

# Perception of **-non-native-** voiceless fricatives

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# Overview

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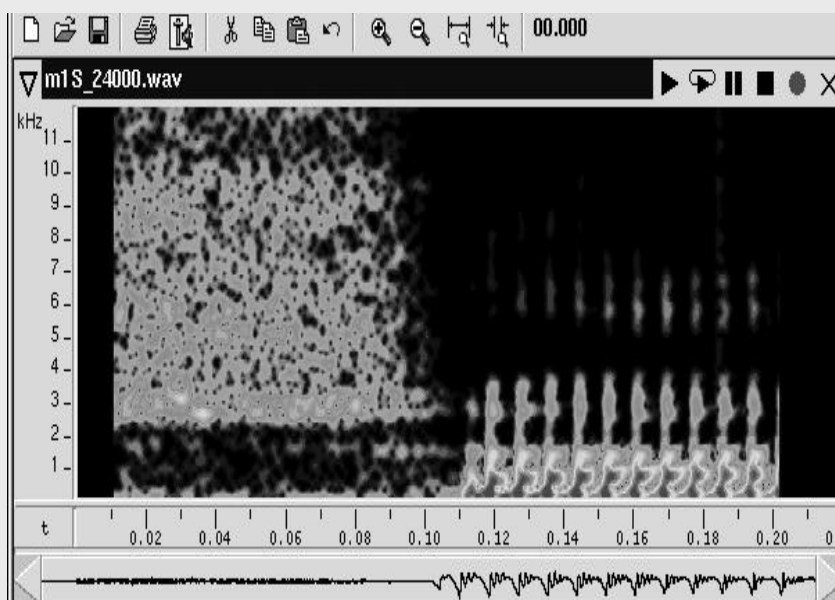
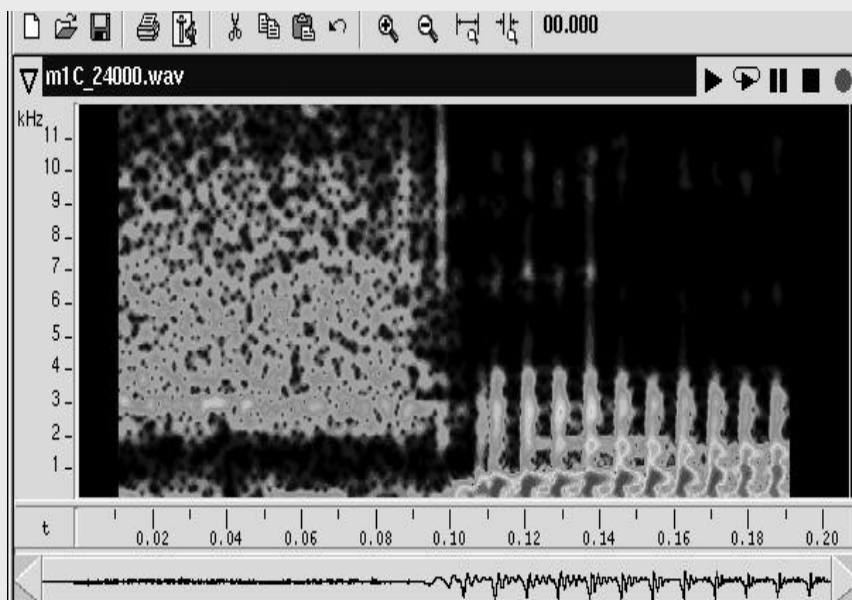
# 1. Perception of non-native speech sounds

- Language-specific phonetic perception starts early (Werker & Tees 1984, Tsao et al. 2000)  
and modifies speech perception abilities to native language contrasts (Kuhl 2000)
- ➔ Native phonology functions like perceptual a „sieve“ (Trubetzkoy 1939)
- Most difficulties exist with non-native speech sounds that are phonemic in the second language but allophonic in the native language (e.g. Takagi 2002)

