Neurophysiology of non-native sound discrimination: Evidence from German vowels and consonants in successive French-German bilinguals using an MMN oddball paradigm

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modyco Modèles, Dynamiques, Corpus UMR 7114 Sciences du langage.

cnrs dépasser les frontières

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Introduction 1/3

- Production and perception in a second language (L2)
- French learners of German
- French and German are two typologically different languages
  - **French**: syllable timed, group final stress, nasal vowels
  - **German**: stress timed language, short and long vowels, more fricatives
- Anterior production studies showed the following :
  (Wottawa, Adda-Decker, & Isel, 2016 ; Wottawa & Adda-Decker, 2018 ; Wottawa, Adda-Decker, & Isel , 2018)

Production difficulties
- [ç]
- vocalic opposition

→
- Duration → little difficulties
- Quality → higher difficulties

Introduction 2/3

- Electroencephalography (EEG) allows to record how linguistic information is processed in real time
- Recording of wave-forms: oscillation patterns, or positive and negative peaks are analyzed

- Different paradigms allow to analyze various processes
  - syntactic processing
  - semantic processing
  - phonological processing

- In linguistics, most often paradigms with *event related potentials* are used → response to a stimulus

Introduction 3/3

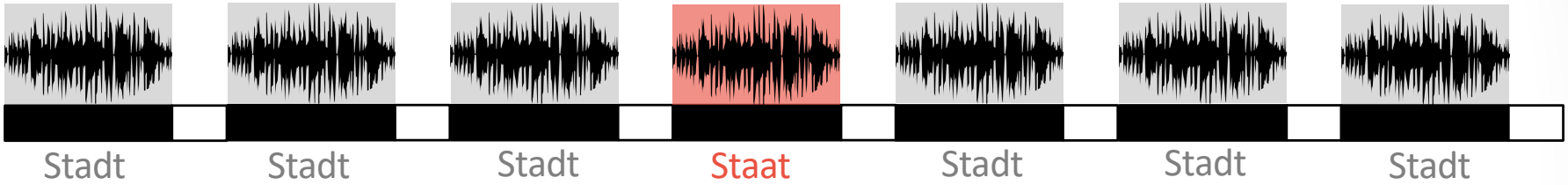
- Different stimuli types can be used
  - written stimuli
  - audio stimuli
  - a combination of written and audio stimuli (i.e., priming paradigms)

- Research question
  - To what extend the perception of German phonological contrasts absent in French is successful in French learners of German?

  - Field of study: **phonology**
  - Stimuli type: **audio stimuli**
  - Paradigm choice: passive paradigm (no decision task is associated), measure of **automatic responses**

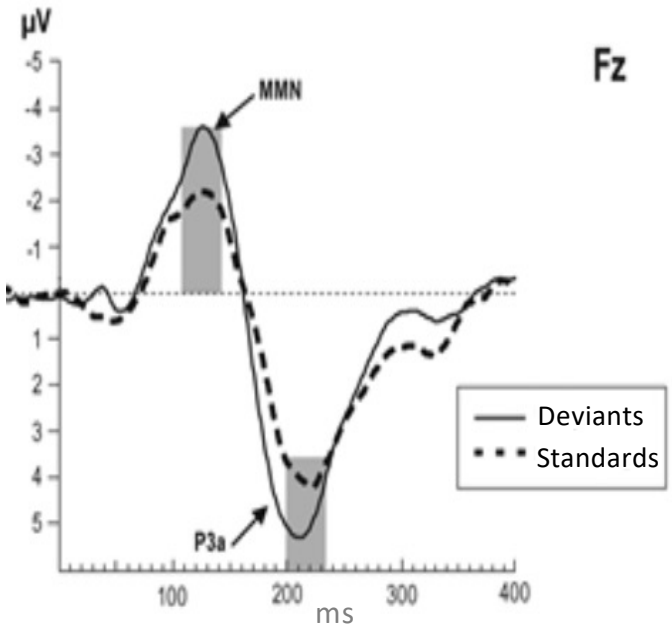
The *oddball* paradigm

- EEG experiment – *oddball* paradigm

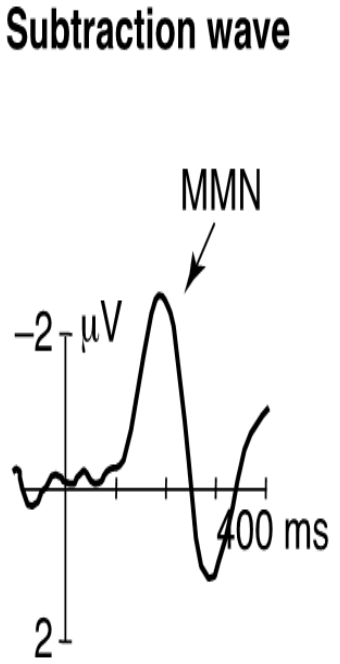


- Stimuli chains:
  frequent (standard, 90%), rare (deviant, i.e. 10%)

