Societas Linguisitica Europaea, Bucharest, 24-27.08.2022

Perception in L2 and L3: The relationship between English and Norwegian vowel assimilation patterns and the Euclidean distances

Anna Balas, Magdalena Wrembel, Jarosław Weckwerth, Kamil Kaźmierski, Zuzanna Cal, Karolina Rataj

Adam Mickiewicz University in Poznań

Plan of the talk

- Introduction: non-native speech perception and Euclidean distances
- Hypotheses
- Methodology
- Results
- Statistical analysis
- Conclusions

Non-native speech perception

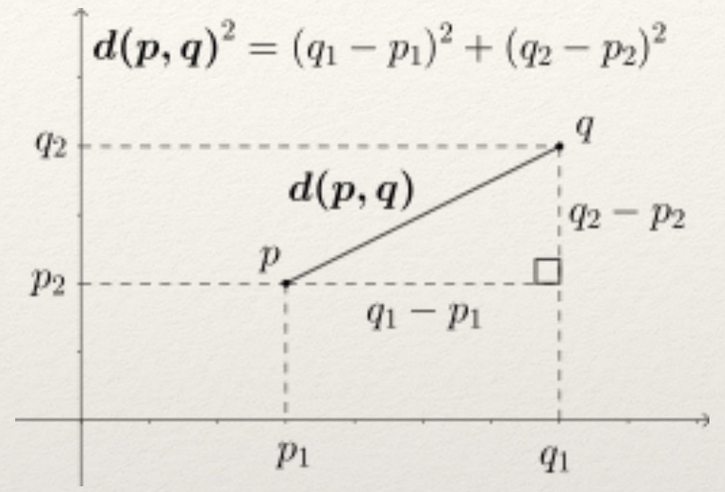
- So far non-native vowel perception studies concentrated on L2:
  - Perceptual assimilation and discrimination (Best and Tyler 2007, Tyler et al. 2014)
  - The relationship between vowel perception and acoustic parameters (Escudero, Simon, Mitterer 2012)
  - The role of language dominance (Amengual and Chamorro 2015)

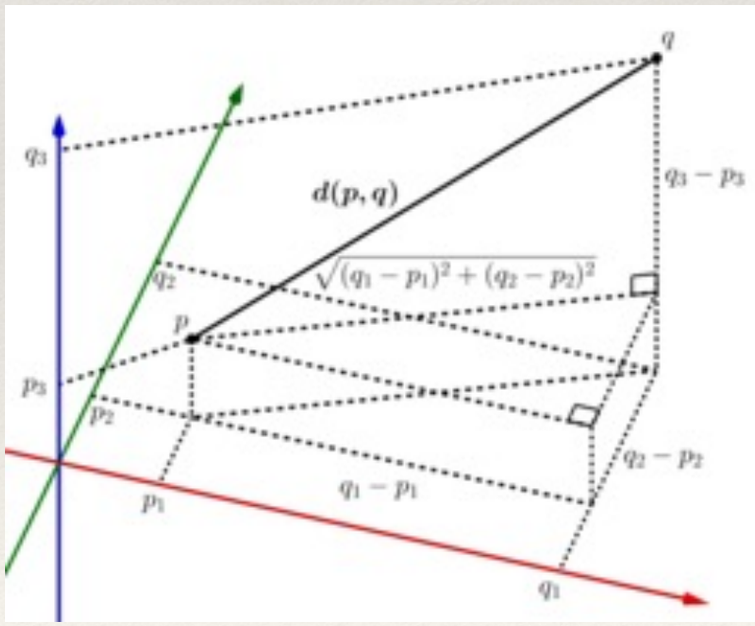
Aim of the study

- In the present contribution, we want to explore the relationship between L2 and L3 perception and acoustic similarity operationalized as the Euclidean distance between L2 English/L3 Norwegian and L1 Polish vowels.

