

The neurophysiology of phonemic contrasts perception by multilingual listeners in diverse learning settings

Hanna Kędzińska, Karolina Rataj, Anna Balas, Zuzanna Cal, Chloe Castle, Magdalena Wrembel

13.09.2023



ADAM MICKIEWICZ
UNIVERSITY
POZNAŃ



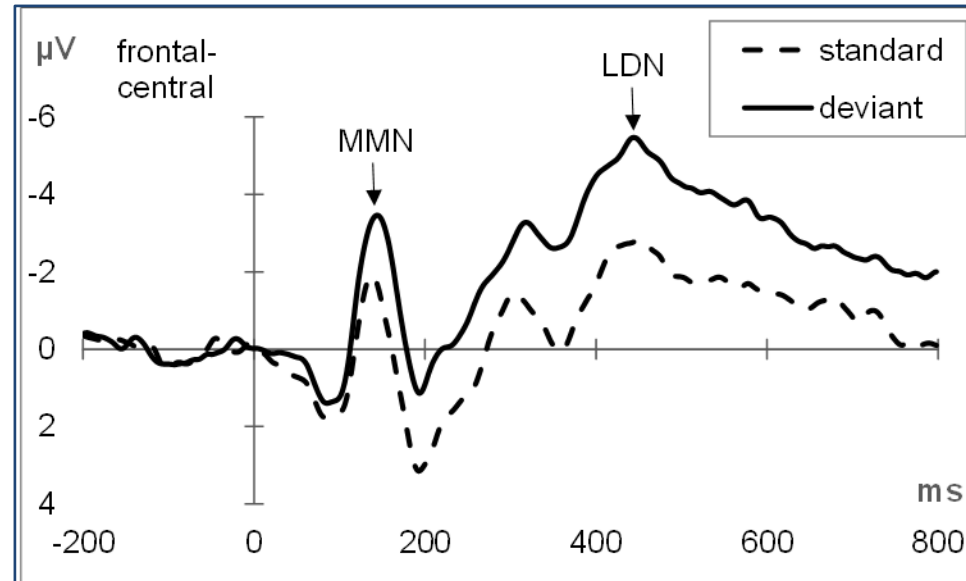
UiT Aurora Centre



Oddball paradigm

Oddball:

a sequence of frequently occurring standard stimuli interrupted by the occasional appearance of deviant stimuli)



MMN:

a negative-going wave deflection of frontocentral distribution with a peak at around 150-250 milliseconds from change onset.

P300 and LDN:

often following the MMN. **P300** is associated with switch of attention, **LDN** involves additional cortical resources to extract the difference.

Previous studies

A similar MMN response to Finnish vowel contrast in native speakers of Finnish and a group Hungarian late learners of Finnish (a naturalistic setting) (Winkler et al., 1999).

A significant difference between native speakers of English and advanced Finnish students of English (a classroom setting) (Peltola et al., 2003).

MMN was **attenuated in poor L2 perceivers** (the importance of individual speech-specific capabilities) (Díaz et al., 2016).

Different neural responses in adult Mandarin learners of English with **high and low proficiency levels** (Liang and Chen, 2022).

Research questions

R1Q : Will phonological contrasts be equally easy to detect and process in **native and non-native** languages?

RQ2: Will any significant distinctions emerge in **L3/Ln as opposed to L1 and L2?**

RQ3: Will there be any statistically significant differences between **formal** and **naturalistic** language learners?



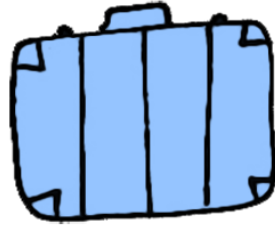
Hypotheses

(1) We predict the **MMN effect** to be **stronger in native when compared with non-native** speech (Jakoby et al., 2011; Liang & Chen, 2022; Näätänen et al., 1997; Song & Iverson, 2018).