Expected vent related potentials (ERPs) with the *oddball* paradigm



Gumenyuk et al. (2011)



Van Zuijen (2006)

P3a

(Sutton et al. 1956)

- positive ERP
- involuntary attention shift

MMN *Mismatch Negativity*

(Näätänen, 1978)

- negative ERP
- automatic auditory response (acoustic differences)
- MMN = rare - frequent

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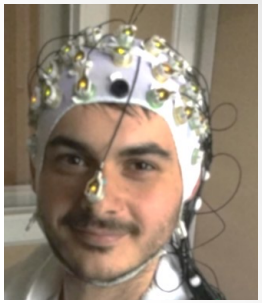
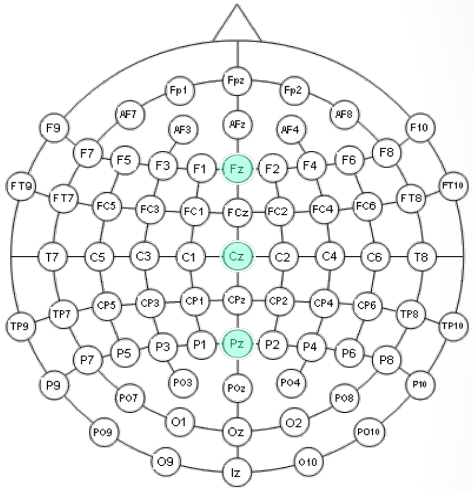
MMN in detail



- MMN – early negativity (time window: 150-250 ms)
- Auditory MMN
- Detection of auditory
- Comparison three central electrodes
  Fz, Cz and Pz

