

# The neurophysiology of phonemic perception in multilingual speakers

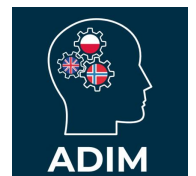
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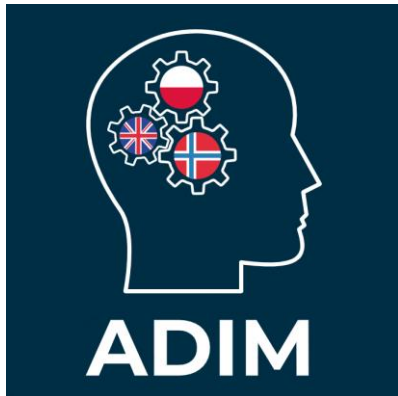


UiT Aurora Centre



# Phonemic perception in L2/Ln

Jakoby et al., 2011; Liang & Chen, 2022; Song & Iverson, 2018



vital  
component  
of successful  
L2/Ln  
learning

L3/Ln

reduced phonemic  
discrimination  
mechanisms in the

L2

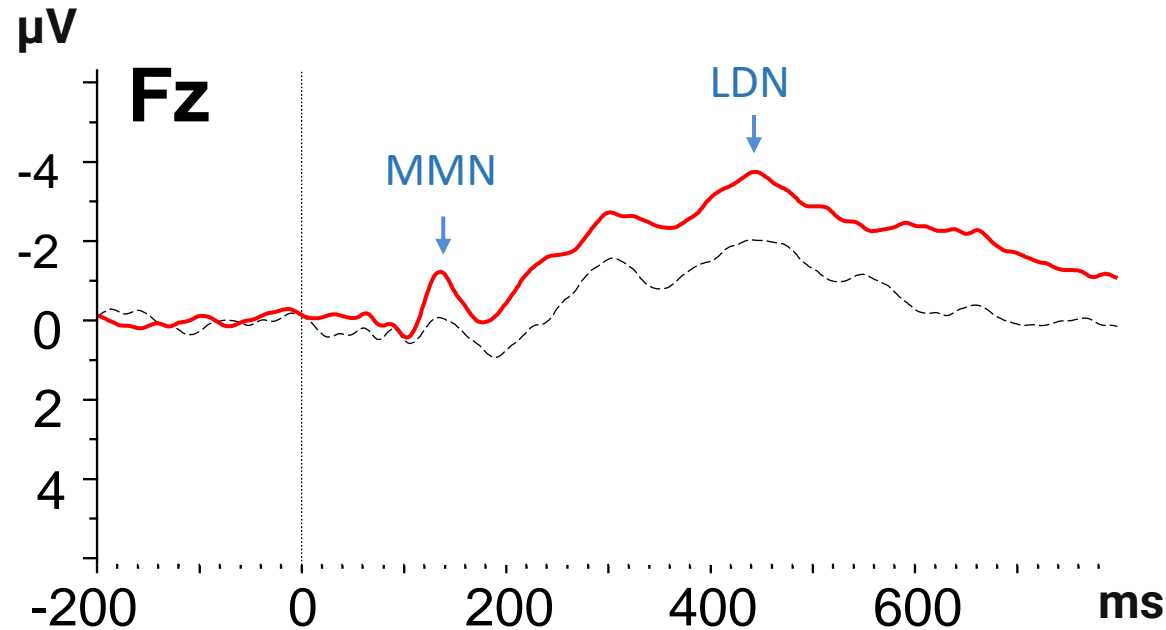
unknown language

# Oddball paradigm



## Oddball:

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



## P300 and LDN:

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



## MMN:

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

# Previous studies

## MMN

**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

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## Questions

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

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

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

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## Predictions

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)

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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

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# Participants



- **23 participants:**

- mean age = 22.55 (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),
- Norwegian as chronologically the third (N = 9), the fourth (N = 11), the fifth (N = 1) or the sixth (N = 1) language