2) The scale of the **MMN effect in L2 when compared with L3/Ln** is, however, **impossible to predict** due to the lack of previous studies which would focus on such a comparison.

Participants

UiT, Tromsø



- **21 participants:**
 - mean age = 32.9 (range: 22–47),
 - nine males,
 - college graduates (BA-PhD, N = 15),
 - college students (N = 3),
 - high school graduates (N = 3),
 - naturalistic Norwegian learners,
 - AoA (English) = 9.48 years (range: 4–29),
 - AoA (Norwegian) = 27.33 years (range: 20–43),

AMU, Poznań



- **23 participants:**
 - mean age = 22.6 (range: 18–38),
 - five males,
 - college students (N = 18),
 - college graduates (MA, N = 4),
 - formal language learners,
 - AoA (English) = 5.86 years (range: 3–10),
 - AoA (Norwegian) = 20.27 years (range: 13–36),

Experimental stimuli

Sounds

Polish: /ɨ/-/ɛ/ **English:** /ɪ/-/ʊ/ **Norwegian:** /i/-/y/

We used possibly similar standard sounds in Polish, English and Norwegian.

Vowel	F1	F2	F3	ED
/ɨ/	468	1948	2821	231
/ɛ/	675	1916	2722	
/ɪ/	394	1828	2882	483
/ʊ/	390	1345	2896	
/i/	357	1917	2587	161
/y/	313	2015	2708	

The deviant sound were selected to be language-specific with approximately comparable distance from the standard one.



Preparation

Experiment

Tests

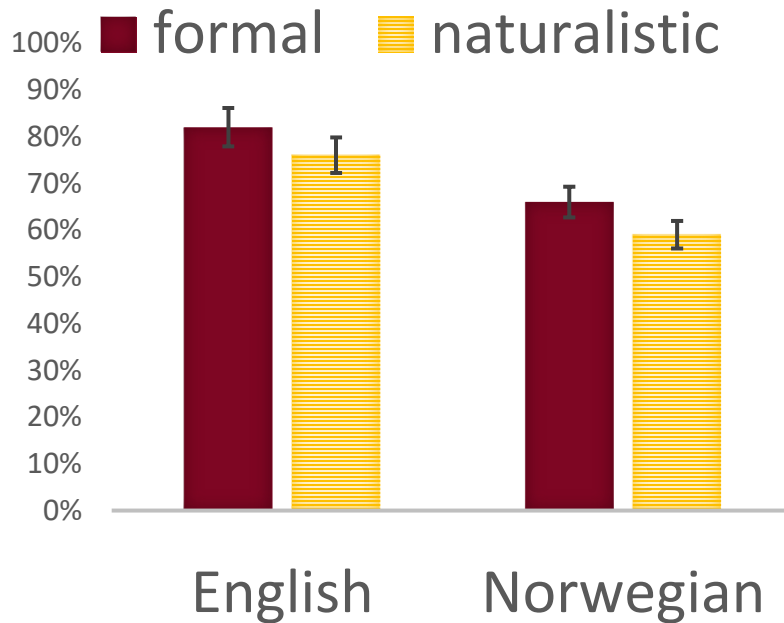
- consent, surveys
- cap preparation
(32 / 64 active electrodes)

