LING 1010

Language and Mind

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03.08.21: The acquisition of morphology

Nativism vs Empiricism

Just to recap, here are the properties of Nativism and Empiricism, including their stances on the type of innate knowledge that is possible.

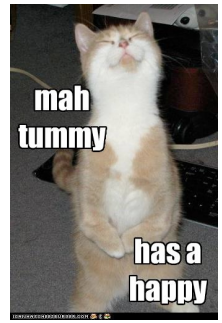
Modern Nativism	**Modern Empiricism**
 Substantial innate knowledge	 Minimal innate knowledge
 Input/experience still plays a role, but less than the role it plays in empiricism.	 Input/experience plays the largest role in learning
 The innate knowledge can be domain-specific.	 If there is innate knowledge, it is domain-general

Some puzzles in learning words/morphemes

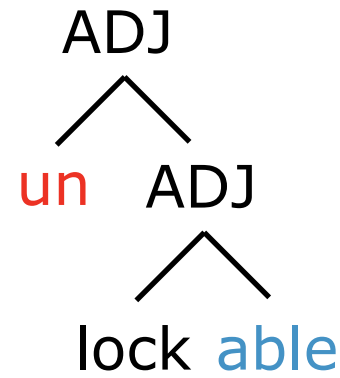
There are tons of open research questions when it comes to learning words.
Today we are going to talk about three of the most basic questions

sound **meaning**

[k æ t]



lexical entries

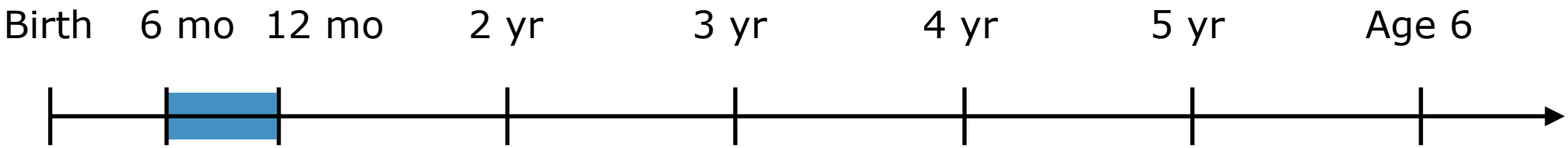


morphological rules

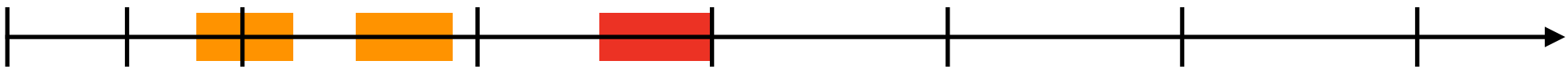
1. How do children segment the speech stream into words?
2. How do children learn what a given word means?
3. How do children learn morphological rules?

The timeline we are talking about

Just to orient today's discussion relative to last time, we can look at the timeline of word/morphology acquisition:



babbling begins at 6mo, becomes variable and language-specific by 12 mo.



First words are produced between 10-15 mo.

For many children, word learning accelerates dramatically around 18 mo. This is called the **vocabulary explosion**.

Complex morphology appears on words.

