Reproducibility in corpus-based computational analyses of learner speech

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  - Research Gaps | Research Questions
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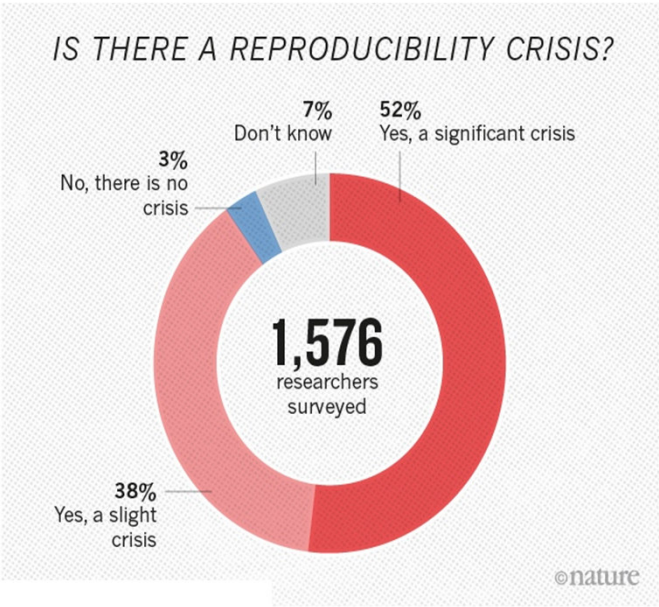
Reproducibility Crisis

Controversial ongoing methodological crisis that originated in medicine (Ioannidis 2005) and swiftly expanded to STEM, the social sciences, and psychology when **replications of seminal experiments failed** - calling into question the reliability of widely accepted published research

Reproducibility is a defining feature of science, but the extent to which it characterizes current research is unknown.
(Open Science Collaboration 2015)



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Published: 25 May 2016

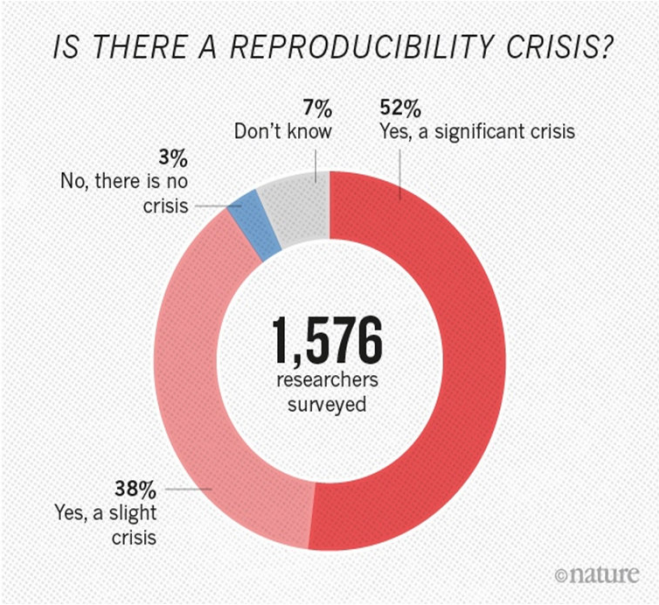
1,500 scientists lift the lid on reproducibility

Monya Baker

Nature **533**, 452–454 (2016) | Cite this article

"More than 70% of researchers have tried and failed to reproduce another scientist's experiments, and more than half have failed to reproduce their own experiments."
(Baker 2016: 452)

Reproducibility Crisis



Results and **Effects**

- Public **loss of trust** in science
- Substantive **efforts to improve** transparency and reproducibility (in STEM and "hard" social sciences)
- Examples: increased efforts to support replication, pre-registration, and establishing a culture of sharing & infrastructures for sharing (OSF, GitHub, RNotebooks)

Reproducibility Crisis

Problem has been identified in (Corpus Linguistics) **BUT**

focus on data (data citation, data sharing) **NOT analyses**

Open Access Veröffentlicht von De Gruyter Mouton 6. Dezember 2017

Reproducible research in linguistics: A position statement on data citation and attribution in our field

Andrea L. Berez-Kroeker, Lauren Gawne, Susan Smythe Kung, Barbara F. Kelly, Tyler Heston, Gary Holton, Peter Pulsifer, David I. Beaver, Shobhana Chelliah, Stanley Dubinsky, Richard P. Meier, Nick Thieberger, Keren Rice und Anthony C. Woodbury

Aus der Zeitschrift Linguistics

see Marsden & Bolibaugh 2021 (to the right), document available through:

https://pure.york.ac.uk/portal/en/publications/reproducibility-and-research-integrity-in-applied-linguistics

This preprint contains the text of a submission of written evidence to the UK Parliament, House of Commons Science and Technology Committee inquiry on reproducibility and research integrity (submitted: 24 September 2021. Viewable on the parliament website here). It is not peer-reviewed.

