LSci 51/Psych 56L: Acquisition of Language

Lecture 5

Biological bases of language acquisition II

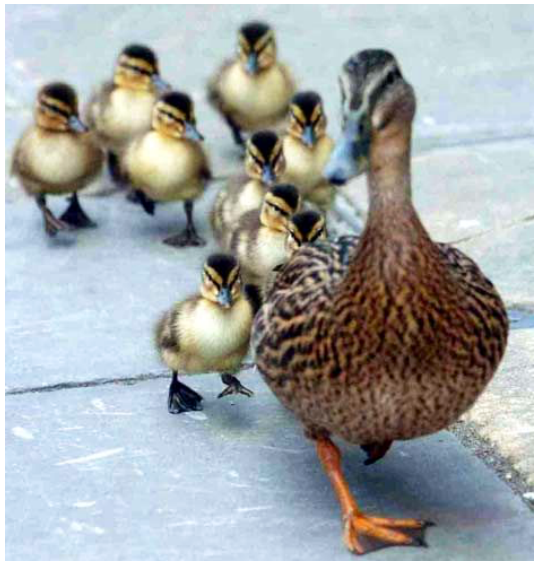
Announcements

Be working on the review questions and HW2

The critical period hypothesis

Critical & sensitive periods

"critical period for language" = biologically determined period during which language acquisition must occur in order for language to be learned fully and correctly



Other biologically determined deadlines:

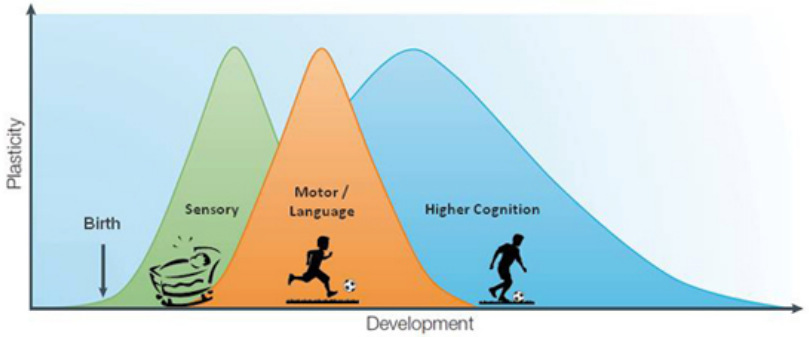
- imprinting: chicks & ducklings follow first thing they see forever (it's likely their mommy)

- visual cells in humans: if cells for both eyes don't receive visual input during the first year or so of life, they lose the ability to respond to visual input

Critical & sensitive periods

"sensitive period": biologically determined period during which learning must occur for development to happen correctly, but development can still occur partially after this period

Fig 1: Windows of plasticity in brain development



Adapted from Hensch, T. K. (2005). Critical period plasticity in local cortical circuits. *Nature Reviews Neuroscience, 6*(11), 877–888.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(1) Ideal experiment: deprive children of all linguistic input during the purported critical/sensitive period and see how language development occurs.

Problem: ideal experiment isn't so ideal ethically or logistically

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(2) Some historical and modern cases that have unintentionally provided lack of linguistic input to children:

"wild children": like Victor of Aveyron, Oxana Malaya of the Ukraine

http://www.radiolab.org/story/293679-forbidden-experiment/

Problem: unclear that lack of language is solely due to lack of linguistic input (may be other factors)

Critical & sensitive periods

One success story for lack of linguistic input with a young child: Isabelle

1930s: 6-year-old Isabelle discovered hidden away in a dark room with a deaf-mute mother as her only contact.

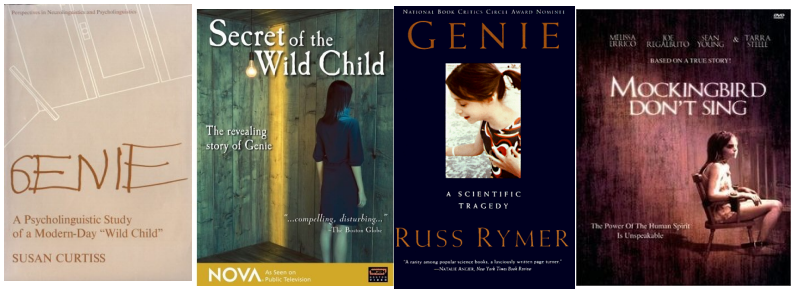
She was taught to speak and by age 8, appeared to be normal. Potential implication: Isabelle discovered before critical/sensitive period was over.

Critical & sensitive periods

A more thorough study: Genie

Critical & sensitive periods

A more thorough study: Genie

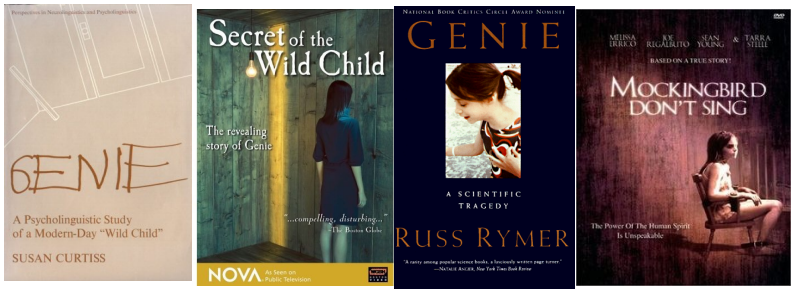


1970s: 13-year-old Genie brought by her mother to social services after escaping mentally ill father; until mother's escape, had no language input (and very horrific living conditions)

By age 17, she had a five-year-old's vocabulary, and could express meanings by combining words together.

Critical & sensitive periods

A more thorough study: Genie



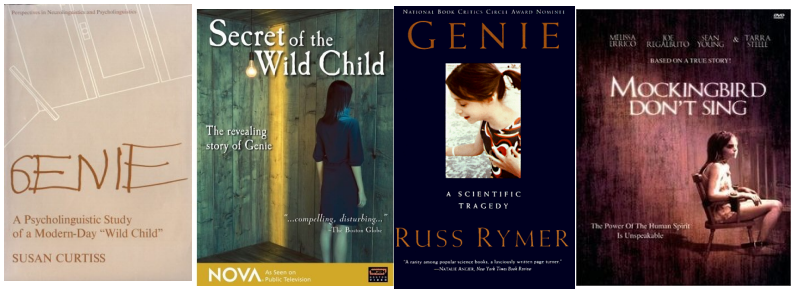
However…her syntactic skills lagged far behind - deficient in both production and comprehension.

"Mama wash hair in sink."
"At school scratch face."
"I want Curtiss play piano."
"Man motorcycle have."

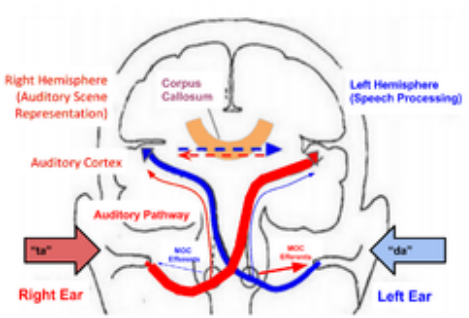
"Like go ride yellow school bus."
"Father take piece wood. Hit. Cry."
"Applesauce buy store"
"Father hit Genie cry long time ago."

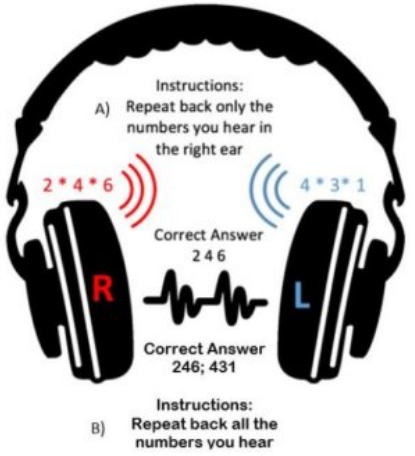
Critical & sensitive periods

A more thorough study: Genie



Dichotic listening tasks showed language was a right-hemisphere activity for her (while it's a left-hemisphere activity for most adults and children, leading to a "right-ear advantage" for language sounds).

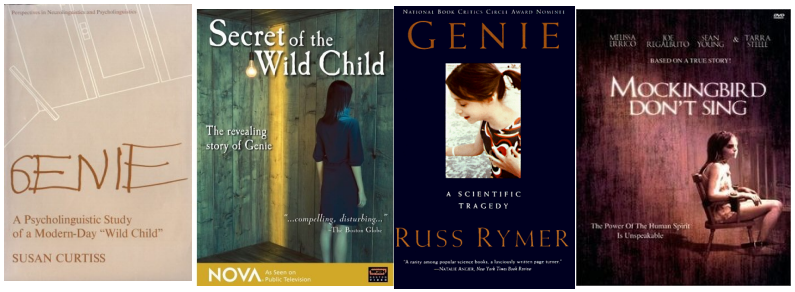




https://www.sciencedaily.com/releases/2017/12/171206090611.htm

Critical & sensitive periods

A more thorough study: Genie



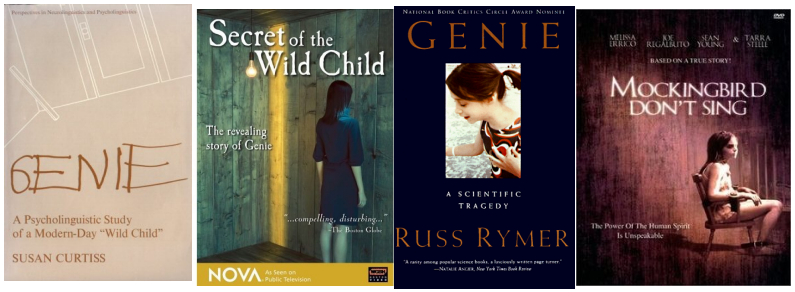
Dichotic listening tasks showed language was a right-hemisphere activity for her (while it's a left-hemisphere activity for most adults and children, leading to a "right-ear advantage" for language sounds).

