Discreteness and asymmetry in phonological representations: features and quantity contrasts in the mental lexicon

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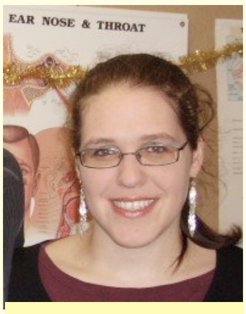

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WORDS & their variants and asymmetries

No word is ever spoken in exactly the same way, even by the same speaker.

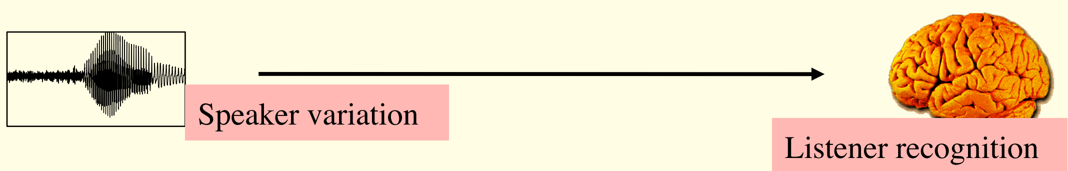
- Adult speech is produced with great speed and accuracy at an average rate of **three words per second**
- Our **mental lexicon** contains **tens of thousands** of words

The problem facing a phonologist...

Uneven pronunciation (non-linguistic)
- Differences in vocal tract size, age and gender
- Noisy environments
- Mispronunciations

Varying pronunciations: linguistic contexts
- Surrounding context changes the sounds of a word

Given this variation how do listeners parse the acoustic signal, access their mental lexicons, and identify words?



Our approach attempts to address the following:

- Asymmetries: How can we identify the types of possible word variations, complexities and asymmetries in the output.
- Speaker & Listener differences: How does the speaker plan her output and how does the listener identify and recognise words despite the variation?
- Lexical representation: How are words represented in the mental lexicon? Should the output and input be identical? This goes for phonological as well as morphological variants.

We attempt to combine synchronic theoretical data (& evidence from language change which tells us what variations may or may not lead to change), with experimental evidence asking how and with what difficulties the speaker and listener resolve complexities of word variation and word formation.

Phonological Representations in Language Production & Language Comprehension

- Phonologists usual description

REPRESENTATION

↓

RULES

↓

OUTPUT

- Phonologists do not worry about

REPRESENTATION

↑

?

OUTPUT

Speaker - Hearer problems and asymmetries

- The speaker is in control - knows what to say, how to say it
- The listener is dependent on the speaker
- The child is initially only a listener and then a speaker as well

But identifying words in running speech is difficult!

Languages are replete with asymmetries

- No language has equal number of vowels and consonants
- Verb final languages are more frequent than verb initial languages
- Front rounded vowels imply back rounded vowels
- Dual number implies plural number contrasts
- Retroflex consonants imply dental/alveolar consonants
- Nasal vowels occur only with oral vowels
- Interdental non-sibilant fricatives occur only with sibilant fricatives
- Etc...

Asymmetries in assimilation leading to change

Languages are replete with asymmetries:

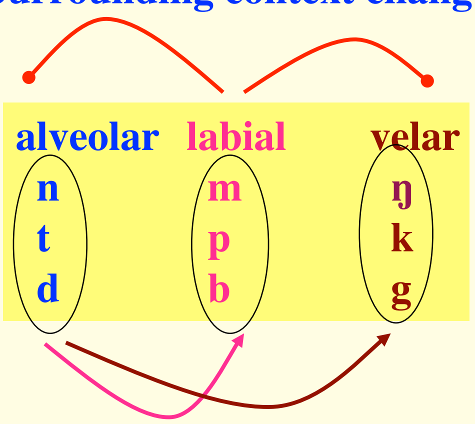
Vowel Deletion : Vowels are usually deleted finally (apocope) or medially (syncope) — not initially
Vowel Insertion: Vowels are inserted medially (epenthesis) or initially (prothesis) — not finally

Consonants affecting vowels: manner not place features; e.g. vowel nasalisation
Sanskrit candra > Bengali cãd
Nasal vowels do not lose nasality before oral consonants

Vowels affecting vowels: place & height, not manner; raising, fronting, rounding
Germanic u —> ü /— i; English has converted all [ü]s to [i]
Umlauted vowels do not become back rounded vowels in similar contexts

Consonants affecting consonants: place & manner, not height
Place assimilation (eventually place can change)
Vowels affecting consonants: place & height, not manner
Retroflexion, Palatalisation (eventually palatals & retroflexes become phonemes)

Surrounding context changes the beginning or end of a word



alveolar > labial if labial follows
n > m if m,p,b follow

alveolar > velar if velar follows
n > ŋ if ŋ,k,g follow

hand bag *ha***[nd] [b]***ag* ⟶ ha**[m][b]**ag
hand gun *han***[nd] [g]***un* ⟶ ha**[ŋ][g]**un

Asymmetry

But /m/ remains unchanged
gum drops ***gum*[m] [d]*rops*** ⟶ ***gum[n][d]rops**
cream cake ***crea*[m] [k]*ake*** ⟶ *** crea[ŋ][k]ake**

Surrounding context changes the beginning or end of a word

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Consonants at **word onset** tend to be less vulnerable to change. Nevertheless, they may change - affected by the end of the preceding word.

Celtic languages: **Mutation**
Italian: **Radoppiamento** (gemination across words) - when the preceding words end in a stressed vowel, the initial consonant of the word is doubled: *caffé caldo* > *caffé* [**kk**]*aldo*

Bengali: initial [t, d] assimilate to preceding /r/ and geminate
didi[**r**][**d**]æor ⟶ didi[**d**][**d**]æor ***elder-sister's brother-in-law***
didi[**r**][**g**]ari ≠> *didi[**g**][**g**]ari ***elder-sister's car***

The listener may ultimately reanalyse what she hears, and initial geminates can become phonemes: true for assimilations as well as gemination.

Surrounding context changes the beginning or end of a word

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Swiss German (North) 1000 years ago the ancestor of the dialect was spoken by **Notker,** an Abbot of the monastery at St Gall

b **d** **g** word-initial **after** ***sonorants*** and word-final
p **t** **k** word-initial **after** ***obstruents***

ín díu óugen begínnet
'it begins in the eyes'

Íh pegínne
'I begin'

díu súnna gât
The sun goes

er férrost kât
'he goes the furthest'

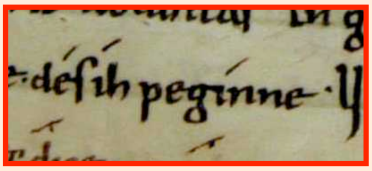
Martianus Capella **(Codex Sangallensis 872) and dates from early 11th century.**

Lahiri & Krahenmann 2004 Transactions of the Philological Society

Surrounding context changes the beginning or end of a word

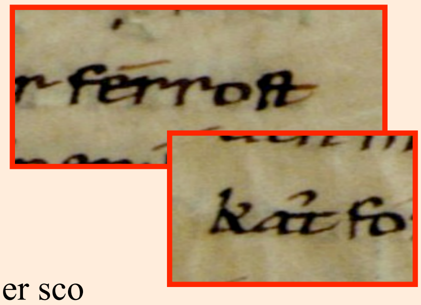
<p b>

dés ih pegínne



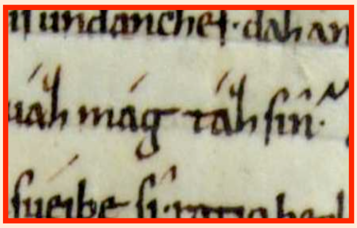
<k g>

Sô er férrost kât
fóne déro súnnun

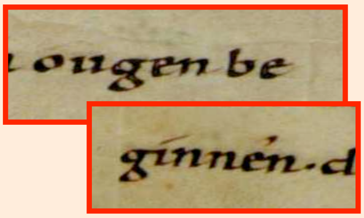


<t d>

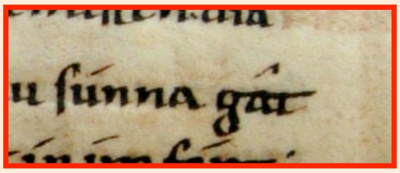
Uuás mág táz sin̂?



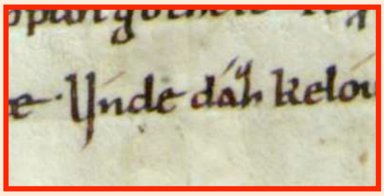
díu óugen begínnên. dáz er sco
ˆne uuérde



Des hímeles hóhi. dâr diu
súnna gât



Uńde dáz kelóuben so
uúaz íh pefindo fóne dír



Surrounding context changes the beginning or end of a word

Notker's system

<p/b t/d k/g>

alternating < b d g> <p t k> were contextually determined

[sonorant] [obstruent] ¡ > [obstruent] ¡ [obstruent] ¡

p t k

pp tt kk

Compare Old Swiss German to Modern Swiss German, we know that 1000 years ago:
<**p t k**> = [p t k] / when obstruents precede
<**b d g**> = [pp tt kk] / when sonorants precede

Modern Swiss German:
/**p t k**/ and /**pp tt kk**/ occur context independently! **They are phonemes.**

French loans into Swiss German brought in new [p t k] in the environment of sonorants.

Returning to word final position: an example of assimilation [n] > [m]

WORDS & their variants and asymmetries

How do listeners cope with variation?

Varying pronunciations: linguistic contexts

- Surrounding context changes the sounds of a word
- Listeners may misperceive

Berlitz English schools for Germans:

Message from ship in distress "Mayday, Mayday, we are sinking"

German coastguard

What are you [s]inking about?

Learn English!

Native listeners always assume that they are hearing WORDS and not nonwords; thus they try to find the closest match.

Do human listeners treat all variants in the same way?

Assimilations : Speaker ⟷ Hearer

RECALL

n > m or **ŋ**

hand bag	*ha***[nd] [b]***ag*	=>	ha**[m][b]**ag
hand gun	*han***[nd] [g]***un*	=>	ha**[ŋ][g]**un

But /m/ remains unchanged

gum drops	*gum***[m] [d]***rops*	≠≠>	*gum**[n][d]**rops
cream cake	*crea***[m] [k]***ake*	≠≠>	* crea**[ŋ][k]**ake

Mispronunciations: Speaker ⟷ Hearer

n > m	***sonnet >***	****sommet***
	honey >	****homey***
m > n	***tummy >***	****tunny***
	summer >	****sunner***

Assimilations : *Speaker* ⟷ *Hearer*

Mispronunciations: *Speaker* ⟷ *Hearer*

Do listeners tolerate **all** possible assimilations and mispronunciations?