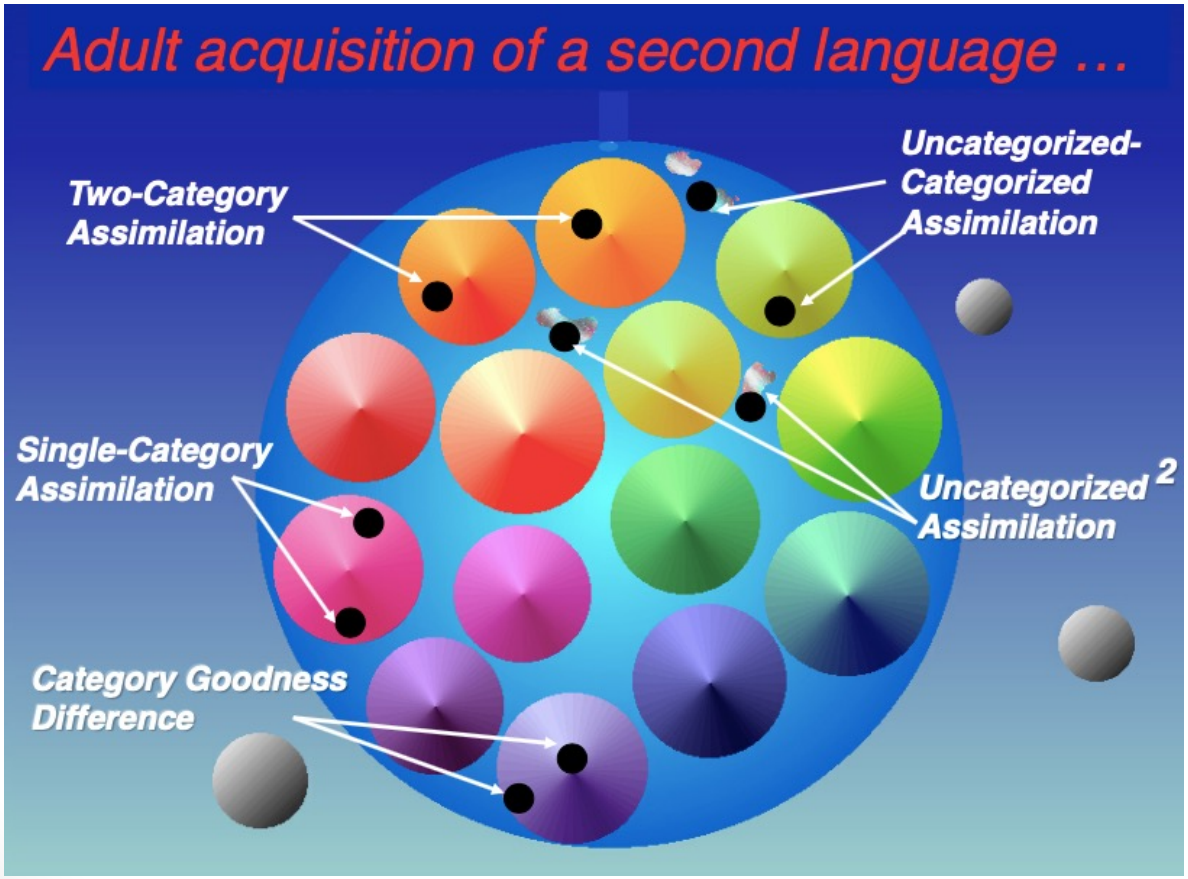


EEG cap , 64 electrodes

- In L2 research
- Investigating auditory discrimination
  - of phonological or phonetic categories in L2 learners
  - the vast majority of studies are carried out on L2 vowel perception

PAM-L2 model (Best & Tyler, 2007)

- Non-native perception model of **phonological contrasts**
- Based on the comparison of the phonological systemps of the speakers' L1 and L2



according to Best (2014)
Presentation au LabEx EFL

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Methods

- Participants
  - 20 German native speakers
    (recorded in Leipzig; age: M=24.4, 21-28 years)
  - 20 French learners of German
    (recorded in Paris; age: M=22.8, 19-34 years)

- Procedure
  - participants were comfortably seated and watched a silent movie (passive paradigm) wearing an EEG cap with 64 electrodes
  - stimuli were presented in blocs
  - 6 up to 9 standards before the deviant (avoids habituation)

Stimuli choice

- German words and pseudo-words
  - long and short vowels:
    bitte – biete, messt – mähst, Stadt – Staat,
    - three vowel pairs were chosen according to their spectral differences
      [ɪ-iː] > [ɛ-ɛː] > [a-aː]
      (McAllister, Flege & Piske, 2002; Wottawa, 2020)
  - [ʃ] – [ç]: Feschel – Fechel, Gepisch – Gepich
    - two word positions: internal and coda
- 7 native German speakers (all women)
  - only female voices in order to avoid reactions according to gender (Casado and Brunellière, 2016)
- Multi-speaker experiment: categorial discrimination
  - participants need to overcome acoustic changes and pay attention to phonemic information
    (Strange & Shafer, 2008)