... for example the two Polish phonemes:

palato-alveolar voiceless  
fricative /C/

postalveolar voiceless  
fricative /S/



... but perceptual abilities are not lost:

● language-independent phonetic perception exists

(Werker 1994, Beddor & Strange 1982, Best et al. 1988, Bohn 1995)

● enhancing acoustic cues enables phonetic learning

(Hazan & Simpson, in press, Jamieson & Morosan 1986, McCandliss et al. 2002)

## 2. The case of fricatives

- Less categorical perception  
(Liberman et al. 1967, Healy & Repp 1982, Repp 1984)
- Center-portion perceptually more relevant than transitions  
(Manrique & Massone 1981, LaRiviere et al. 1975, Harris 1958)
  - **Observation: duration of fricatives**  
(Gordon et al., in press)
- variations within a fricative category can be perceived
- Noise similarity
  - general auditory perception may aid perception of difficult non-native fricatives  
(cf. Best et al. 1988, Best 1995)
- **Acoustic salience despite native language influence?**

### 3. Comparing the perception of Polish fricatives, German allophonic fricatives and German phonemic fricatives

Acoustic salience and phonological categories

➔ /S-C/ - a „difficult“ Polish contrast

➔ /c-x/ - a German allophonic contrast

➔ /s-S/ - a German phonemic contrast

# 4. Acoustic investigation:

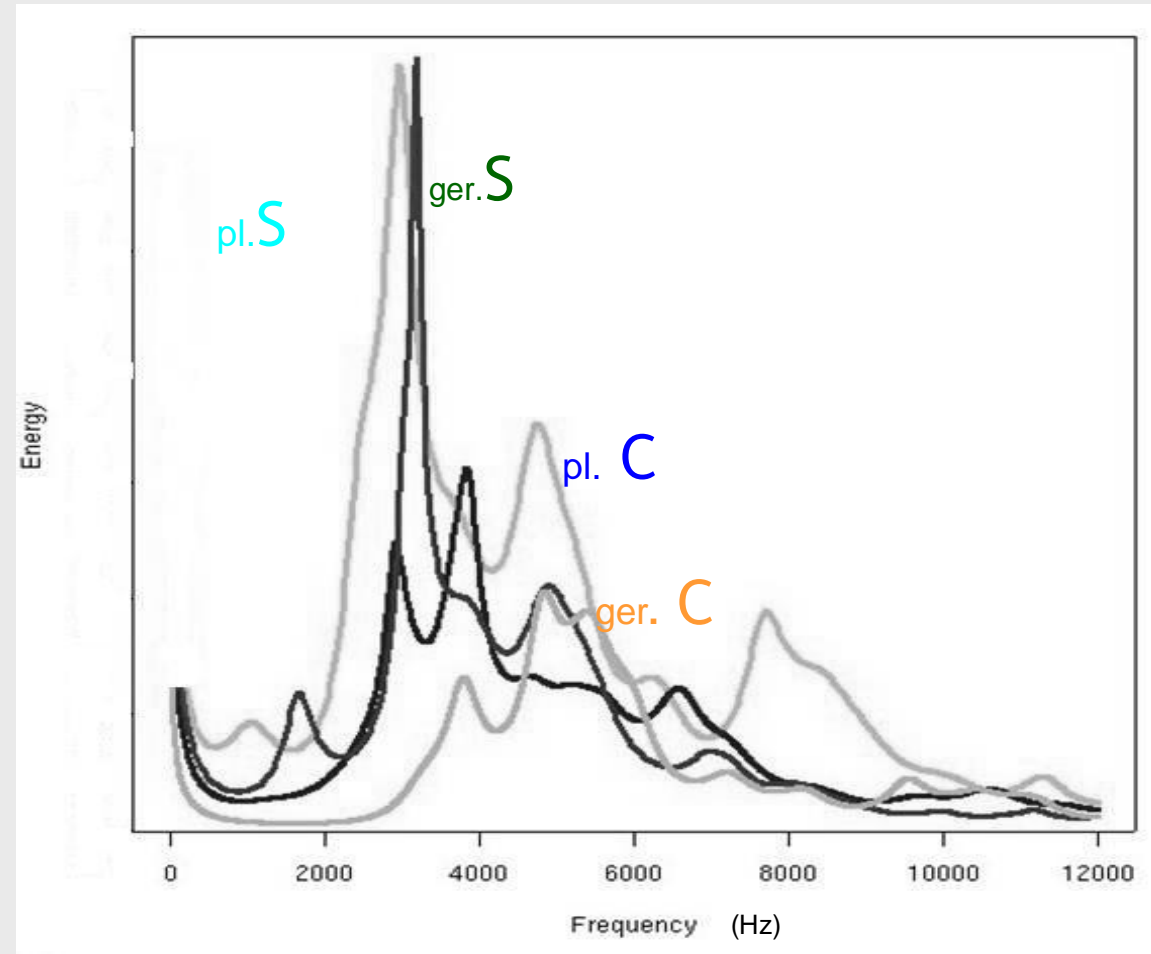
## Spectra of German /S,c/ and Polish /S, C/