- sound stimuli presentation
- cartoon watching

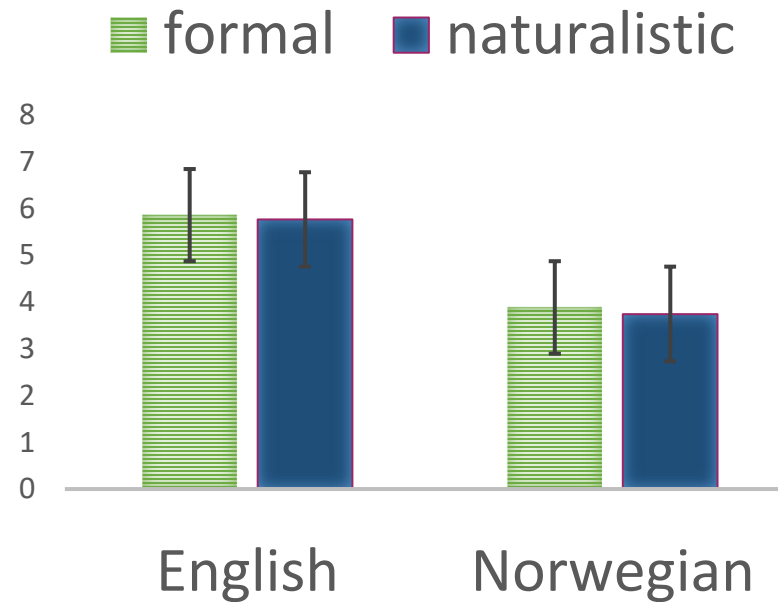
- proficiency tests
- gating task

Behavioral tests results

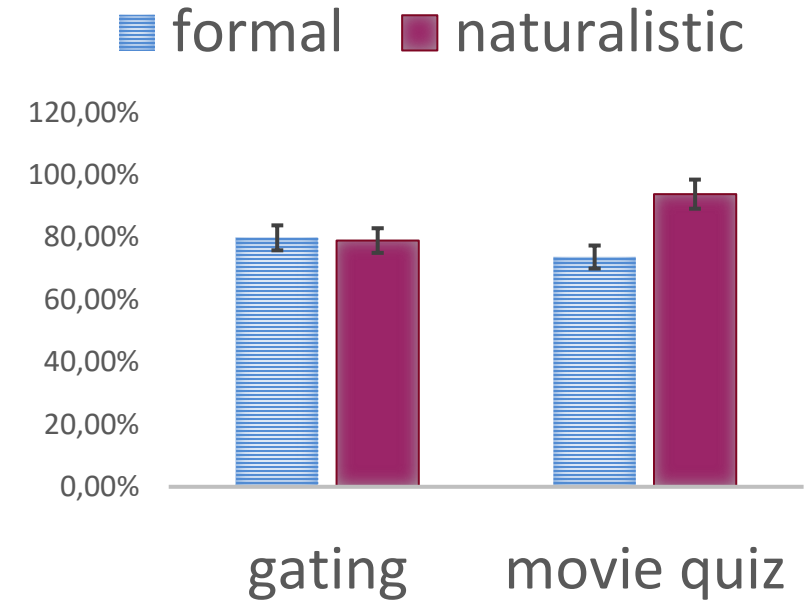
PROFICIENCY TESTS



SELF-ASSESSMENT

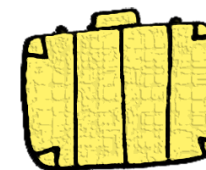