# Experimental stimuli

## Sounds

**Polish:** /i/-/ɛ/

**English:** /ɪ/-/ʊ/

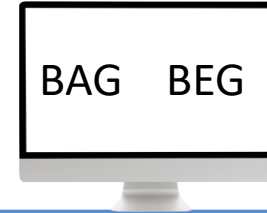
**Norwegian:** /i/-/y/

Vowel	F1	F2	F3	ED
/i/	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	

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

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

# Procedure



## Preparation

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

## Experiment

- sound stimuli presentation
- cartoon watching

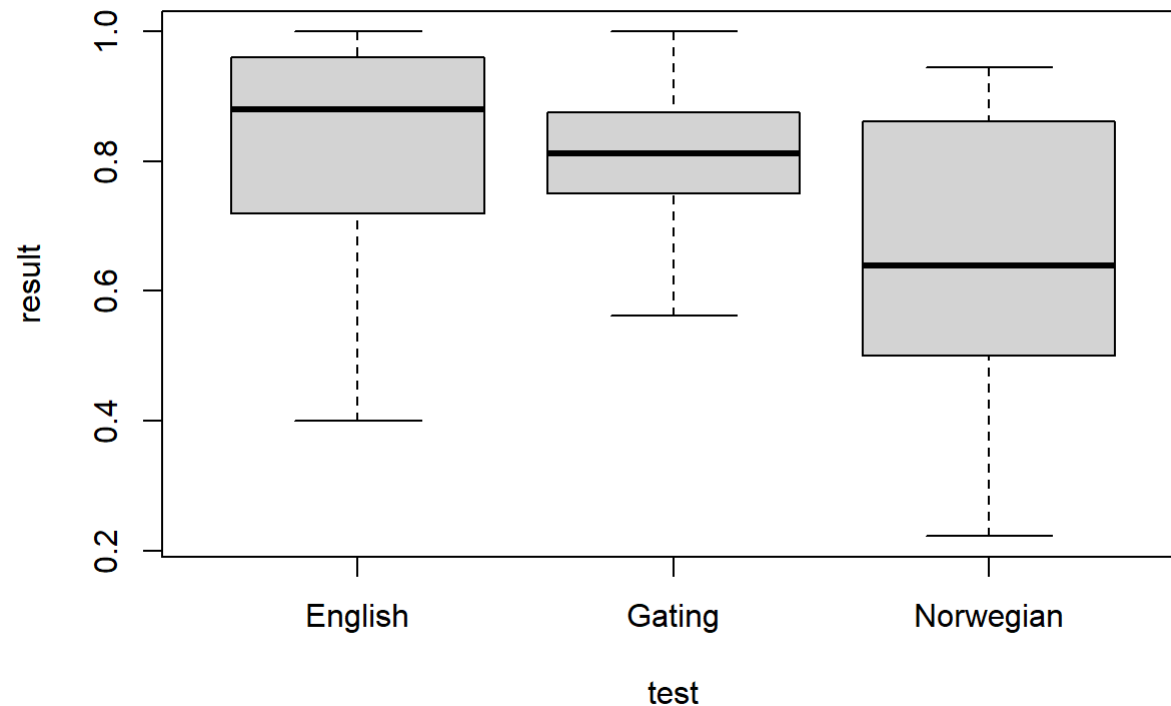
## Tests

- language tests
- gating task



# Behavioral tests results

Proficiency tests and gating task results



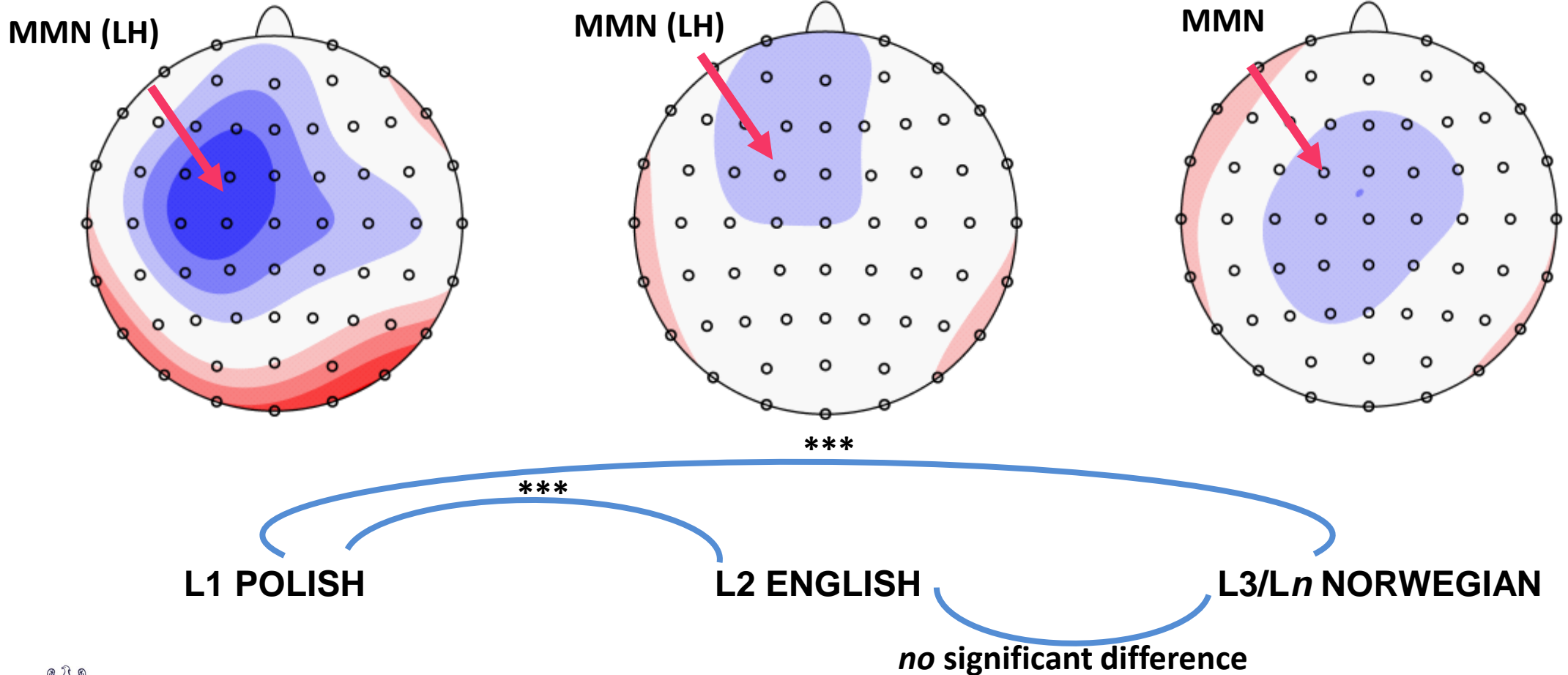