Reproducibility and research integrity in applied linguistics

Professor Emma Marsden, University of York, emma.marsden@york.ac.uk

Dr Cylcia Bolibaugh, University of York, cylcia.bolibaugh@york.ac.uk

We work in the area of applied linguistics, with a focus on the learning of languages (second, foreign, additional languages after the first language). This is a multidisciplinary field, sitting at the intersection of social sciences (education), arts & humanities (linguistics, languages) and learning sciences (psychology, including neuroscience).

We are writing in our capacity as Director (Emma Marsden) and Co-Director (Cylcia Bolibaugh) of two open research and impact initiatives: IRIS (Instruments and materials for Research Into Second languages) and OASIS (Open Accessible Summaries In Language Studies).

Availability of data and code underpinning published findings

Sharing of data and code underpins computational reproducibility, and is necessary for the verification of individual studies, as well as for the carrying out of meta-analyses. Failure to share data results in a cumulative loss of research value as findings cannot be incorporated into research syntheses and meta-analyses.

(Corpus) Linguists need to know about and implement transparent workflows to produce reliable and replicable results!

How to improve reproducibility | replicability | robustness

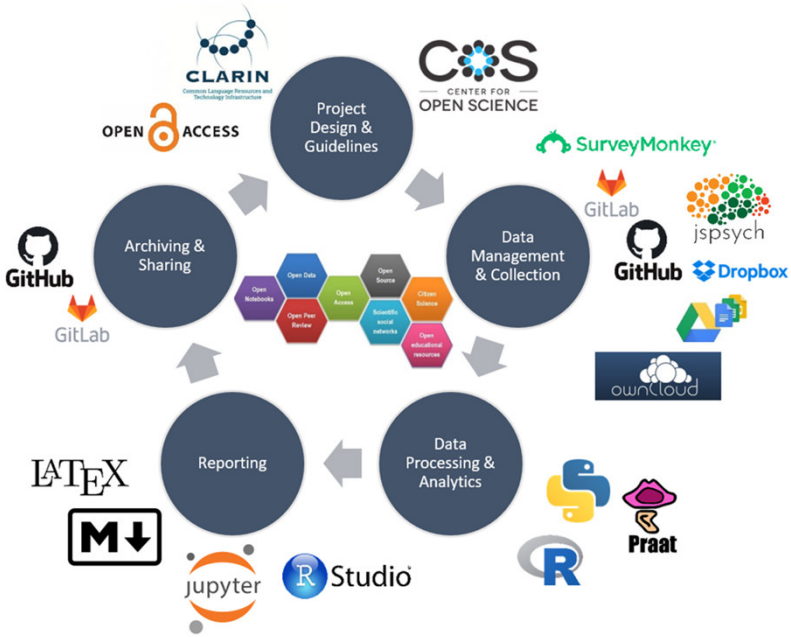
Data management

- **File naming**: consistent and meaningful
- **Folder templates**: Use templates across teams | labs
- **3-2-1 rule**: 3 copies of data on 2 media one of which
  should be the cloud

Documentation

- document where to find what
- helpful for on-boarding people
- useful when sharing projects

allows to recover what has been done and helps avoiding data loss (bus factor): how many people can be run over by a bus without the project coming to a halt?)



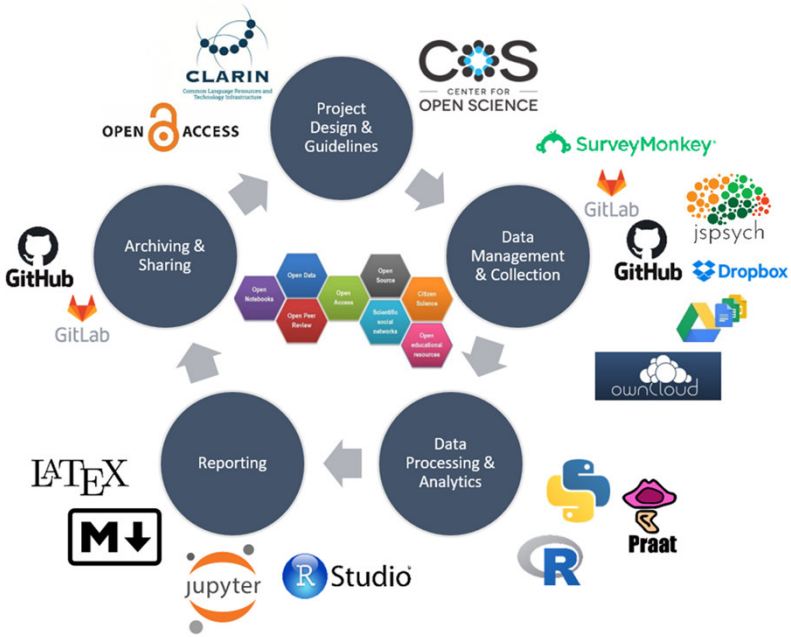
How to improve reproducibility | replicability | robustness