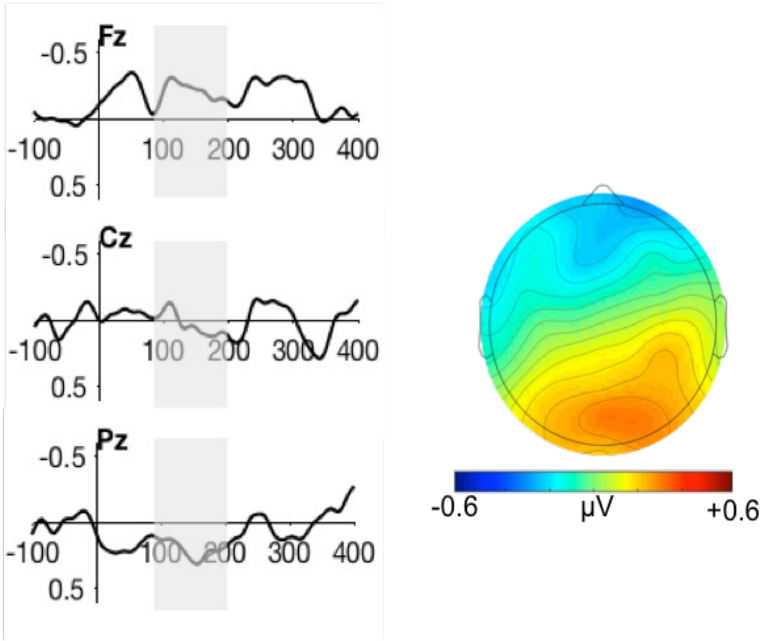
Hypotheses

- German natives
  - good perception of all presented contrasts fronto-central MMN and P3a
- French learners of German
  - Short and long vowels
    - *category goodness difference*
    - some discrimination difficulties
    - great spectral difference = more successful discrimination ([ɪ-iː] > [ɛ-ɛː] > [a-aː])
  - [ʃ]-[ç] opposition
    - *single category assimilation*
    - none or litlle discrimination of the phones

Results – vowel contrasts

MMN, 90-200 ms (negativity, blue)

A German natives

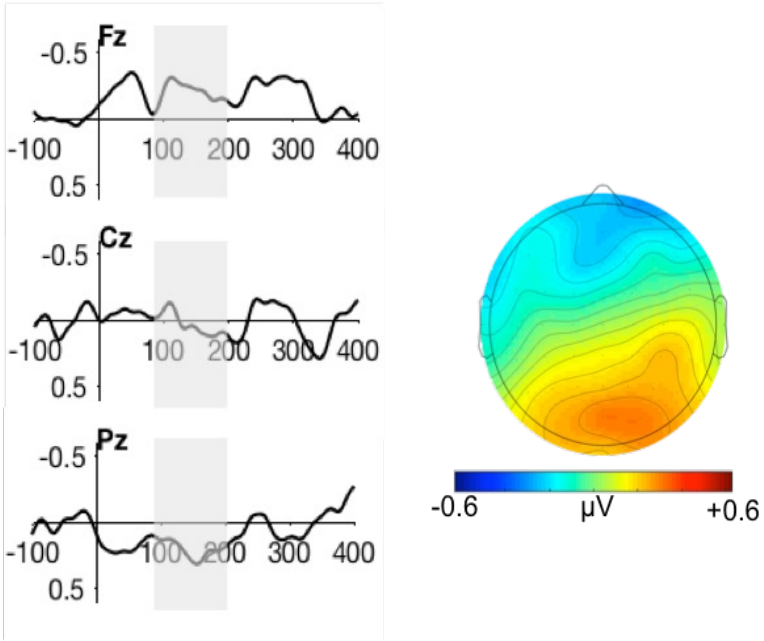


- MMN at Fz

Results – vowel contrasts

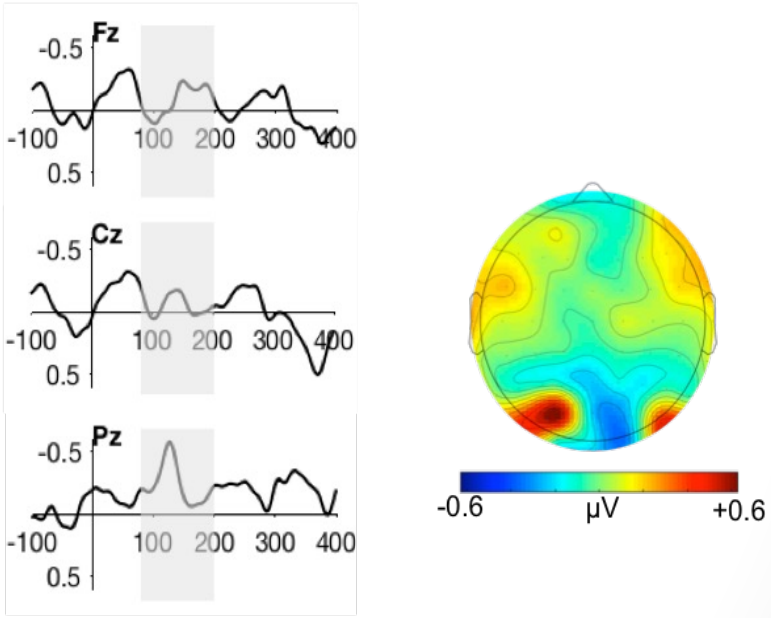
MMN, 90-200 ms (negativity, blue)

A German natives



- MMN at Fz

B French learners of German



- emerging and distributed MMN (Fz, Cz, Pz)

