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Education and Culture DG

Lifelong Learning Programme

ЦЕНТЪР ЗА РАЗВИТИЕ НА ЧОВЕШКИТЕ РЕСУРСИ

New Bulgarian University

INTENSIVE PROGRAMME: SPECIAL ABILITIES AND TALENTS - PATTERNS OF COGNITIVE PROCESSES IN PEOPLE WITH DISABILITIES

Laura Zozaya
Spain

Neural Substrates of Language Acquisition

Patricia Kuhl and Maritza Rivera-Gaxiola

Institute for Learning and Brain Sciences, University of Washington, Seattle, Washington 98195; email: pkkuhl@u.washington.edu

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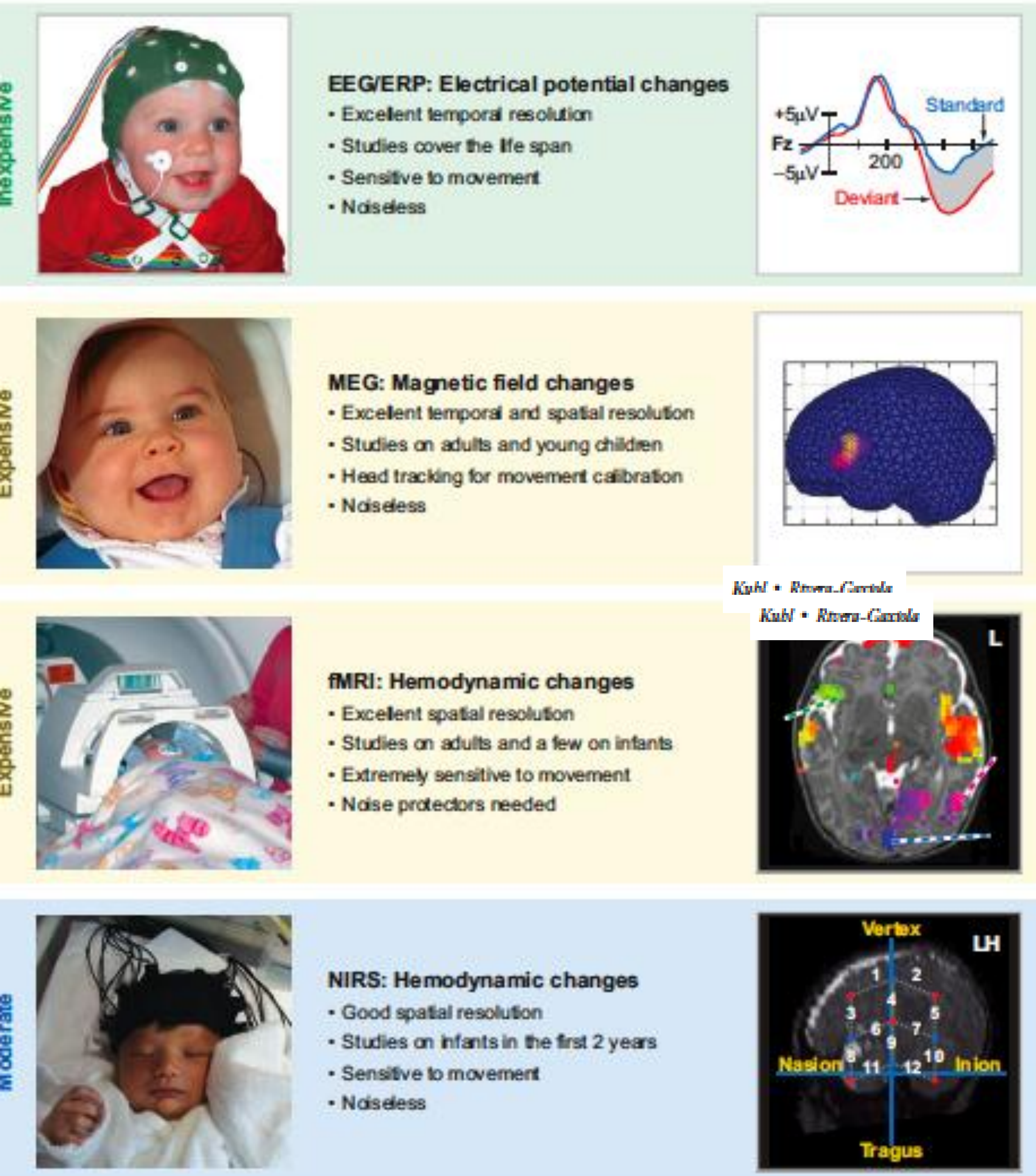
Windows totheyoungbrain