Hypothesis: **NO**

Lexical representation of words are sparse

Some mispronunciations are accepted, some are not

Listeners tolerate **m** for **n**

Listeners do not accept **n** for **m**

sommet* is accepted as a variation of ***sonnet*

sonner* is **not accepted as a variation of *summer*

From Signal to Representation

What is the *relevant* information that should be represented?

- **not the acoustic signal - too much variation**
- **if not the signal then some more *abstract* information**
- **how abstract is *abstract*?**

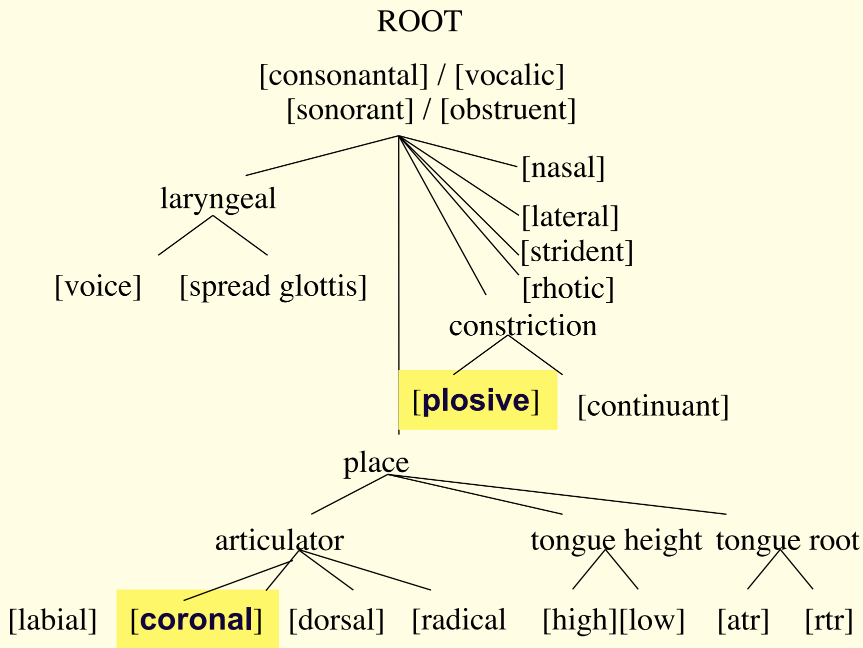
The less specification in the lexicon, the larger the options available:

- ***specific* enough to keep entries distinct**
- ***abstract* enough to allow for recognition**

Our model — FUL (Featurally Underspecified Lexicon) makes claims on two levels:

***What* is represented?**

***How* does the signal map on to the representation**



(Feature tree in FUL, cf. Lahiri & Reetz, 2002, 2010, Journal of Phonetics)

Features & Segments

Vowels & Consonants share the same features
Universally, two features are underspecified, [CORONAL] and [PLOSIVE]

[LABIAL]	labial consonants, rounded vowels
[CORONAL]	front vowels, dental, palatal, palatoalveolar, retroflex consonants
[DORSAL]	back vowels, velar, uvular consonants
[RADICAL]	pharyngealized vowels, glottal, pharyngeal consonants
[HIGH]	high vowels, palatalized consonants, retroflex, velar, palatal, pharyngeal consonants
[LOW]	low vowels, dental, uvular consonants
[ATR]	palatoalveolar consonants
[RTR]	retroflex consonants

How does this work for perception? What features are extracted and how do they match to the representation?

Lahiri & Reetz, 2002, 2010; Lahiri 2012

The FUL model:

Lexical Phonological Representation

- Each contrastive sound (phoneme) has a set of phonological features.
- The phonological representation of each phoneme is abstract such that not all features are present. Underspecification leads to asymmetries.
- Contrasts and asymmetries in representation are reflected in language change and language processing.

Mapping from Signal to Representation

- The perceptual system analyses the signal for rough acoustic features which are transformed into phonological features and mapped directly onto the lexicon.
- A three-way matching procedure (*match*, *mismatch*, *nomismatch*) determines the choice of candidates activated.
- Features from the signal which conflict with the representation *mismatch*, and constrain activation of candidates.

Feature Representation

How does it work?

Asymmetry in place assimilation

green[n] [b]*ook* ⟶ gree[m][b]ook

green[n] [g]*lass* ⟶ gree[ŋ][g]rass

But *crea*[m] [d]*ress* ⟞ *crea[n][d]ress

crea[m] [g]*lass* ⟞ * crea[ŋ][g]lass

signal		 *representation*
/n/ /t/ /d/	[CORONAL]	*underspecified*
/m/ /p/ /b/	[LABIAL]	[LABIAL]
/ŋ/ /k/ /g/	[DORSAL]	[DORSAL]

[CORONAL] extracted from the signal conflicts with the others

[LABIAL] and [DORSAL] extracted from the signal conflicts with each other, but not with unspecified [CORONAL]

Matching process

features from the signal

labial nasal

features, stored in the lexicon

unspecified PLACE **nasal**

***so[m]et**

***green[m] [b]ox**

[m]

no mismatch

/n/

sonnet green

features from the signal

coronal nasal

features, stored in the lexicon

labial **nasal**

ha*[n]*er

crea*[n] [d]*ress

[n]

mismatch

/m/

hammer cream

gree[m], *so*[m]*et* does not mismatch /n/; tolerated as a variant of *green, sonnet*
cree[n], *ha*[n]*er* mismatches /m/; does not activate *cream, hammer.*

Models of word recognition

Storage of all variants experienced by the listeners (exemplars?) *Connine et al; Johnson, Pierrehumbert*

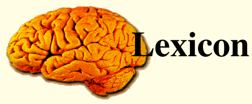
Feature Parsing model: no assimilation is complete; partial assimilated cues help retrieve the intended articulation *Gow*

Context dependent activation - assimilation may be complete; the following context helps retrieve intended articulation *Gaskell et al*

Abstract representation; under-specification is not based on assimilation alone; contrasts determine representations *FUL*

Models of word recognition

What variations can be tolerated or accepted?
Can variations out of context be accepted?



real word	*variant*	Existing Variants	Context dependent	Feature parsing	FUL	
green	gree[m]	√	√	√	√	gree[n]
sonnet	so[n]net	x	x	x	√	so[n]net
neck	[m]eck	x	x	x	√	[n]eck
cream	crea[n]	x	x	x	x	crea[m]
hammer	ha[n]ner	x	x	x	x	ha[m]mer
mouse	[n]ouse	x	x	x	x	mouse

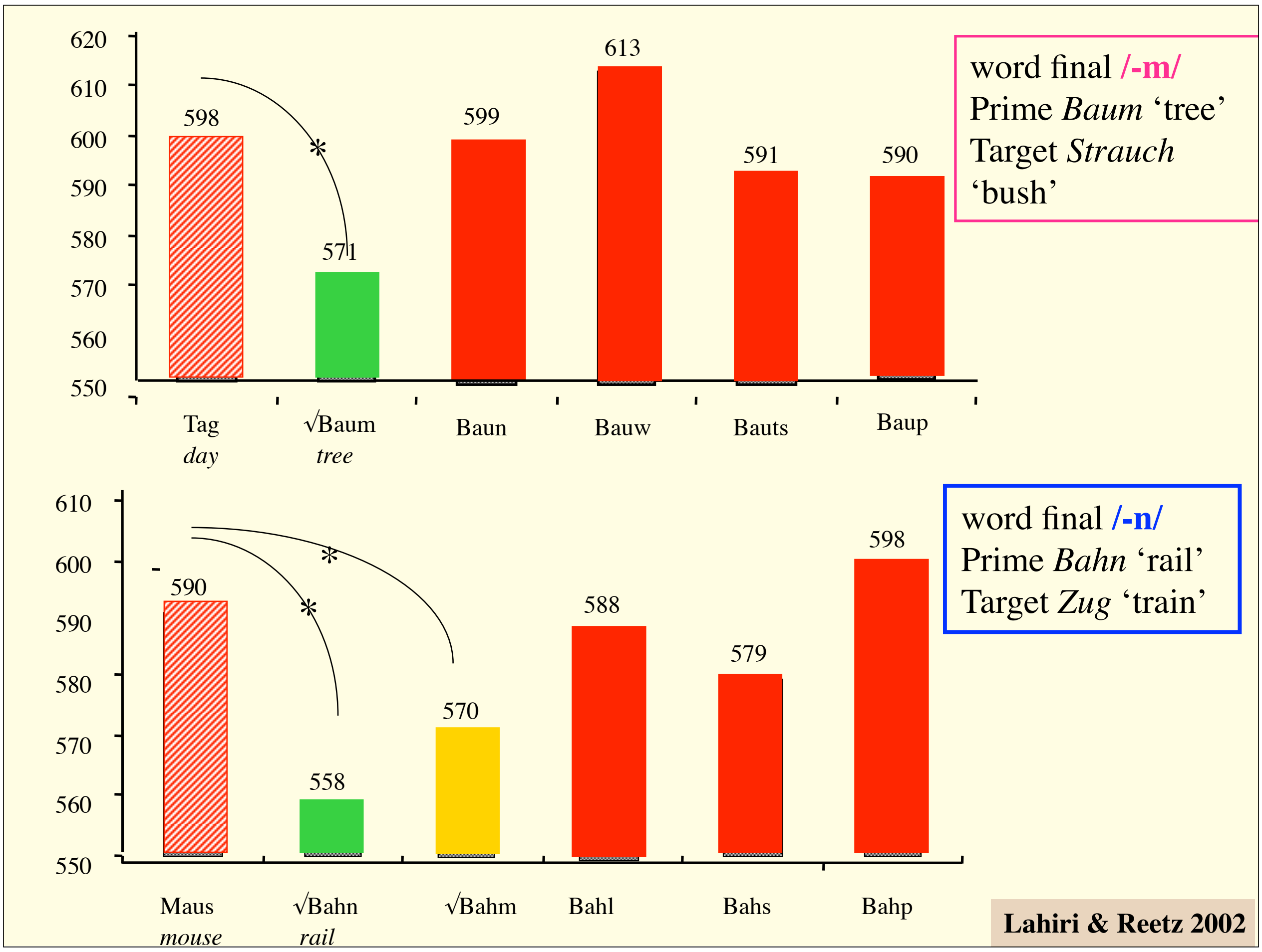
TASK: Lexical decision - word/nonword
*sonnet - *sommet; hammer - *hanner*

