From speech to script

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MTA RCNS Brain Imaging Centre
BME TTK Department of Cognitive Science
PE PMFTK Institute of Hungarian and Applied Linguistics

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Brain Imaging Centre

Methods available

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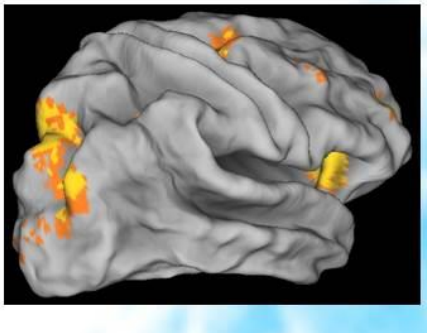
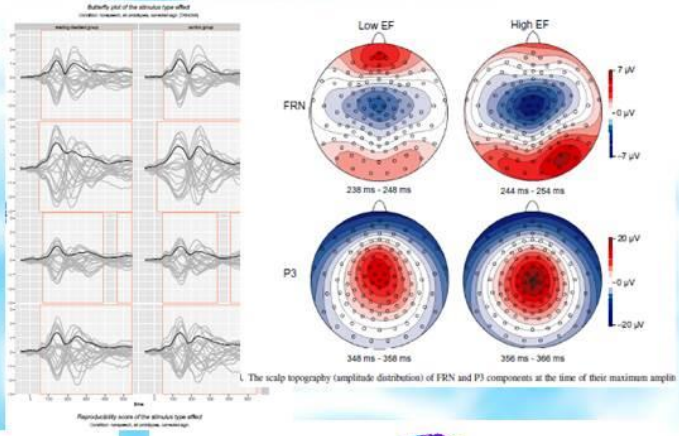
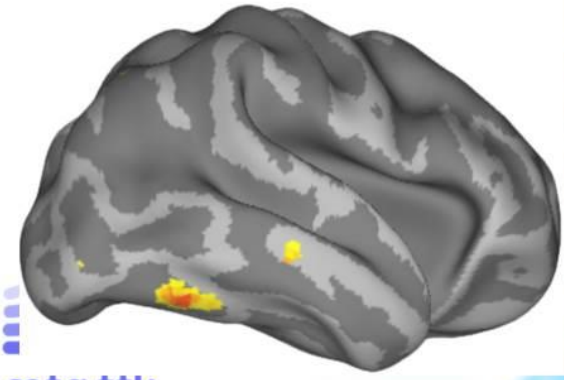
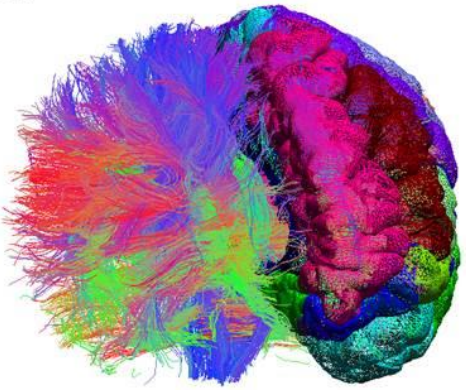




1. The scalp topography (amplitude distribution) of FRN and P3 components at the time of their maximum amplitu





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MAGYAR TUDOMÁNYOS AKADÉMIA
TERMÉSZETTUDOMÁNYI KUTATÓKÖZPONT

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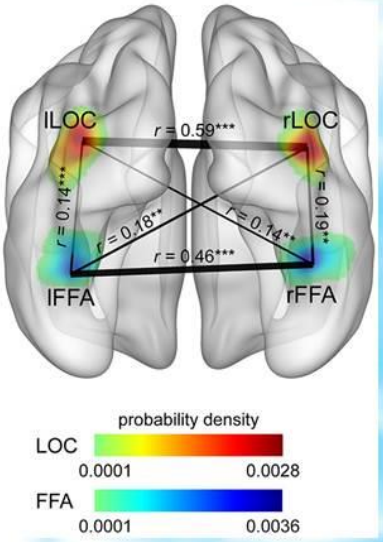
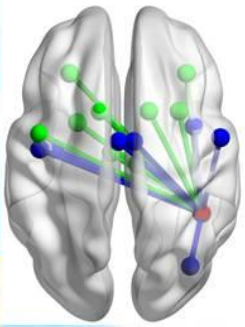
MULTIDISZCIPLINÁRIS IDEGTUDOMÁNY





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Intuitions about learning to read

- Entirely visual process
- Immediate word recognition; mandatory
- But also immediate access to sound
- Silent reading: inner ‘speech’ occurs in developing and experienced readers (reading aloud was the standard form of reading up till the 19th century)
- How visual is the reading process?
- Why speech is so important?