EEG (ERPs): scalprecordingsofelectricalactivitytha t can be time-lockedtospecificsensorystimuliorcog nitiveprocesses

MEG: magneticfieldsfromelectricalcurrents producedduringsensory, motor, orcognitivetasks

fMRI: changes in bloodoxygenationlevelsthatoccur in response to neural firing/activation

NIRS (Near-infraredSpectroscopy):uses infraredlighttomeasurechanges in bloodconcentration in thecortex, as anindicatorof neural activity

(Kuhl& Rivera-Gaxiola 2008)

Neural SignaturesofPhoneticalLearning

- Perception of the *phonetic units of speech* - vowels/consonants-

- **At birth**: Universal capacity to detect differences between phonetic contrasts used in the world's languages (Eimas et al. 1971, Streeter 1976).

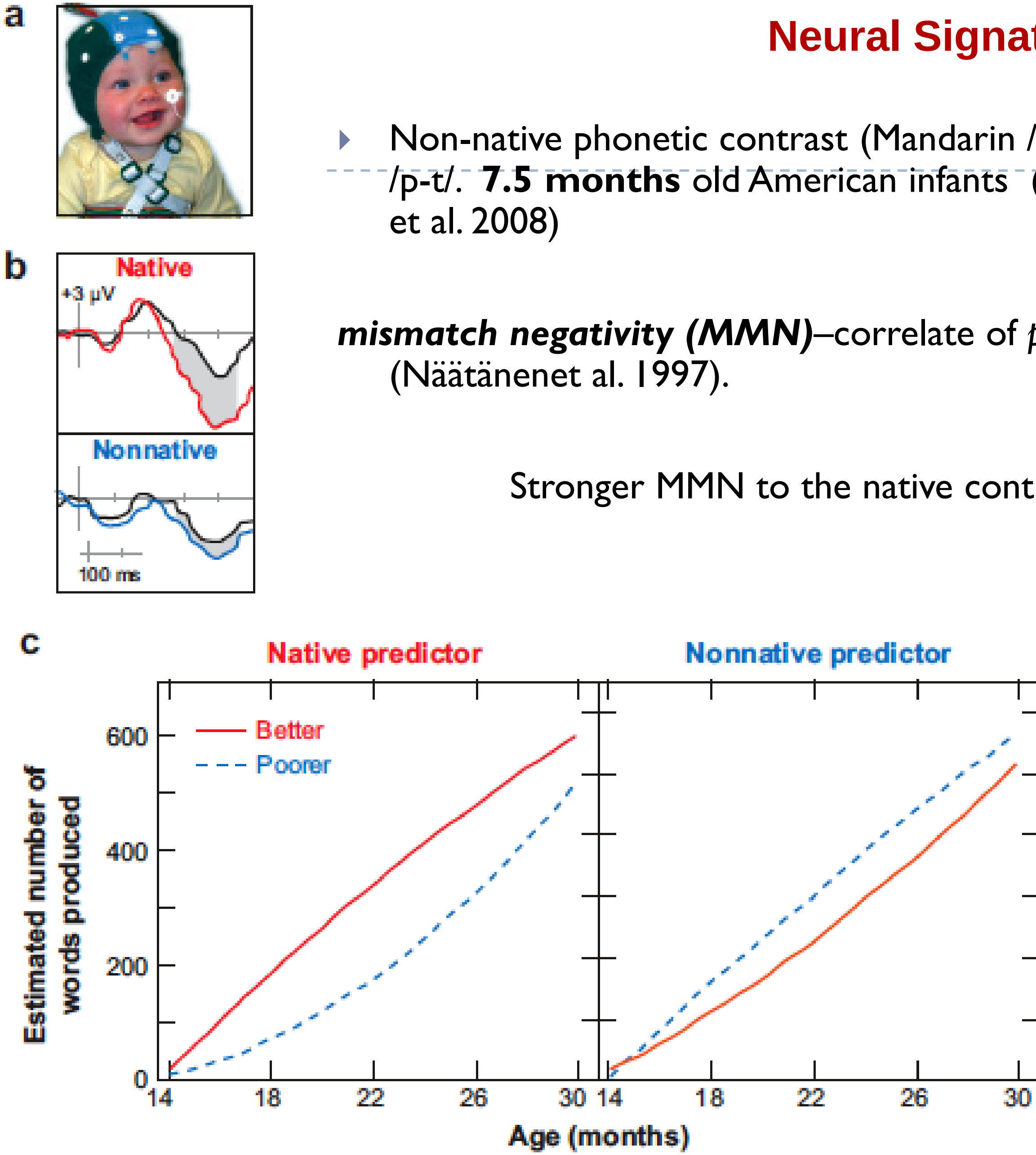
  Capacity altered by *language experience* **6 months** for vowels and