## OTHER RESULTS:

- **English skills** self-assessed as **5.85** (range: 5.25–7,  $SD = 0.60$ )
- **Norwegian skills** self-assessed as **3.88** (range: 2–6.5,  $SD = 1.16$ )
- **movie comprehension test** average of 73.64% correct responses (range: 50%–100%,  $SD = 16.20\%$ )
- **mean laterality quotient (LQ)** equal to 85.91% (range: 45.00%–100,00%,  $SD = 16.74\%$ )

-2  $\mu$ V 0  $\mu$ V 2  $\mu$ V

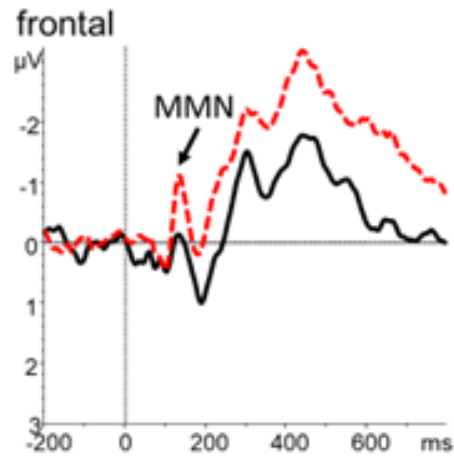
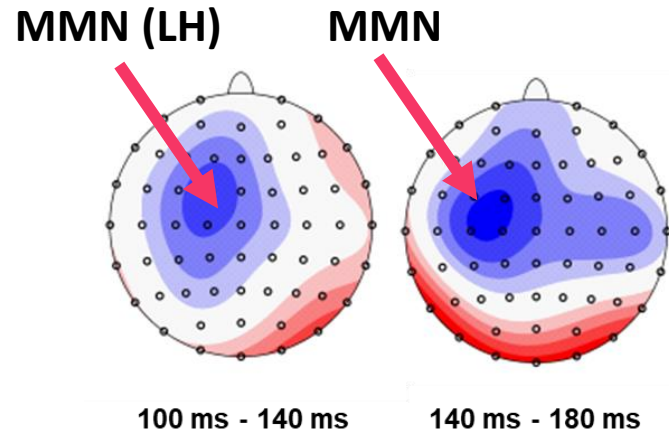
# MMN 100-180 ms

a linear mixed effects analysis of the relationship between the processed **language**, the status of the processed **sound** as standard or deviant and **hemisphere** (left or right)