OTHER TASKS



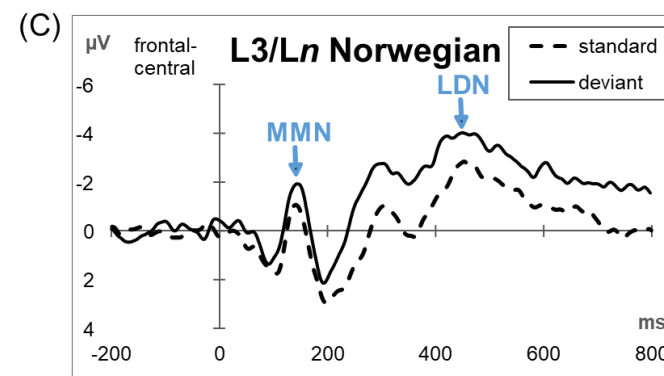
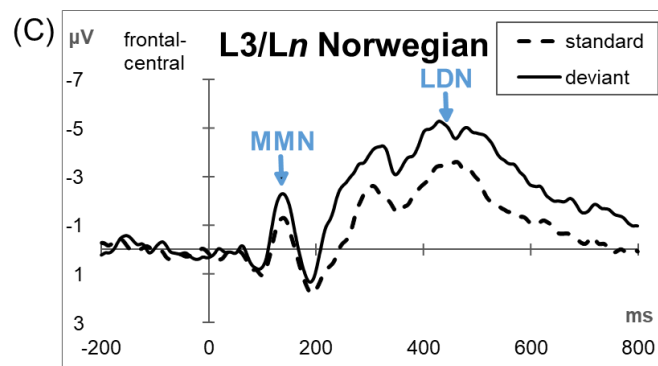
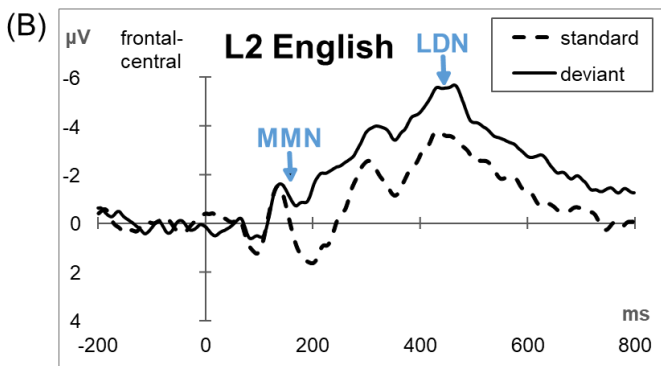
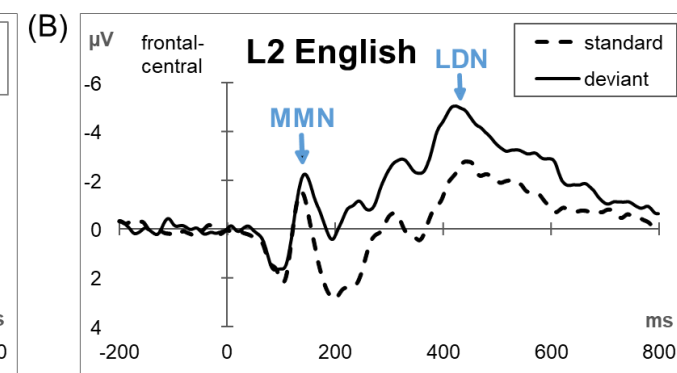
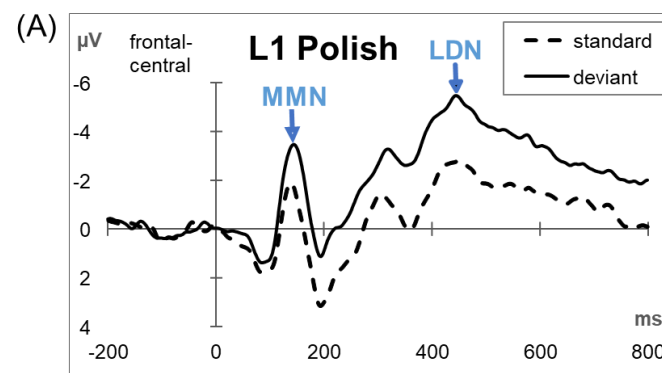
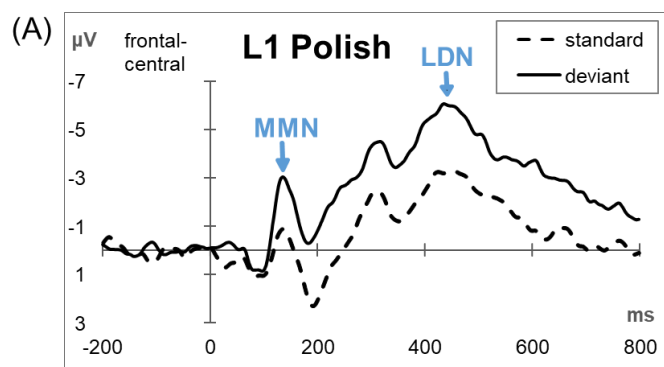