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Facts on Speech & Script

- Learning spoken language
  - starts immediately after birth: sensitivity for native speech sounds
  - is spontaneous
  - is an implicit learning process
- Learning written language
  - Starts when spoken language is already proficient
  - Mostly not spontaneous; needs schooling
  - requires explicit instruction for years
- Learning to read seems to require a real effort; nevertheless 90% of people learn to read fluently without obvious difficulties
- So, what is special about learning a script?

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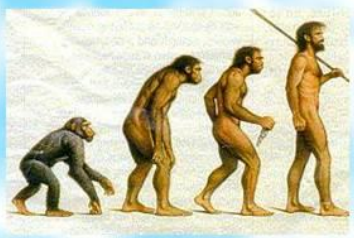
Speech & Script

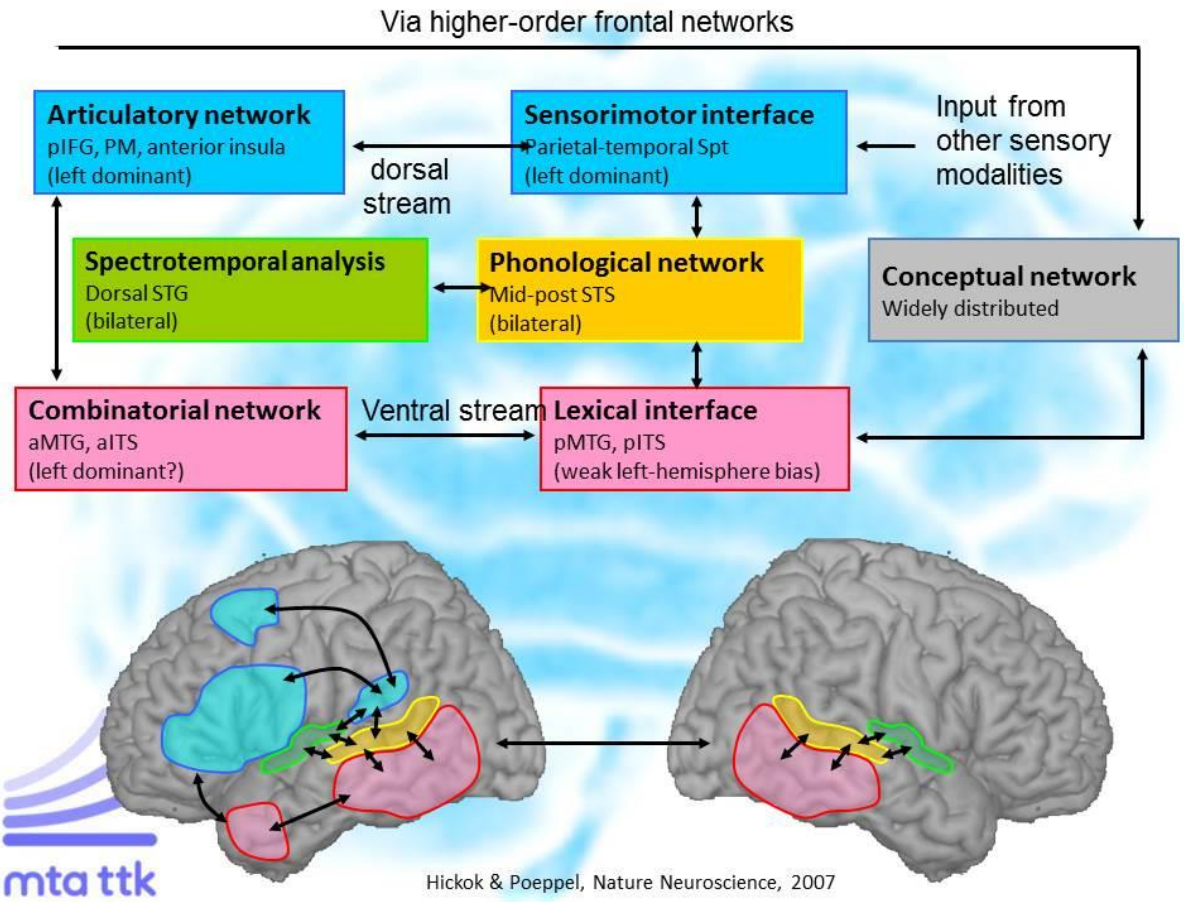
Speech: old and natural
Script: new and artificial