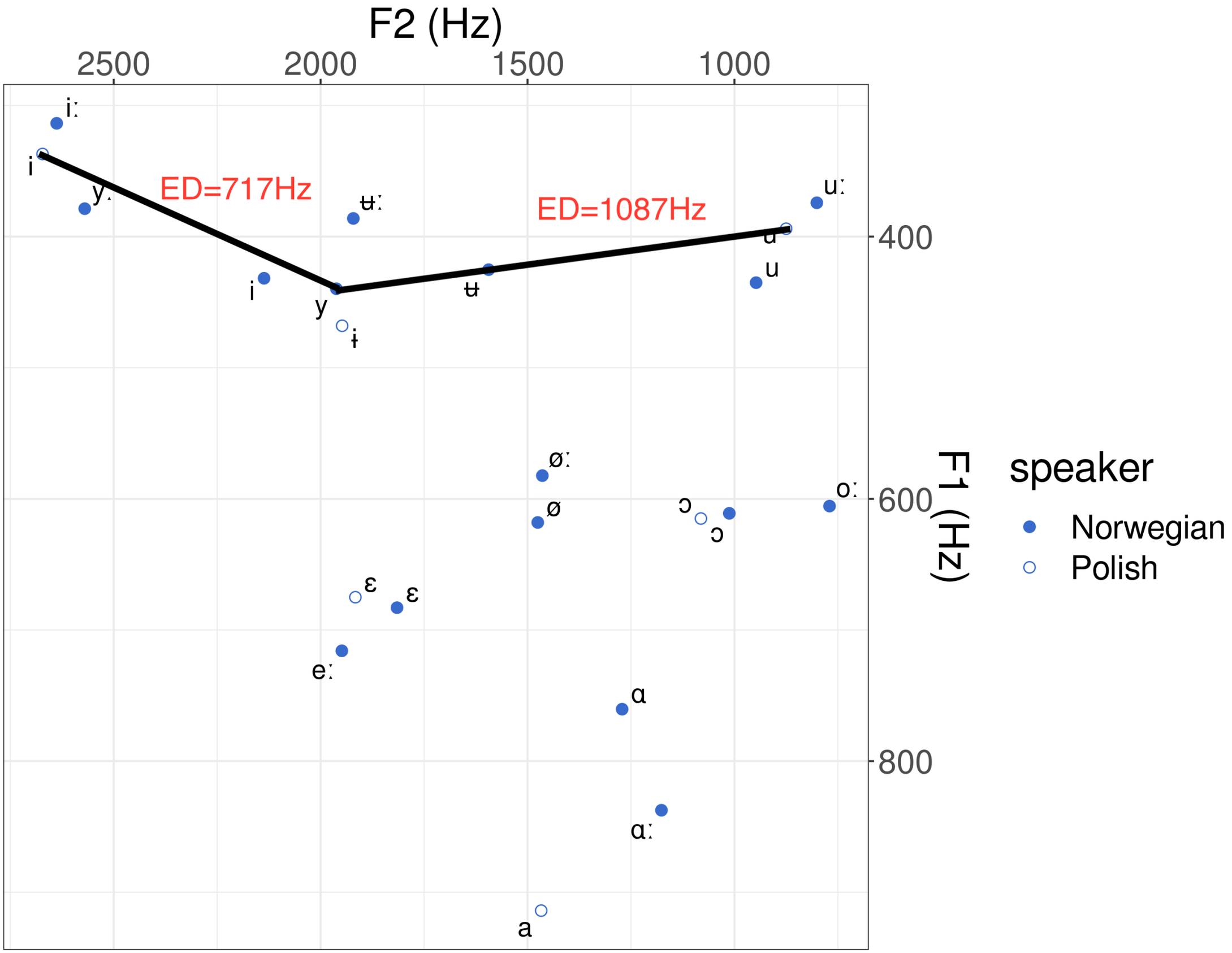
Euclidean distance

- Euclidean distance between vowels: the distance between two points in vowel space (Hz).
  - May be two-dimensional or three-dimensional: F1-F2 or F1-F2-F3.





Norwegian and Polish vowels



Hypotheses

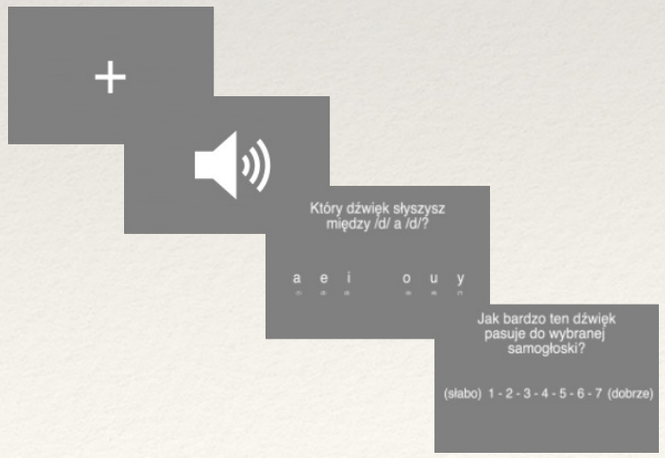
- H1: The smaller the Euclidean distance between two vowels, the higher the likelihood of assimilating a given L2 English/L3 Norwegian vowel to a L1 Polish vowel category.
- H2: If we take into account the Euclidean distance, L2 vowels should be perceived as worse exemplars of L1 categories than L3 vowels.
- H3/RQ: Does the Euclidean distance predict assimilation better in L2 or L3?
- H4: Lip rounding and duration differences may influence assimilation patterns.