Two word utterances Function words and longer utterances

Word Segmentation

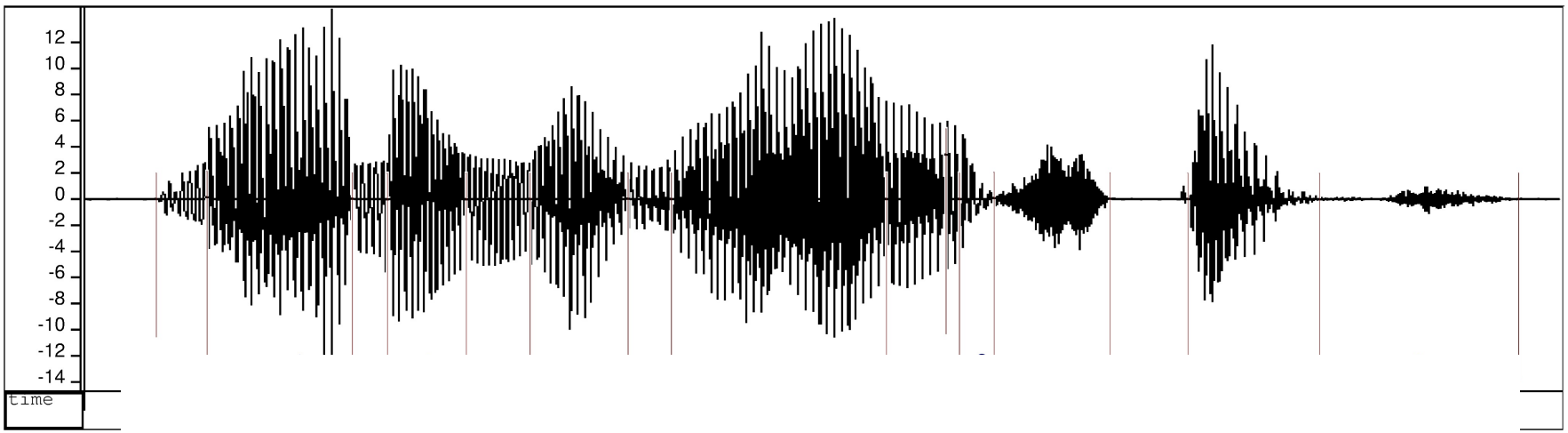
Don’t be fooled by your adult processing ability!

When you hear speech, you feel like there are individual words in the speech stream. Don’t be fooled by this!

Adults have already learned words. So you can use this knowledge to help you segment novel speech streams.

To get an idea of the problem that children face, try listing to a language that you don’t know, and figuring out where the word boundaries are!

Or just look at a waveform without the words superimposed, and try to guess where the word boundaries are:



There are segmentation errors

We can also see that the word segmentation problem is real by the fact that people make word segmentation errors:

Examples from daily speech:

The sky is falling.
This guy is falling.

The white house is under attack.
The white house is under a tack.

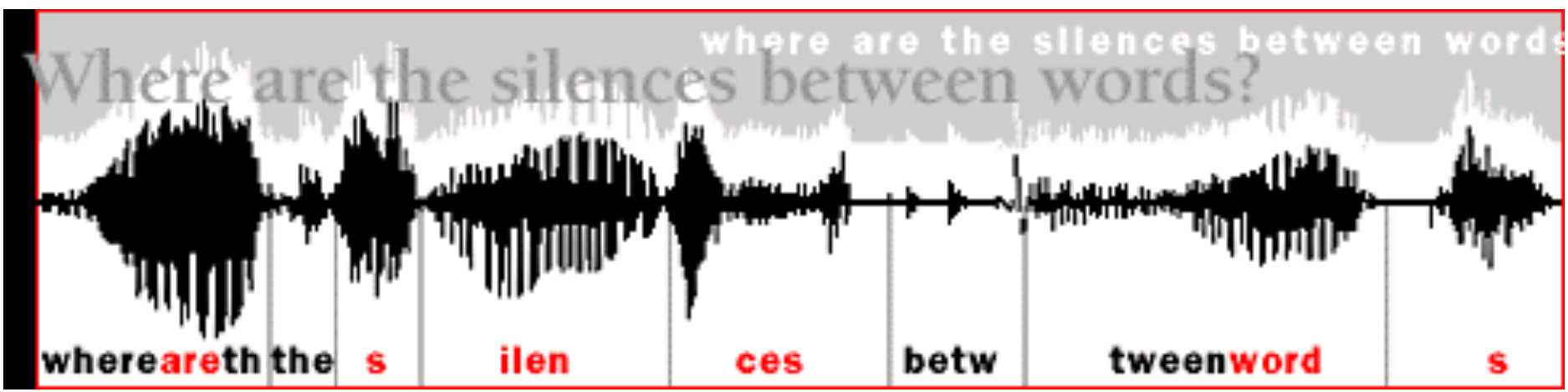
Examples from history:

a napron	⟶	an apron	The n is reanalyzed as being part of the determiner!
an other	⟶	a nother	"That is a whole nother thing!"