- **Evolutionary development**

- **Individual development**

Speech: **primary** language system
Script: **cultural invention** to represent speech
parasite on the spoken language system



Hickok & Poeppel, Nature Neuroscience, 2007

How does reading start?

- Before any reading can start a functionally effective script code must be established, that is:
- The ultimate prerequisite for reading development is learning the relations between visual letters and speech sounds
- The basis of alphabetic orthographies is a limited set of grapheme-phoneme associations which varies as a function of orthographic transparency
- Surprisingly this fundamental multisensory association process has hardly been investigated

(1) Alterations of speech-script links

Within- an between-category changes in SS processing

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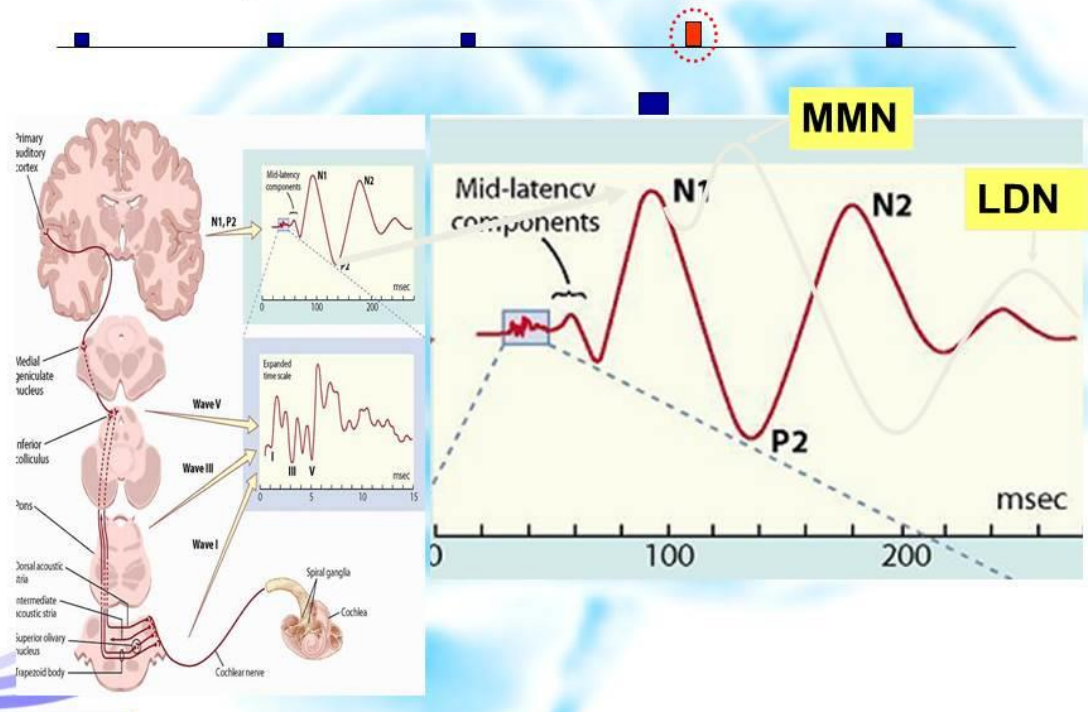
Brain responses to sounds and speech



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Our way to go
Behavior, Brain and Genes

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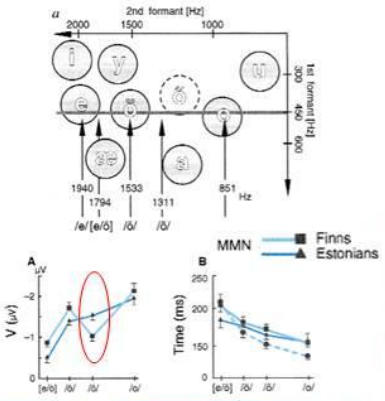
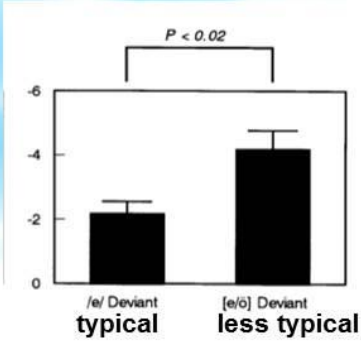
What the MMN can show?