Methodology: Participants

- Participants: 24 L1 Polish, L2 English (advanced, mean of language learning duration: 12.23), L3 Norwegian (2 months of intensive instruction). Mean age: 19.86. 17 females, 7 males. Instructed setting.

Methodology: Stimuli and procedure

- Participants assimilated 10 English and 16 Norwegian monophthongs (in separate blocks, on separate days) embedded in nonce words /dVd/ to six Polish vowel categories (orthographic labels were used, as Polish orthography is transparent).
- They also rated the goodness of fit of each non-native vowel to the chosen L1 category.
  - Likert scale from 1 to 7.



Results: confusion matrix – assimilation of L3 Norwegian vowels to L1 Polish categories

	/a/	/e/	/i/	NA	/ɔ/	/u/	/ɨ/
TID /iː/			100%				
			5,77				
FIN /i/		26.39%	33.33%	1.38%		1.38%	37.5%
		5.21%	5	4		3	5.41%
LYS /yː/		1.39%	70.83%			4.17%	23.61%
		1	4.59			4.33	5
SYND /y/		8.33%	16.66%	1.39%	2.78%	8.33%	62.5%
		5.17	5.25		5	2.33	4.64
STED /eː/	6.94%	88,89%		2,78%	1,39%		
	5.6	5.14		4	2		
BEST /e/	5.56%	93.06%	1.39%				
	5	5.9	2				
LØP /øː/	5.56%	19.44%			58.33%	6.94%	9.72%
	3.75	5.14			4.45	3.2	3.57
SØNN /øː/	8.33%	36.11%		4.17%	33.33%	6.94%	11.11%
	5	4.35		5.33	4.29	3.2	3.25

	/a/	/e/	/i/	NA	/ɔ/	/u/	/ɨ/
DAG /ɑː/	100,00%						
	5.53						
TAKK /ɑ/	98.61%			1.39%			
	5.69			4			
RAD /oː/			1.39%		97.22%	1.39%	
			5		5.25	7	
NOK /o/				1.39%	98.61%		
					5.58		
BOK /uː/					38.89%	61.11%	
					5.43	5.02	
ROM /u/					72.22%	27.78%	
					5.08	4.9	
GUD /ʉː/		1.39%	2.78%	1.39%	1.39%	75%	18.06%
		1	7	5	5	4.72	4.23
SLUTT /ʉ/			1.39%	1.39%	9.72%	63.89%	23.61%
			3	7	5	4.65	4.11

	/a/	/e/	/i/	NA	/ɔ/	/u/	/ɨ/
TID /iː/			100%				
			5,77				
LYS /yː/		1.39%	70.83%			4.17%	23.61%
		1	4.59			4.33	5
SYND /y/		8.33%	16.66%	1.39%	2.78%	8.33%	62.5%
		5.17	5.25		5	2.33	4.64
GUD /ʉː/		1.39%	2.78%	1.39%	1.39%	75%	18.06%
		1	7	5	5	4.72	4.23
SLUTT /ʉ/			1.39%	1.39%	9.72%	63.89%	23.61%
			3	7	5	4.65	4.11