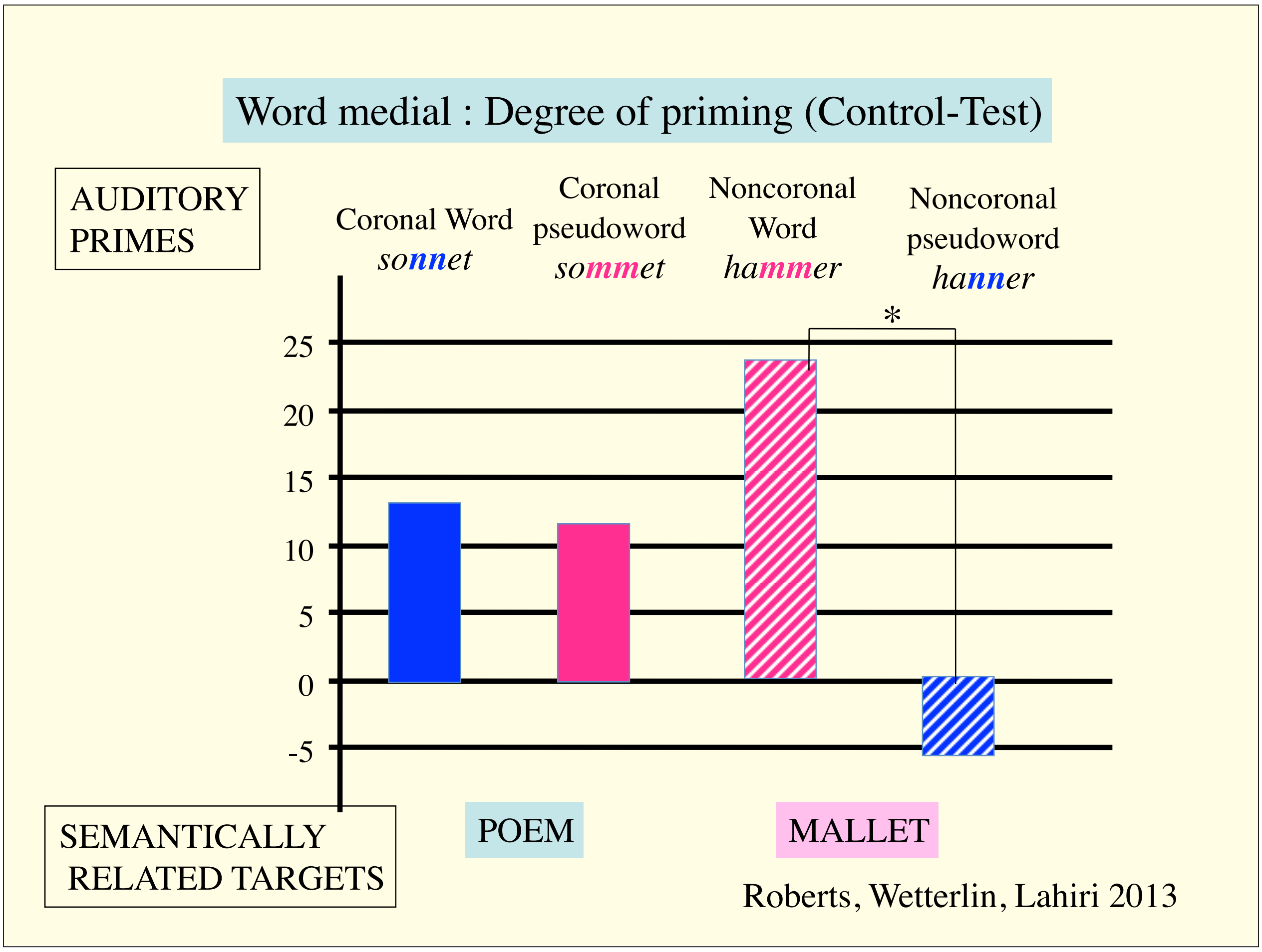
SEMANTIC PRIMING

auditory PRIME	*visual* TARGET	REACTION TIME

TEST
sonnet → **POEM** → **RT 1 FAST**
***sommet** → **POEM** → **RT 1 FAST**
CONTROL
river → **POEM** → **RT 2 SLOW**

TEST
hammer → **MALLET** → **RT 1 FAST**
***hanner** → **MALLET** → **RT 2 SLOW**
CONTROL
billet → **MALLET** → **RT 2 SLOW**


620
610
600
590
580
570
560
550
598
571
599
613
591
590
*
Tag
day
√Baum
tree
Baun
Bauw
Bauts
Baup
word final /-m/
Prime *Baum* 'tree'
Target *Strauch* 'bush'
610
600
590
580
570
560
550
590
558
570
588
579
598
*
*
Maus
mouse
√Bahn
rail
√Bahm
Bahl
Bahs
Bahp
word final /-n/
Prime *Bahn* 'rail'
Target *Zug* 'train'
Lahiri & Reetz 2002


Word medial : Degree of priming (Control-Test)
AUDITORY PRIMES
Coronal Word
sonnet
Coronal pseudoword
sommet
Noncoronal Word
hammer
Noncoronal pseudoword
hanner
*
25
20
15
10
5
0
-5
SEMANTICALLY RELATED TARGETS
POEM
MALLET
Roberts, Wetterlin, Lahiri 2013

Semantic priming : English mispronounced words (ERP of targets)

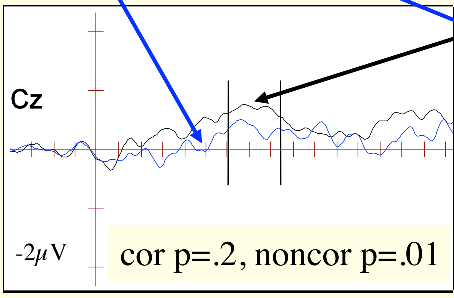
Difference of differences:

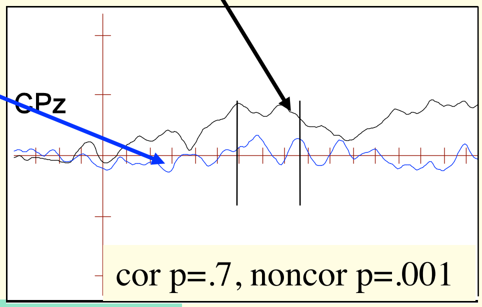
*sonnet & *sommet   POEM   hammer *hanner   MALLET*

*razor & *raver   billet   *birret*

((cntrl-ident corword) - (cntrlnw-cornw)) = expect "flat"

((cntrl-noncorword) - (cntrlnw-noncorword) = enhanced N400





*sonnet & *sommet both accepted as words*
*The brain rejects *hammer as a variant of hammer*

Word onset asymmetries and lexical activation

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CORONAL SETS	NON-CORONAL SETS
matching onset fragment	***matching onset fragment***
non-NONNE	**mons-MONSTER**
dich-DICHTER	**gar-GARTEN**
dam-DAMPFER	**bru-BRUDER**
trau-TRAUBE	**kum-KUMMER**
trich-TRICHTER	**pin-PINSEL**

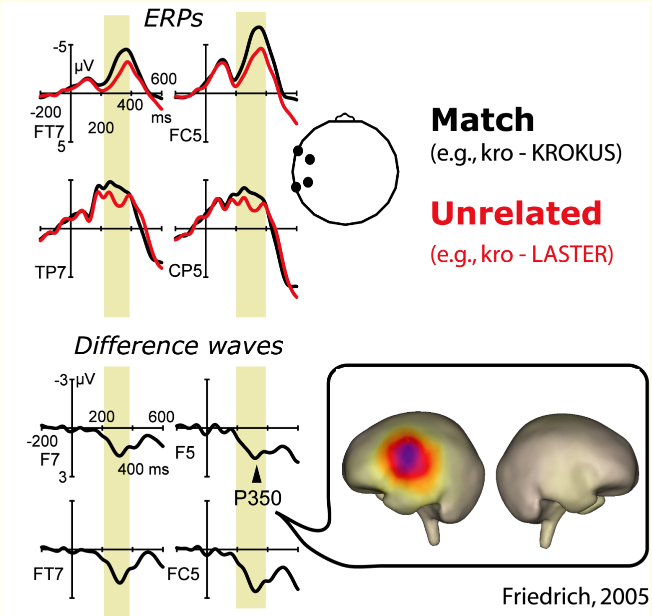
Change initial consonant of fragment

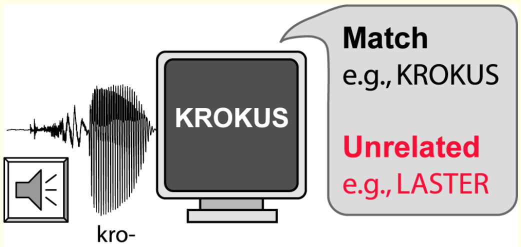
non-conflicting onset fragments	***mismatching onset fragment***
mon-Nonne	**nons-MONSTER**
bich-DICHTER	**dar-GARTEN**
gam-DAMPFER	**dru-BRUDER**
krau-TRAUBE	**tum-KUMMER**
prich-TRICHTER	**tin-PINSEL**

Word onset asymmetries and lexical activation

Word fragment priming

P350 lexical activation effect





P350 = left-hemispheric correlate of lexical activation for matching words

Word onset asymmetries and lexical activation

Task: cross modal lexical decision with *fragment* priming

mon- → MONSTER

non- → NONNE

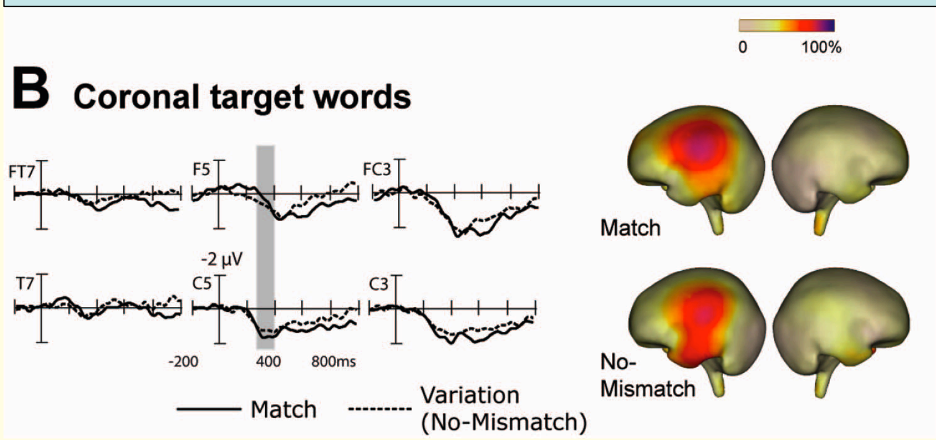
mon- → NONNE

non- —● MONSTER

Friedrich, Lahiri, Eulitz (2008). Neurophysiological evidence … symmetries with … *sychology*, HPP.