- **Larger MMN for native** compared to non-native phonemes (Näätänen et al., 1997) NOT in our sample – WHY?
- **Between-categories** : larger MMN for prototypical compared to non-prototypical (category boundary) phonemes (Aaltonen et al., 1987) – NOT in all languages- WHY?
- **Within-categories:larger MMN for non-prototypical compared to prototypical** (Ikeda et al., 2002) –our paradigm was different





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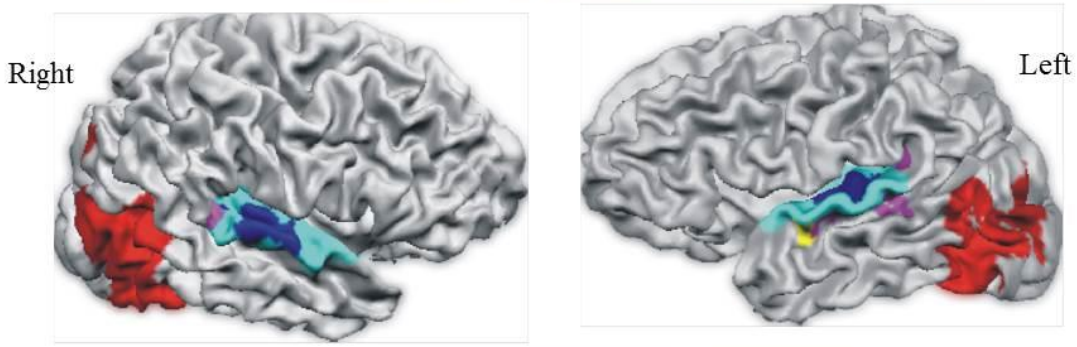
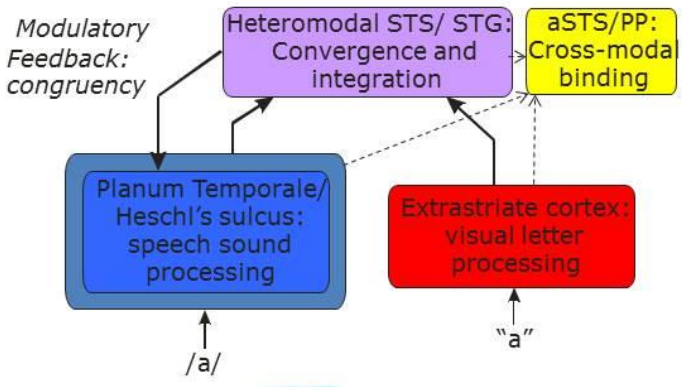
(2) The SSL integration, incongruency supression

SSL brain model (Neuron, 2004)





Integration of letters and speech sounds (fMRI): basic design

- subjects passively viewed and listened to
  - Letters *(unimodal visual):* examples: o,i,r,s, etc.
  - Speech sounds *(unimodal auditory):* /o/, /i/, /r/, /s/
  - Letter-sound pairs *(bimodal = audiovisual)*
    - Congruent ("o" + /o/)
    - Incongruent ("o" + /i/)