  by **10 months** for consonants.

- ***Transition in phonetic perception***:
  - **Native language phonetic abilities** significantly **increase** (Cheour et al. 1998; Kuhl et al. 1992, 2006; Rivera-Gaxiola et al. 2005b, Sundara et al. 2006)
  - while the ability **to discriminate phonetic contrasts not relevant to the language** of the culture **declines** (Werker& Tees 1984, Cheour et al. 1998, Best &McRoberts 2003, Rivera-Gaxiola et al. 2005b, Kuhl et al. 2006).

- **Native language neural commitment (NLNC) hypothesis** (Kuhl 2004): Initial native language experience produces changes in the neural architecture and connections that reflect the patterned regularities contained in ambient speech.
  - Excellent native phonetic precursor of language.
  - excellent non-native phonetic abilities would not promote native-language learning.

Neural SignaturesofPhoneticalLearning



- Non-native phonetic contrast (Mandarin / -th/) and a native contrast English /p-t/. **7.5 months** old American infants (Rivera-Gaxiola et al. 2005b; Kuhl et al. 2008)

mismatch negativity (MMN)–correlate of *phonetic discrimination* in adults (Näätänenet al. 1997).

Stronger MMN to the native contrast – Native learning begun

- Better discrimination of the native contrast resulted in faster vocabulary growth,

whereas,

- better discrimination of the non-native contrast resulted in slower vocabulary growth

- Replicated by FinnishandRussiancontrasts (Silven et al. 2006)