Asymmetries in representation is also reflected for word initial stops and nasals

A Non-… Differ…



non-NONNE

mon-NONNE

Consonant & Vowel alternations

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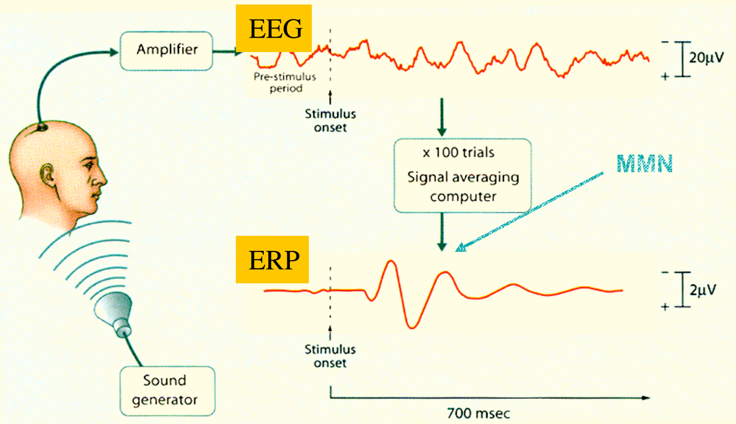
Mismatch Negativity: Basic assumptions

(i) Mismatch Negativity is sensitive to language-specific phoneme representations

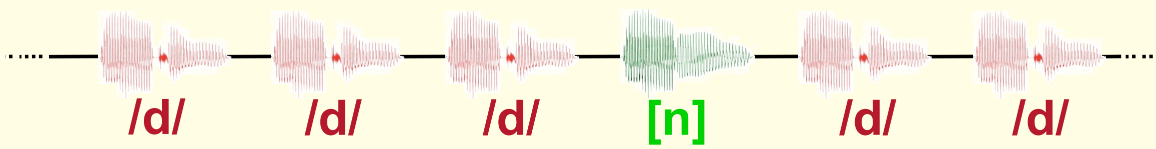
(ii) ***standard stimuli*** create a central sound representation > taps the phonological representation in the mental lexicon **(*underlying representation*)**

(iii) percept created by the ***deviant stimulus*** corresponds in part to the set of phonological features extracted from the **speech signal**

Mismatch Negativity - MMN

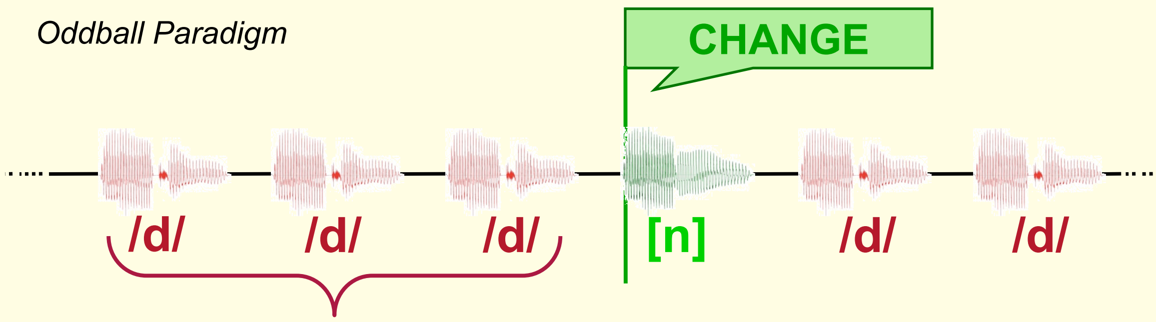


Oddball Paradigm



MMN

Oddball Paradigm



Series of **Standards** build a "central sound representation"
→ ***underlying representation (UR)***

Features from **Deviants** are extracted from the signal

Automatic change detection

Different stages in the extraction and processing of

Acoustic signal

↓

Acoustic/phonological features

↓

- Creating a Central Sound Representation (CSR)
- Detecting changes in the feature set and updating the CSR
- Top-down influence of the mental lexicon

Extraction of phonological Features from the speechsignal
- N100-Component in MEG and EEG

Representation of phonological features in the CSR and the mental lexicon

- Mismatch Negativity (MMN)

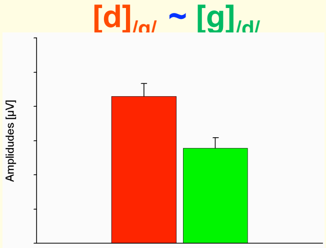
Manner Features: mismatch & tolerance

	Stimuli	[g]	[d]	[n]	[z]
Features in the acoustic signal *(activated from Deviant)*	*place features*	[DORSAL]	[CORONAL]	[CORONAL]	[CORONAL]
	manner features	[PLOSIVE]	[PLOSIVE]	[NASAL]	[STRIDENT]
Features in the mental representation *(activated from Standard)*	*place features*	[DORSAL]	[ ]	[ ]	[ ]
	manner features	[ ]	[ ]	[NASAL]	[STRIDENT]

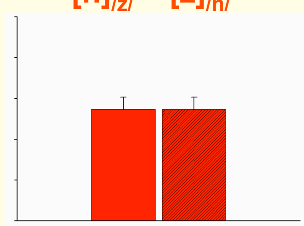
[DORSAL] ~ [CORONAL] | [NASAL] ~ [STRIDENT]

$[d]_{/g/} \sim [g]_{/d/}$ | $[n]_{/z/} \sim [z]_{/n/}$

Hypothesis



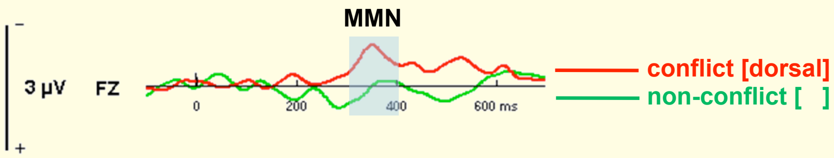
asymmetric MMNs

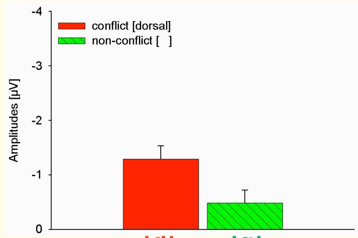

symmetric MMNs

Cornell, Lahiri, Eulitz 2012
Journal of Experimental Psychology, General

Manner Features: conflict & tolerance

Place contrast: [DORSAL] ~ [CORONAL]: $[d]_{/g/}$ ~ $[g]_{/d/}$





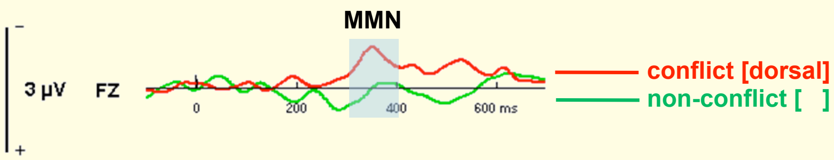
$[d]_{/g/}$ ~ $[g]_{/d/}$

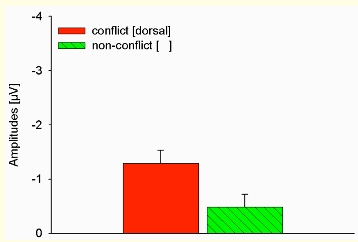
(t (25) = 2.55; $p < .05$)

Cornell, Lahiri, Eulitz 2012, *Journal of Experimental Psychology, General*

Manner Features: conflict & tolerance

Place contrast: [DORSAL] ~ [CORONAL]: $[d]_{/g/}$ ~ $[g]_{/d/}$

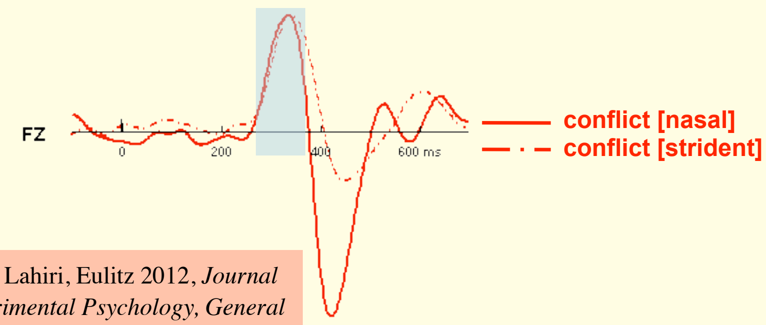


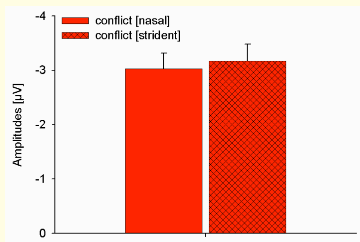


$[d]_{/g/}$ ~ $[g]_{/d/}$

(t (25) = 2.55; $p < .05$)

Manner contrast: [NASAL] ~ [STRIDENT]: $[n]_{/z/}$ ~ $[z]_{/n/}$





$[n]_{/z/}$ ~ $[z]_{/n/}$

(t (25) = -.43; $p > .05$)

Cornell, Lahiri, Eulitz 2012, *Journal of Experimental Psychology, General*

Manner Features within Coronal

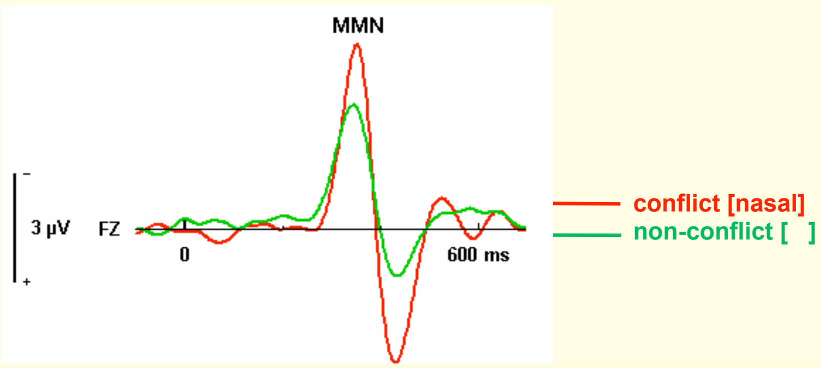
	Stimuli	[g]	[d]	[n]	[z]
Features from the acoustic signal *(from the Deviant)*	*place features*	[DORSAL]	[CORONAL]	[CORONAL]	[CORONAL]
	manner features	[PLOSIVE]	[PLOSIVE]	[NASAL]	[STRIDENT]
Features in the mental representation *(activated from the Standard)*	*place features*	[DORSAL]	[ ]	[ ]	[ ]
	manner features	[ ]	[ ]	[NASAL]	[STRIDENT]