The word segmentation problem

You may recall from the first section of class that we learned that there is no obvious way to identify individual speech sounds in a stream of speech.

Well, this problem scales up to words too. The stream of speech is a continuous modulation of amplitude and frequency. There are no obvious breaks in the physical signal that correspond to breaks between words.



The **word segmentation problem** is the fact that children must somehow decide where the breaks are between words in the speech stream, despite the fact that there are no physical breaks in the stream (i.e., they must segment the speech stream into words)

Transitional Probabilities

One way children might solve the problem is to track how often each sound follows other sounds.

T h i s i s j u s t a s c h e m a t i c

We call this the **transitional probability** - it is the probability of transitioning from one specific sound (e.g. s) to the letter that comes after it (e.g. j).

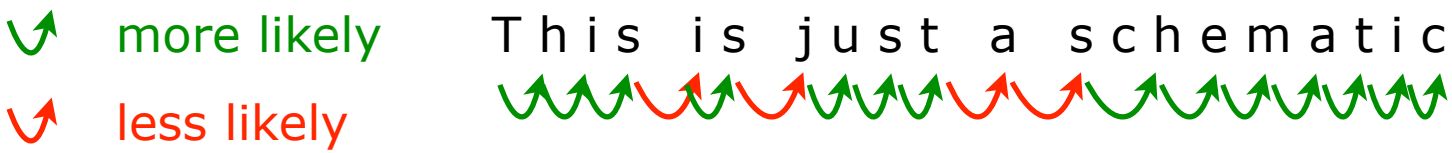
It is really easy to calculate (on a computer). You simply find every instance of a sound (e.g. s) in a corpus, and then look at the sound that comes after it each time. You then pick one sound (e.g. j), and divide the number of times you see j after s by the number of times s appears:

$$\text{transitional probability (s j)} = \frac{\text{\# of j's following s's}}{\text{\# of s's}}$$

(For the mathematically minded, this is the same thing as a conditional probability. It is the probability of j given that you already saw a s, or p(j|s).)

How do transitional probabilities help?

The idea behind transitional probabilities is that sounds that appear next to each other inside of a word will be more frequent than sounds that do not appear next to each other in a word.



The reason this will be true is that the sequence of sounds inside a word will be spoken every time the word is spoken. Sequences of sounds outside of words will only be spoken when those two words happen to be stuck next to each other.

So, children can use the transitional probabilities of sounds to guess word boundaries:

word internal sequences will have high transitional probability

word boundaries will have low transitional probability

Children need more

It turns out that transitional probabilities alone are not quite enough to solve the word segmentation problem.

This is an open area of research, but current research suggests that children use multiple sources of information to identify word breaks:

1. Children may use the transitional probability between phonemes.

2. Children may also use the transitional probability between syllables because most low frequency transitions happen across word boundaries:

3. Children may use the fact that words tend to have one primary stress as a way to help identify separations between words:

Word Segmentation: Nativism vs Empiricism

So now we can look at the knowledge that children must have in order to solve the word segmentation problem, and ask which theory it fits with:

Modern Nativism



Modern Empiricism



The ability to track transitional probabilities

Knowledge of syllable boundaries

Knowledge that words only have one primary stress

Learning word meanings

Nouns first

Very young children (<18 mo) are often described as having a **noun bias**. The first 50 or so words that they learn tend to be nouns: names for people they are around (mama, dada, etc), the food they eat, body parts, clothing, animals/pets, toys, tec.