FAIR data

- Findable, Accessible, Interoperable, Reusable
- Sharing data (OSF, GitHub, etc.)

Practice shift

- Pre-registration
- Upskilling for MA students
- Stronger focus on replication studies
- Submitting notebooks | code & data alongside papers
- Acknowledge data sets as research outputs



Show case

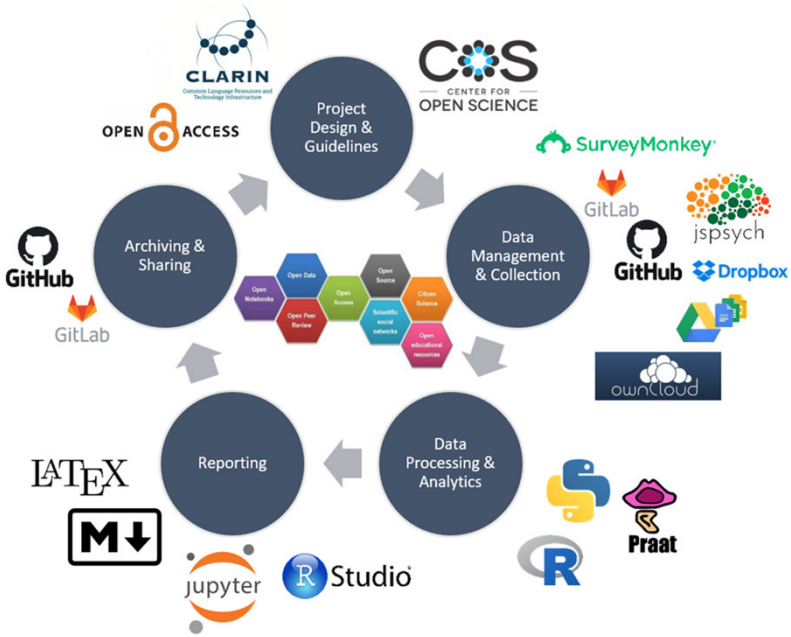
A corpus-based computational analysis of high-front and -back vowel production of L1-Japenese learners of English and L1-English speakers

What have I done?

- Created a GitHub repository which contains all relevant information (SST2022-EngVwlJpn)
- Documented where to find the data and how to download it
- Uploaded the processed data and the R notebooks used in processing and analysing the data
- Created and uploaded a Jupyter notebook which allows everyone to perform the analysis

The GitHub repo can be accessed via my GitHub repository: https://github.com/MartinSchweinberger/SST2022-EngVwlJpn

The associated paper is available here.



Background and Motivation

Pronunciation is a challenge for L2 English learners

Problem

- Pronunciation is most immediate and direct
- Everybody automatically and subconsciously categorizes and infers judgements based on pronunciation (gender, age, cultural background, nativeness, socio-economics, education, etc.)
- Pronunciation is crucial for intelligibility
- Pronunciation is affecting real-life opportunities (jobs, partner choice, etc.)

Pronunciation is important for learners as well as teachers of English!

Background and Motivation

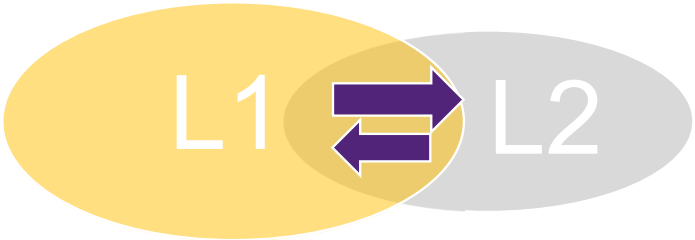
Why is pronunciation a challenge for L2 English learners?