Results – vowel contrasts

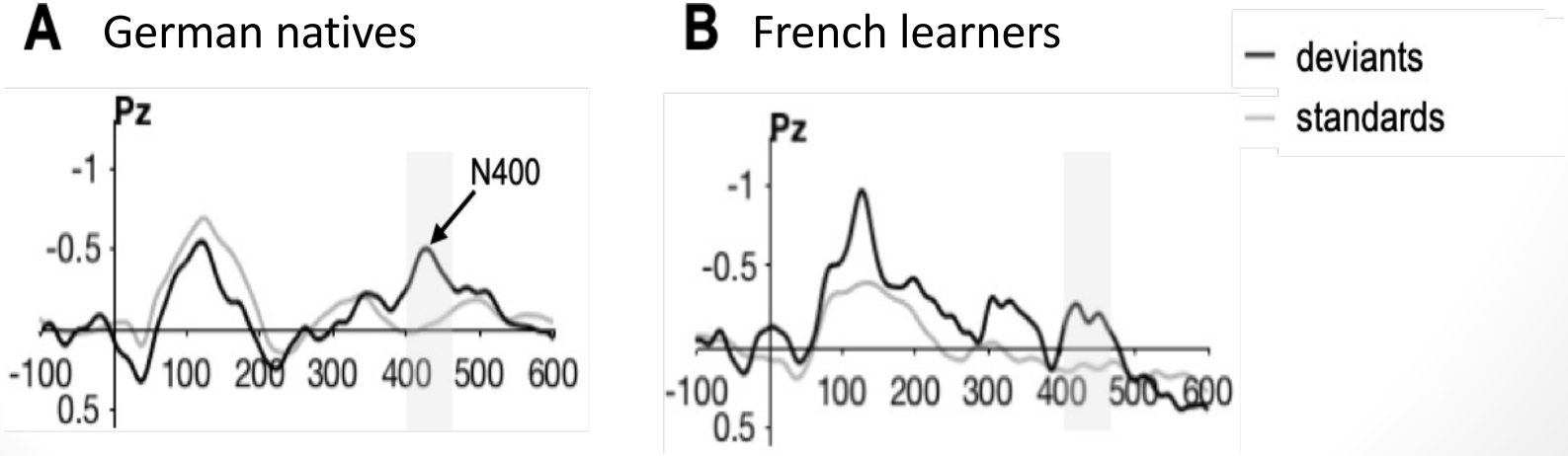
P3a, 190-240 ms (positivity)

- No P3a was found: not for German natives or French learners of German

Results – vowel contrasts

Late negativity, 400-460 ms (negativity)

- Unexpected result
  - The *oddball* paradigm is not associated to a late negativity
  - the time window and topography (at Pz) suggest a variant of the N400 (= lexical access)
  - The *oddball* paradigm could be understood as a type of priming experiment, standards = primes for the deviant, if semantically incongruent → N400



Discussion – vowel contrasts

- **MMN:** German natives ☑ French learners of German ❑
  - Sensitivity seems to be independant of spectral differences
    → duration is more robust than are spectral differences
  - German natives present a clear frontal MMN
    → expected processing, stimuli seem OK
  - French learners of German emerging and distributed MMN
    → processing of vowel contrasts still in acquisition?
- **P3a:** German natives ❑ French learners of German ❑
  - Absence linked to the multi-speaker paradigm in German natives?
    → too much variation in the paradigm to show a P3a?
- **N400:** German natives ☑ French learners of German ❑
  - Indicates probably the phonological processing of the vowel contrast
    → Non-natives: the phonological opposition is not (yet) achieved

Results – [ʃ]-[ç] opposition

MMN, 80-160 ms (negativity)

- No MMN was found for neither speaker group.