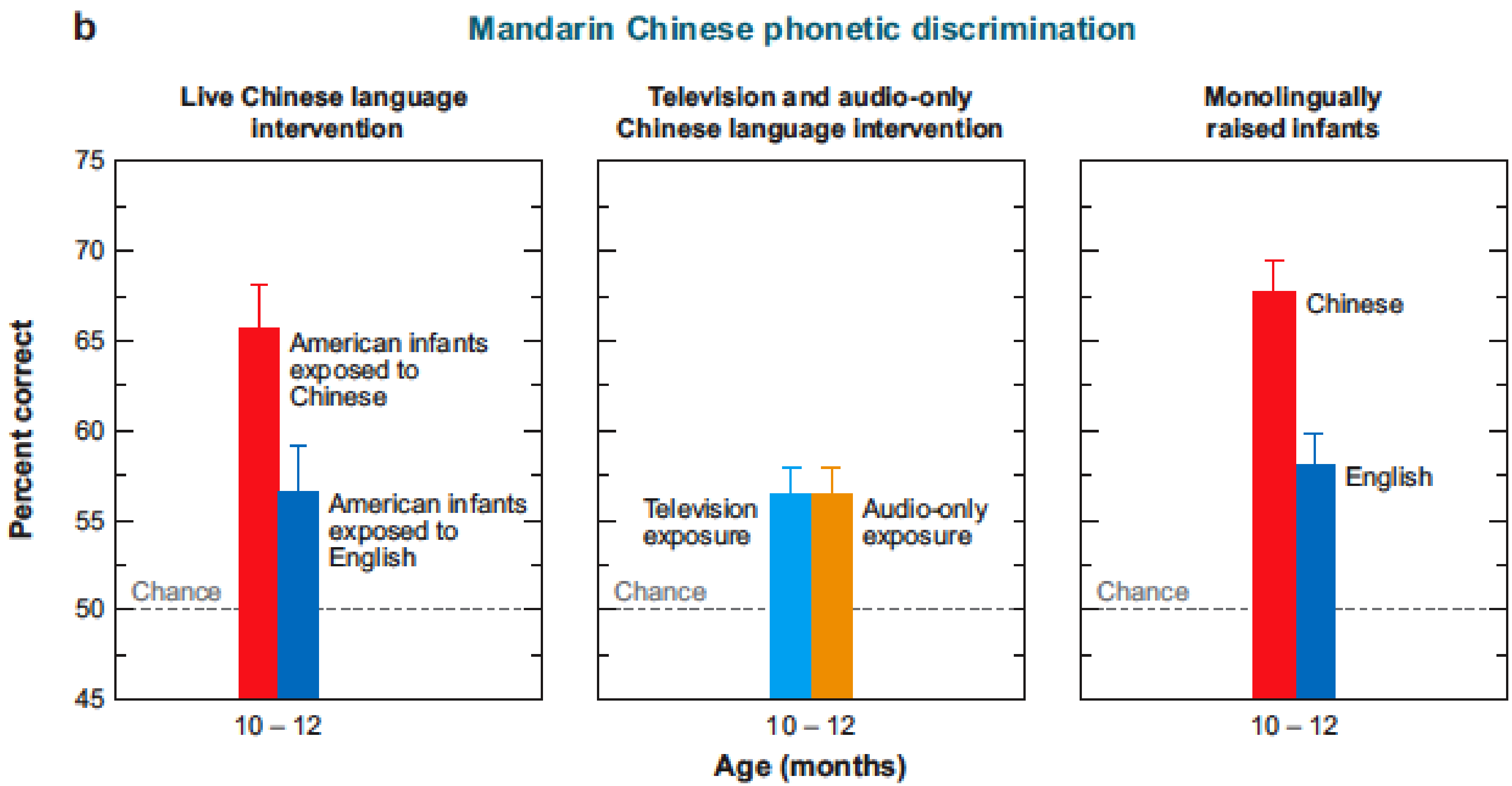
The role of Social Factors in earlylanguagelearning

- Plays a more significant role in early language learning in natural language learning situations (Kuhl et al. 2003, Kuhl 2007, Conboy et al. 2008).

Study about infants Capability of phonetic and word learning at **9 months** from "natural first-time exposure" to a foreign language. (Kuhl et al. 2003).

- American Infants *heard 4 native speakers* of Mandarin Chinese (male and female) during 12 25-min sessions of book reading and play across a 4–6 week period.
- A control group of infants also came for the same time and variety of reading and play sessions but heard only English.
- Two additionalgroups were exposed to the identical Mandarin material over the same number of sessions via either *standard television* or *audio-only* presentation.
- After exposure: test Mandarin syllables not phonemic in English, using both behavioral (Kuhl et al. 2003) and brain (Kuhl et al. 2008) tests.