Here is a wordle that a mother made of her child's first words. Size indicates the order in which they were learned (based on her hearing the child produce them).

A video of first words:

https://www.youtube.com/watch?v=dlqq4-fRIdY

http://nipitinthebud.wordpress.com/2013/04/19/first-words-wordles/

Nouns seem easy to learn, but they are not

Let's say you see this:

And I say "glorp".

What do you think "glorp" is referring to?

It could be any number of things!

It could be the full bear.

It could be a piece of the bear, like its arm or sunglasses.

It could be a property of the bear, like soft or brown.

It turns out that children appear to have a bias to associate words with **whole objects**, not subparts of them. So words for whole objects tend to be learned before words for smaller parts of objects.

Nouns seem easy to learn, but they are not

Now let's say you see these:

Should a child use "glorp" for these?

The question here is one of specificity. If the word was general, like animal, all three could be "glorp". If the word was specific, like pilot bear, then none of these could be "glorp".

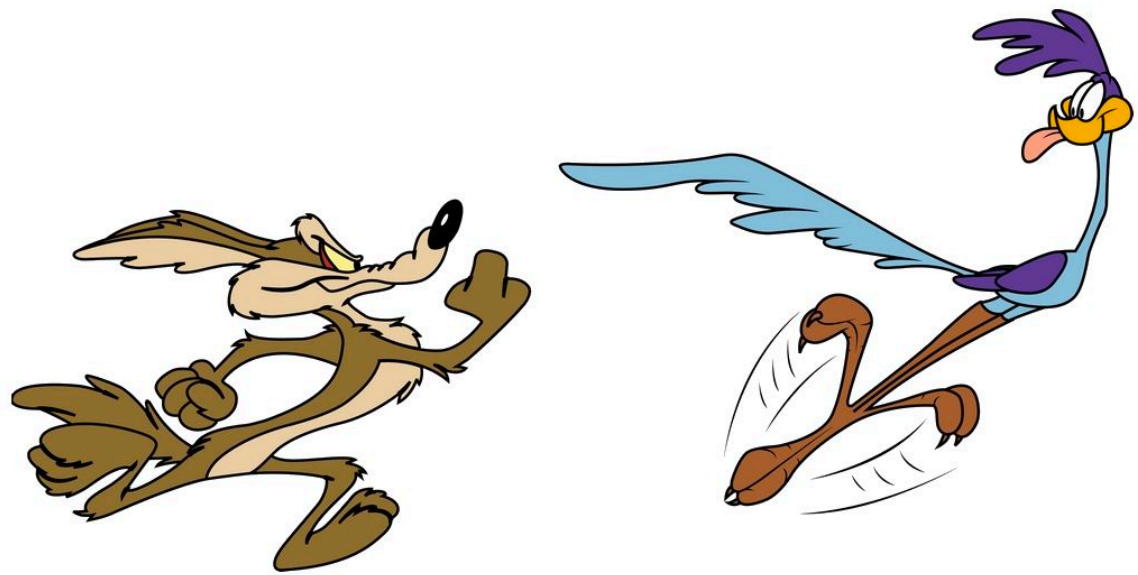
This is an open area of investigation. Children seem biased to **midlevel categories** like "bear" over more general or specific categories. But what counts as midlevel vs general/specific is hard to define. More work is needed!

Verbs are even harder than nouns

The challenge with verbs is that they have very subtle meaning differences that **cannot be easily deduced from real-world context.**

Let's say you see this scene, and I say "blicking".

It could mean chasing, or it could mean fleeing.