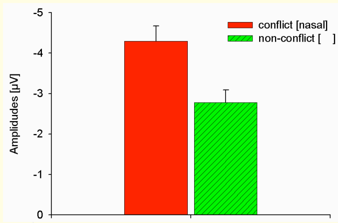
Hypothesis

Manner Contrast	Manner Contrast
[NASAL] ~ [PLOSIVE]	[NASAL] ~ [STRIDENT]
$[n]_{/d/} < [d]_{/n/}$	$[n]_{/z/} = [z]_{/n/}$

Manner Features within Coronal

Manner contrast: [NASAL] ~ [PLOSIVE]: $[n]_{/d/}$ ~ $[d]_{/n/}$





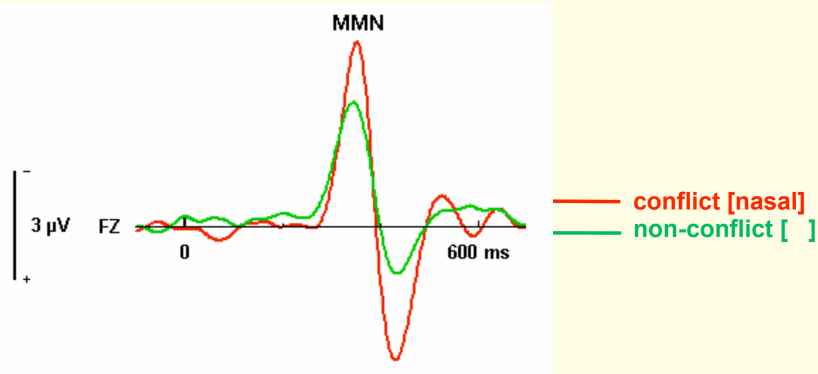
$[d]_{/n/}$ ~ $[n]_{/d/}$

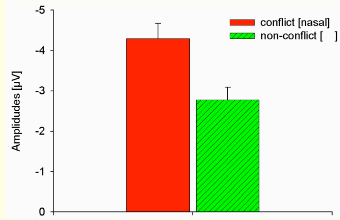
(t (25) = 3.05; p < .05)

Cornell, Lahiri, Eulitz 2012, *JEP General*

Manner Features within Coronal

Manner contrast: [NASAL] ~ [PLOSIVE]: $[n]_{/d/}$ ~ $[d]_{/n/}$

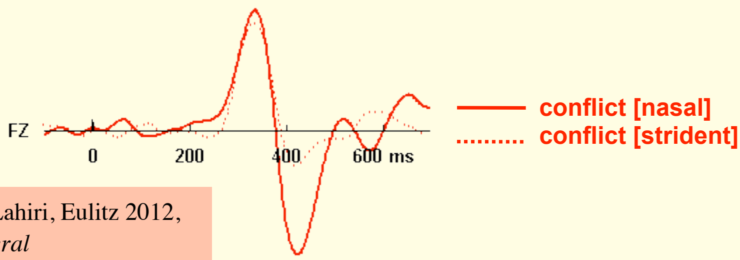


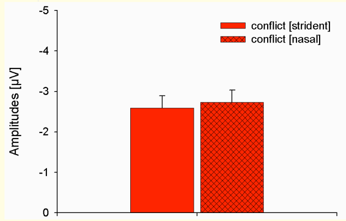


$[d]_{/n/}$ ~ $[n]_{/d/}$

(t (25) = 3.05; p < .05)

Manner contrast: [NASAL] ~ [STRIDENT]: $[n]_{/z/}$ ~ $[z]_{/n/}$





$[n]_{/z/}$ ~ $[z]_{/n/}$

(t (25) = .54; p > .05)

Cornell, Lahiri, Eulitz 2012, *JEP General*

Sound frequencies

Weighted for word frequency, based on token counts of the CELEX corpus.

V[C]V: the *individual* frequency counts for the four consonants in medial position

[eC]V: the phonotactic probablility counts for [en], [ez], [ed] with a following V

CV[C]VC: the frequency counts for /n/, /z/, /d/ and /g/ in an intervocalic position

nonword stimuli	**V[C]V**	**[eC]V**	**CV[C]VC**
eni	2.97	3.12	4.48
edi	0.37	1.12	4.03
ezi	0.91	1.48	4.02
egi	2.48	0.26	4.26

Our results	MMN predictions based on frequencies		
$[n]_{/d/} < [d]_{/n/}$	$[n]_{/d/} > [d]_{/n/}$	$[n]_{/d/} > [d]_{/n/}$	$[n]_{/d/} > [d]_{/n/}$
$[n]_{/z} = [z]_{/n/}$	$[n]_{/z} > [z]_{/n/}$	$[n]_{/z} > [z]_{/n/}$	$[n]_{/z} > [z]_{/n/}$
$[n]_{/g/} < [g]_{/n/}$	$[n]_{/g/} > [g]_{/n/}$	$[n]_{/g/} > [g]_{/n/}$	$[n]_{/g/} > [g]_{/n/}$

Sound frequencies

Our findings cannot be explained by individual sound frequency effects of our stimuli.

The intervocalic frequency (V[C]V) turns out to be highest for [n], slightly lower for [g] and lowest for [z]. Again, one could argue that a high frequency deviant would elicit a higher MMN response; however, in our results the MMN amplitude of the deviant [d] compared to the standard /n/ is increased compared to the reversed condition.

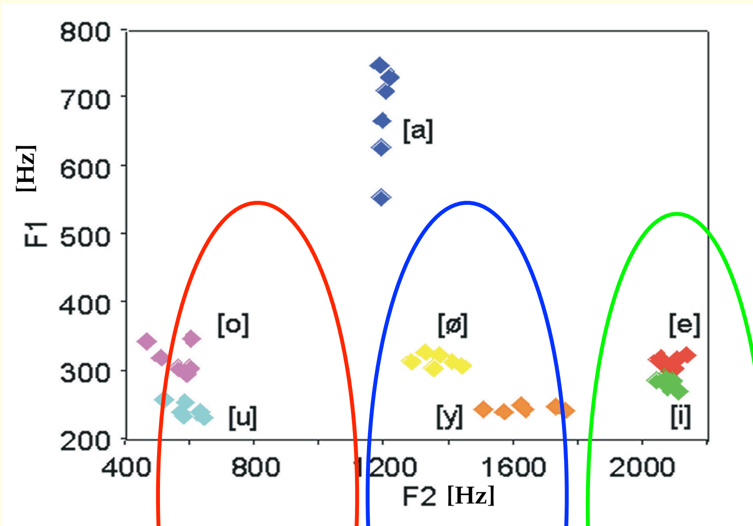
Additionally, the largest sound frequency difference is between [n] and [z], but here we find equal MMN amplitudes. These results show a pattern which cannot be explained by frequency effects, nor phonotactic probability influences.

CELEX lexical database (Baayen, Piepenbrock & Gulikers, 1995)

Vowel alternations

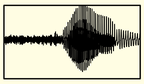
UNIVERSITY OF OXFORD

German vowels *acoustics & representation*



features in the signal	[DORSAL]	[CORONAL] [LABIAL]	[COR]
features in the mental representation	[DORSAL] [LABIAL]	[ ] [LAB]	[ ]

Vowel alternations



Lexicon

‘Deviant’
= signal

‘standard’ stimuli (repeated)
= TAPS LEXICAL REPRESENTATION

[DORSAL] [o] → [-----] /e//ø/

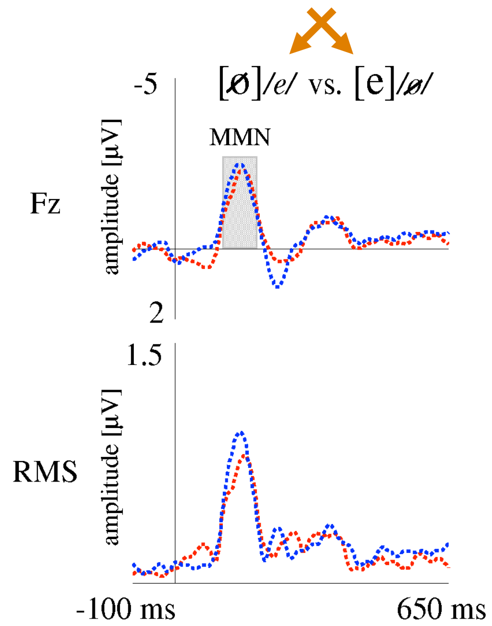
[CORONAL] [e] [ø] ⊣ [DORSAL] /o/

mismatch

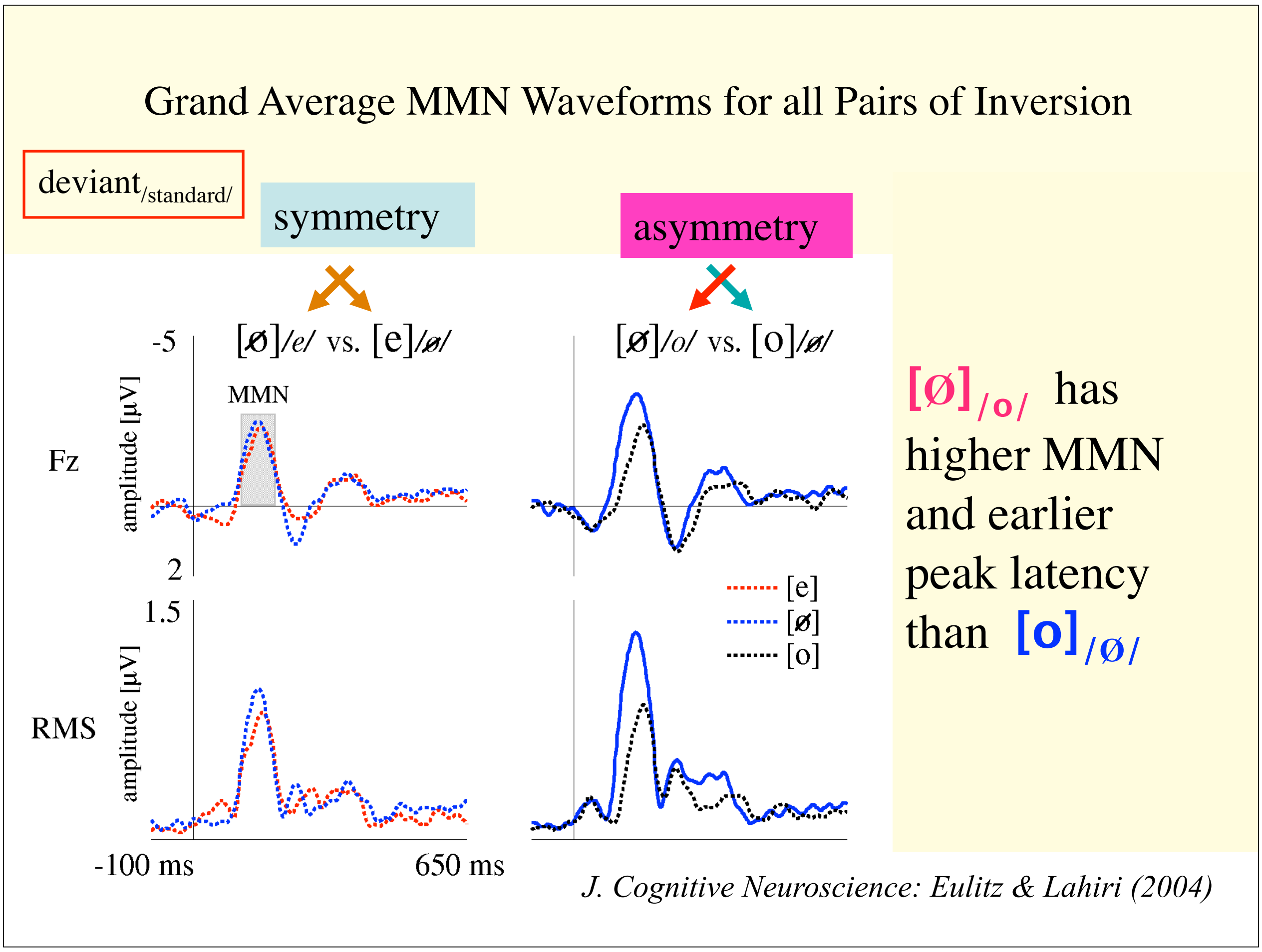
Grand Average MMN Waveforms for all Pairs of Inversion