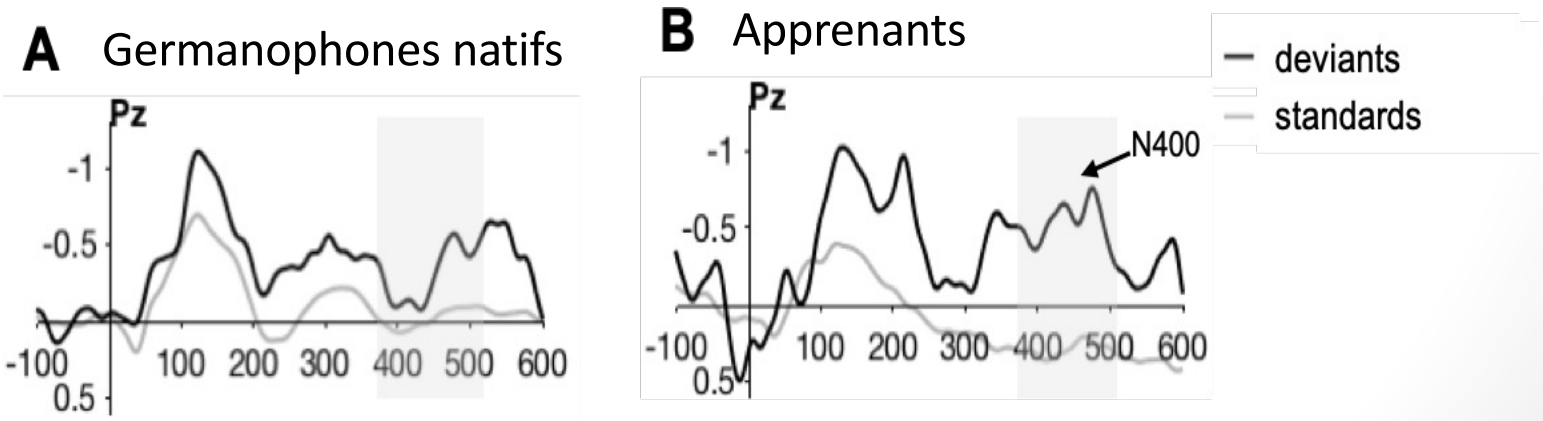
P3a, 190-240 ms (positivity)

- No P3a was found for neither speaker group.

Results – [ʃ]-[ç] opposition

Late negativity, 380-520 ms (negativity)

- Verification if the N400 variant is present for this opposition
  - late processing is not only based on the stimulis acoustics
- N400 variant is present in non-native listeners but not in German natives



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Discussion – [ʃ]-[ç] opposition

- **MMN:** German natives ❑ French learners of German ❑
  - Only little acoustic differences between [ʃ] and [ç]
    → not salient enough to elicit an MMN in our experiment

- **P3a:** German natives ❑ French learners of German ❑
  - Absence of the P3a is linked to a weak phonetic contrast

- **N400** German natives ❑ French learners of German ☑
  - Absence of the N400 variant in German natives because the opposition is not phonological ?
    →Processing of [ʃ] and [ç] as phonetic variants ?
  - N400 variant in French learners of German
    → Words presenting [ʃ], might be processed as French pseudo-words

General discussion 1/3

- Both groups, German natives and French learners of German, perceive vowels differently from consonants
  - Vowels and fricatives are processed in different ways in German natives and French learners of German

- The MMN seems to depend on the « load » of the acoustic differences of the stimuli
  - the perception of vowel contrasts (duration, spectral differences) leads to an automatic auditory response
  - the perception of the fricatives [ʃ]-[ç] does not lead to this automatic auditory response, linked to the multi-speaker design?

General discussion 2/3

- The P3a marks an involuntary attention shift qui seems to be masked by the multi-speaker design
  - acoustic properties change for every item in the stimuli chain
    → is there an involuntary attention shift for each stimuli?

- The N400 variant seems to translate lexical access

	Natives	Non-natives
Vowel contrast	Lexical change bitten [ˈbɪtən] (to ask) / bieten [ˈbiːtən] (to offer)	Vowel variation does not lead to a new interpretation of the word.
[ʃ]-[ç] opposition	No new interpretation of the pseudo-words : phonetic variants ?	Lexical search: German pseudo-words with [ʃ] relate to French phonatactics?

General discussion 3/3

- Checking hypotheses:
- German natives
  - good perception of all presented contrasts ❑ fronto-central MMN and P3a

    Processing differences of vowels and consonants (MMN, variante de la N400)
- French learners of German
  - Short and long vowels
    - *category goodness difference*
    - some discrimination difficulties ☑ emerging MMN
    - great spectral difference = more successful discrimination ([ɪ-iː] > [ɛ-ɛː] > [a-aː]) ❑ No effect of vowel quality
  - [ʃ]-[ç] opposition
    - *single category assimilation*
    - none or litlle discrimination of the phones ❑

      New insights,

      lexical access for pseudo-words containing [ʃ] = processing

Danke schön !

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