However, newborn babies who have damage to the left hemisphere have enough neural plasticity to develop their right hemisphere enough to have "normal" language.

https://www.sciencedaily.com/releases/2018/02/180217184834.htm

Critical & sensitive periods [Extra]

A more thorough study: Genie



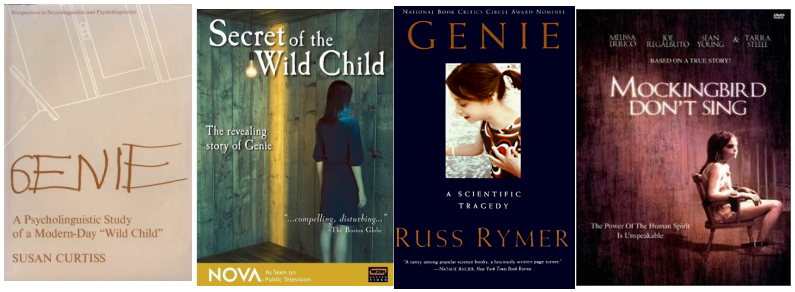
Dichotic listening tasks showed language was a right-hemisphere activity for her (while it's a left-hemisphere activity for most adults and children, leading to a "right-ear advantage" for language sounds).

"This finding makes sense in very young brains…[i]maging shows that children up to about age four can process language in both sides of their brains, and then the functions split up: the left side processes sentences and the right processes emotion in language." - Elissa Newport

https://www.sciencedaily.com/releases/2018/02/180217184834.htm

Critical & sensitive periods

A more thorough study: Genie



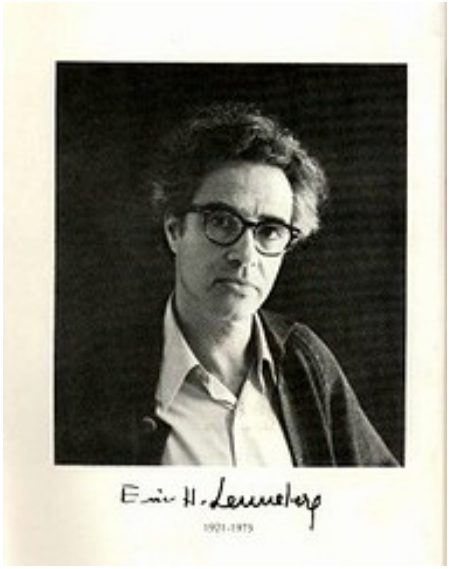
Potential Implication: Genie discovered after critical period was over.

However, Genie may have had other cognitive disabilities…

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Lenneberg (1967):
“the only safe conclusions to be drawn from the multitude of reports is life in dark closets, wolves’ dens, forests, or sadistic parents’ backyards is not conducive to good health or normal development”



Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Another study: Chelsea (Curtiss 1988)

Family background: A partially deaf woman incorrectly diagnosed as "retarded". From a loving home.

Discovered at age 31, and fitted with hearing aids

Outcome: Learned a large vocabulary, but syntax and morphology worse than Genie.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Another study: Chelsea (Curtiss 1988)

Sample speech from Chelsea:

(1) *The small a the hat*

(2) Orange Tim car in

(3) I Wanda be drive come

(4) Breakfast eating girl

(5) They are is car in the Tim

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(2) Late acquisition of sign language (ASL): deaf-of-hearing children whose parents don't know sign language. Children are eventually exposed to sign language when they encounter other deaf children.

Ethically better: individuals have normal early childhood experience, except for lack of language input

Note: 95% of Deaf children are born to hearing, non-signing parents, who most frequently use only spoken language (Mitchell and Karchmer, 2005)

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(2) Late acquisition of sign language (ASL): deaf-of-hearing children whose parents don't know sign language. Children are eventually exposed to sign language when they encounter other deaf children.

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016: Hearing parents often expose their Deaf children to sign language by enrolling them into schools for the Deaf, where both peers and teachers use ASL. First exposure to ASL for Deaf children is thus frequently the age of entrance to a school for the Deaf.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

If a critical or sensitive period is true, children who learn earlier should be better than children who learned later…

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

If a critical or sensitive period is true, children who learn earlier should be better than children who learned later - this is what Newport (1990) found. Children who were 4 to 6 years old when first exposed to ASL were far superior in their sign language ability when compared to children who were exposed after age 12.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Also important: not just about how long sign language speakers had known the language. Speakers who had been signing for more than 30 years showed this same difference. Those exposed younger were far superior in their language skills to those exposed when they were older.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Age of ASL acquisition has long-lasting effects on syntactic acquisition, narrative comprehension, sentence memory, sentence interpretation, and online grammatical processing that appear even when learners were adults who were tested after years of sign language experience (Mayberry and Fischer, 1989, Mayberry 1992, Mayberry and Lock 2003, Boudreault and Mayberry 2006).

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016: Testing ASL-learning children between 7 and 18 years old, with different histories of exposure to ASL

- Native [= 1+ Deaf parent at home] vs. non-native signer
- age of entry into the signing school.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016

Syntax judgment task: Choose a response to a question like
"Who thinks we have a test tomorrow?"

(1a) Correct response: MY FRIEND*i* HE*i* THINK WE HAVE TEST TOMORROW.

(1b) Word order violation: TEST TOMORROW THINK WE HAVE MY FRIEND HE*j*.

(1c) Word order violation: TOMORROW MY FRIEND HE*j* HAVE THINK TEST.

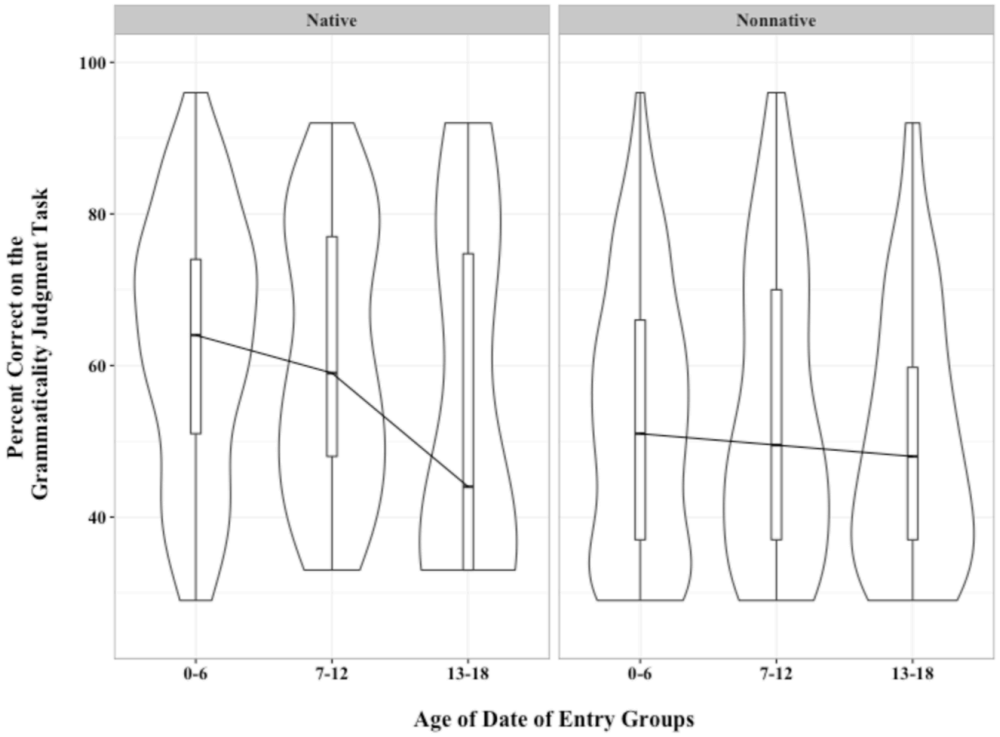
(1d) Syntactic violation: MY FRIEND*i* HE*j* THINK WE HAVE TEST TOMORROW