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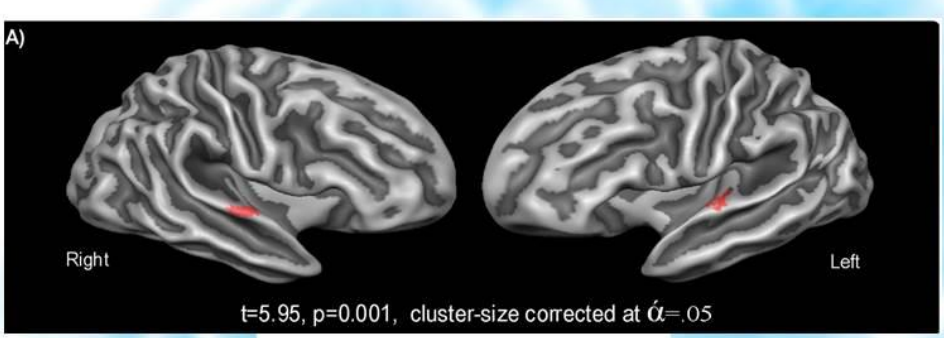
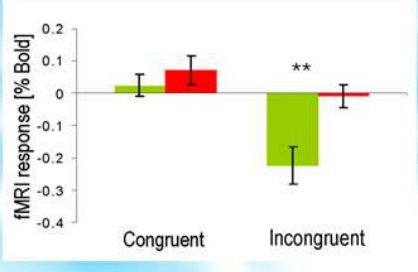
Dyslexia: no suppression incongruent letter-sound pairs





Multisensory Index:
(AV-Amax)/Amax*100

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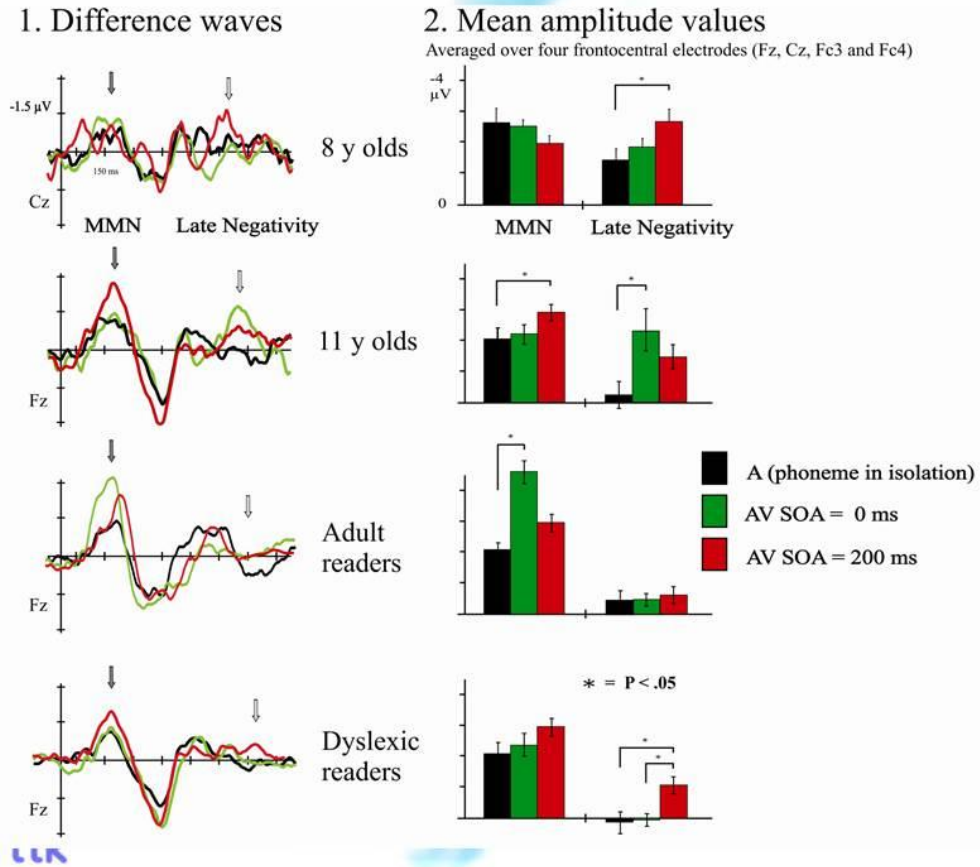
Fluent readers Dyslexic readers

(3) Timing & tuning



Nature of AVS and SS associations

Audiovisual speech

- Basis: Evolution
- Relation type: Natural
- Time window: Wide
- Elements: Familair

Letter-sound assoc.