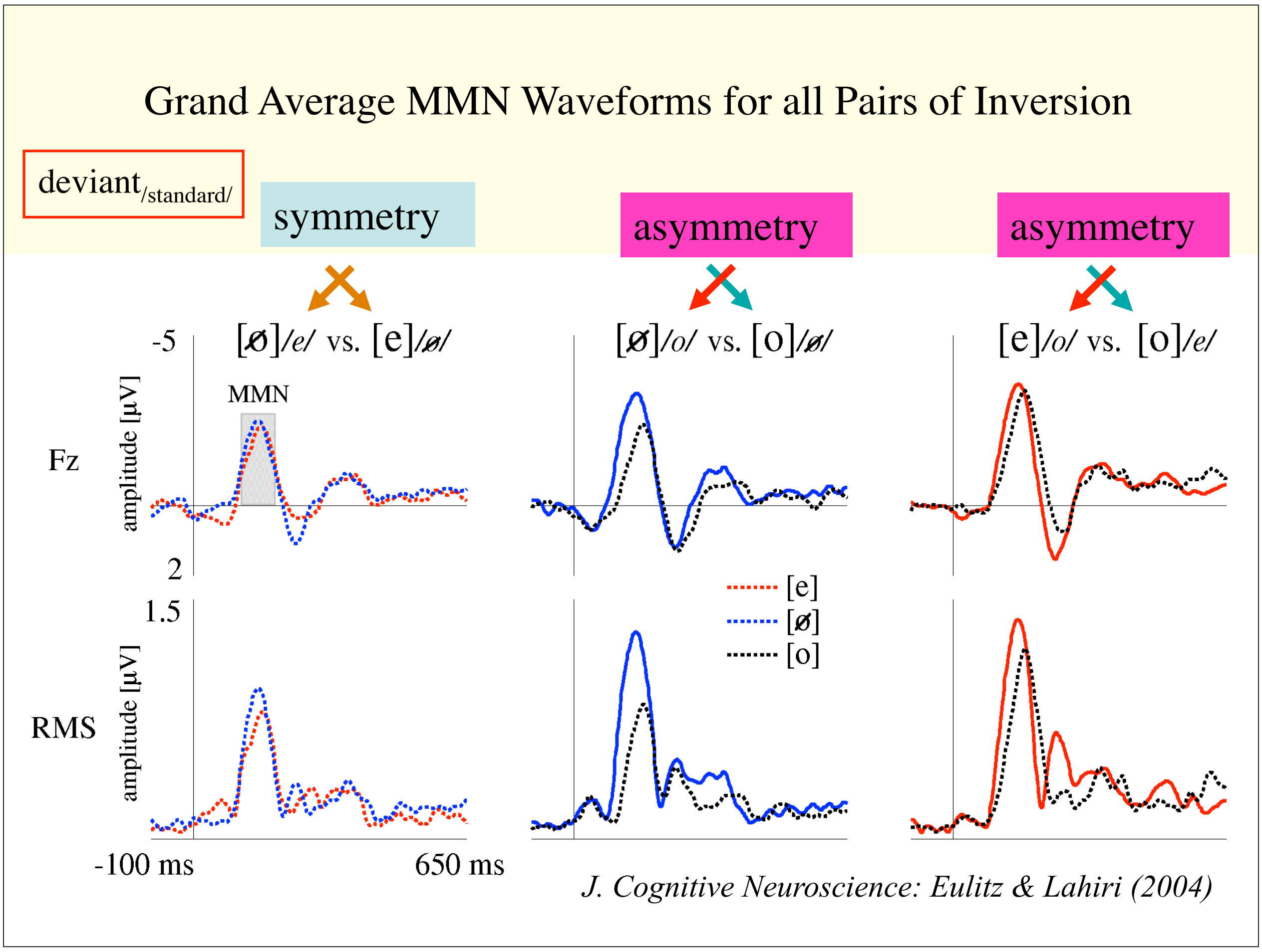
deviant$_{/standard/}$

symmetry



J. Cognitive Neuroscience: Eulitz & Lahiri (2004)


Grand Average MMN Waveforms for all Pairs of Inversion
deviant/standard/
symmetry
asymmetry
[ø]/e/ vs. [e]/ø/
[ø]/o/ vs. [o]/ø/
-5
2
MMN
Fz
amplitude [µV]
1.5
RMS
[e]
[ø]
[o]
-100 ms
650 ms
[ø]/o/ has higher MMN and earlier peak latency than [o]/ø/
J. Cognitive Neuroscience: Eulitz & Lahiri (2004)


Grand Average MMN Waveforms for all Pairs of Inversion
deviant/standard/
symmetry
asymmetry
asymmetry
[ø]/e/ vs. [e]/ø/
[ø]/o/ vs. [o]/ø/
[e]/o/ vs. [o]/e/
-5
2
MMN
Fz
amplitude [µV]
1.5
RMS
[e]
[ø]
[o]
-100 ms
650 ms
J. Cognitive Neuroscience: Eulitz & Lahiri (2004)

WORDS & their variants and asymmetries

LONG vs. SHORT

- Half of the world's languages have a long-short consonantal contrast
- The timing contrast in languages is usually binary - long vs. short
- Underlying geminates are represented by a single set of features and a single release
- Medial geminates invariably belong to two syllables;

```
 σ   σ       σ   σ
 | \ /       |   |
p a  t:a    p a  t a
```

- Lexical geminates cannot be separated by vowels and are never treated as two separate entities which undergo separate phonological processes
- Primary acoustic cue is closure/consonant duration (cf. for a summary Ridouane 2010)

Questions & Hypotheses

How do we distinguish between long an short?

Is a mispronunciation based on durational information still accepted as the corresponding real word?

(A) No mispronunciations with durational changes are accepted

(B) All mispronunciations are accepted provided only durational information is changed

(C) We can see a difference between **long > short** and **short > long** changes in terms of lexical access

Hypothesis: Long subsumes short (when you hear a long consonant, the short is already activated); short is not enough to identify long.

Length distinctions in Bengali

- Extensive consonantal inventory:
  - 16 stops, 4 affricates, 3 nasals & 2 liquids over 5 places of articulation
  - all consonants contrast in length word medially
- Examples
  - *pata* 'leaf' vs. *pat:a* 'whereabouts, location'
  - *kana* 'blind' vs. *kan:a* 'tears'
  - *kor-to* 'do.3p.past' > *kot:o* = geminate through assimilation
- Predominant acoustic cue for gemination is consonant (closure) duration (Lahiri & Hankamer 1988; Hankamer et al. 1989, Ridouane 2010)

Gemination in Bengali

- Gemination occurs naturally in Bengali in assimilation and other phenomena

Assimilation:

- *mar-tam* > *mat:am* (beat-1P.PAST) – *mar-a* (beat-INF)
- *bɔr-di* (*bɔro* 'big' & *didi* 'sister') > *bɔd:i*

Concatenation:

- *k^{h}el-lam* > *k^{h}el:am* (play-1P.PAST) **k^{h}elam (k^{h}e-lam > k^{h}elam)*

➔ no degemination processes

➔ short > long is a common feature of the language

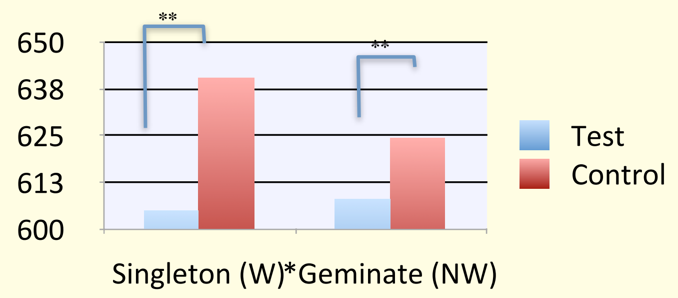
Stimuli

Experiment	Prime	Target
Semantic Priming (short – long)	*ʃona* ‘gold’ **ʃon:a*	*rupo* ‘silver’ রুপো
Semantic Priming (long – short)	**ʃuno* *ʃun:o* ‘zero’	*khali* ‘nothing’ খালি

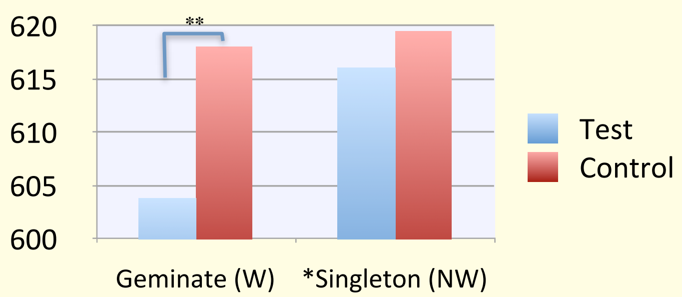
➔ Average length for singleton (**89ms**) & geminate (**207ms**)