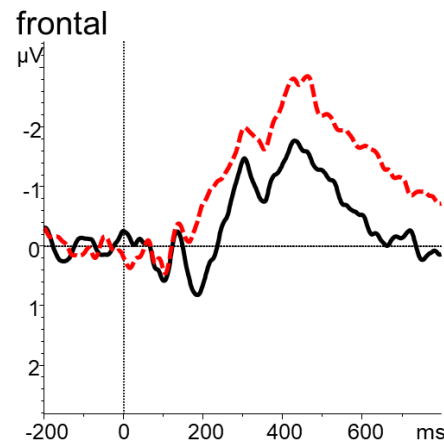
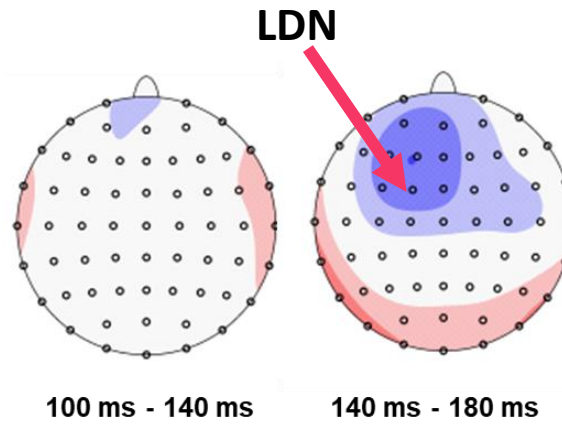


-2  $\mu$ V 0  $\mu$ V 2  $\mu$ V

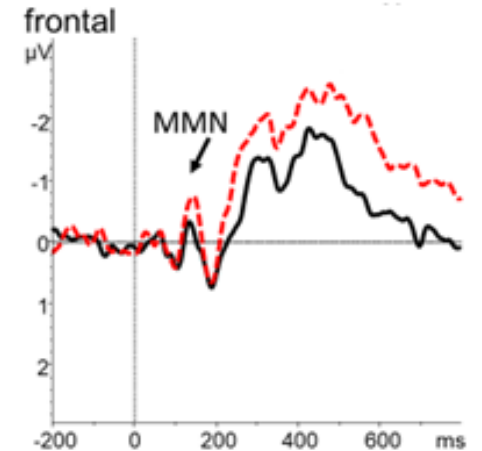
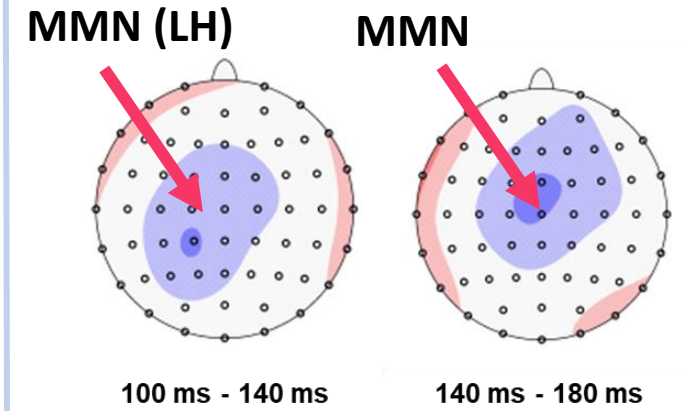
# ERP results: MMN



**L1 POLISH**



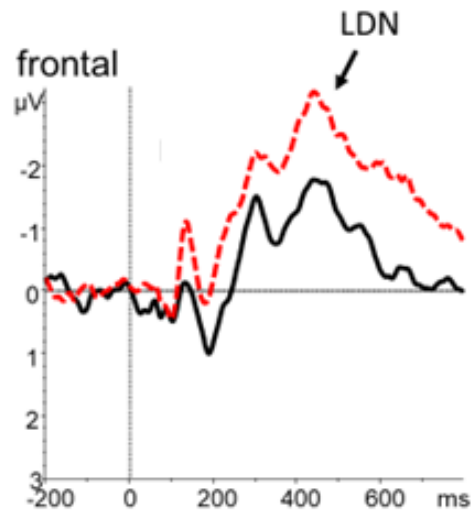
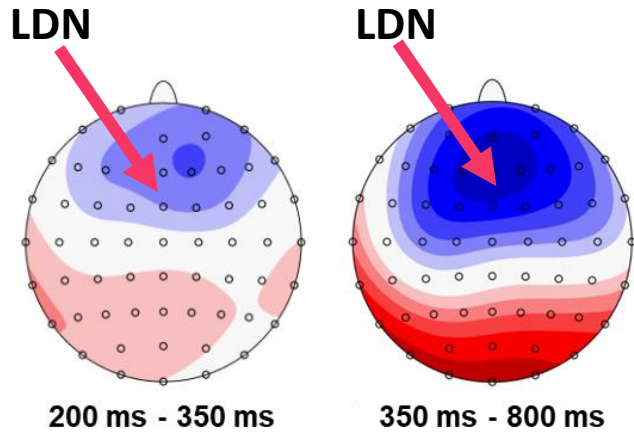
**L2 ENGLISH**