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016

Syntax judgment task



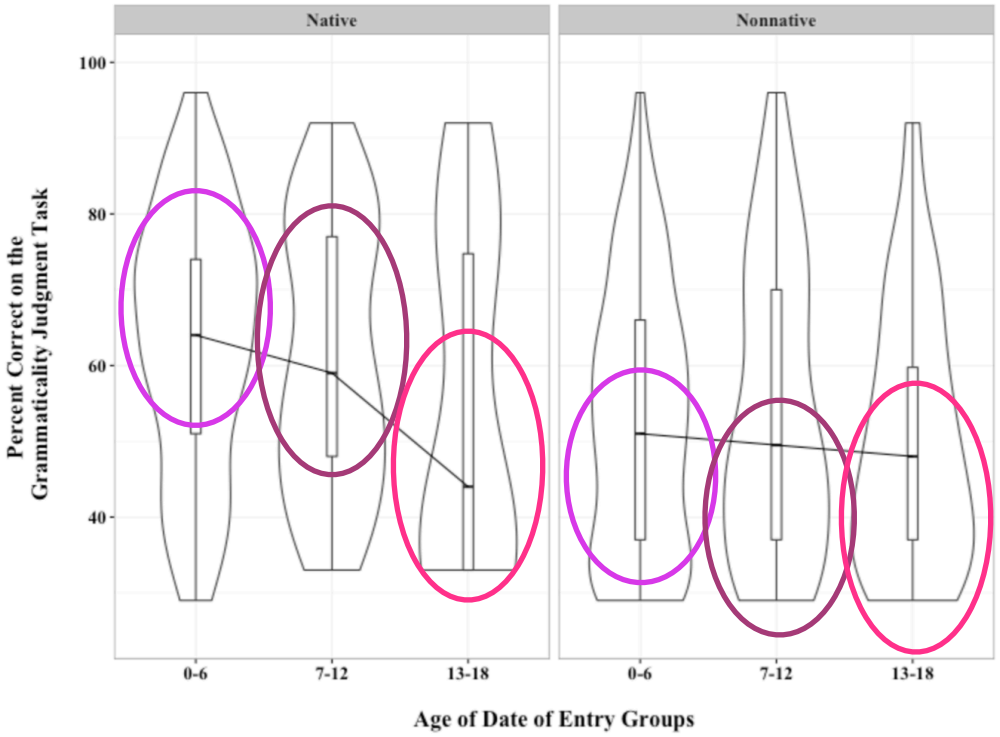
Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016

Syntax judgment task

Input effect 1: Generally poorer performance when you don't have a Deaf parent at home to give you systematic ASL input.



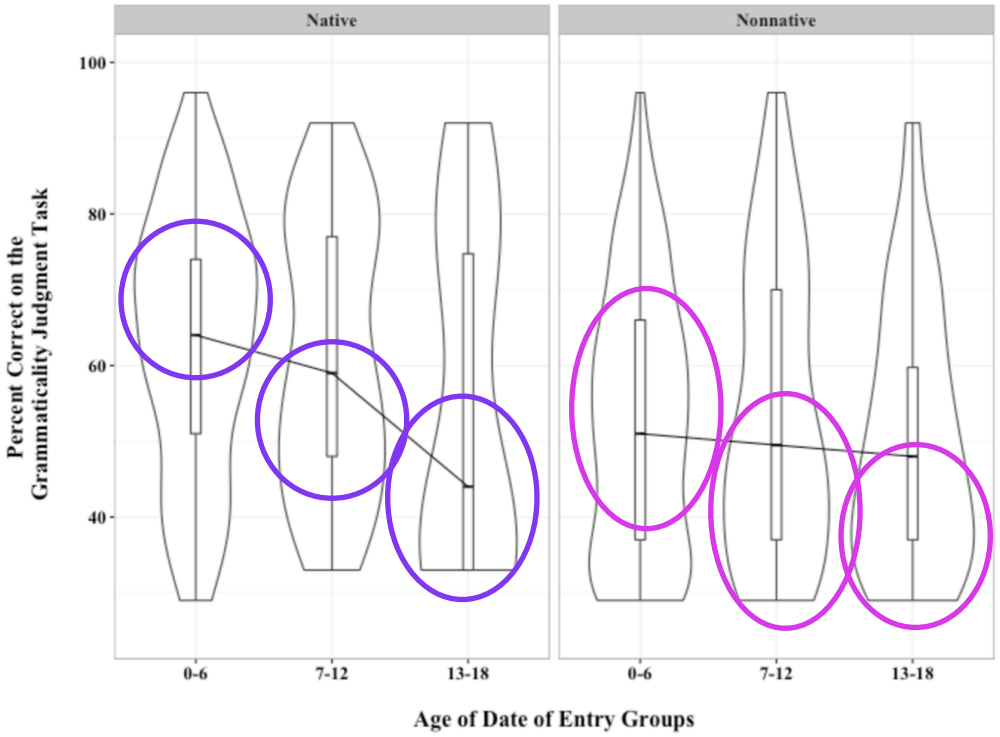
Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016

Syntax judgment task

Input effect 2:
Poorer performance the older you are when you first enter the signing school (and are exposed to systematic input).



Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister 2016

Implication: Age of systematic language exposure matters. The older you are, the harder it is to achieve native ASL proficiency, especially for the syntactic components of ASL.

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(3) Look at second language learning.

Why? Children who learn a second language when they are young often become indistinguishable from their native-born peers. In contrast, people who are older have very different outcomes.

Critical & sensitive periods

Functional magnetic resonance imaging (fMRI) studies confirm different neural processing for language in individuals who learned before age 7 to 8 vs. individuals who learned after this age (Kim et al. 1997, Dehaene et al. 1997, Wartenburger et al. 2003, Saur et al. 2009)

Critical & sensitive periods

Event-related potential (ERP) studies confirm differing left-hemisphere specialization for language in individuals who learned before age 4 vs. individuals who learned between 4 and 7 vs. individuals who learned after 7 (Weber-Fox & Neville 1996, 1999, Isel 2005)

[Extra]

Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Testing age differences in second language acquisition:

- Oyama 1976: testing Italian immigrants learning English

Age of arrival was better predictor of accent than how many years the immigrant had been speaking English

- Oyama 1978: Age of arrival was better predictor of comprehension than number of years speaking the language (not just about motor skill learning ability)

Critical & sensitive periods

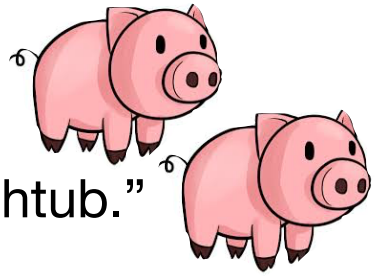
How do we test for a critical/sensitive period for language acquisition?

Testing age differences in second language acquisition:

Johnson & Newport 1989: testing grammatical competency of Chinese & Korean natives living in the US

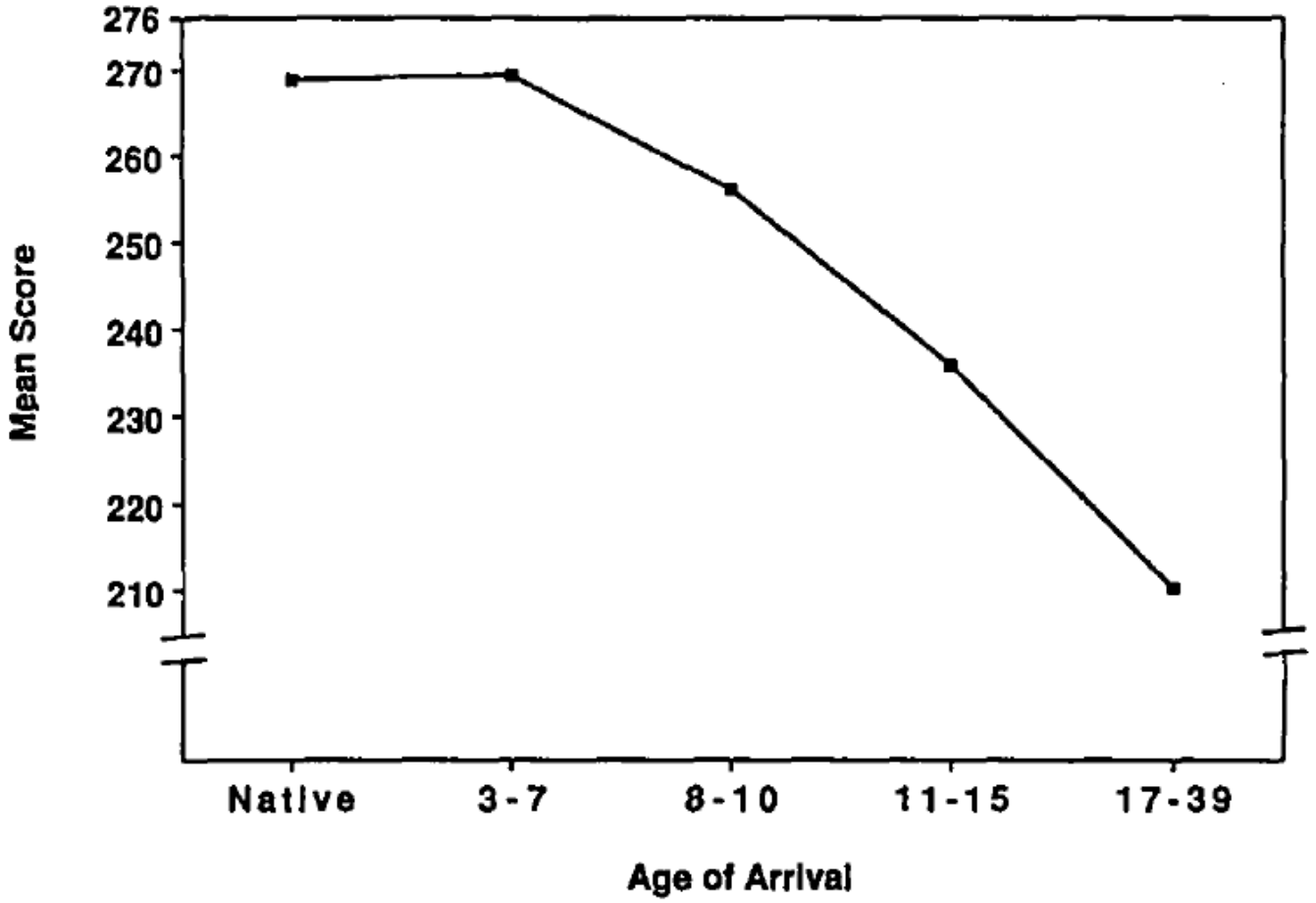
Heard recorded voices speaking sentences, and had to judge whether they were correct or not.