The role of Social Factors in earlylanguagelearning



- Phonetic learning from first-time exposure could occur at **nine months of age**.
- Learning in the live condition was robust

Neural Signaturesof Word Learning

- **18 and 24 months of age**—"vocabulary explosion" (Ganger & Brent 2004, Fernald et al.2006)

- Between **four and a half months** (Mandel et al. 1995) and**six months**
  - Infants show recognition of their own name
  - Look and look appropriately to pictures of their mothers or fathers when hearing "Mommy" or "Daddy" (Tincoff&Jusczyk 1999)
- By **7 months** prefer known words (Jusczyk&Hohne 1997)
- **11 months** infants prefer to listen to words that are highly frequent over infrequent words (Halle & de Boysson-Bardies 1994).

- How is early word recognition evidenced in the brain? EEG studies/ differences in amplitude and scalp distributions

- Codification of the critical features of word
  - Reactions to mispronunciations—"tup" for cup or "bog" for dog—*level of phonological detail* in their mental representations of words.

Infants' EarlyLexicons

- By **one year of age** infants do not accept mispronunciations of common words (Fennell &Werker 2003), words in stressed syllables (Vihman et al. 2004), or monosyllabic words (Swingley 2005),

representations of these words are well-specified

- Visual fixation of two targets : between **14 and 25 months of age**

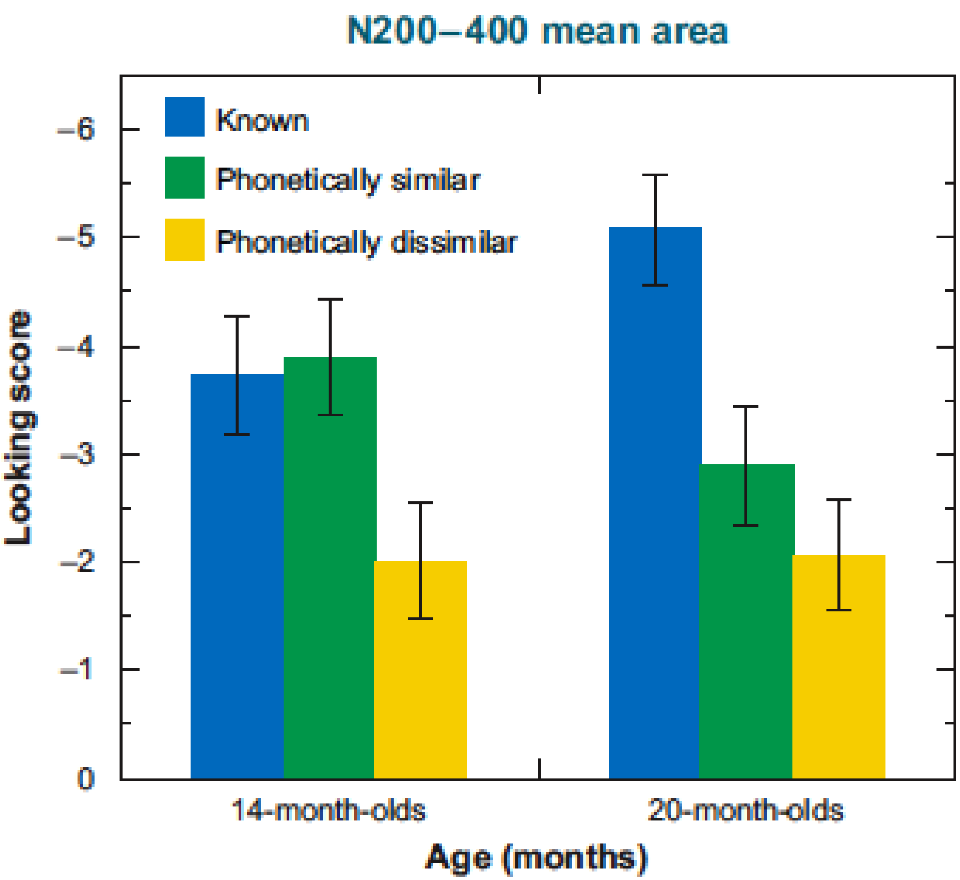
less tendencies to fixate the mispronounced item (Ballem& Plunkett 2005)

By **17 months of age**: associate similar-sounding nonsense words with novel objects (Bailey & Plunkett 2002, Werker et al. 2002).