- Culture
- Arbitrary
- Narrow
- Mix: Letter unfamilair + partly fam. sound

- **Symmetric: primary** cortex involvement - visual + auditory
- **Asymmetric**: only auditory cortex directly involved in integration

Blomert & Froyen, *IJP*, 2010

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(4) Grapheme-Phoneme association / integration

Normal readers

- 7-8 yrs: no integration + weak association
- 11 yrs: automatic integration + association
- Adults: integration in narrow time window
- → gradual tuning of auditory/multisensory cortex

Dyslexic readers

- 11 yrs: no integration + weak association
- 8-9 yrs: congruent = incongruent LS pairs
- Adults: congruent = incongruent LS pairs
- → failure to establish automatic integration

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What do we know about the suprasegmental processing of spoken utterances?

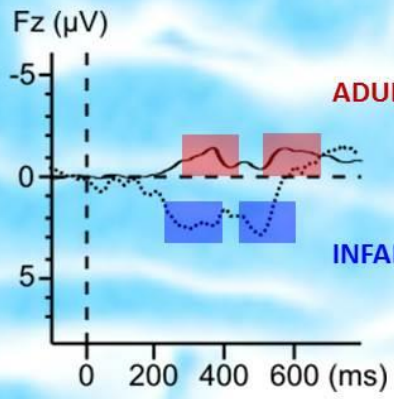
Speech segmentation

- Lexical segmentation (Norris & Cutler, 1994)
- Rhythm-based segmentation (Nazzi et al, 1998)
- Prosody-based segmentation (Jusczyk & Houston, 1999)
- Statistical probability – based segmentation (Thiesen & Saffran, 2003)

Predominant patterns of words

- Lexical (English, Spanish)
- Fixed (French, Finnish, Hungarian)

HUNGARIAN PSWs



ADULT : Honbolygó & Csépe (2013)

INFANTS : Csépe et al (submitted)

Q1: **Emergence of templates**

Early preference (4-5 months) of differential processing of language-typical stress assignment (iambic vs trochaic)

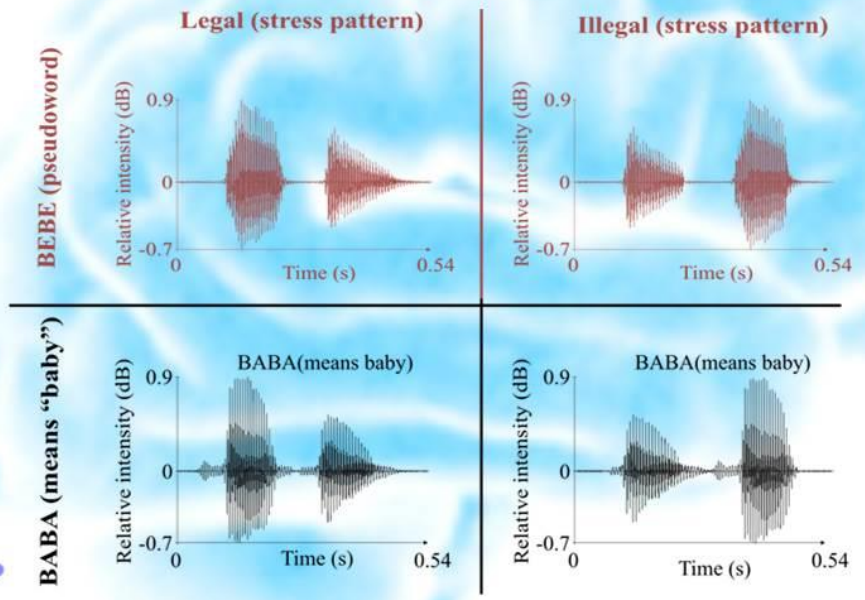
Late discrimination (10-11 months) in processing language-typical and – atypical stress patterns

Q2: **Role of lexicalization**

Suppression (Cutler, 1994)