"The farmer bought two pig at the market."



"Tom is reading book in bathtub."

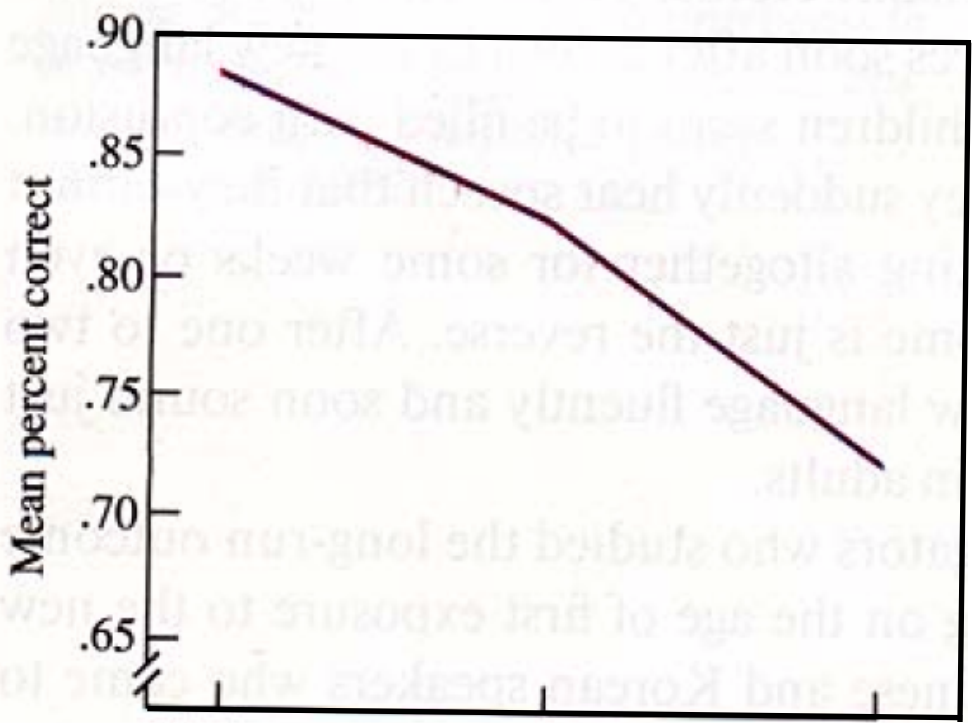
Second-language proficiency dependent on age of initial language exposure (even with same number of years of exposure total)



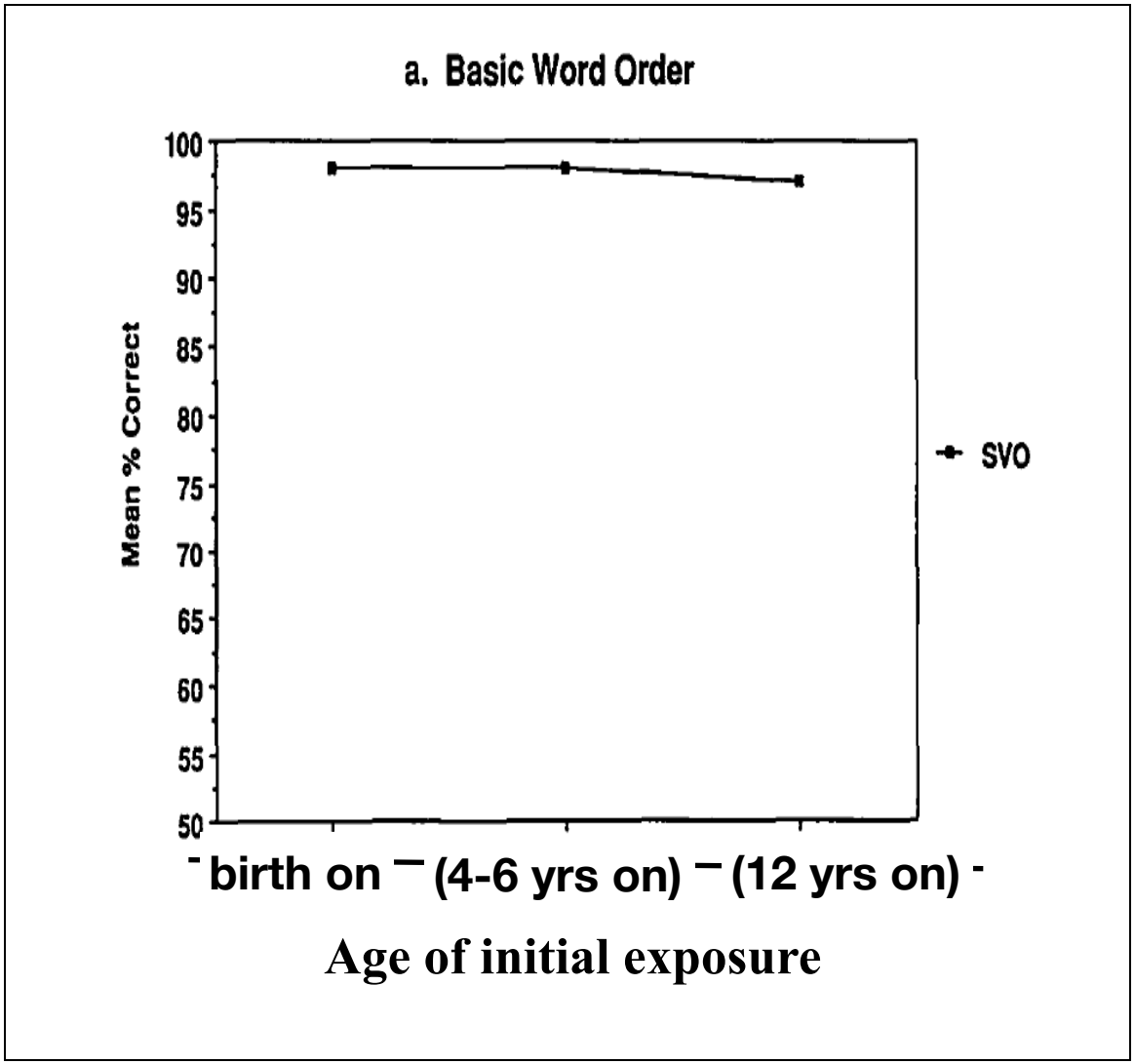
Second-language proficiency dependent on age of initial language exposure (even with same number of years of exposure total)

Morphology:
e.g. verb agreement in production

Tom is/*are reading book in bathtub



Second-language proficiency dependent on age of initial language exposure – but not all aspects are dependent



Basic word order: SVO

Subject Verb Object

Ex: “Penguins like fish.”

As opposed to

“Fish penguins like”
(Object Subject Verb)

Second-language proficiency dependent on age of initial language exposure – but not all aspects are dependent

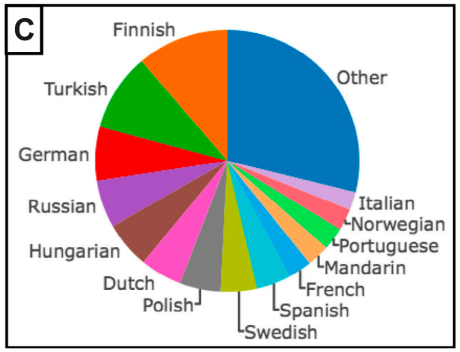
Balari & Lorenzo 2015:
Phonology and certain aspects of morphosyntax (how words and word pieces combine together to form phrases) seem to be set earlier while lexical knowledge seems to remain attainable for quite some time.

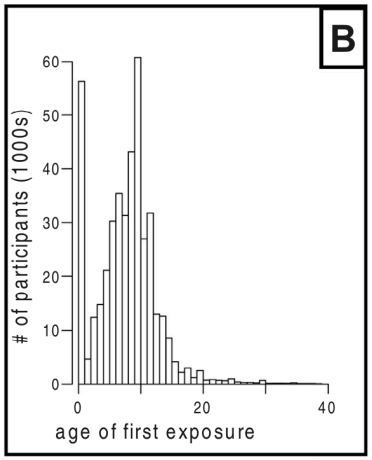
Second-language proficiency…is more complicated

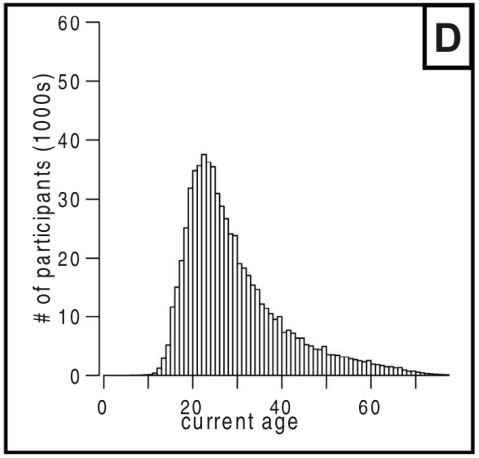
https://www.sciencedaily.com/releases/2018/05/180501083830.htm

Hartshorne, Tenenbaum, & Pinker 2018:

"…several hundred thousand subjects of diverse ages and linguistic backgrounds would be required to disentangle age of first exposure, age at testing, and years of exposure…"







http://archive.gameswithwords.org/WhichEnglish/

The resulting dataset is available at http://osf.io/pyb8s.