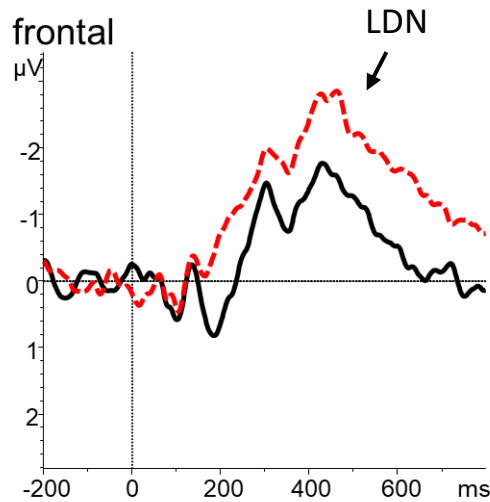
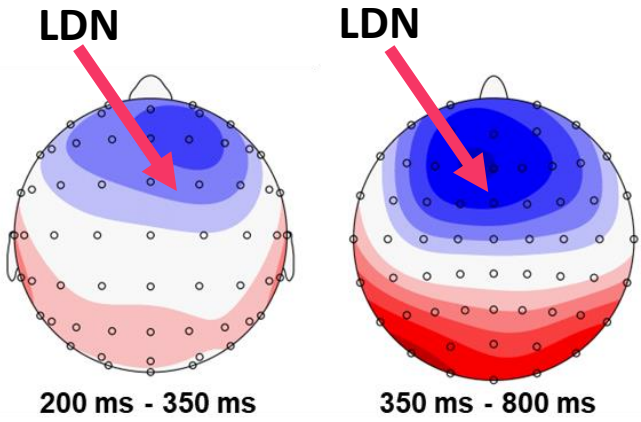
**L3/L<sub>n</sub> NORWEGIAN**

# ERP results: LDN

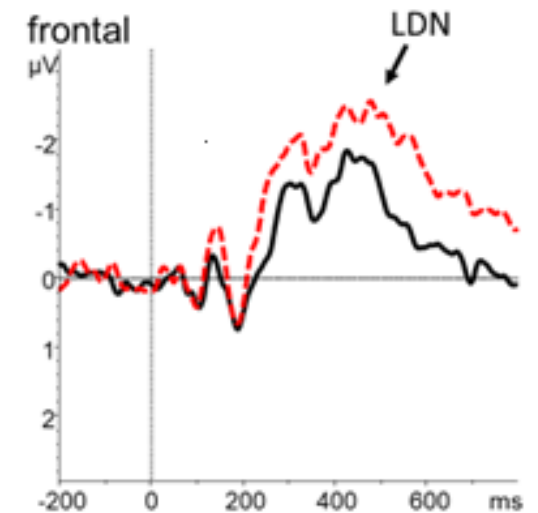
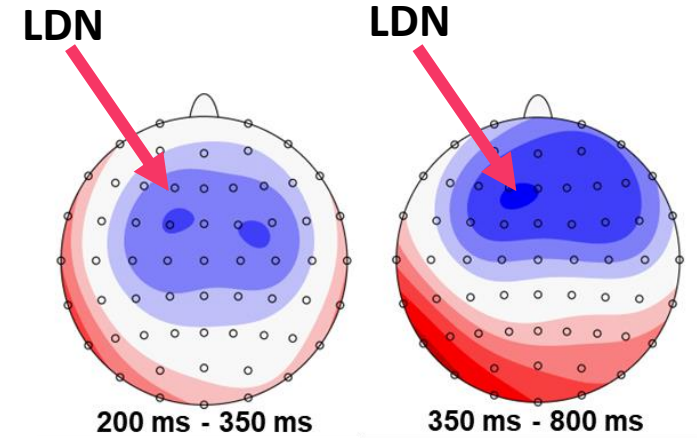
-2  $\mu$ V 0  $\mu$ V 2  $\mu$ V