Results: Model of Assimilation Count

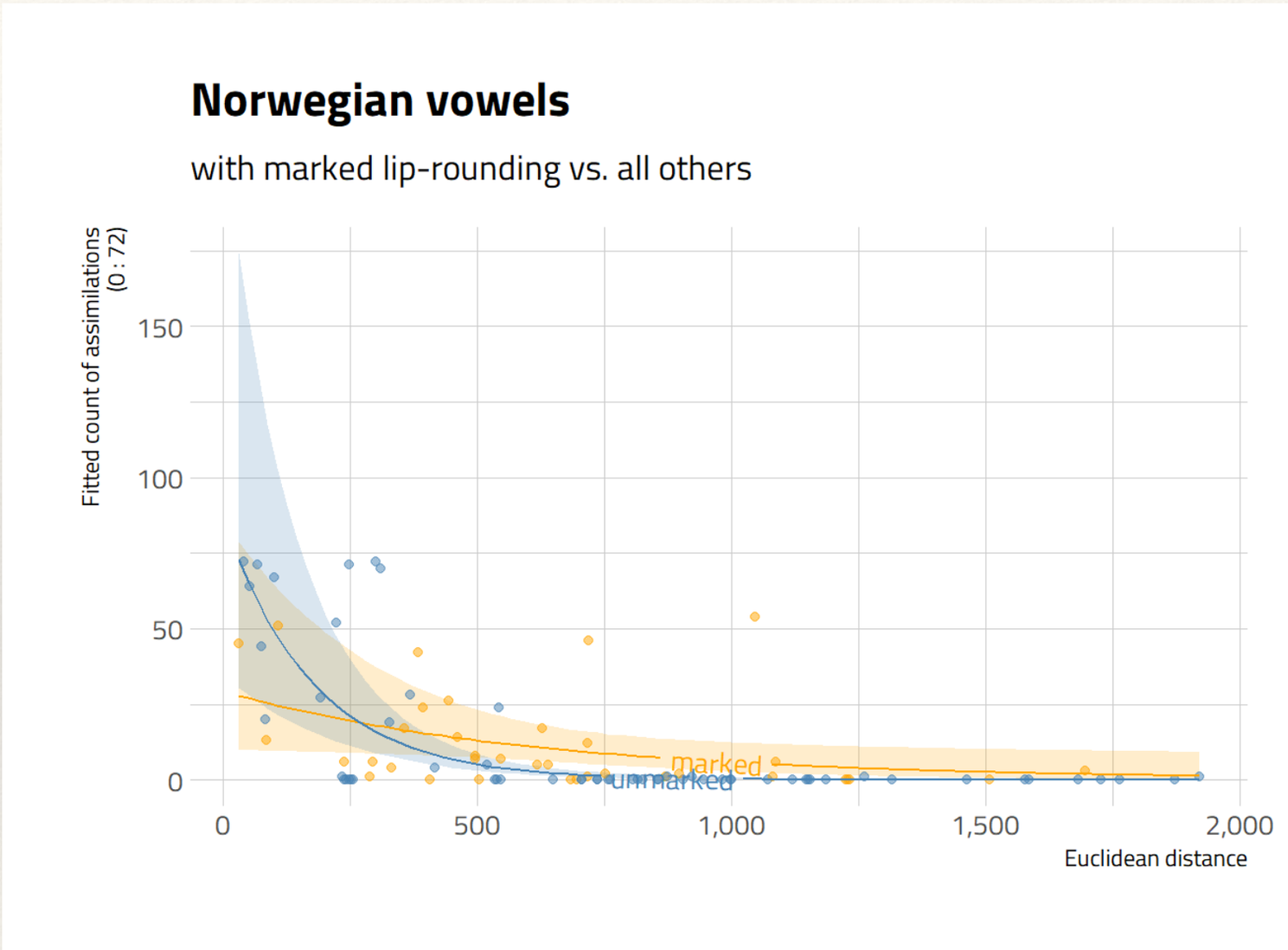
- Poisson regression for count data: Number of times a given Norwegian vowel was assimilated to a Polish vowel as response variable.
  - The values range from 0 (a given Norwegian vowel was never assimilated to a given Polish vowel) to 72 (a given Norwegian vowel was assimilated to a given Polish vowel by all 24 participants in all three instances)
- Why is this model suitable?
  - Poisson distribution is restricted to non-negative values.
  - It captures the distribution in logarithmic scale which is appropriate for this kind of data.
- However, the Poisson model suffered from overdispersion (numerous 0 counts). Remedy: fitting a negative binomial model instead.

A negative binomial model

- What it captures:
  - Is the F1-F2 Euclidean distance related to how often a given Norwegian vowel is assimilated to a given Polish vowel?
  - Is the impact of Euclidean distance different for short vs. long vowels?
- Result: ED is negative and significant ($z = -6.751$, $Pr(>|z|) = 1.46e-11$***), which means that the larger the Euclidean distance, the fewer assimilations are predicted

The influence of lip rounding on assimilation rates as determined by Euclidean distance – no indication

- H4 predicted that Euclidean distance may have a weaker effect on assimilation rates in the case of vowels which have „more marked lip rounding", i.e. high front or central rounded vowels.
- The interaction ed:marked_rounding is positive and significant, but the effect of marked_rounding is not significant -> hard to interpret.
- Unmarked vowels have higher predicted assimilation rates when the Euclidean distance = 0; the decrease in the predicted assimilation count for unmarked vowels is steeper.