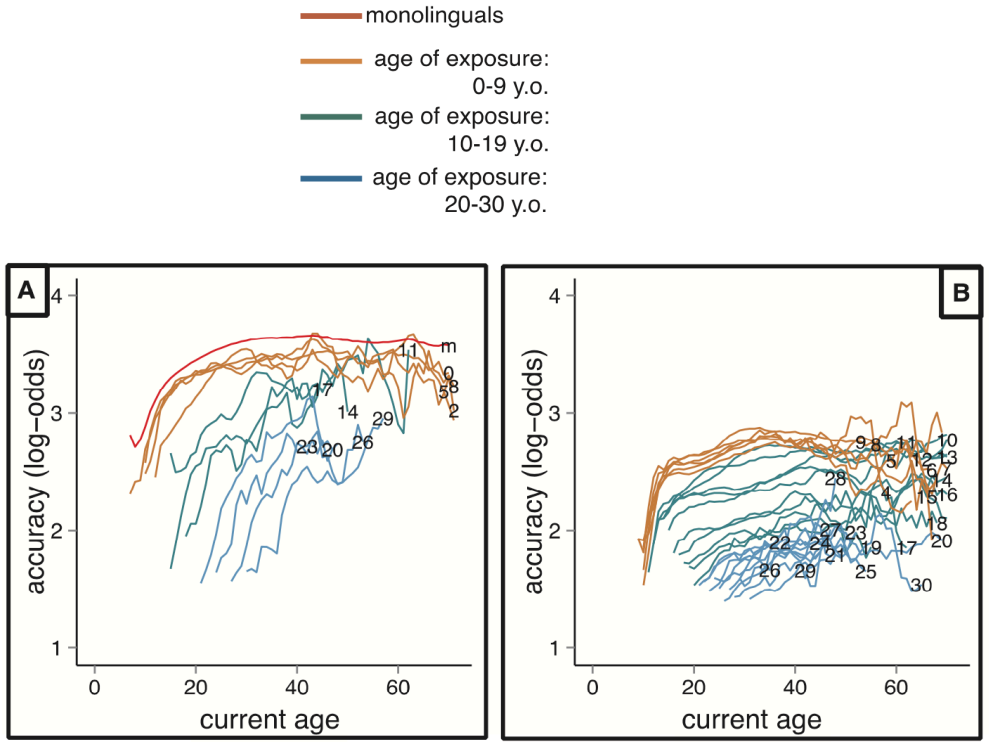
Second-language proficiency…is more complicated

https://www.sciencedaily.com/releases/2018/05/180501083830.htm

Hartshorne, Tenenbaum, & Pinker 2018:

Learning rate cut-off around 17

"…good support for the existence of a critical[/sensitive] period for language acquisition, and suggests that our estimate of when the learning rate declines (17.4 years old) is likely to be reasonably accurate."



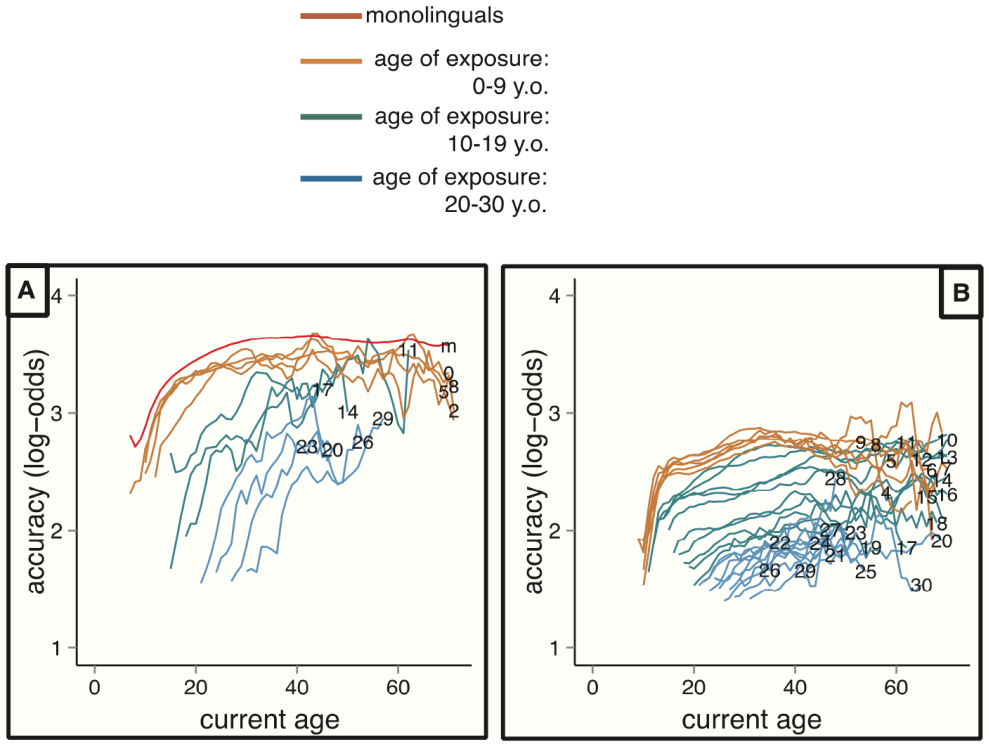
Second-language proficiency…is more complicated

https://www.sciencedaily.com/releases/2018/05/180501083830.htm

Hartshorne, Tenenbaum, & Pinker 2018:

Effects on ultimate attainment

"…Thus, even native speakers—who are able to make full use of the critical period—take a very long time to reach mature, native-like proficiency. By implication, someone who started relatively late in the critical period—that is, someone who had limited time to learn at the high rate the critical period provides—would simply run out of time."



Second-language proficiency…is more complicated

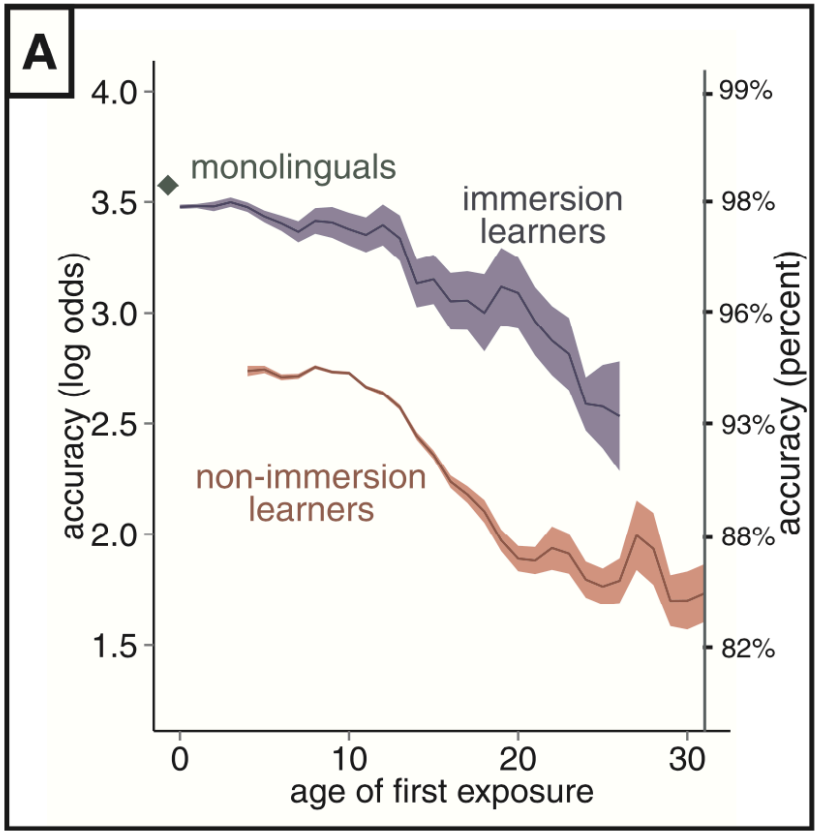
https://www.sciencedaily.com/releases/2018/05/180501083830.htm

Hartshorne, Tenenbaum, & Pinker 2018:

"…we analyzed ultimate attainment curves by focusing on the 11,371 immersion learners and 29,708 non-immersion learners who had at least 30 years of experience (ensuring asymptotic learning) and who were at most 70 years old (avoiding age-related decline)"

"Immersion learners showed only a minimal decline in ultimate attainment until an age of first exposure of 12 years."

"Non-immersion learners showed similar results: From 4 years to 9 years, proficiency showed no decline…followed by a steep decline."