Differences:

Frequency of main peak  
poles and zeroes

Overall shape

- Polish /C/ is a new category for German listeners
- Polish /C/ may be perceptually assimilated to German /S/ or /c/



LPC-spectra: Fs-range: 0-12kHz; method: autocorrelation; order: 26; window: Hanning; stepsize: 0.01sec.  
Spectra are averaged over 9 realizations each of 6 male Polish and 6 male German speakers for /S, C, s/ and 9 realizations each of 6 male German speakers for /c-x/

# Measuring the shape of fricative-spectra:

**Mean** = center of gravity

$\{f_1(p_1) + \dots + f_i(p_i)\} \rightarrow$  **Significance: ger.,pl. 0.000**

**Median**= point at which 50% of energy has passed

$\rightarrow$  **Significance: ger.,pl. 0.000**

**Symmetry**= displacement from center of gravity

$\{[(f_1 - \text{Mean})^3]p(1) + \dots + [(f_i - \text{Mean})^3]p(i)\} / \text{S.D.}^{1.5} \rightarrow$  **Significance: ger. 0.016, pl. 0.122**

**Peakedness**= shape in relation to Gaussian distribution

$\{[(f_1 - \text{Mean})^4]p(1) + \dots + [(f_i - \text{Mean})^4]p(i)\} / \text{Var}^{2.3} \rightarrow$  **Significance: ger.,pl. 0.000**

