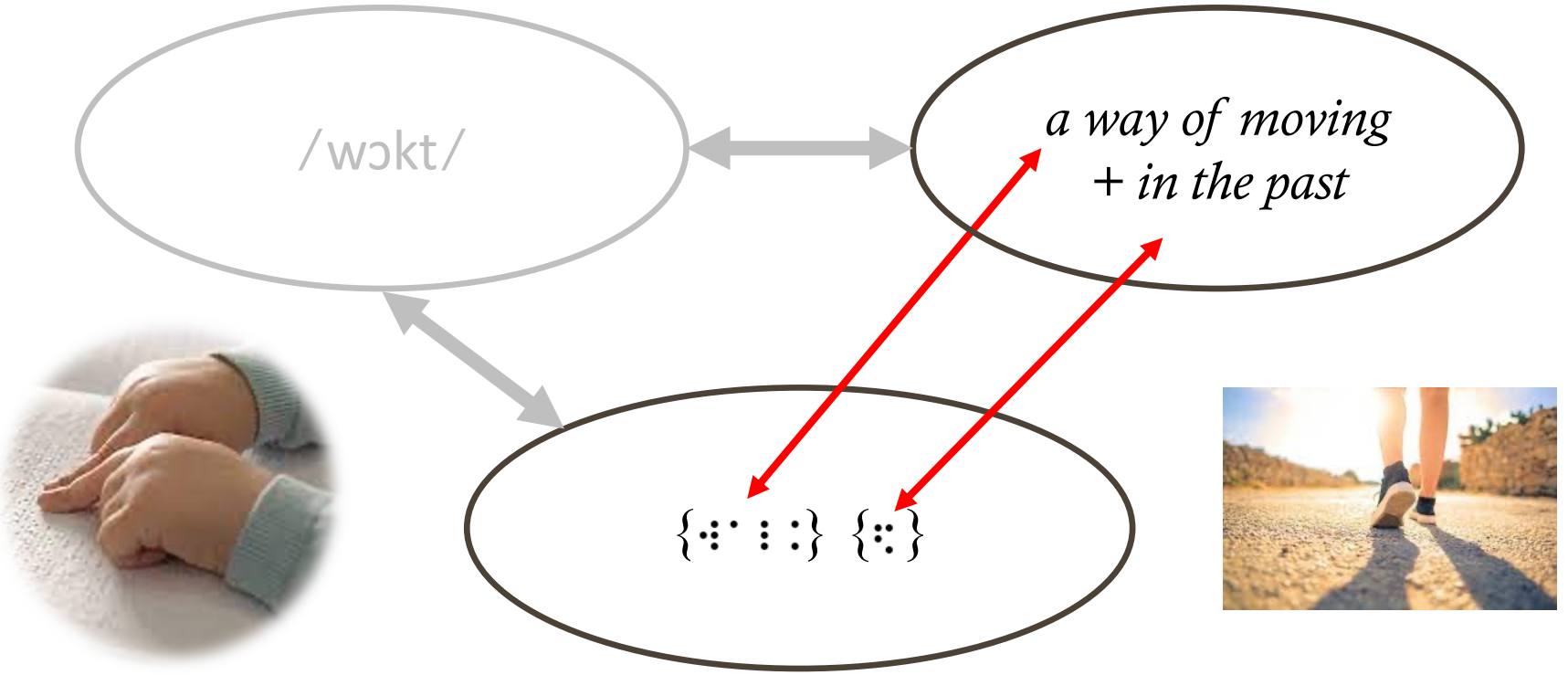
Learning Problem #3: Morphology in writing

- AES (+others) have difficulties with morphology when writing, not when speaking
  - Single dissociation between writing and speaking
- Another individual (VBR) has difficulties with morphology when speaking, but not when writing
  - Double dissociation between writing and speaking
  - Written and spoken morphology are stored separately and can be separately damaged

Braille and morphemes



Braille and morphemes



Some braille contractions align with morphemes → contraction use is more accurate (Lauenstein, 2007)