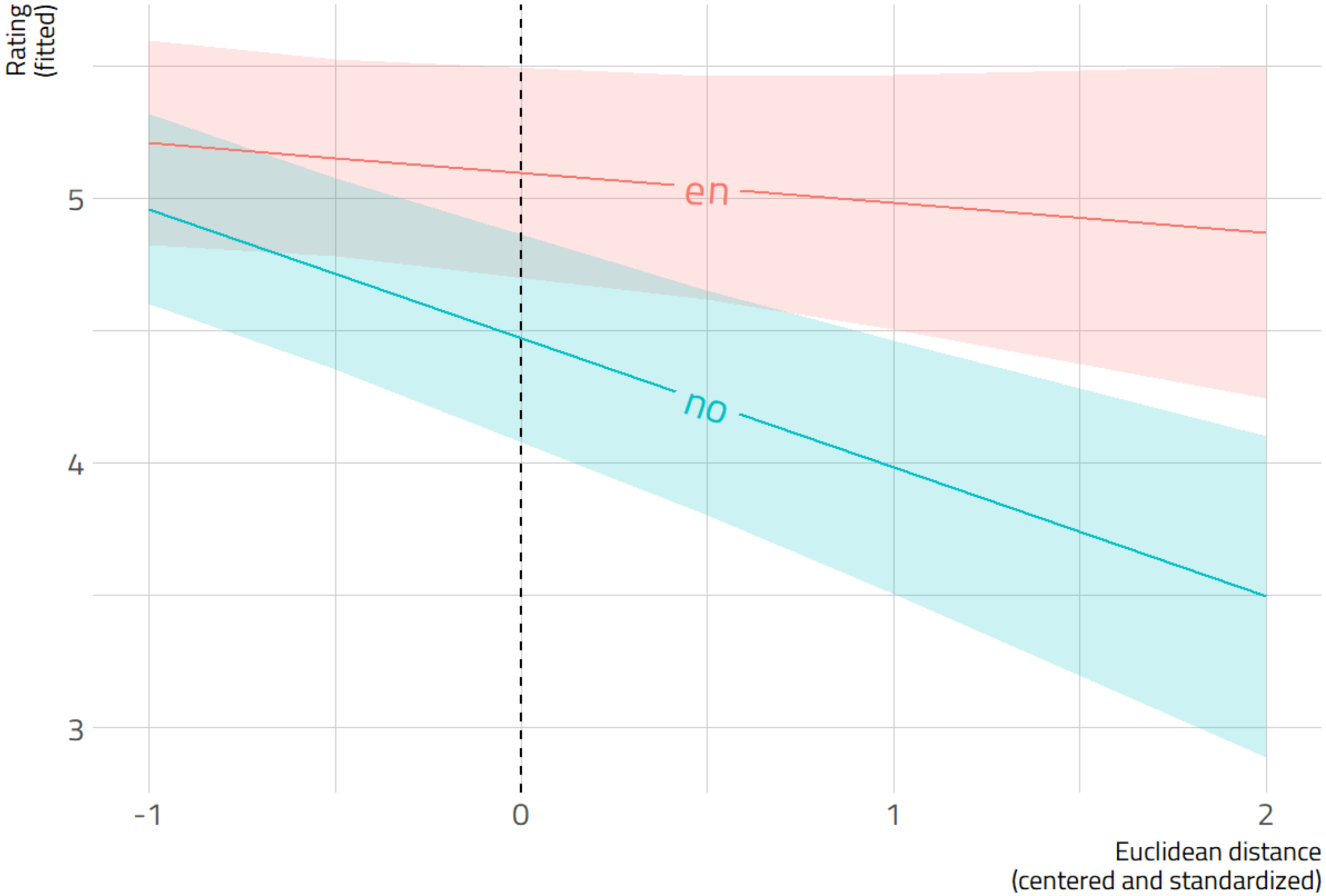


The influence of the Euclidean distance on perception in L2 and L3

- H3/RQ: Does the Euclidean distance predict assimilation better in L2 or L3?
- Coefficient in the Norwegian model of the standardized Euclidean distance predictor; ed_z = -1.706004
- Coefficient in the English model of the standardized Euclidean distance predictor; ed_z= - 0.6104734.
- The absolute value of the coefficient is larger in Norwegian, which suggests that there is a stronger effect of the Euclidean distance in L3 than in L2.
- Interpretation: assimilations in the better-known L2 have stabilized taking into account other factors/features?