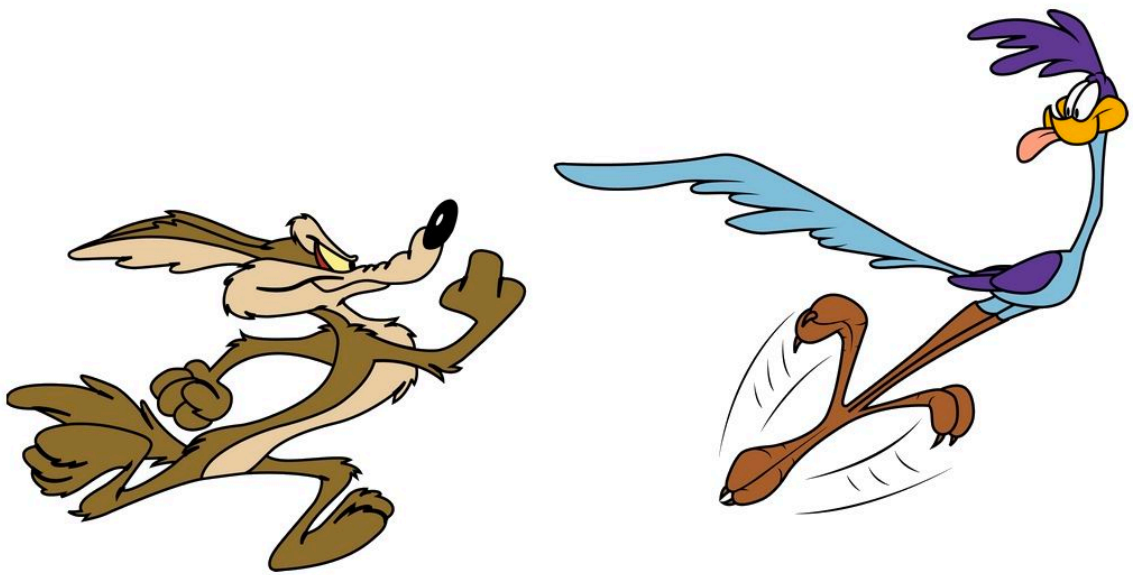


The issue is that any scene that is compatible with chasing will also be compatible with fleeing (if the objects in it are living, animate beings). So a child can't possibly figure out the correct meaning of blicking from the scene.

This is not a small problem. There are many such pairs: buy/sell, give/receive, etc. And there are other pairs that show subtle differences of other kinds (like look vs see). The bottom line is that verbs have subtle meanings!

Verbs are even harder than nouns

One interesting solution to this problem was proposed by Barbara Landau and Lila Gleitman (1985). They suggested that children could use **syntax** to help them learn verb meanings.



If I say the full sentence:

Roadrunner blicks coyote.

And if you already know that the subject of a sentence is the agent of the action (the doer)…

Then you can deduce that the meaning of blicks is flee, because the sentence is about the roadrunner being the agent of the action.

This is called **syntactic bootstrapping**. The word bootstrapping is metaphorical - syntax is the metaphorical bootstrap that they use to pull on the metaphorical shoe of verb meaning.

Abstract word meanings are the hardest

Some nouns and verbs have meanings that refers to things we can see or hear in the physical world:

bear, apple; chase, flee; etc.

But some nouns and verbs have meanings that refer to things that cannot be seen or heard in the physical world:

idea, thought; think, dream; etc.

There is no way for these words to be learned from observing the physical world. So they must be learned through more complex inferential processes.

Unsurprisingly, these abstract words are learned later than concrete nouns and verbs. This suggests that children use everything else that they learn to help them — like the syntax of sentences (to figure out if a word is a noun or verb) and the meanings of other words (to guess the meaning of the unknown word).

Word learning: Nativism vs Empiricism

So now we can look at the knowledge that children must have in order to solve the word segmentation problem, and ask which theory it fits with:

Modern Nativism

Modern Empiricism

The ability to identify actors/objects

The ability to make inferences from information

The ability to use syntactic knowledge to learn verb meanings and also abstract words.