ERP RESULTS



FORMAL L3 LEARNERS (AMU)

NATURALISTIC L3 LEARNERS (UiT)

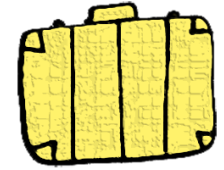
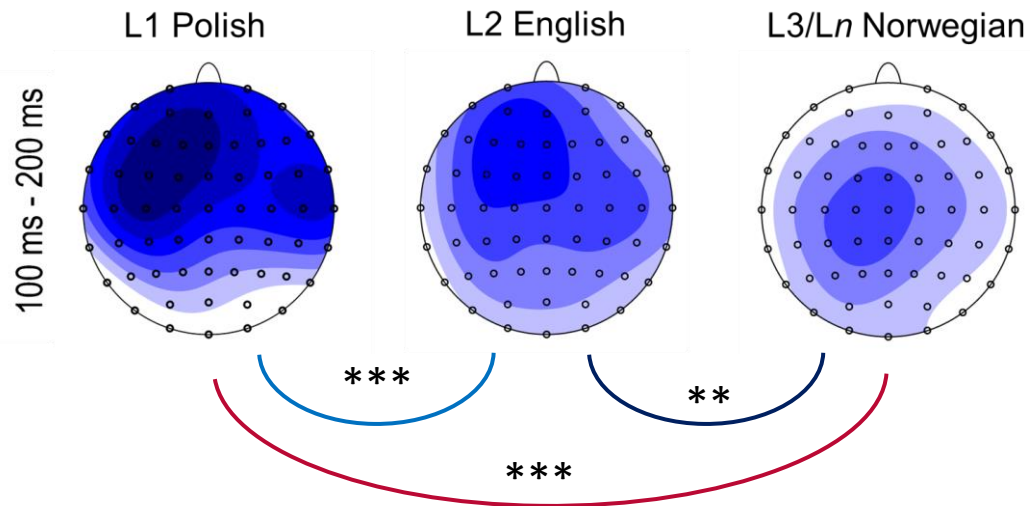


-2 μ V 0 μ V 2 μ V

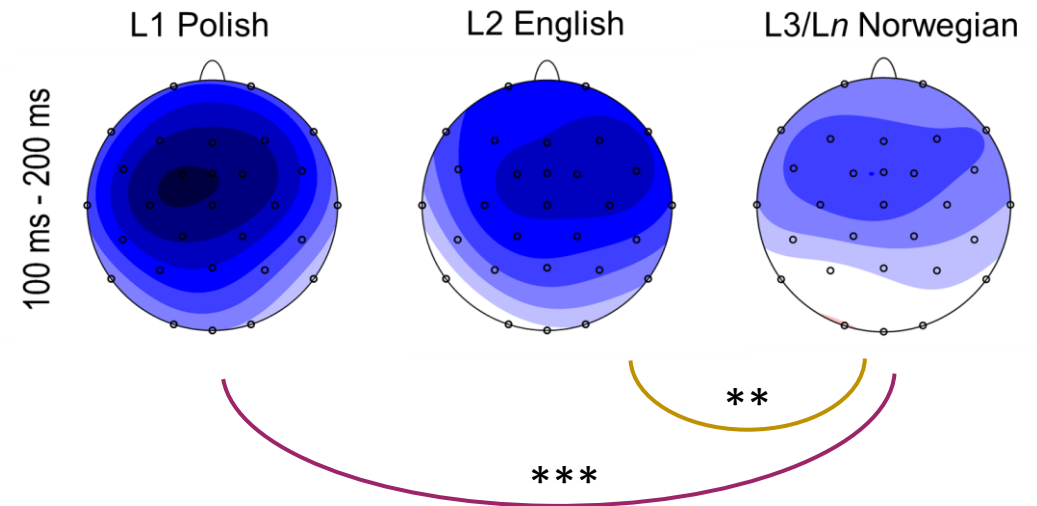
ERP RESULTS: MMN



FORMAL L3 LEARNERS (AMU)