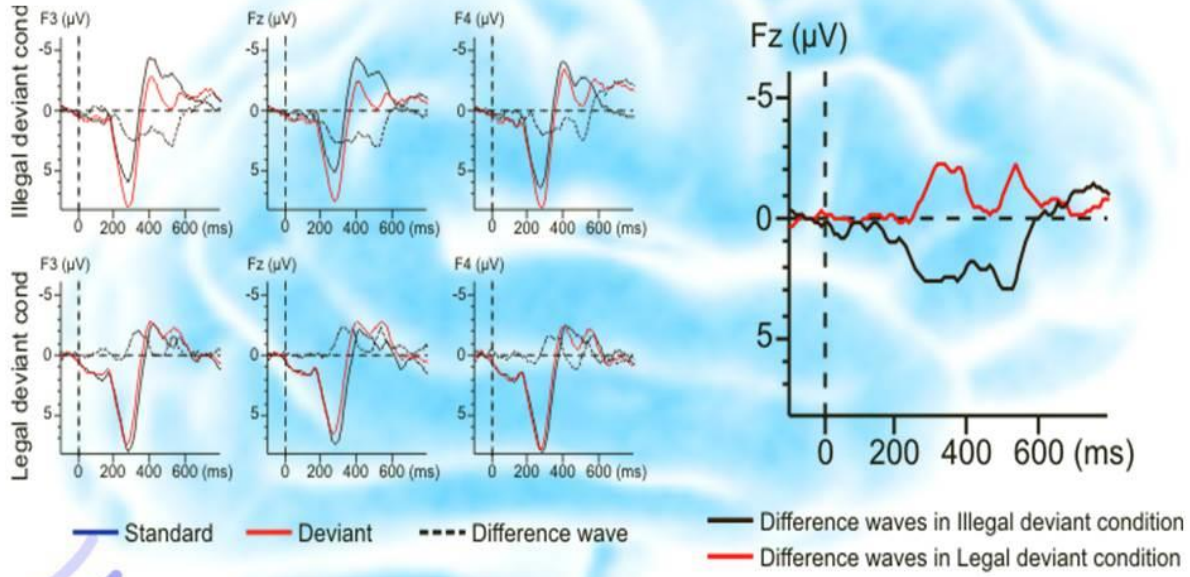
Facilitation (Werker & Curtin, 2005)