Second-language proficiency…is more complicated

https://www.sciencedaily.com/releases/2018/05/180501083830.htm

Hartshorne, Tenenbaum, & Pinker 2018:

Protracted development

"…we found that native and non-native learners both require around 30 years to reach asymptotic performance, at least in immersion settings…"

Important period for native-like ultimate attainment up to 10-12

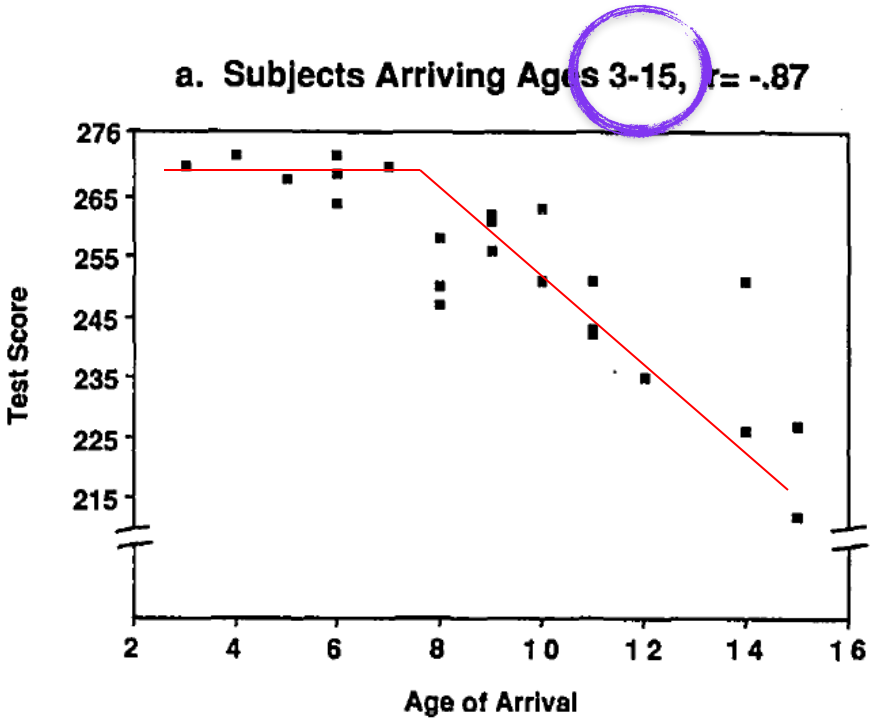
"…we found that ultimate attainment—that is, the level of asymptotic performance—is fairly consistent for learners who begin prior to 10–12 years of age…"

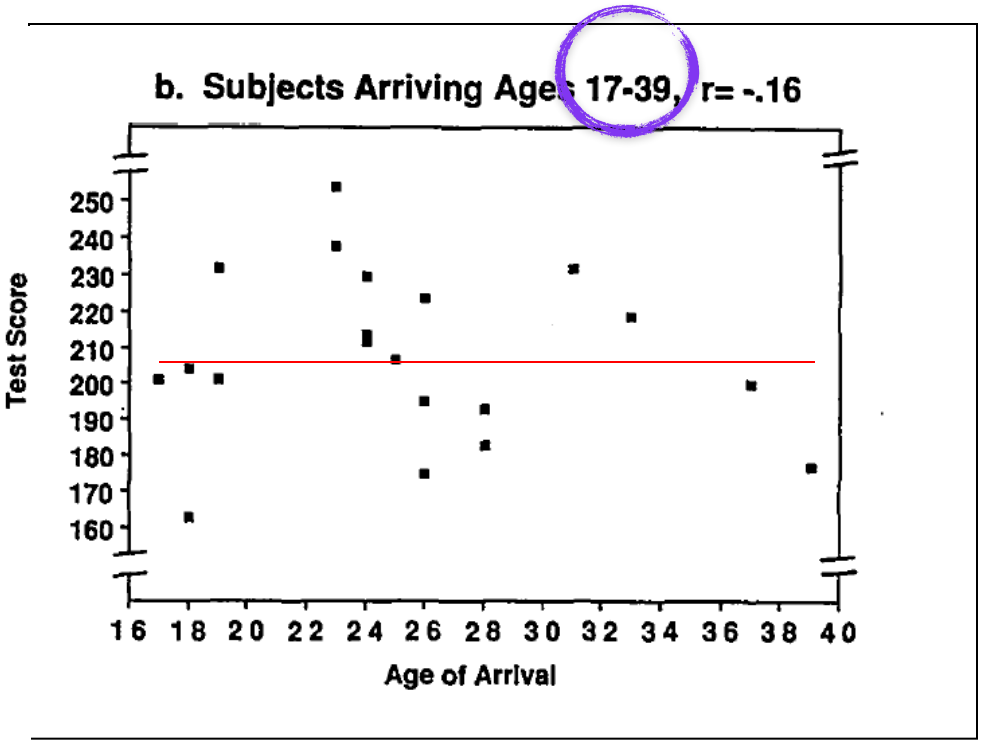
Sensitive period shape

"…a plateau followed by a continuous decline. The end of the plateau period must be due to changes in late adolescence rather than childhood, whether they are biological, social, or environmental."

[Extra]

Before and after the critical/sensitive period (sometimes called “maturation”)





<u>During Maturation</u>

Decline in ability with maturation.

<u>After Maturation</u>

No relationship between Age of Arrival and Test Score

[Extra]

Some evidence for critical/sensitive period

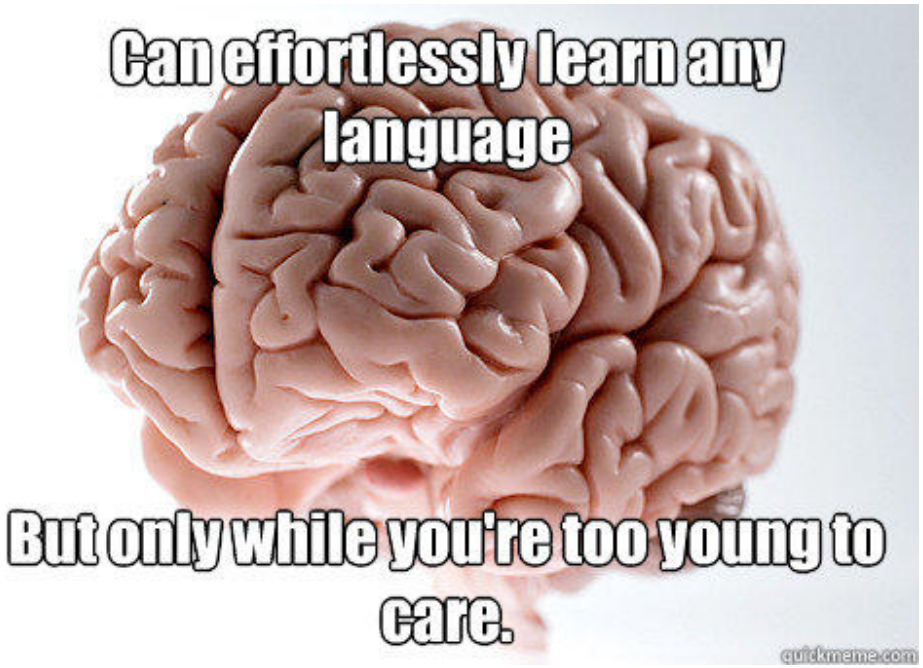
Johnson & Newport (1989) also found that performance was not correlated with:

- Formal instruction in English
- Amount of initial exposure to English
- Reported motivation to learn English
- Self-consciousness in English
- Identification with American culture

Sum up: Critical/sensitive period

- Language learning becomes harder after age 10-12, with learning rate declining sharply after age 17
- Applies to both first and second language learning
- Applies to spoken and signed languages
- Critical/sensitive periods may be similar to other biologically-programmed abilities in humans and other species