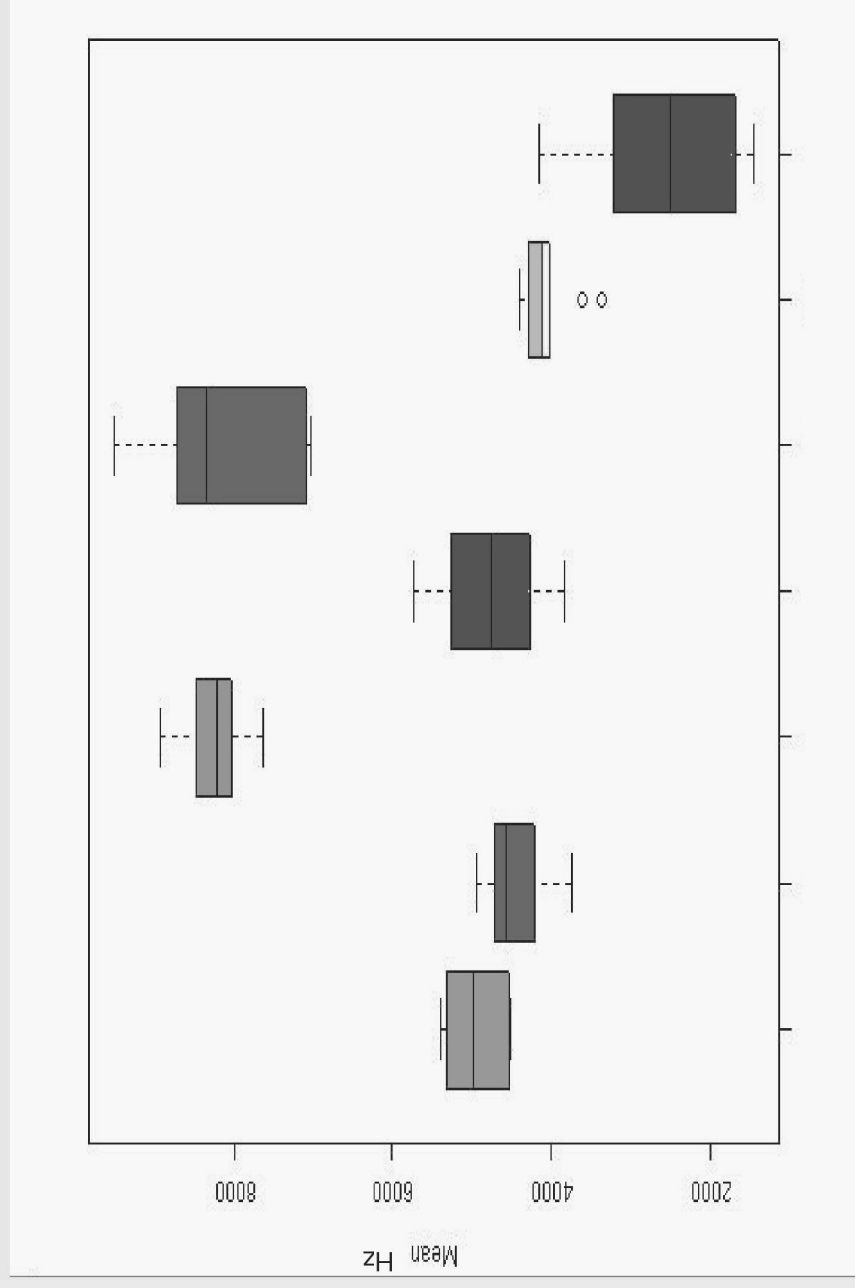
(Mathies et al. 1994, Forrest et al. 1992, Wokurek 2003)

Measurements were averaged over center-portion of fricative; calculated to 512 point FFTs; sample-rate=24kHz

# Example: distribution of spectral means

→ German /s, c/  
very close to  
Polish /C/

→ Variability  
for German  
allophones



ger./c/ pl./C/ ger./s/ pl./s/ ger./S/ pl./S/ ger./x/ pl./x/

## Possible perceptual confusions: combined z-scores for spectral measures

polish \ german	S	s	C	X
S	2.34	11.49	<b>2.27</b>	5.2
s	6.14	0.67	5.61	16.53
C	<b>1.23</b>	10.98	<b>1.65</b>	8.67

→ probable cases of perceptual confusion:

Polish /C/ to German /S/

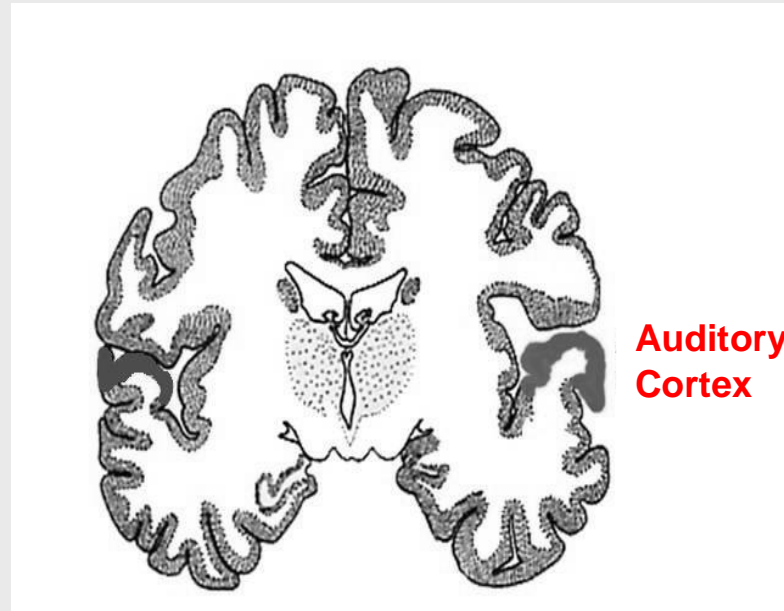
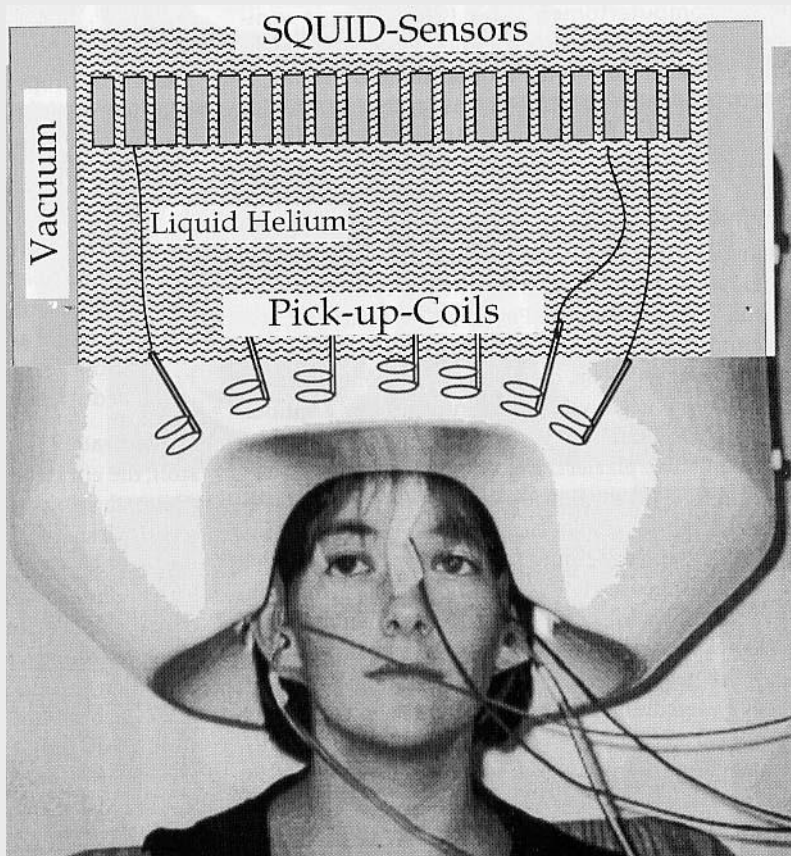
Polish /C to German /S/

-----  
combined z-score for German /c-x/ difference:

**2.56**

# 5. Testing the perception of voiceless fricatives using Magnetoencephalography

MEG measures magnetic fields on the surface of the scalp

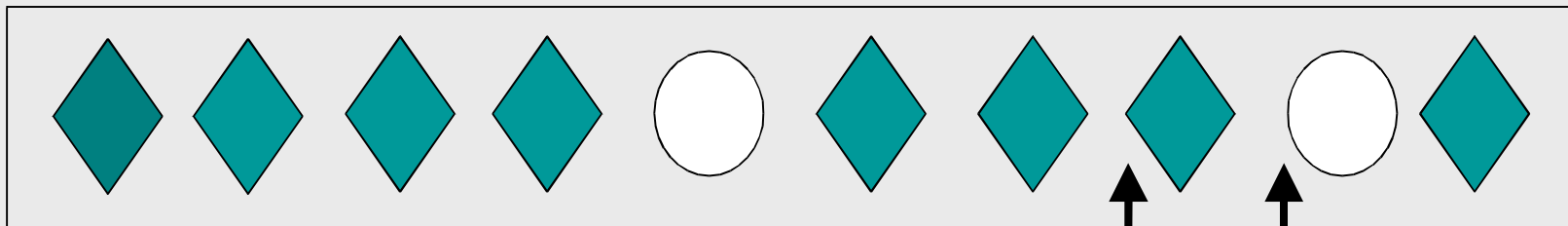


to detect language-  
representations  
in Auditory Cortex

Birbaumer & Schmidt 2003

# MEG-Setup:

Oddball-Design:



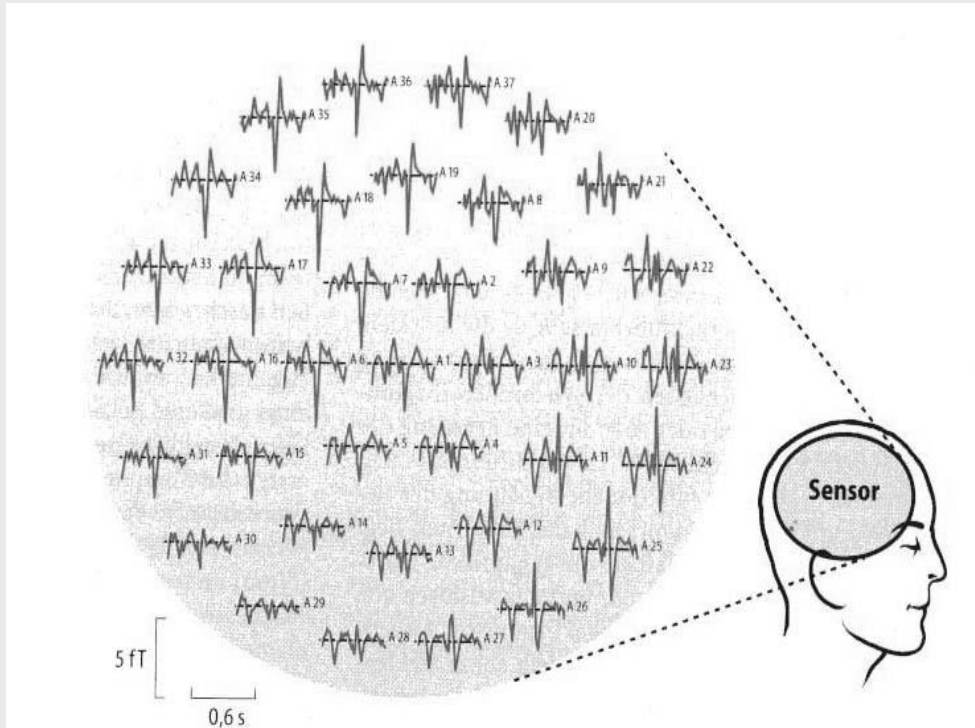
Standard: 90%

Deviant: 10%

ISI: 750ms  
(60ms-10s)