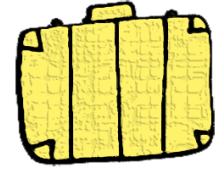
NATURALISTIC L3 LEARNERS (UiT)



a linear mixed effects analysis

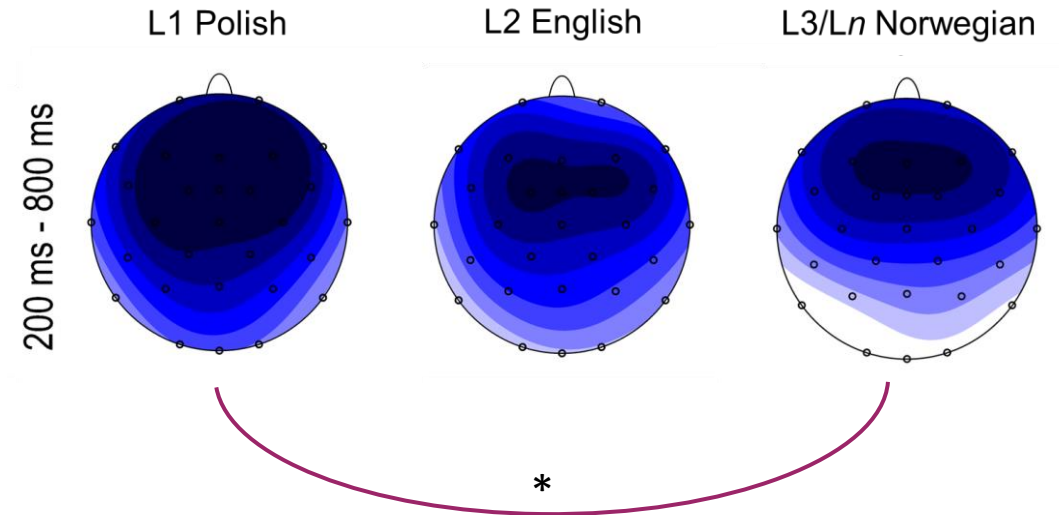
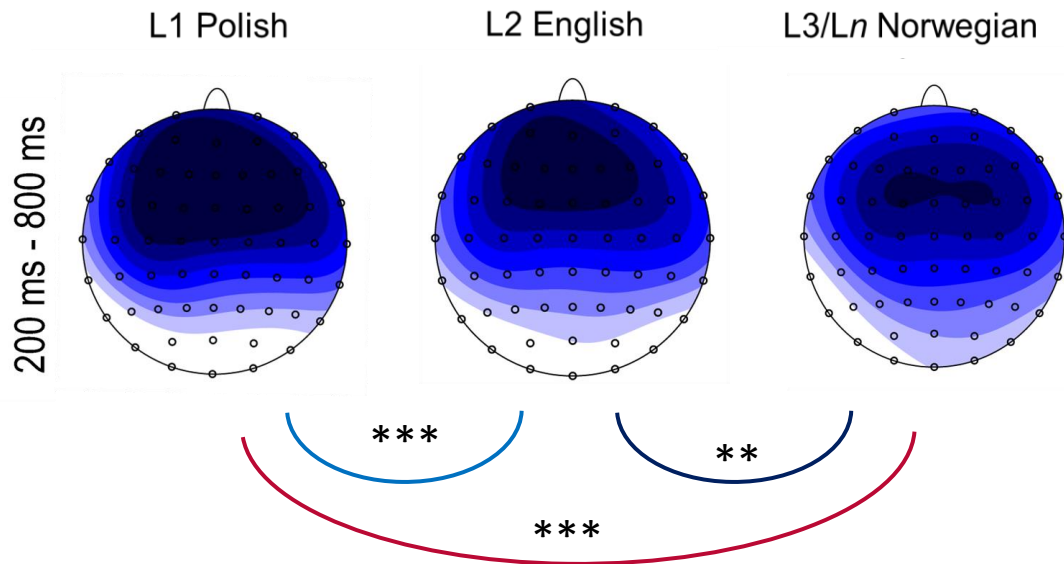
-2 μ V 0 μ V 2 μ V