Sum up: Critical/sensitive period

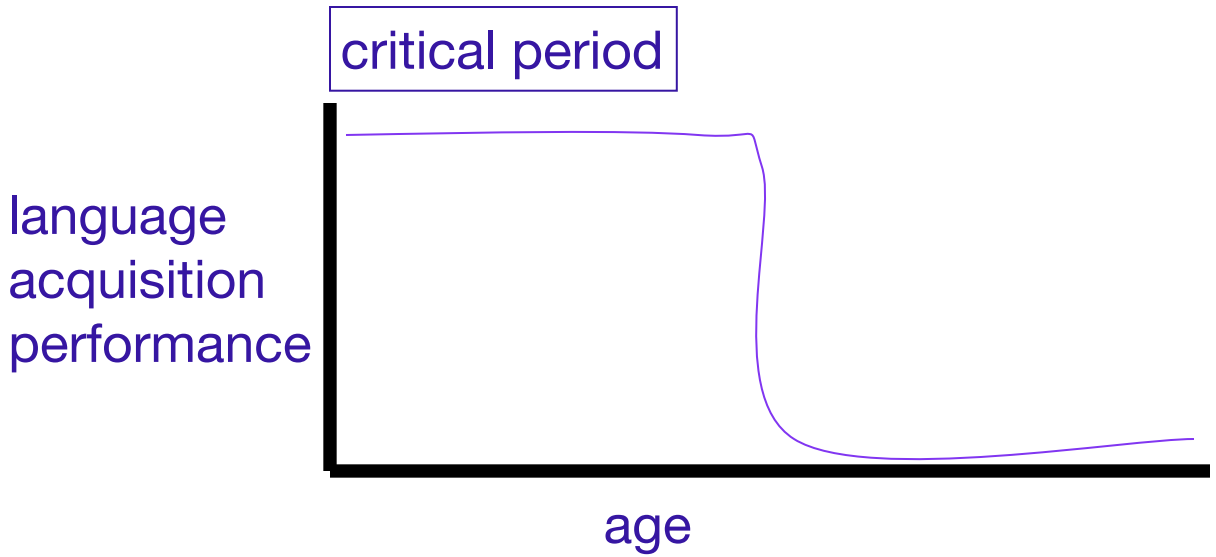


http://www.quickmeme.com/meme/36f39x/

Critical vs. sensitive, revisited

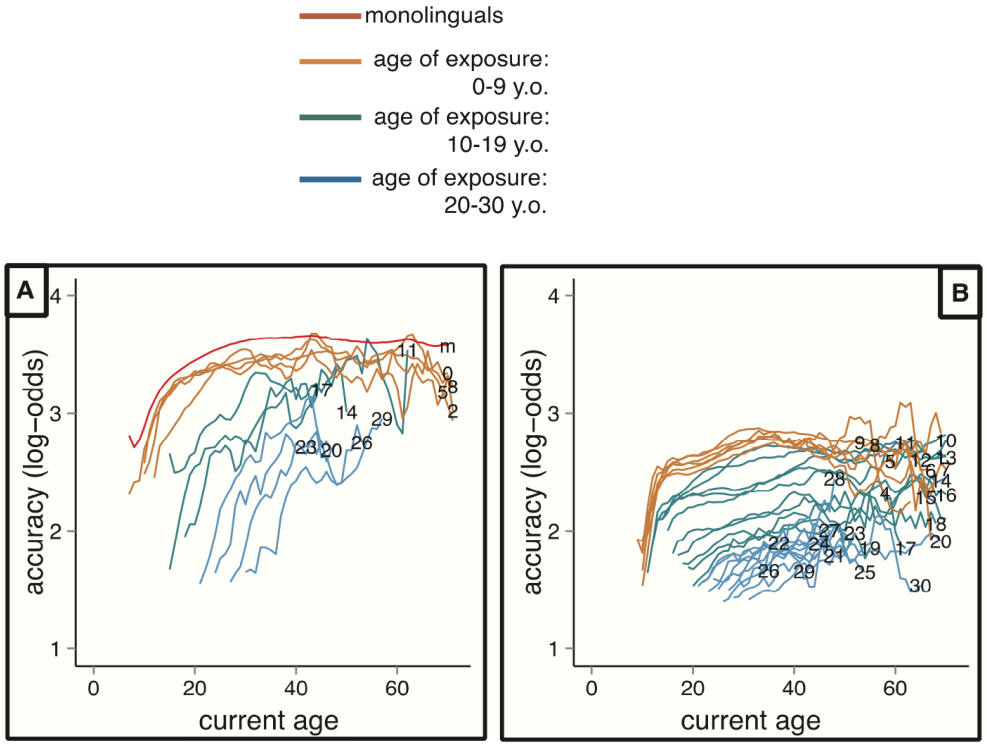
If there is truly a critical period of language acquisition, people learning language after this period should not succeed very well at all (they should be equally bad). In contrast, people within the critical period should do very well (they should be equally native-like).

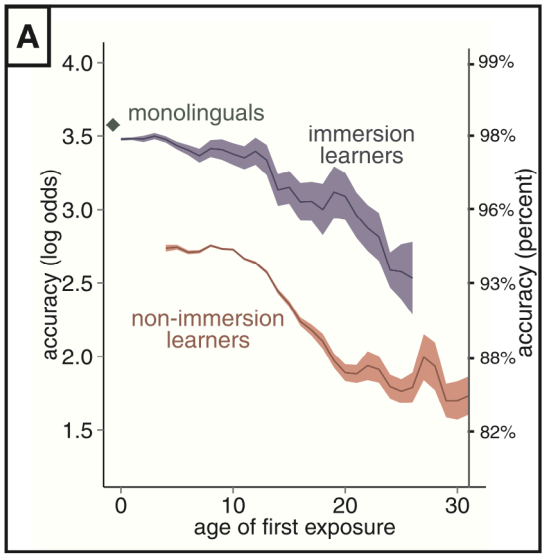
Expectation: discontinuous function of performance



Critical vs. sensitive, revisited

However, most of the evidence we've seen suggests that there is a smoother drop-off. (support for sensitive period)





Hartshorne et al. 2018

[Extra]

Critical vs. sensitive, revisited

However, most of the evidence we've seen (including the one below) suggests that there is a smoother drop-off. (support for sensitive period)

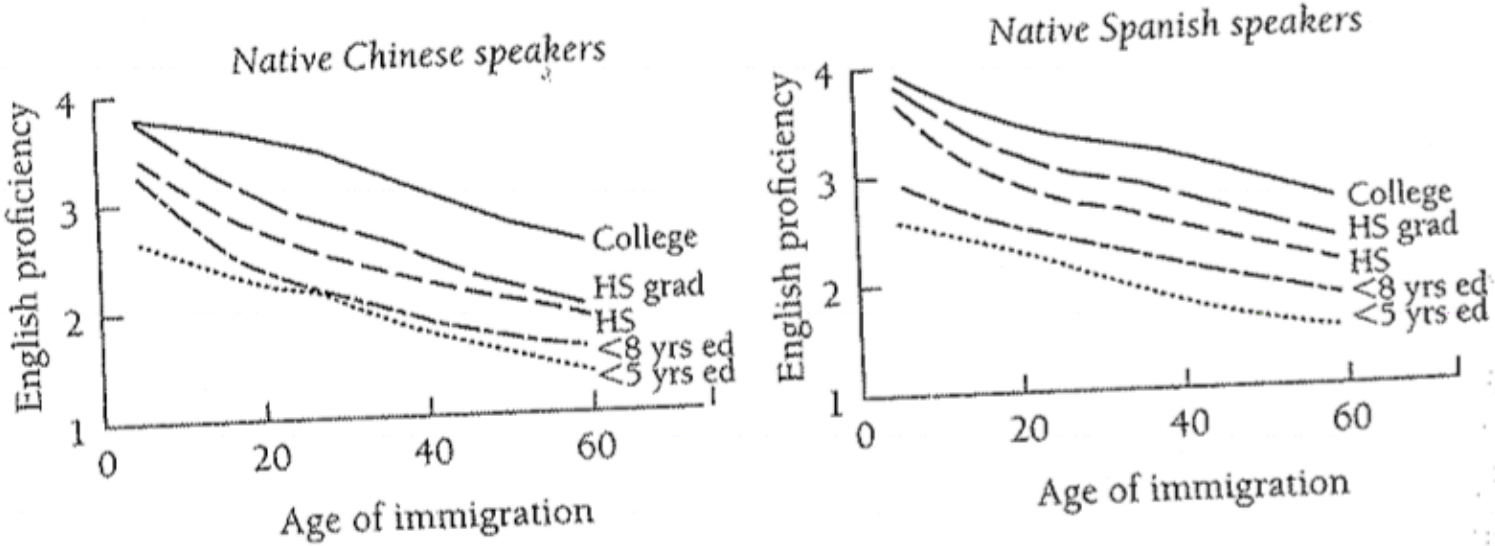
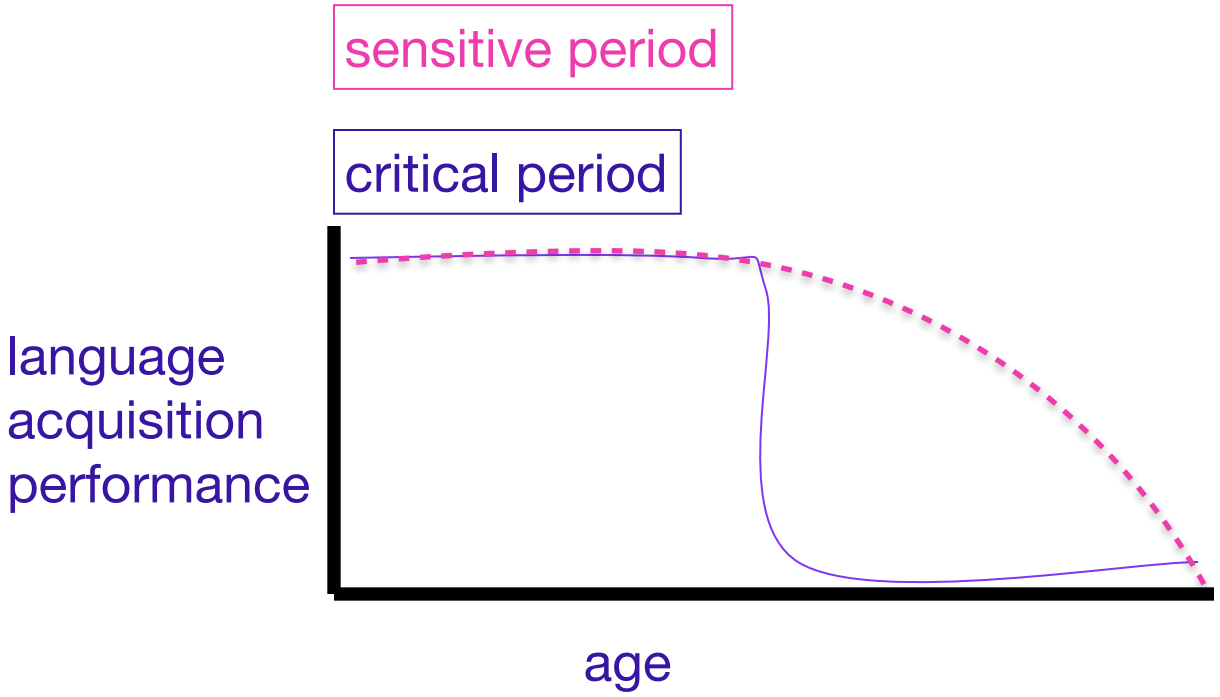


FIGURE 2.6 | THE RELATION BETWEEN AGE OF IMMIGRATION AND ENGLISH PROFICIENCY FOR NATIVE CHINESE AND SPANISH SPEAKERS WHO IMMIGRATED TO THE UNITED STATES

Hakuta, Bialystok, & Wiley 2003

Critical vs. sensitive, revisited

Since we don't often see this sharp drop-off in performance, it's more likely there is a sensitive period for learning aspects of language, rather than a critical period.