Languages interact in the minds of multilingual speakers

Languages are not independent but affect each other

Speech Learning Model (SLM) (Flege 1995)

- L1 and L2 sound systems exist in a shared phonetic space in the bilingual mind
- As a result, the L2 sound system is affected by the L1 system (and vice versa)

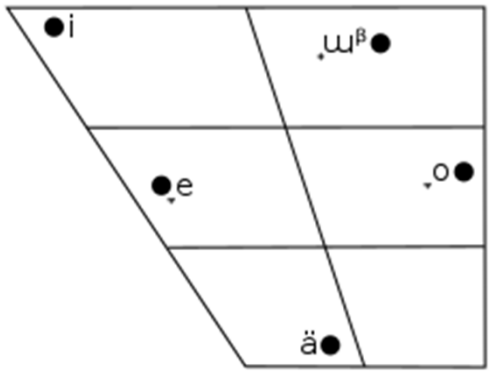


Background and Motivation

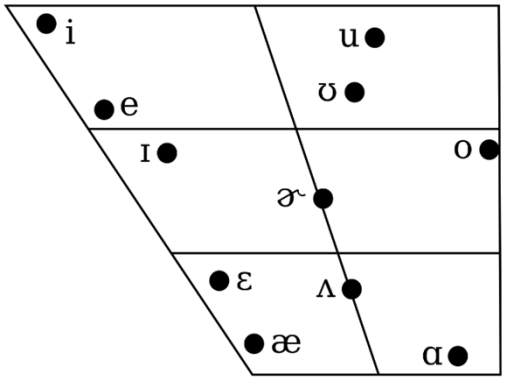
English vowels are particularly challenging for Japanese-L1 learners
(Franklin & Stoel-Gammon 2014)

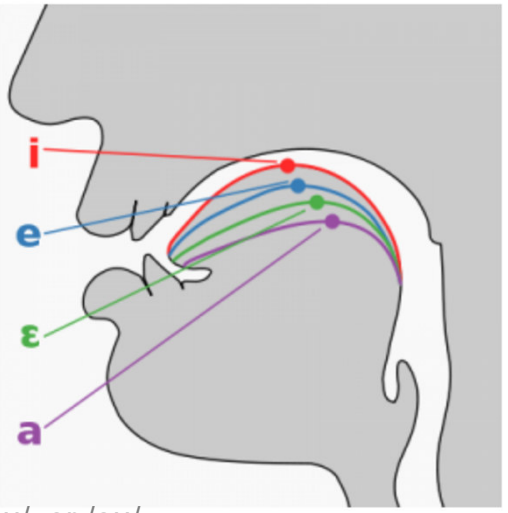
- Differences in inventory size (JPN: 5 vowels* vs. ENS: app.** 11 vowels) (Homma 1992)
- Differences in how vowels are differentiated (ENS: formants + duration | JPN: duration)

Japanese vowel chart



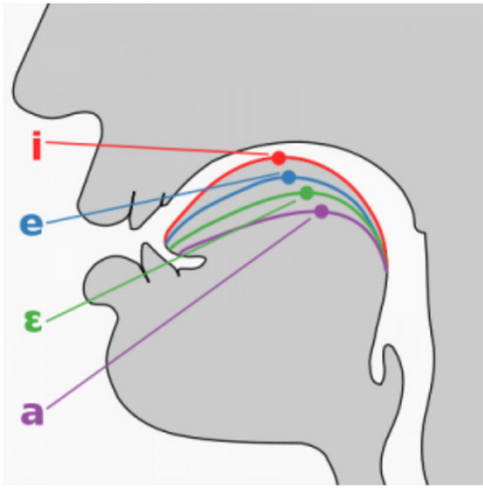
Vowel chart of
southern Californian Engl.





* Monophthingal vowels, i.e., vowels with a fixed tongue position (not vowels with a moving tonue position like /au/ or /ou/.
** Depending on the variety of English.

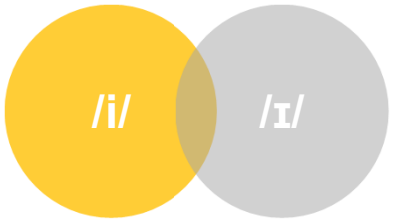
Research Gaps | Research Questions



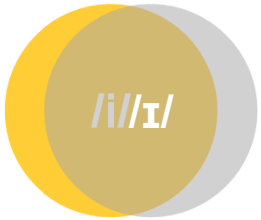
What has been said about English vowels produced by Japanese learners?