L1 POLISH



L2 ENGLISH



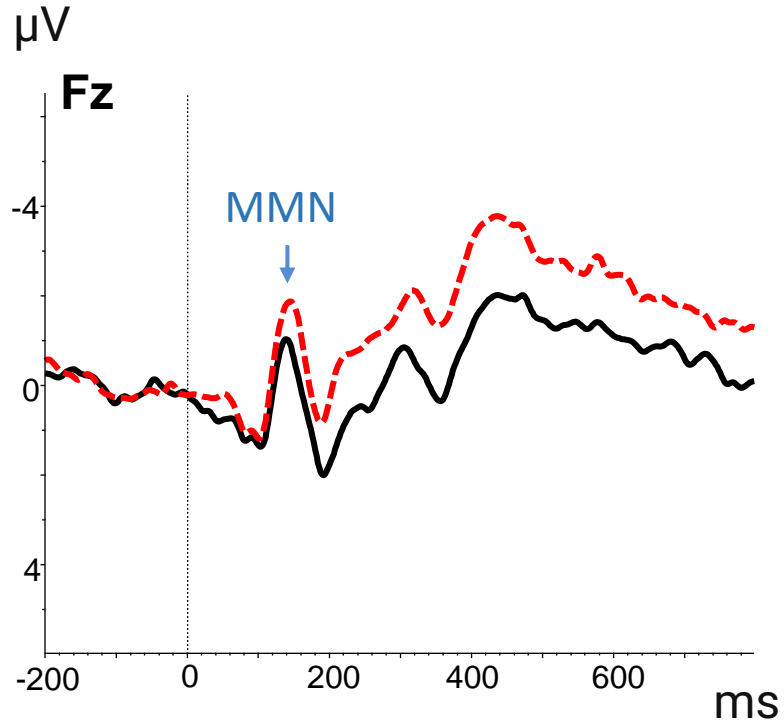
L3/Ln NORWEGIAN

# A follow-up study (UiT)

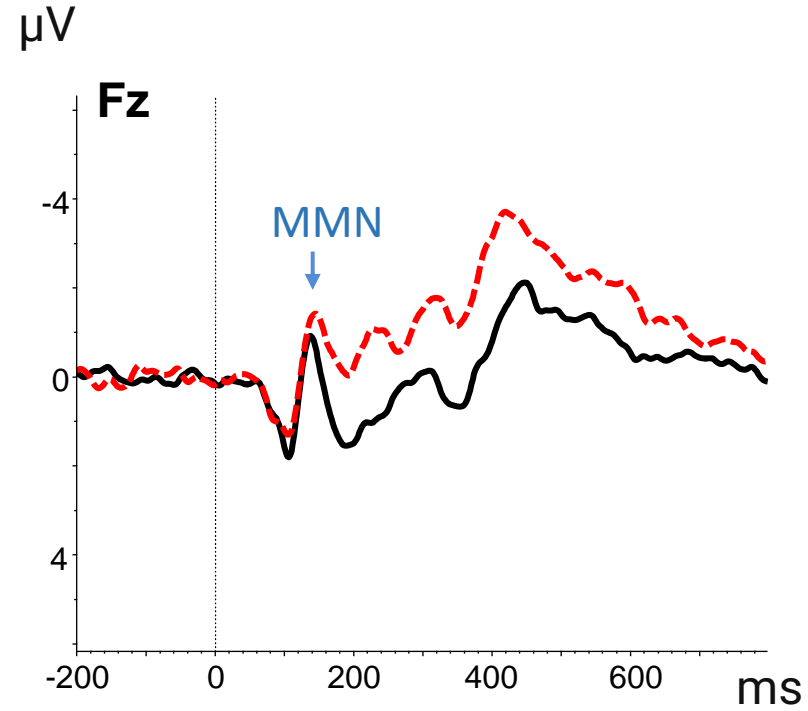


- **17 participants (Jan-Feb 2023):**
  - still ongoing,
  - naturalistic learners of Norwegian,
  - various professions,
  - AoA (English) = 9.76 years (range: 5–29),
  - AoA (Norwegian) = 27.59 years (range: 7–43)