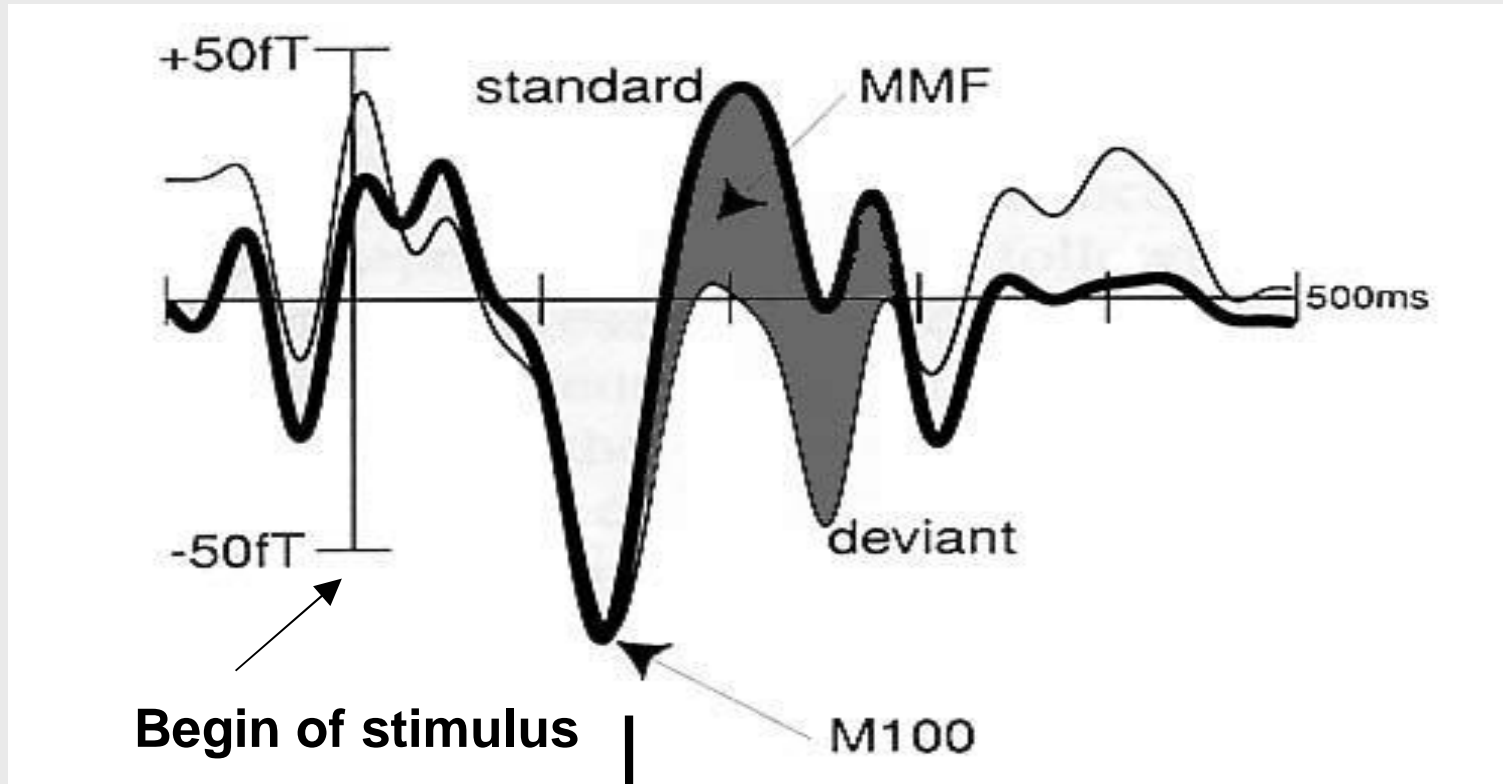
Example: Standard [Ca], Deviant [Sa]





- High signal-to-noise ratio → ERPs detected through averaging-technique
- Localization of current dipole

# Magnetic Mismatch Field (MMF)



Exogenous components

endogenous components

(Phillips 2000)

# Findings of MEG-research:

## Influence of native phonological categories:

- Native sound contrasts:

- Strong MMF in left Auditory Cortex

(Mathiak et al 2001, Phillips et al. 2000, Näätänen et al. 1995, Aaltonen et al. 1997)

- Non-native sound contrasts:

- Small or no MMF, depending on discrimination

(Zhang et al. 2000, Näätänen et al. 1997)

- Bilateral activity for auditory perception of contrast

(Tsui et al. 2000)

- Longer latency of MMF for auditory perception of contrast (Winkler et al. 1999)

## 6. Expectations:

- Pl. /S-C/ : Perceptual assimilation to German /S/ or /c/ or possible acoustic salience of fricative?
  - Small or no MMF - bilateral activity and longer latency of MMF
- Ger. /c-x/: Activation of only one phonological category?
  - Small or no MMF – clear left-lateralized MMF – bilateral activity and longer latency of MMF
- Ger. /s-S/: Phonemic perception
  - clear left-lateralized MMF