Consistent with studies showing that children with **better *native-language phonetic learning*** skills showed advanced *vocabulary development* (Tsao et al. 2004; Kuhl et al. 2005b, 2008; Rivera-Gaxiola et al. 2005a).

Infants' EarlyLexicons

Mills et al. (2004) compared children's ERP responses when responding to familiar words that were either correctly pronounced or mispronounced, and non-words



At the earliest age tested, **14 months**, a negative ERP component (N200–400) distinguished known vs. *dissimilar nonsense* words

("bear" vs. "kobe")

but not: known vs. phonetically similar non-sense words

("bear" vs."gare").

By **20 months**, this same ERP distinguished correct pronunciations, mispronunciations, and nonwords, supporting the idea that

between **14 and 20 months**, *children's phonological representations* of early words become increasingly detailed.

Neural SignaturesofEarlySentenceProcessing

- *Phonological abilities* : *segmentation of the speech signal* into *words*, and *extract word meaning.*

How the young brain decodes syntactic and semantic information in sentences?

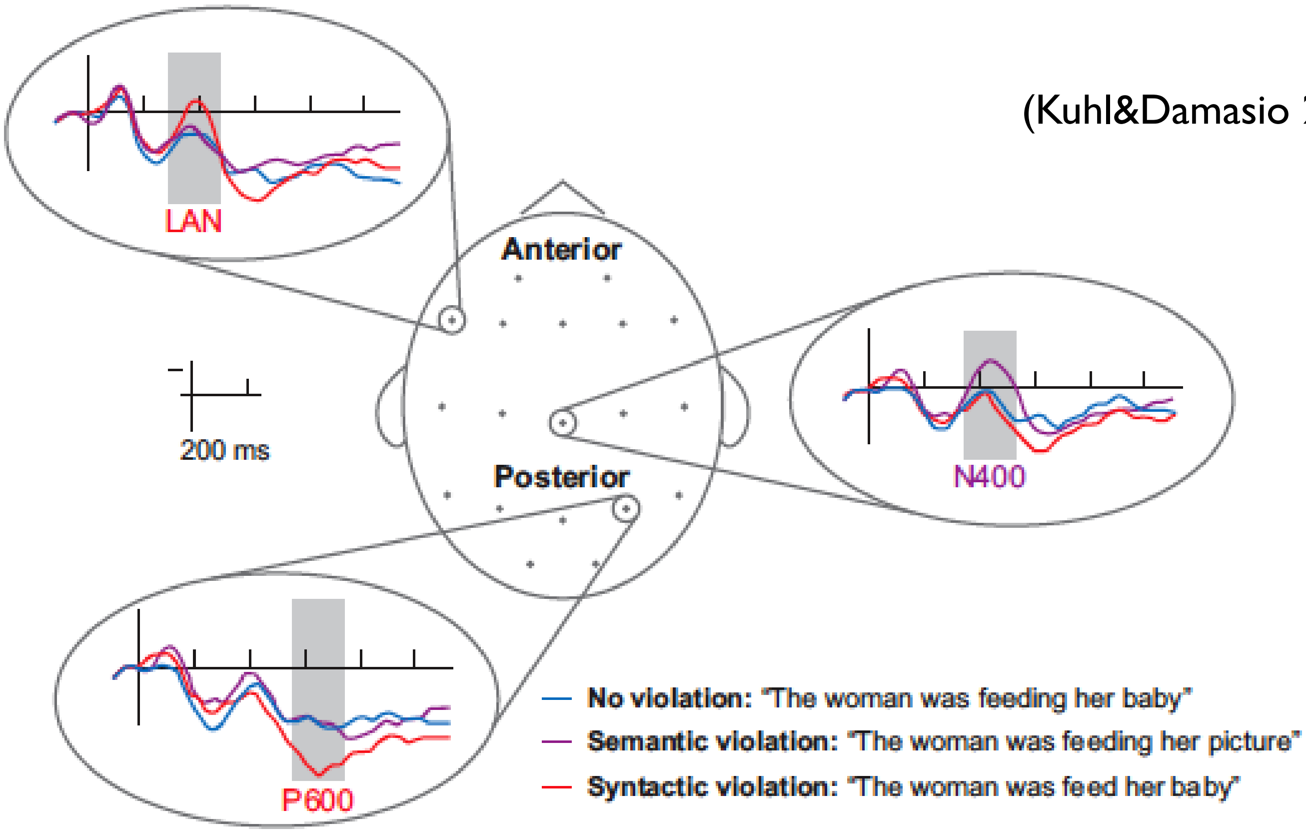
In adults, specific neural systems process *semantic*vs. *syntactic*information within sentences, and the ERP components elicited in response to syntactic and semantic anomalies are well established