ERP RESULTS: LDN



FORMAL L3 LEARNERS (AMU)

NATURALISTIC L3 LEARNERS (UiT)



a linear mixed effects analysis

Discussion

Predictions testing

- **Will phonological contrasts be equally easy to detect and process in native and non-native languages?**
- The MMN response was deficient for non-native languages (L2 English, L3/*Ln* Norwegian) when compared to L1 Polish. For naturalistic learners the L1 and L2 contrasts were equally easy to detect, though.
- **Will any significant distinctions emerge in L3/*Ln* as opposed to L1 and L2?**
- We have observed differences between L2 English and L3/*Ln* Norwegian in terms of MMN (in formal AND naturalistic learners) and in terms of LDN (in formal learners).
- **Will there be any statistically significant differences between formal and naturalistic language learners?**
- Yes, especially in terms of L2 English.

Discussion

Main findings

- Statistically significant **MMN** difference between L1 Polish and L2 English in formal (but not naturalistic) language learners.
 - This finding opens the discussion on the participants' language dominance as a factor influencing phonemic perception mechanisms.
 - L2 English as the more dominant language (even in Norway).
 - The level of proficiency and speech specific capabilities might also influence the effect (Diaz et al., 2016; Liang & Chen, 2022).
 - No P300 component was observed (which we expected on the basis of previous research).

Discussion

Main findings

- Different LDN patterns. In naturalistic learners, the **LDN was less pronounced in L3/Ln Norwegian** when compared with L1 Polish (but not with L2 English). In formal learners, the differences were more clear-cut.
 - The MMN and LDN patterns do not seem to perfectly overlap.
 - This finding opens the discussion on the significance of LDN.
 - While typically associated with pre-attentive cognitive evaluation of the stimulus (Jakoby et al., 2011), the component is also associated with extracting the phonological difference between STANDARD and DEVIANT (Escera et al., 2000).

Open questions

- Late onset of the MMN in L2 English (in general).
 - Especially well-visible in the case of formal learners.
 - Time windows selection (especially for the MMN).
Splitting the 100-200 ms time window into two: 100-150 and 150-200 as a way to manifest this.
- LDN significantly lower in Norwegian than in English (in .
 - What are the implications of this finding?
 - Is the component pre-attentive? (see Jakoby et al., 2011 for a discussion)
 - How strongly is the component's strength associated with standard/deviant difference ratio?

Conclusion

- First of all, we have **replicated previous findings** concerning the impaired phonemic perception in non-native languages in both formal and naturalistic language learners.
- More crucially, the findings seem to suggest that foreign language **status as L2 or L3/Ln modulates auditory language processing**.
- At the same time, the results suggest the relevance of **language learning setting** as a factor influencing phonemic perception mechanisms.



Thank you!

This research has been supported financially by the Polish National Science Centre (NCN) in Poland.

GRIEG-1 ID nr: DEC-2019/34/H/HS2/00495

Period: Dec 2021-April 2024

PIs: Magdalena Wrembel, Marit Westergaard

We thank **Tristan Czarnecki-Verner**, **Agnieszka Pludra**, **Anna Skałba**, **Patrycja Kakuba** and **Kamil Malarski** for their assistance with the EEG recordings in Poznań,
Jason Rothman for the opportunity to conduct the study in the PoLaR lab,
Vincent DeLuca and **Mahdis Jafari** for their invaluable help during data recordings in Tromsø,
and **Kamil Kaźmierski** for his comments on data analysis.