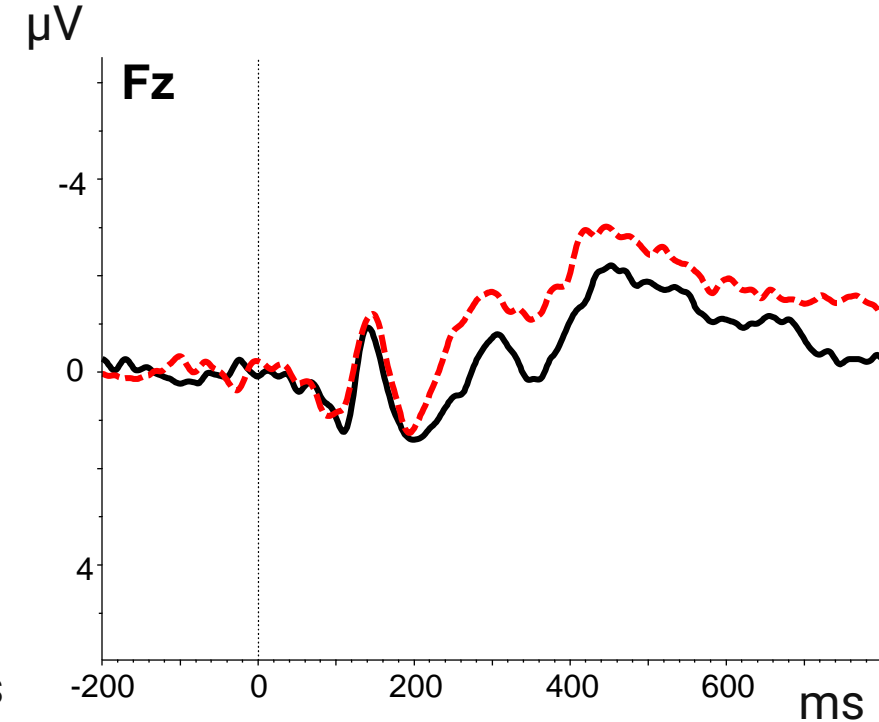
# ERP results: UiT (ongoing)