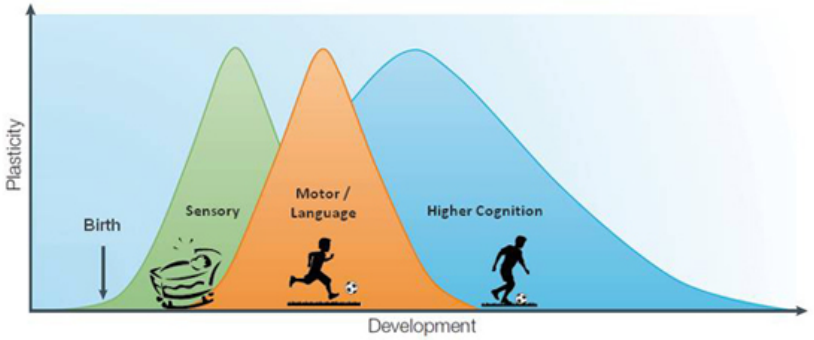


[Extra]

Critical vs. sensitive, revisited

"…rather than postulating one critical period for language acquisition, a more plausible hypothesis is that grammatical development is characterized by several *sensitive phases*…a phase can be characterized by an optimal period for the acquisition of the phenomenon in question… characterized by a relatively *short onset*, followed by an extended *optimal period* and a *gradual offset*…"
– Meisel, 2013

Fig 1: Windows of plasticity in brain development



Adapted from Hensch, T. K. (2005). Critical period plasticity in local cortical circuits. *Nature Reviews Neuroscience, 6*(11), 877–888.

[Extra]

So why are younger children better?

See Thiessen, Girard, & Erickson 2016 for a summary of studies supporting a sensitive instead of a critical period, and why younger children might be better.

The potential relationship to domain-general statistical learning processes:

"From this perspective, developmental change arises, not from a switch from one set of processes to another, but due to changes in the effectiveness of a continuously present set of learning processes…while the [statistical learning] processes of extraction and integration are active across the lifespan, their outcome will differ as a function of the learner's prior experience and maturational state."

[Extra]

So why are younger children better?

See Thiessen, Girard, & Erickson 2016 for a summary of studies supporting a sensitive instead of a critical period, and why younger children might be better.

The potential relationship to domain-general statistical learning processes:

"…there are two major factors that may plausibly be linked to changes in language learning outcomes associated with increasing age. The first is increasing familiarity of language, which makes a learner better adapted to the languages with which they are familiar, but less able to adapt to novel languages. The second factor is maturational changes, which alter both the cognitive architecture supporting statistical learning, and the degree of plasticity with which the learner's neurobiological organization can adapt to novel input."

[Extra]

So why are younger children better?

See Thiessen, Girard, & Erickson 2016 for a summary of studies supporting a sensitive instead of a critical period, and why younger children might be better.

Why there's an age effect:

"…the advantage of younger language learners relates, in part, to the fact that infants and young children are highly adaptable learners, but not yet strongly adapted to their particular linguistic environment."

So why are younger children better?

"Less is more" hypothesis: Newport 1991

Children can remember less than adults (and have other cognitive limitations, like less attention). Perhaps language is actually easier to figure out if the input is limited to smaller chunks. Adults remember more and can store longer chunks, which makes their analytical task harder.

So why are younger children better?

"Less is more" hypothesis: Newport 1991

Studies supporting the idea that a limitation on the way children process input leads to better learning performance: Yang 2020, Pearl & Phillips 2018, Phillips & Pearl 2015, Phillips & Pearl 2012, Pearl, Goldwater, & Steyvers 2011, Pearl, Goldwater, & Steyvers 2010, Pearl 2009, Pearl & Lidz 2009, Pearl 2008, Pearl & Weinberg 2007, Dresher 1999, Lightfoot 1999, Lightfoot 1991

So why are younger children better?

Some experimental support for the utility of “Less is more” when learning a foreign language as an adult: Chin & Kersten 2010

Adults learning French over two one-hour sessions
- full sentences vs. small phrases that incrementally increased length to full sentences (to simulate children’s steadily expanding processing abilities)

Adults learning incrementally outperformed adults learning from full sentences on language proficiency tests of vocabulary and grammar.

So why are younger children better?

Some experimental support for the utility of “Less is more” when learning a language as an adult: Finn et al. 2014

Adult subjects listened to an artificial language they were meant to learn. One group was told to pay close attention (active listeners) while the other group listened more passively — they were distracted by doing a puzzle or coloring while they listened.

Active listeners: More cognitive resources focused on task.
Passive listeners: Fewer cognitive resources focused on task.

The passive listeners outdid the active listeners when it came to learning morphology (how words combine together)!

So why are younger children better?

Some experimental support for the utility of “Less is more” when learning a language as an adult: Finn et al. 2014

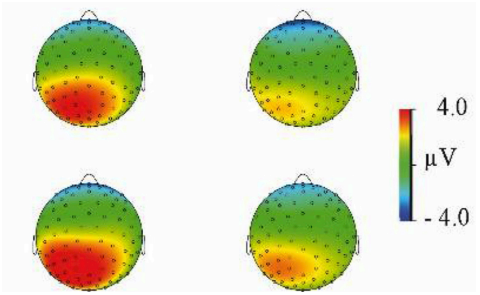
"We found that effort helps you in most situations, for things like figuring out what the units of language that you need to know are, and basic ordering of elements. But when trying to learn morphology, at least in this artificial language we created, it's actually worse when you try.” — Amy Finn

http://www.sciencedaily.com/releases/2014/07/140721142211.htm

So why are younger children better?

Some additional neuroscientific support for the utility of “Less is more” when learning a language as an adult:
Kurkela, Hämäläinen, Leppänen, Shu, & Astikainen 2019

Adults who listened passively to unfamiliar speech sounds over a period of several consecutive days had “change detection” responses in their brains when trying to detect differences between those speech sounds. This means passive listening was beneficial, as opposed to more active listening.



https://www.sciencedaily.com/releases/2018/12/181217120017.htm

So why are younger children better?

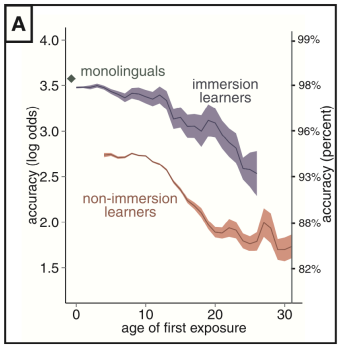
But just mimicking aspects of children's language exposure doesn't always work: Hudson Kam 2017

Adults exposed to an artificial language either learned both sounds and meaning together (adult-like) or sounds first and then meanings later (infant-like). In this case, the infant-like exposure didn't help adults learn any better.

"Giving adult learners a chance to focus (either explicitly or implicitly) on the forms themselves and the patterns and correlations amongst the forms absent any search for meaning simply does not improve learning aspects of the language that rely on the sound patterns—if anything, the opposite is true…" — Carla Hudson Kam

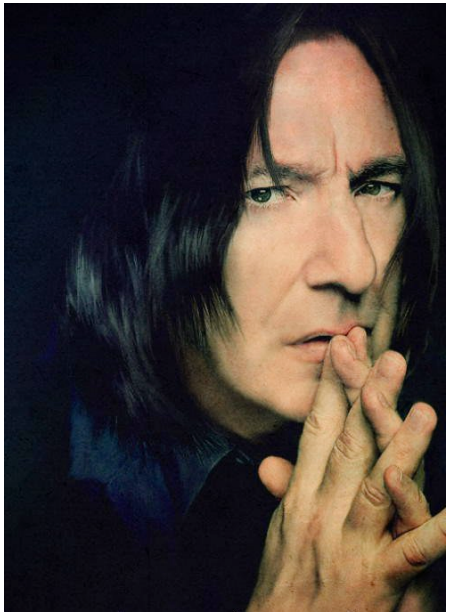
Recap

There appears to be a period during which language is acquired most easily - whether this is a critical period or sensitive period may vary depending on what specific linguistic knowledge we look at. However, most knowledge currently seems to obey a sensitive rather than critical period.



The “less is more” hypothesis is one idea for why children’s minds might be more suited to language learning than adults’ minds.

Questions?



You should be able to answer up through question 21 of the bio bases review sheet, and up through question 14 on HW2.