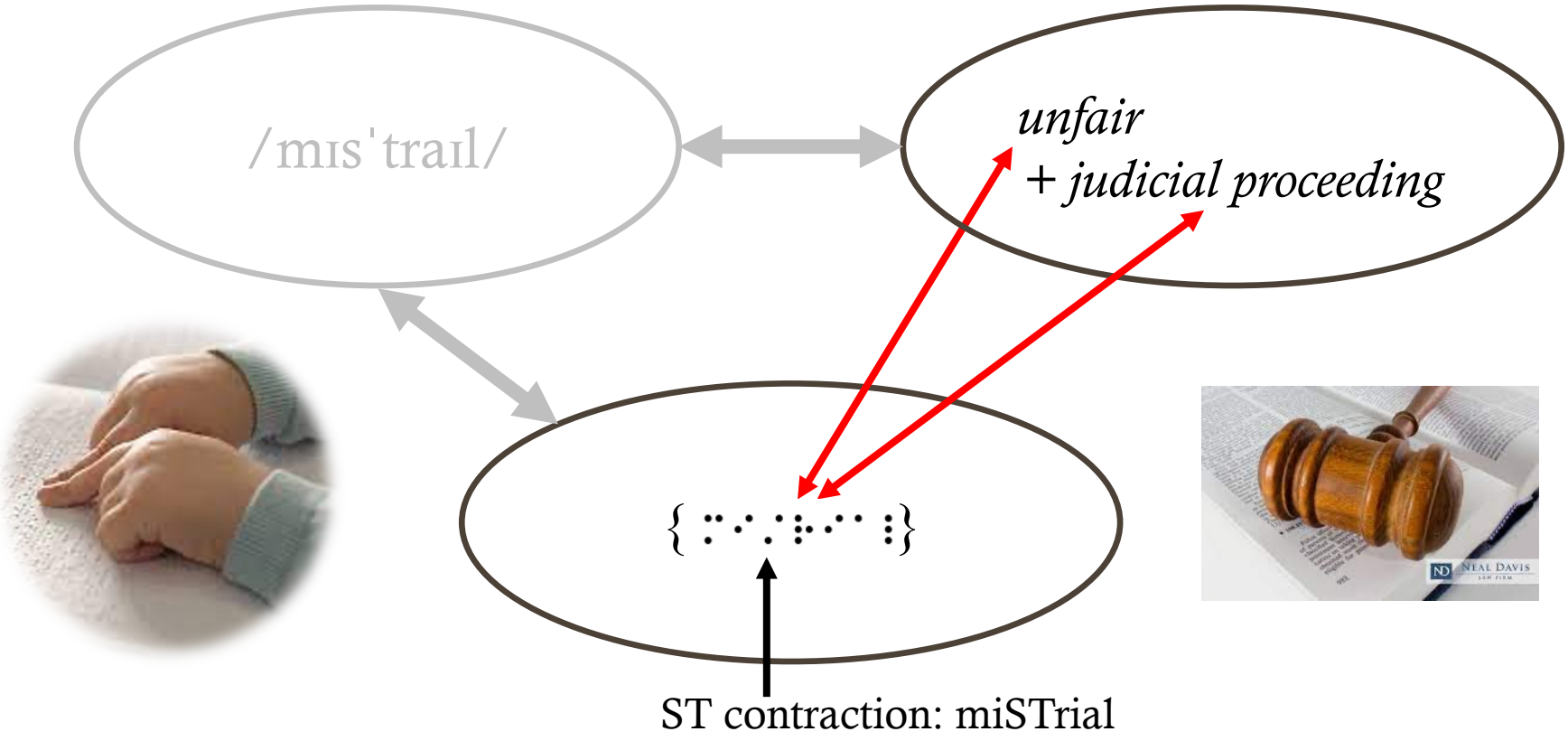
Braille and morphemes

/mɪsˈtraɪl/

unfair
+ judicial proceeding

{MIS} {TRIAL}

Braille and morphemes



Some braille contractions go across morpheme boundaries

Morpheme Bridging Contractions

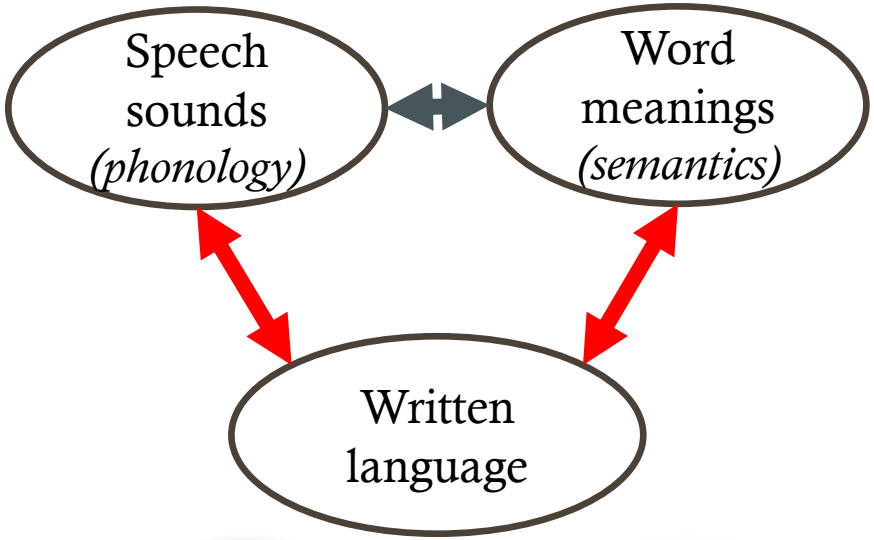
- Fischer-Baum & Englebretson (2016) – disrupts adult tactile braille readers ability to recognize words
- Englebretson, Holbrook, Treiman & Fischer-Baum (2023) – disrupts kids in the Braille Challenge's ability to write words

JOIN US ON FRIDAY @ 3PM FOR MORE OF THIS!

Exploring the Concept of Braille as a Code or a Writing System: Implications for Instruction
Robert Englebretson, Simon Fischer-Baum, Cay Holbrook

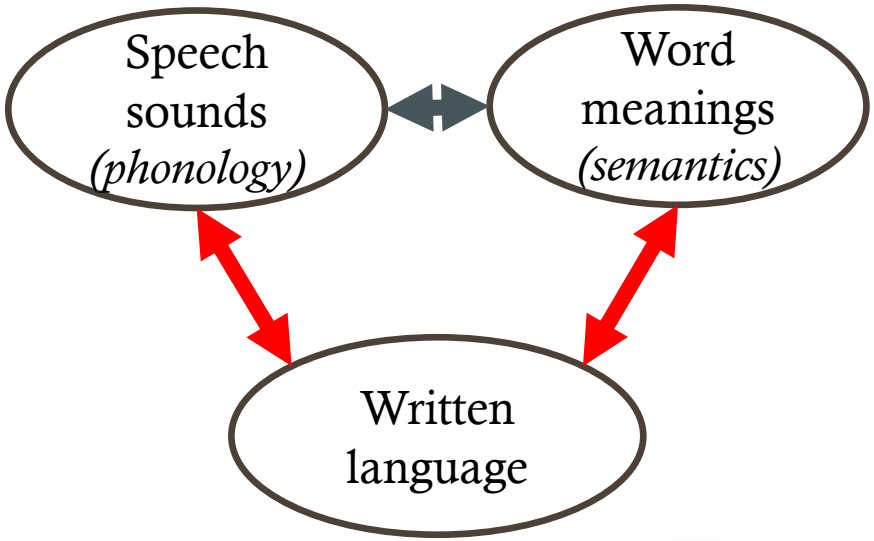
Summary: Learning literacy from the CogSci perspective

- Human minds learn the patterns present in experience
- Language filled with patterns, languages have different patterns
- Written language (braille or print) map onto spoken language
- Learning written language → patterns in those mappings



Summary: Teaching literacy from the CogSci perspective

- These patterns CAN be learned IMPLICITLY
- Effective EXPLICIT instruction supports the kinds of patterns that kids are learning implicitly
  - Alphabetic knowledge
  - Phonics
  - Morphological awareness



Braille & Print - learners

- Braille and print are DIFFERENT writing systems
- For our students that we are imagining – both are writing systems for English – so lots of similarities!
- Because of differences in script AND braille contractions, the patterns being learned by the students likely differ to some degree
- More research needed!

Braille & Print - teachers

- Most educational materials for literacy is built around the patterns learned from English print → may mismatch the patterns being learned for English braille
- TVIs are often one of the few adults in the child's life who knows how to read and write braille
- TVIs aren't just teaching the braille code, but are teaching literacy through braille!

Understanding braille literacy requires multiple perspectives!

Educational settings

Language experience

Socio

ains

Lets continue this conversation on Friday!

Thanks