**POLISH**

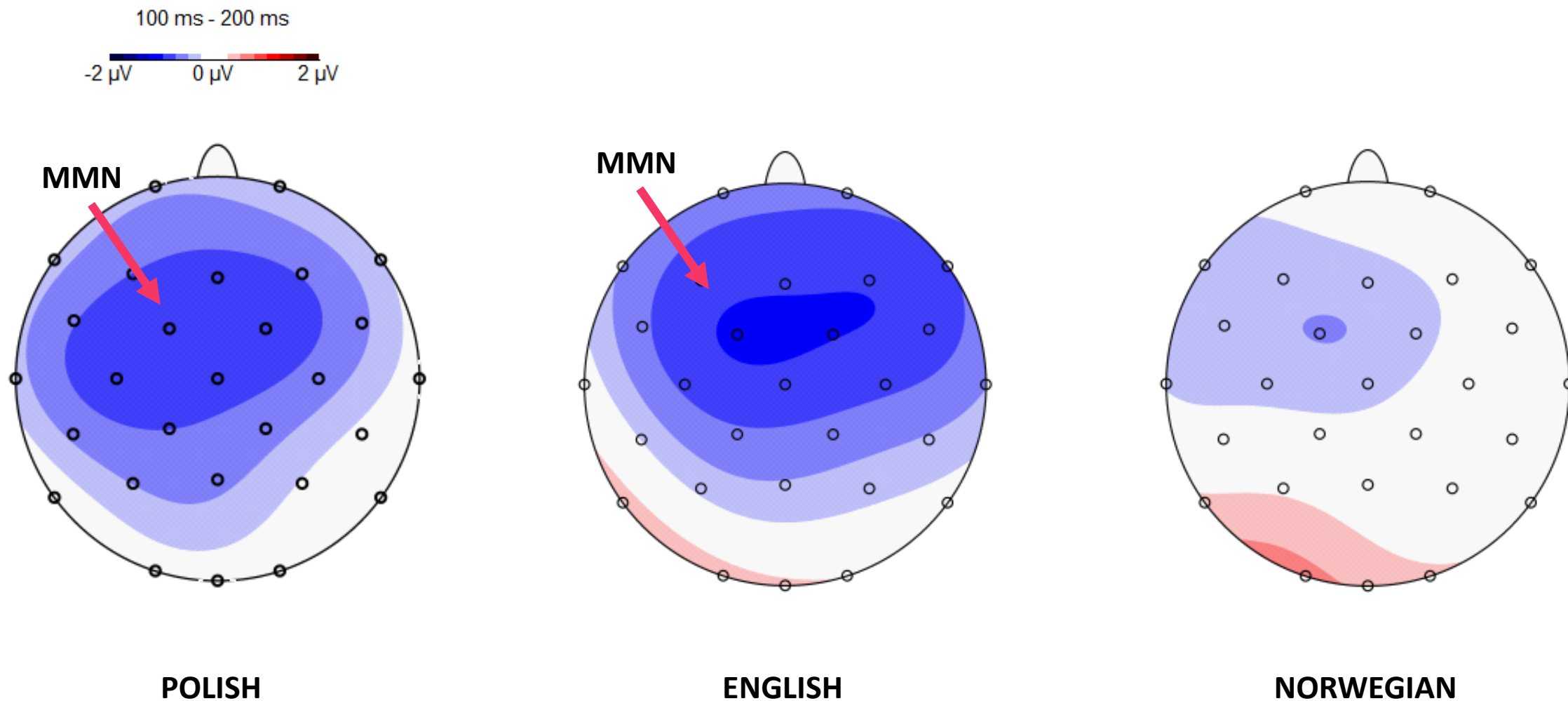


**ENGLISH**



**NORWEGIAN**

# ERP results: UiT (ongoing)



# 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. This is **in accordance with our hypothesis** and with previous research (Jakoby et al., 2011; Liang & Chen, 2022; Näätänen et al., 1997; Song & Iverson, 2018).
- 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).



# Discussion

## Main findings and open questions

- In the early 100-140 ms time window **the MMN emerged in L3/Ln Norwegian but not in L2 English.**
  - This finding opens the discussion on the participants' language dominance as a factor influencing phonemic perception mechanisms.
  - The level of proficiency and speech specific capabilities might also influence the effect (Diaz et al., 2016; Liang & Chen, 2022). Important: no P300 component observed!
  - In our study, the only significant correlation observed was that between the MMN magnitude in Norwegian and L3/Ln proficiency level,  $r(21) = 0.65, p = .02$ .
- The **LDN was less pronounced in L3/Ln Norwegian** when compared with L1 Polish (but not with L2 English).
  - 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).

# Conclusion

- First of all, we have **replicated previous findings** concerning the impaired phonemic perception in non-native languages in formal language learners.
- More crucially, the findings clearly suggest that foreign language **status as L2 or L3/Ln modulates auditory language processing**.
- At the same time, the results suggest **the relevance of the listeners' language proficiency and dominance** as factors influencing phonemic perception mechanisms.

# Open questions

- **AMU study:** Early onset of the LDN in English.
  - The contrast between English and Norwegian only visible in the earlier time window.
  - Time windows selection (especially for the MMN). Specifically, should we split the 100-180 ms time window into two: 100-140 and 140-180?
- **AMU study:** The fact the LDN was significantly lower in Norwegian than in English.
  - 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?



# Acknowledgements

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# Thank you

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# Statistics (extra): MMN (AMU)

## 100-140 ms

Language\*Sound\*Hemisphere

### Compared conditions:

language = **Norwegian**, hem = **left**

contrast	estimate	p.value
<i>deviant - standard</i>	-0.2249	0.0443

language = **Polish**, hem = **left**

contrast	estimate	p.value
<i>deviant - standard</i>	-0.7225	<.0001

a linear mixed effects analysis of the relationship between the processed **language**, the status of the processed **sound** as standard or deviant and **hemisphere** (left or right)

## 140-180 ms

Language\*Sound\*Hemisphere

### Compared conditions:

language = **English**,

hem = **left**

hem = **right**

contrast	estimate	p.value	estimate	p.value
<i>deviant - standard</i>	-0.672	<.0001	-0.347	0.0022

language = **Norwegian**,

hem = **left**

hem = **right**

contrast	estimate	p.value	estimate	p.value
<i>deviant - standard</i>	-0.277	0.0139	-0.387	0.0006

language = **Polish**,

hem = **left**

hem = **right**

contrast	estimate	p.value	estimate	p.value
<i>deviant - standard</i>	-0.859	<.0001	-0.392	0.0005

# Statistics (extra): LDN (AMU)

## 200-350 ms

Language\*Sound

### Compared conditions:

language = **Norwegian**

contrast	estimate	p.value
*** <i>deviant - standard</i>	-0.653	<.0001

language = **Polish**

contrast	estimate	p.value
<i>deviant - standard</i>	-0.959	<.0001

language = **English**

contrast	estimate	p.value
<i>deviant - standard</i>	-0.836	<.0001

## 350-800 ms

Language\*Sound

### Compared conditions:

language = **Norwegian**

contrast	estimate	p.value
*** <i>deviant - standard</i>	-0.918	<.0001

language = **Polish**

contrast	estimate	p.value
<i>deviant - standard</i>	-1.241	<.0001

language = **English**

contrast	estimate	p.value
<i>deviant - standard</i>	-1.069	<.0001