Stimuli

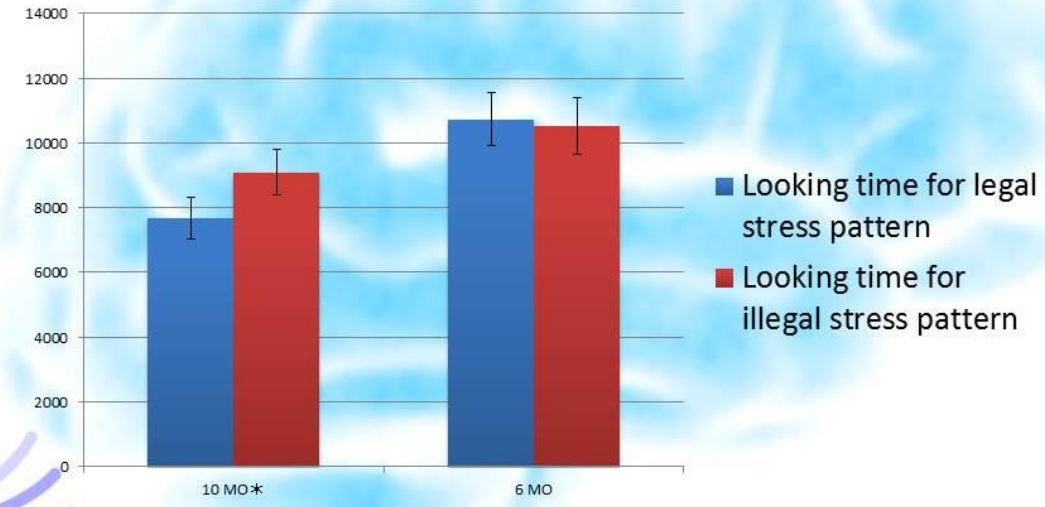


Deviant probability: 0.2, SOA: 730-830 ms

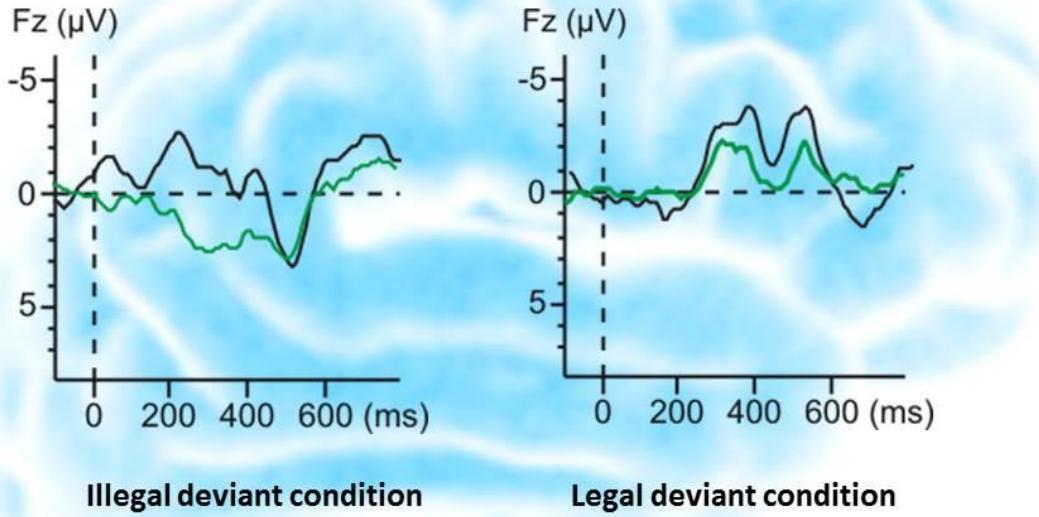
GA ERPs in two conditions



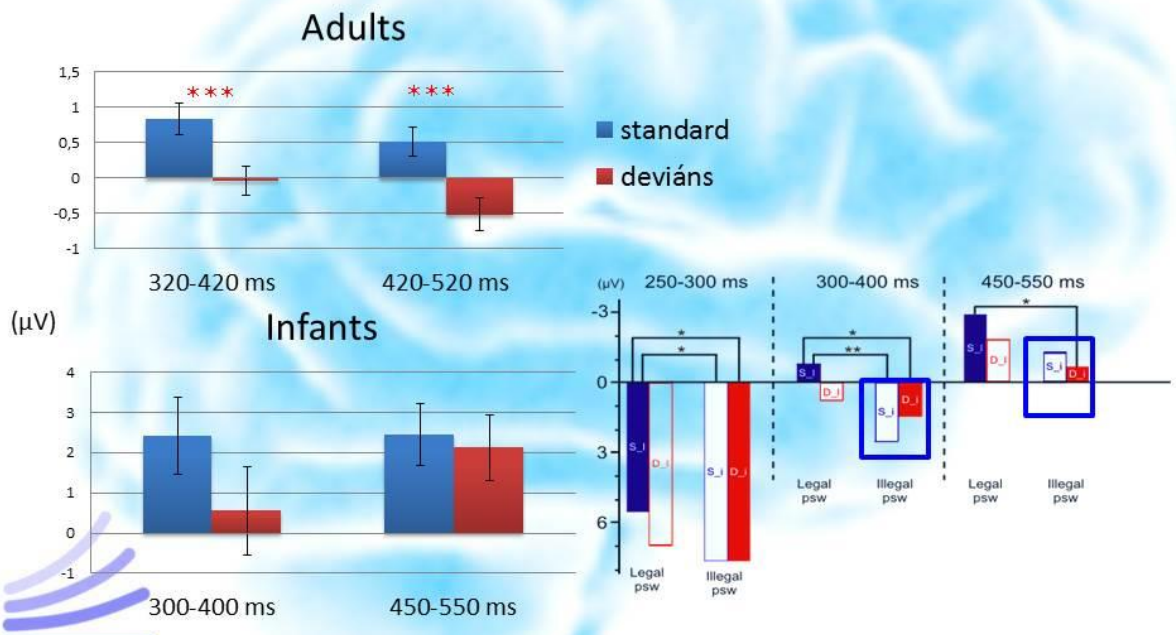
BEBE-HTPP



Effect of lexicalization on template matching



Template legality counts



Conclusions

- **Rule-based** stress pattern processing
- **Emerging template** (6 mo)
- **Differential template role**
  - Exclusive for PSWs
  - Interactive for words
- **From template to interaction**
  - Enhanced sensitivity to violated patterns (6 mo)
  - Effect of lexicalization (10 mo)
- **Lexical status**
  - Infants: facilitation
  - Adults: selection