➔ Difference in length between CVC & CVC_V fragments: **17ms**

Semantic Priming results



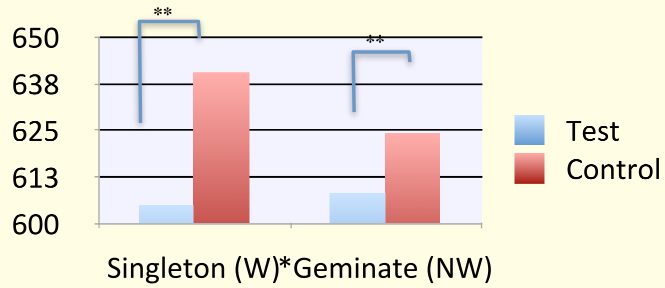
SHORT - LONG
Same amount of facilitation for both singleton (W) and geminate (NW) primes
➔Geminate (NW) prime leads to lexical access

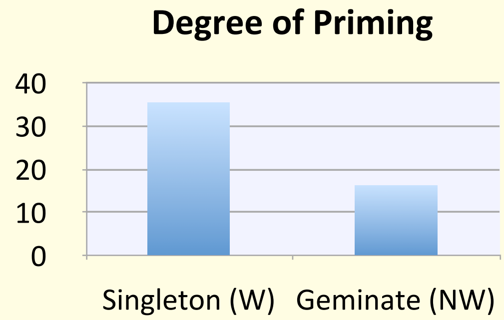


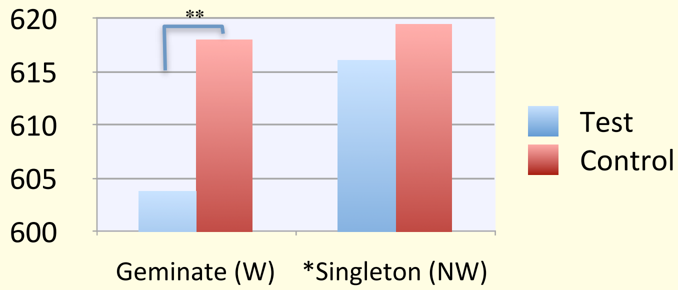
LONG - SHORT
Facilitation effect only for geminate (W) primes

➔Singleton (NW) prime **does not** activate geminate word

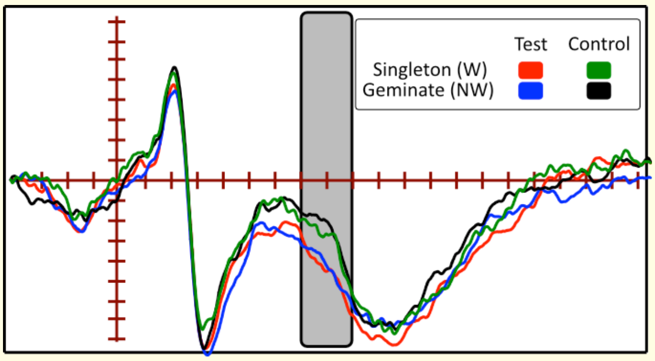
Semantic Priming results





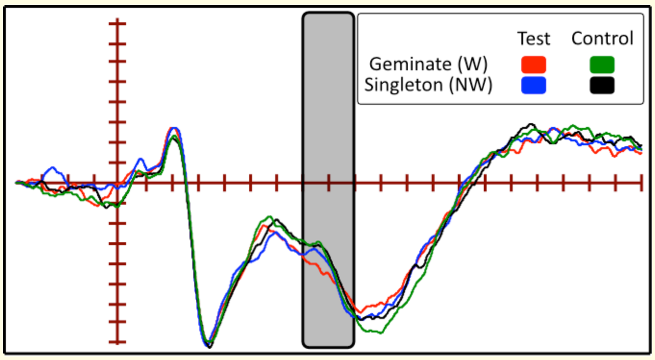


Semantic Priming ERPs



SHORT - LONG

Equal N400 response for singleton (W) and geminate (NW) primes
➔ Geminate (NW) prime leads to lexical access



LONG - SHORT

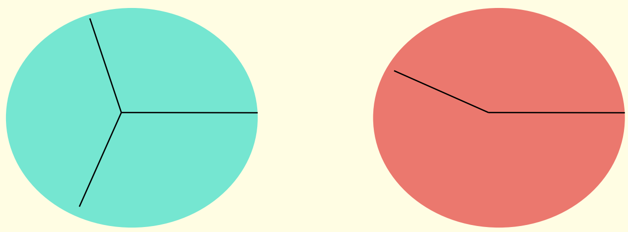
Singleton (NW) prime has significantly higher N400 than geminate (W) prime

➔ Singleton (NW) prime **behaves like the controls**

Summing up

- Facilitation of lexical access occurs when singletons are replaced with geminates but not when geminates are shortened to singletons
- Longer (mispronounced) geminates subsume singleton words, but not the other way around.

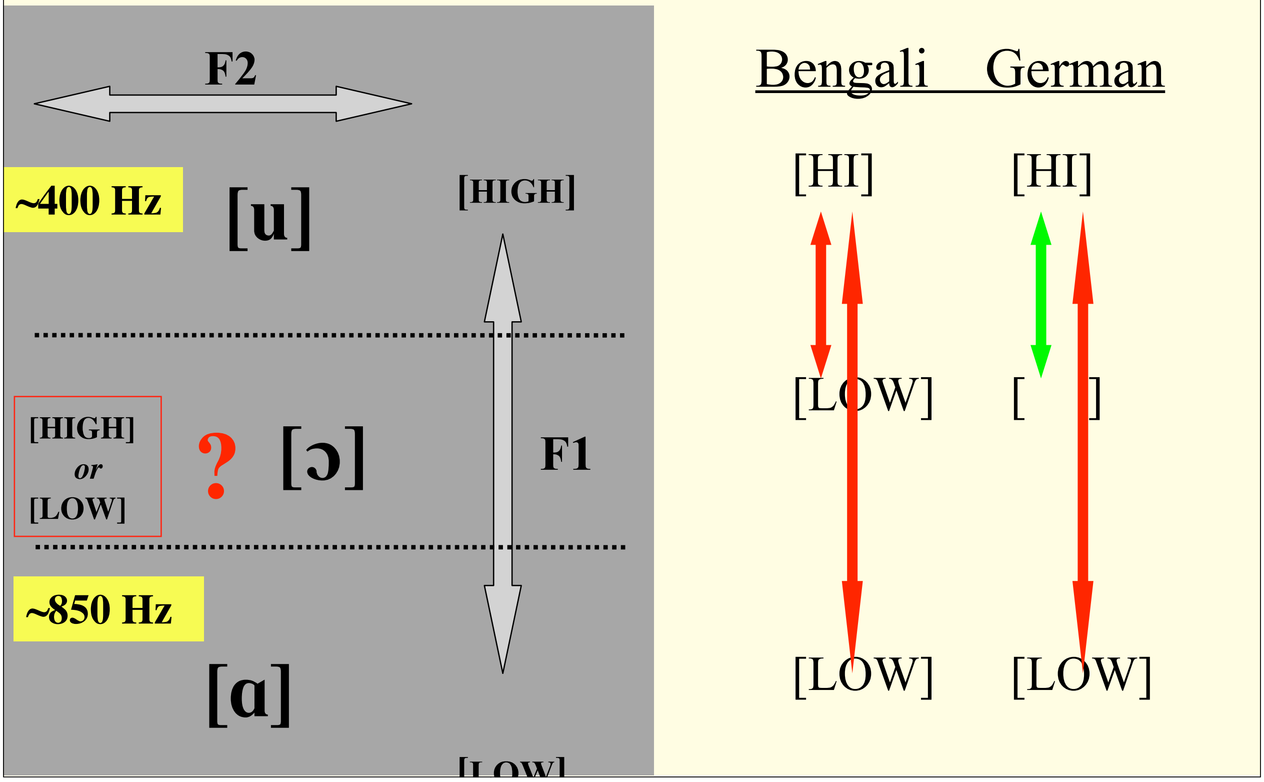
Cutting the cake differently... asymmetry in representation, symmetry in acoustics



same sound, different phonological representation

•One candidate for comparison is Bengali vs. German [ɔ].

Specification for HEIGHT



Bengali Vowels

3 PERS	1 PERS	
$\mathrm{p^h}$æl-e	$\mathrm{p^h}$el-i	throw
$\mathrm{p^h}$er-e	$\mathrm{p^h}$ir-i	return
bɔl-e	bol-i	say
gol-e	gul-i	stir

imperative	participle	
$\mathrm{p^h}$æl	$\mathrm{p^h}$el-etʃe	throw
$\mathrm{p^h}$er	$\mathrm{p^h}$ir-etʃe	return
bɔl	bol-etʃe	say
gol	gul-etʃe	stir
mɑr	mer-etʃe	beat

	DORSAL	CORONAL
HIGH	u	i
	o	e
LOW	ɔ	æ
	ɑ	

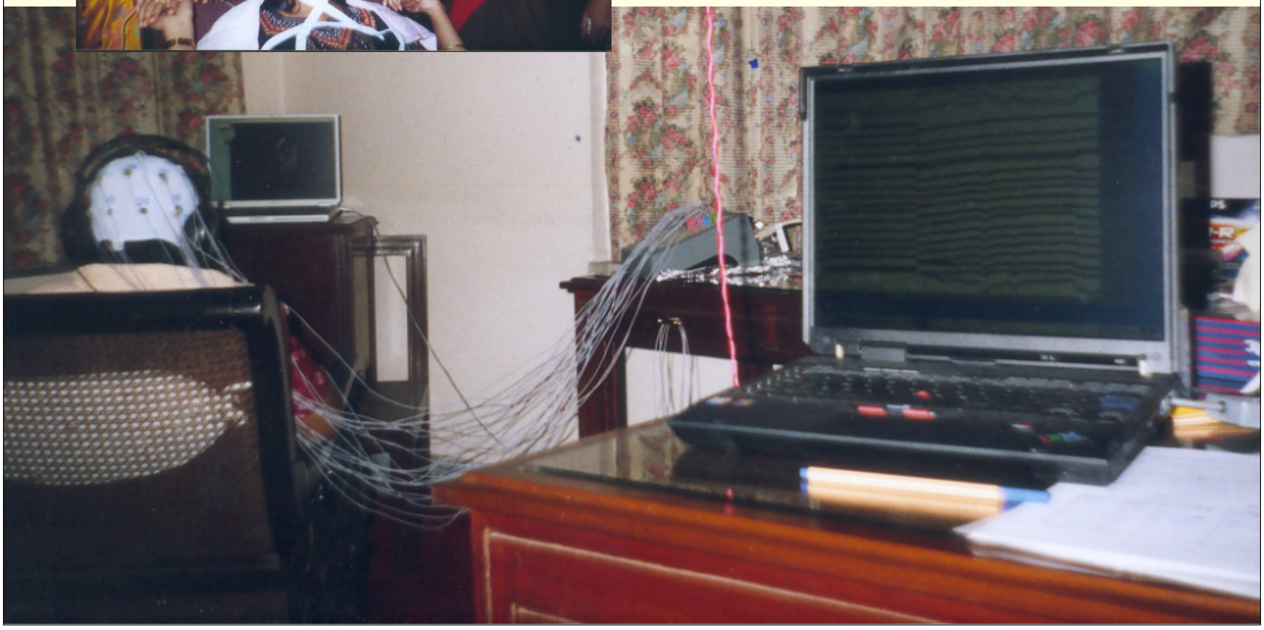
German (relevant vowels)