Are L2 or L3 vowels perceived as better exemplars of L1 categories? Reasoning behind the hypothesis.

- H2: If we take into account the Euclidean distance, L2 vowels should be perceived as worse exemplars of L1 categories than L3 vowels.
- Justification of the hypothesis:
  - It is one of the prerequisites for new category formation (Flege 1995, Flege and Bohn 2021) that listeners perceive differences between non-native and native sounds.
  - Since our participants are more advanced in L2, we expected that the process of new category formation for English vowels would be more advanced, and signaled by lower goodness of fit ratings.


Rating
(fitted)
5
4
3
en
no
-1
0
1
2
Euclidean distance
(centered and standardized)

L2 or L3 vowels as better exemplars of L1?

- Results: mixed effects linear model of Liker rating as a function of centered and standardized Euclidean distance, language and their interaction. The model includes by-participant random intercept.
- Larger Euclidean distance means lower goodness of fit ratings in both languages.
- At mean value of the Euclidean distance (in the plot =0), the English vowels are rated higher than Norwegian vowels. The effect of language is significant.
- Disclosure: it was a general comparison of the two systems. Typologically and phonologically, there are many features that make Norwegian vowels more marked than English vowels. Perhaps due to them English vowels turn out to be more similar to Polish vowels than Norwegian vowels.

Summary of the results

- The smaller the Euclidean distance between two vowels, the higher the likelihood of assimilating a given non-native vowel to a native category.
- There is some indication that marked lip rounding may influence assimilation patterns, but no indication that length plays a role.
- There is a stronger effect of the Euclidean distance in the L3 than in L2.
- L2 English vowels seem more similar to L1 Polish vowels than L3 Norwegian vowels.

Limitations

- To examine the influence of L2/L3 on the perceived similarity of vowels/goodness of fit ratings we would also need a pair in which L2 has more marked vowels than L3. L2 English and L3 Spanish perhaps.

Further research

- This study has been a part of a larger project:
  - Vowel production
  - Comparison of vowel perception and production
  - Syntactic experiments
  - Comparison of the acquisition in natural vs. instructed settings.

References

Alispahic, S., Mulak K.E.., & Escudero P. 2017. Acoustic properties predict perception of unfamiliar Dutch vowels by adult Australian English and Peruvian Spanish listeners. *Frontiers in Psychology* 8 (52).

Best C. & Tyler, M. (2007). Non-native and second language speech perception: Commonalities and complementarities. In M. Munro & O-S. Bohn (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 13-34). Amsterdam: John Benjamins.

Escudero, P., Simon, E., & Mitterer, H. (2012). The perception of English front vowels by North Holland and Flemish listeners: acoustic similarity predicts and explains cross-linguistic and L2 perception. *Journal of Phonetcis* 40 (2), 280-288.

Peirce, J. W., Gray, J. R., Simpson, S., MacAskill, M. R., Höchenberger, R., Sogo, H., Kastman, E., Lindeløv, J.2019. PsychoPy2: experiments in behavior made easy. *Behavior Research Methods*.10.3758/s13428-018-01193-y

Strange, W., Bohn, O-S., Trent, S. & Nishi K. (2004). Acoustic and perceptual similarity of North German and American English vowels. *Journal of the Acoustical Society of America*, 115(4), 1791-1807.

Tyler, M.D., Best C.T., Faber, A. & Levitt, A.G. (2014). Perceptual Assimilation and Discrimination of Non-Native Vowel Contrasts. *Phonetica* 71, 4-21. v Wood, S.N. (2017) *Generalized Additive Models: An Introduction with R* (2nd edition). Chapman and Hall/CRC.

Thank you for your attention.

This study has been a result of a research project Opus-19-HS (UMO-2020-37/B/HS2/00617) CLIMAD „Cross-linguistic influence in multilingualism across domains: Phonology and syntax” financed by the National Science Centre, Poland. PI: Magdalena Wrembel.

NARODOWE CENTRUM NAUKI

Opus