Beginning in a child's **second year** of life, ERP data on sentence processing in children

suggest that adult-like components can be elicited in response to violations in *semantic*and *syntactic*components, but that differences exist in the latencies and scalp distributions of these components in children vs. those in adults (Silva-Pereyra et al. 2005a,b, 2007; Oberecker&Friederici 2006).

Neural SignaturesofEarlySentenceProcessing

(Kuhl&Damasio 2008).

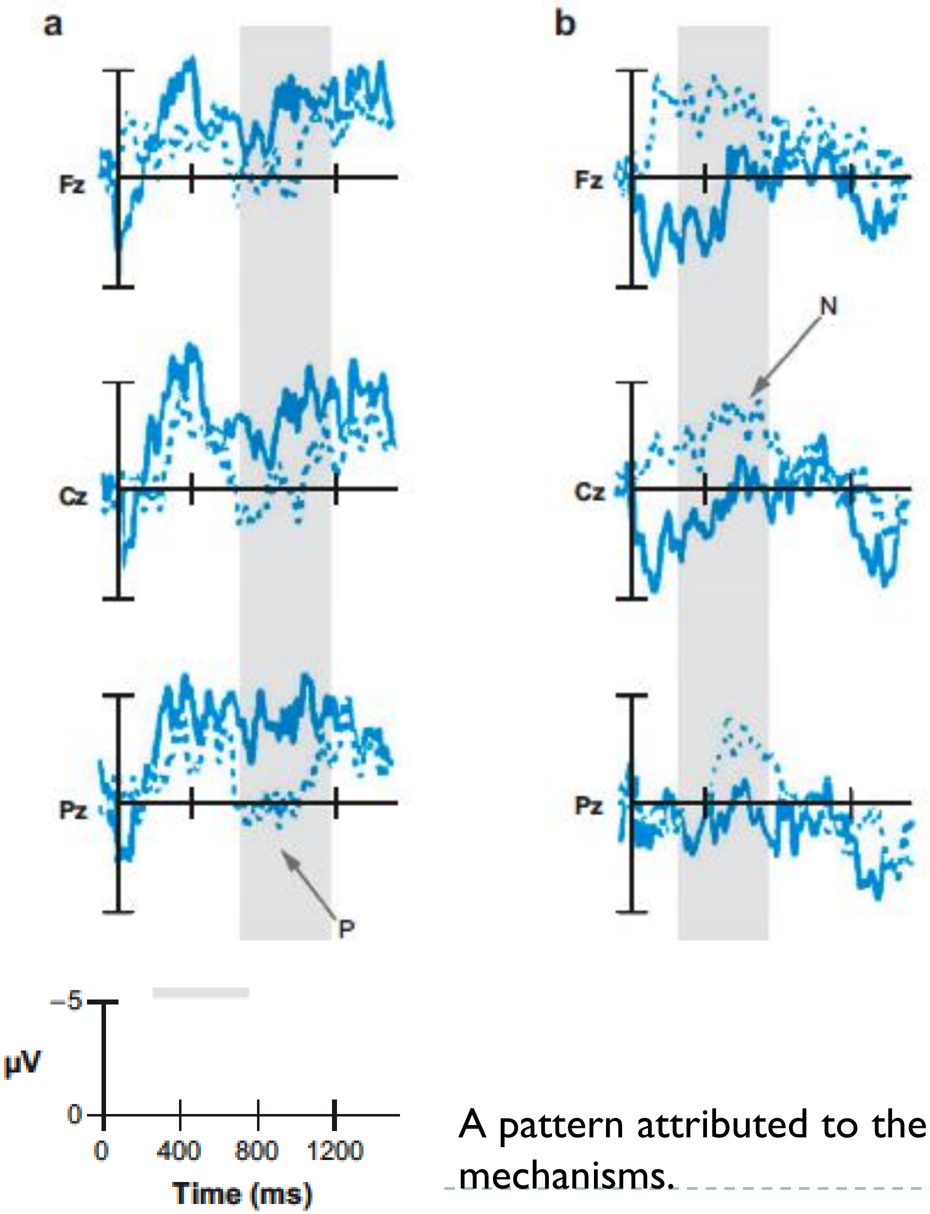


A negative ERP wave occurring between 250 and 500 ms that peaks around 400 ms, referred to as the **N400**, is elicited to *semantically anomalouswords* in sentences (Kutas 1997).

A late positive wave peaking at 600 ms and that is largest at parietal sites, known as the **P600**, is elicited in response to *syntactically anomalous words* in sentences (Friederici 2002).

And a negative wave over frontal sites 300 and 500 ms, known as the *late anterior negativity* (**LAN**), is elicited in response to *syntactic and morphological violations* (Friederici 2002).

Neural SignaturesofEarlySentenceProcessing



- Silva-Pereyra et al. (2005b) recorded ERPs in **30 month old** children of age in response to

(b) semantic(“My uncle will blow the movie”)

and

*(a) syntactic*anomalies (“My uncle will watching the movie”)

when compared with *control sentences*.

In both cases, the ERP effects in

children were more broadly distributed and elicited at later latencies than in *adults*.

(a) P800 (P600)

(b) N600 (N400)

A pattern attributed to the immaturities of the developing neural mechanisms.

BilingualIntants: Twolanguages, onebrain

- How is the transition from ***universal phonetic listening*** (phase 1 of development) to ***language-specific listening*** (phase 2 in development)?

Timing delay?

Very little data address this question