	DORSAL		CORONAL
HIGH	u		i
	o	ɔ	e
LOW	ɑ		

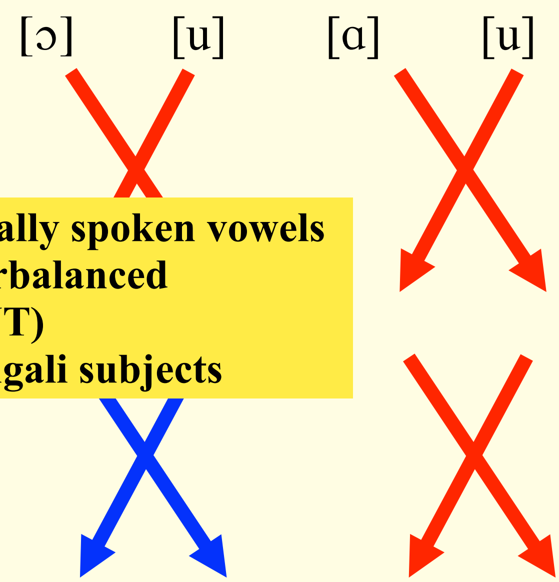
/ɔ/ patterns with /æ/ which groups with /ɑ/ : a piece of evidence for specifying both [LOW]

Lahiri 2000

Mobile EEG-Lab *in* Calcutta



Summary of predictions



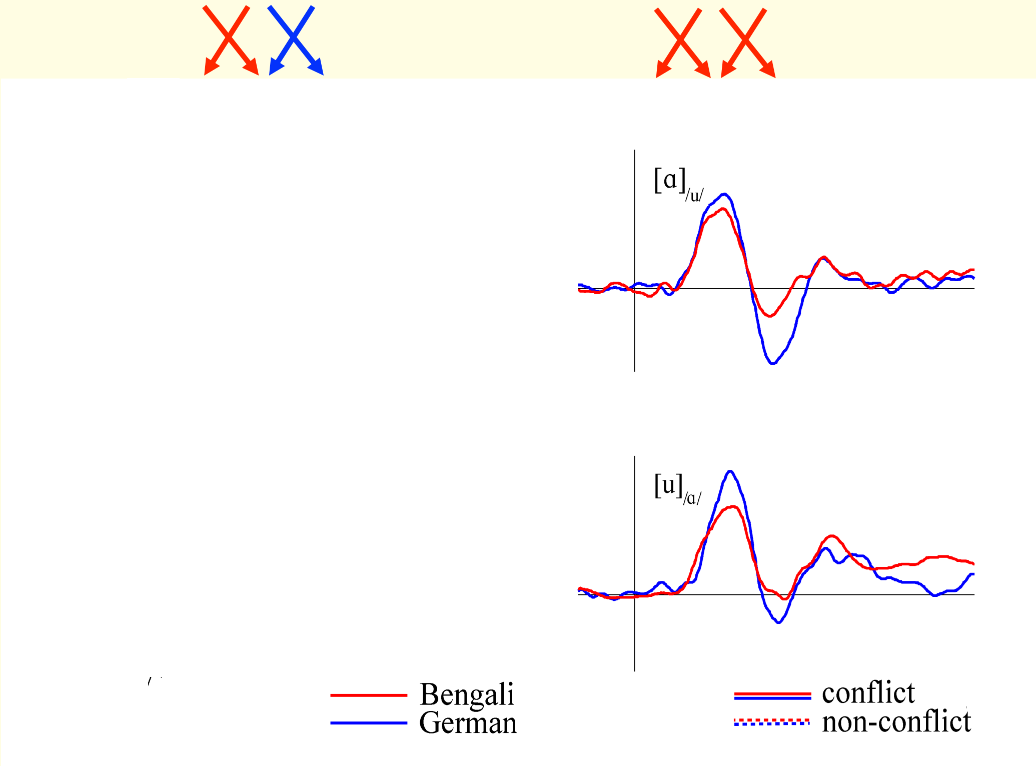
Bengali

- 4 exemplars of naturally spoken vowels
- order of runs counterbalanced
- 21-channel EEG (ANT)
- 14 German & 14 Bengali subjects

German

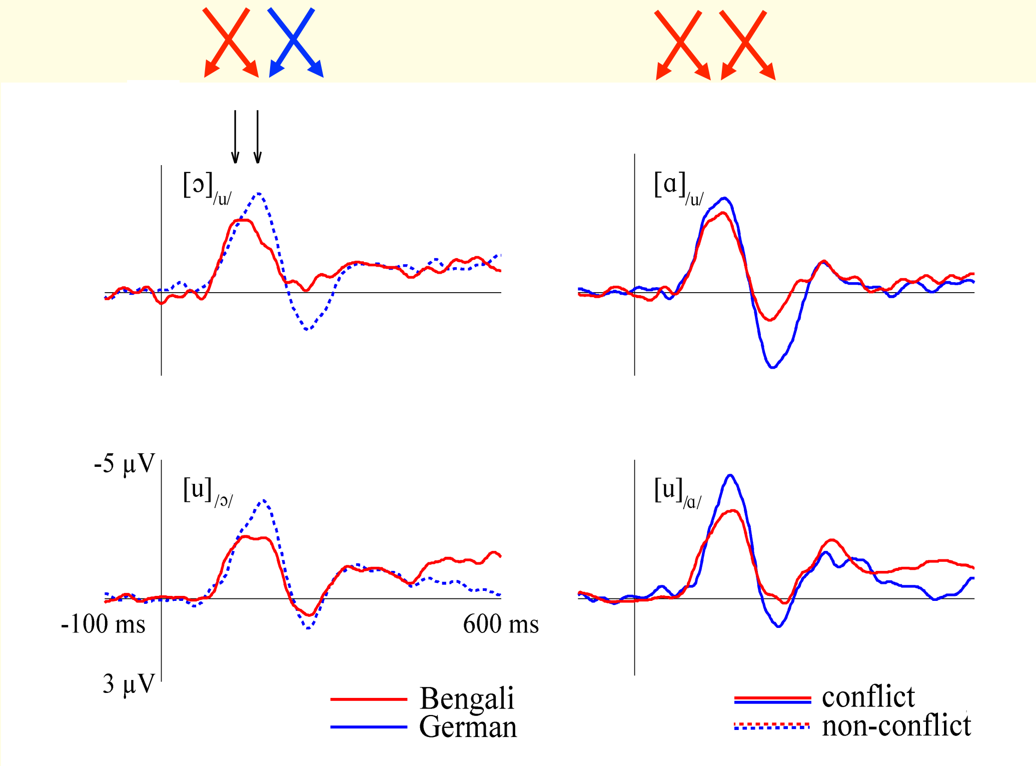
MMN-Latency for $[ɔ]_{/u/}$ and $[u]_{/ɔ/}$: Bengali < German

MMN-waveforms (Bengali and German)



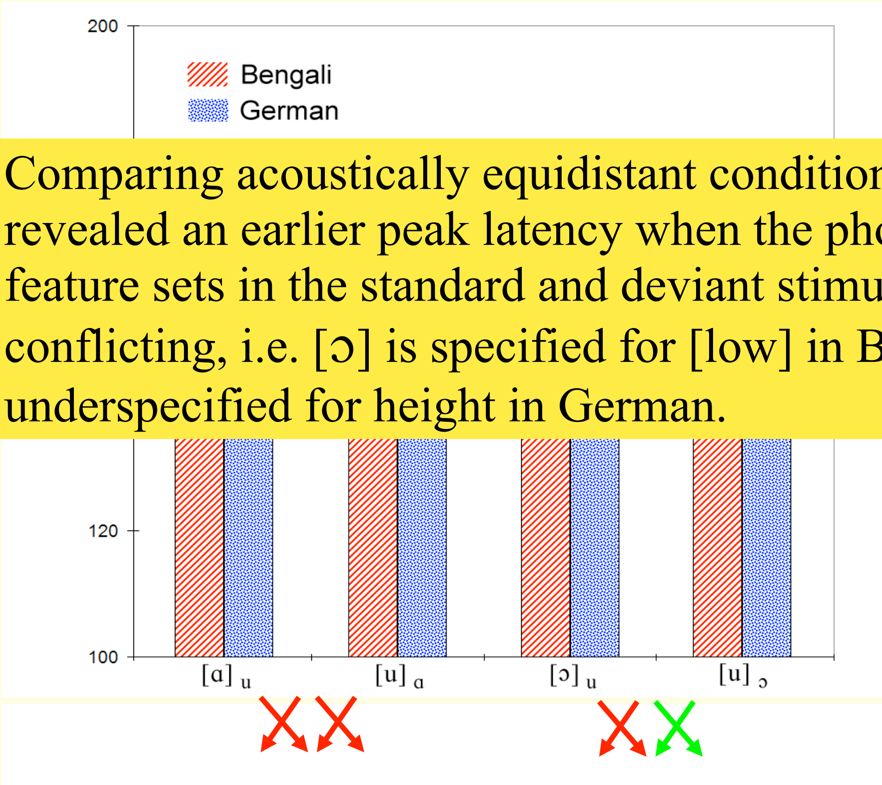
Eulitz, Lahiri (2004); in preparation

MMN-waveforms (Bengali and German)



Eulitz et al. in preparation

Summary of MMN-latencies



Group x Contrast Interaction:

*

Comparing acoustically equidistant conditions, the MMN revealed an earlier peak latency when the phonological feature sets in the standard and deviant stimuli were conflicting, i.e. [ɔ] is specified for [low] in Bengali and underspecified for height in German.

WORDS & their variants

Surface and underlying representations are not necessarily isomorphic; nor are the interfaces straightforward, between

phonology-syntax
morphology-phonology
phonology-phonetics

Despite this human brains are able to deal with the variation, complexity and asymmetry very efficiently.

Our research attempts to use different techniques and takes into account different pieces of evidence to understand *how* variation can be resolved.

We hope to have shown that not all surface complexities are directly represented in the brain for comprehension.