Learning morphological rules

The past tense in English

As you know, the past tense in English is typically formed by adding the suffix -ed to a verb:

talk → talked

jump → jumped

kick → kicked

This looks like a rule:

V + ed → past

But this isn't true for all verbs. There are irregular verbs in English that form the past tense some other way:

sing → sang

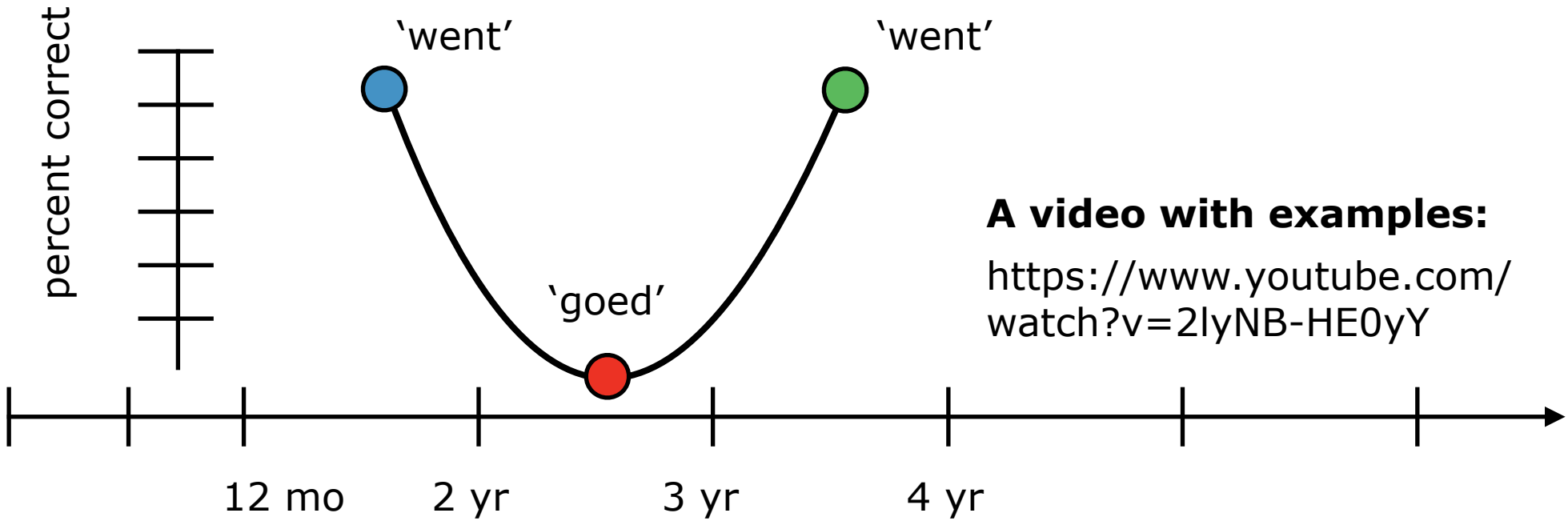
go → went

think → thought

These look like **exceptions** to the past tense rule above.

Children and rule learning

One of the most interesting aspects about morphological rule learning in children is that their performance for irregulars follows a "u-shaped" pattern:



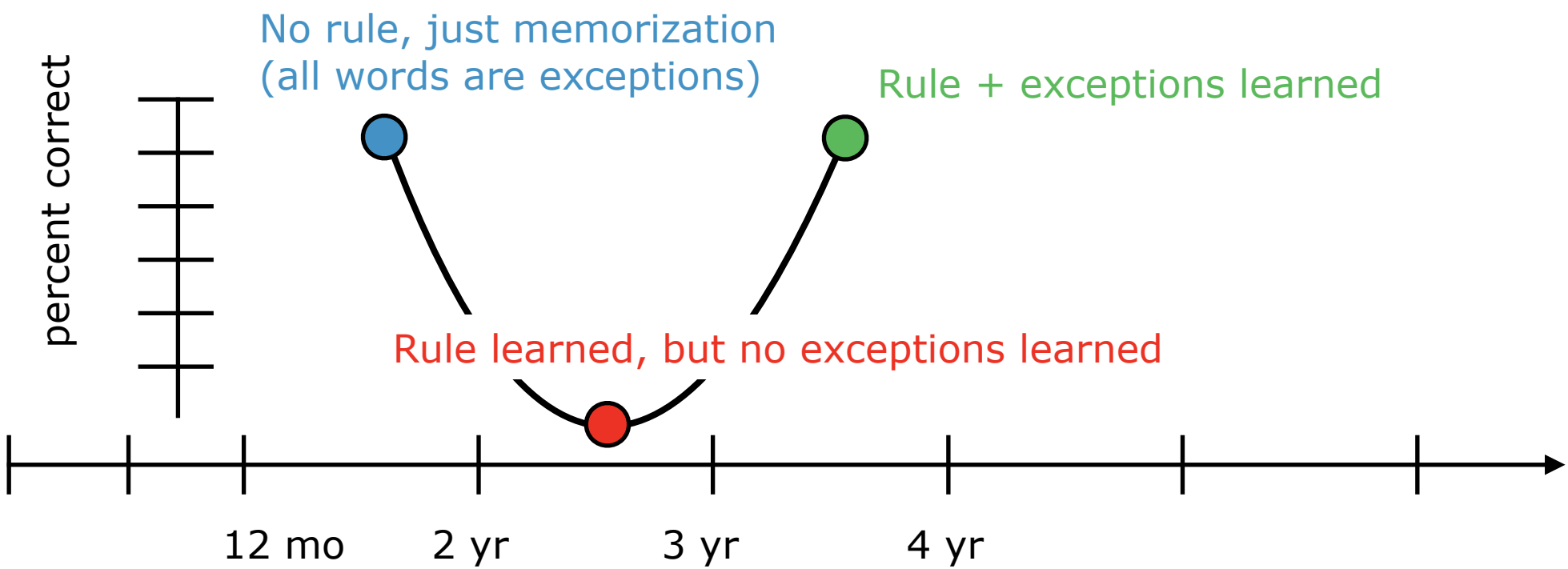
A video with examples:

https://www.youtube.com/watch?v=2lyNB-HE0yY

U-shaped curves like this are incredibly valuable in theories of child development, as they show **two changes in mental ability**: the change from the first part of the U to the minimum, then the change to the second part of the U.

So what is going on?

The U-shape suggests a timeline for the learning of the rule:



Rule learning requires the child to **generalize**. They see several verbs all ending in -ed, and all meaning "past". They must generalize this into a rule.

At the red stage, we say that the child is **overgeneralizing**. They are over applying the rule (applying it to words that don't use it). It takes time for them to learn the exceptions.

Rule learning: Nativism vs Empiricism

So now we can look at the knowledge that children must have in order to solve the word segmentation problem, and ask which theory it fits with:

Modern Nativism



Modern Empiricism



Memorizing the (past tense) form of verbs

Generalizing to a rule

The question is whether there are any aspects of the rule learning that require domain-specific knowledge.

Some Conclusions

The **word segmentation problem** is the fact that children must somehow decide where the breaks are between words in the speech stream

> Transitional probability, syllables, and stress may all be pieces of information that children use.

The **word learning problem** is the fact that children must somehow decide what words mean.

> Nouns seem easy, but are not. Children have several biases to help them learn nouns (the whole object, a midlevel category). Verbs are even harder. Children likely use syntactic bootstrapping to learn verbs. Abstract words are the hardest. Children must use both syntax and semantics to figure them out.

Morphological rule learning follows a **u-shaped curve**, suggesting a phase of memorization, followed by generalization, followed by overgeneralization, followed by the learning of exceptions (memorization).

Many of these abilities seem in line with modern empiricism, but some are on the fence. They may end up requiring domain-specific innate knowledge.