X Infantsexposed to two languages show a *different pattern of phonetic perception* development when compared with monolingual infants (Bosch&SebastiánGallés 2003a,b).

X Phonetic perception in bilingual infants is *identical* to that occurring in monolingual infants (Burns et al. 2007)

Conclusions

Neural signatures of learning:

7 months for native-language phonemes,

9 months for familiar words, and

30 months for semantic and syntactic anomalies in sentences.

Continuity

Languagespecific processing at the phonetic level

—at the cusp of the transition from phase 1:*all phonetic contrasts* are discriminated,

to phase 2, *focus* on the distinctions relevant to their *native language*—

is strongly linked to infants' abilities to process words and sentences.

Theoretically important, and useful for the diagnose of children with developmental disabilities that involve language.

Future Directions

- Are the brain structures activated in infants in response to language the same as those activated in adults, and in both cases, are these brain systems speech specific?
- Why do infants fail to learn language from television presentations—how does social interaction during language exposure affect the brain's ability to learn?
- Is the neural network connecting speech perception and speech production innate, and if so, is this network activated exclusively in response to language?
- How is language mapped in the bilingual brain? Does experience with two or more languages early in development affect the brain systems underlying social and/or cognitive processing?
- How do developmental disabilities such as autism, dyslexia, and specific language impairment affect the brain's processing of speech?
- Which causal mechanisms underlie the critical period for second acquisition— why are adults, with their superior cognitive skills, unable to learn as well as young infants? Can techniques be developed to help adults learn a second language?