- Japanese learners merge spectrally similar vowels (Ingram & Park 1997, Ueyama 2003)

L1 English speaker (ENS)

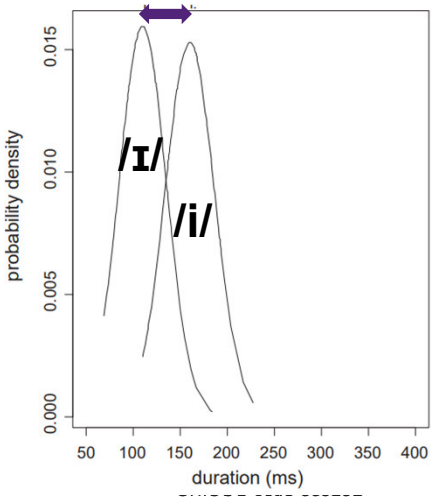


Japanese learner of English (JPN)

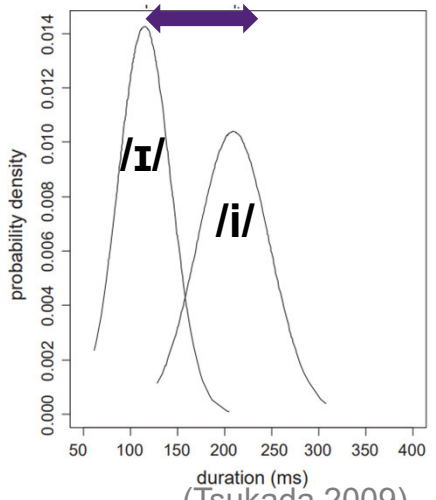


- Japanese speakers are **very sensitive** to vowel duration (Kato et al. 2001) and **exaggerate duration to compensate** for the relative insensitivity to formant differences (Morrison 2002)

L1 English speakers

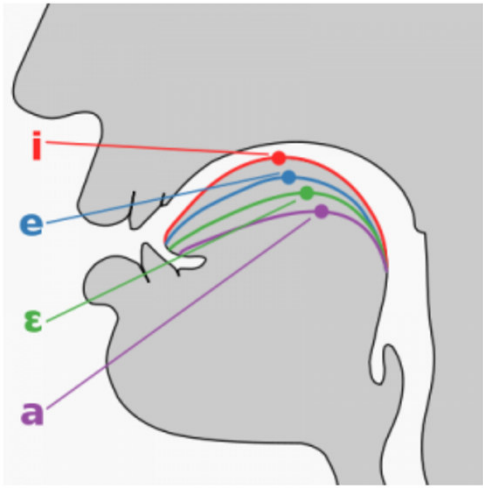


Japanese learners of English



(Tsukada 2009)

Research Gaps | Research Questions



Problems and gaps in previous research

- Investigation mainly done in highly controlled laboratory conditions (scripted word | sentence-reading)
  - ➢ Learner vowel traits in naturalistic speech environments largely unknown
- Small subject size (±10 speakers)
  - ➢ Limited generalisability | applicability of the findings

Larger-scale analysis of vowels
produced under more **spontaneous speech** conditions is needed!

RQ1: Do Japanese learners **merge /i:/ and /ɪ/ as well as /u:/ and /ʊ/**?

RQ2: Do Japanese learners **exaggerate the length of vowels** to compensate lack of spectral differentiation?

Methodology (Data | Analysis)

Data

- *International Corpus Network of Asian Learners of English* (ICNALE) (Ishikawa 2014)
  - Speech and text samples from English learners in Asia and L1 English speakers
  - Spoken monologues: spontaneous speech from **150 Japanese learners** and **132 L1 speakers of English**
  - Before processing

Type	Speakers	/ɪ/	/i:/	/ʊ/	/u:/
ENS	132	2,562	1,205	350	1,895
JPN	150	3,696	1,203	644	1,261
Total	**282**	**6,258**	**2,408**	**994**	**3,156**

  - After processing (final data set)

Type	**Speakers**	**/ɪ/**	**/i:/**	**/ʊ/**	**/u:/**
ENS	105	693	939	189	395
JPN	141	1,122	535	188	281
Total	**246**	**1,815**	**1,474**	**377**	**676**

Methodology (Data | Analysis)

Data Processing (R 4.2, R Core team (2022) in RStudio (RStudio Team 2022))

- Aligning speech with audio using Web-MAUS (Schiel 1999)
  (this produces Praat TextGrids)
- Automated extraction of vowel formants and vowel duration from Praat TextGrids (Wickham et al. 2019)
- Only monosyllabic words were retained and outliers were removed using Kernel Density Estimation

Statistical Analysis

- Mergers → **Bhattacharya affinity** (Johnson 2015, measure of overlap of scatter clouds, 1 = perfect overlap)
- Duration → **Mixed-Effects Regression Model** (lme4: Bates et al. (2015), sjPlot: Lüdeke (2021))
  - DV: duration
  - IVs: type, vowel, gender, age, word type
  - REs: word, speaker

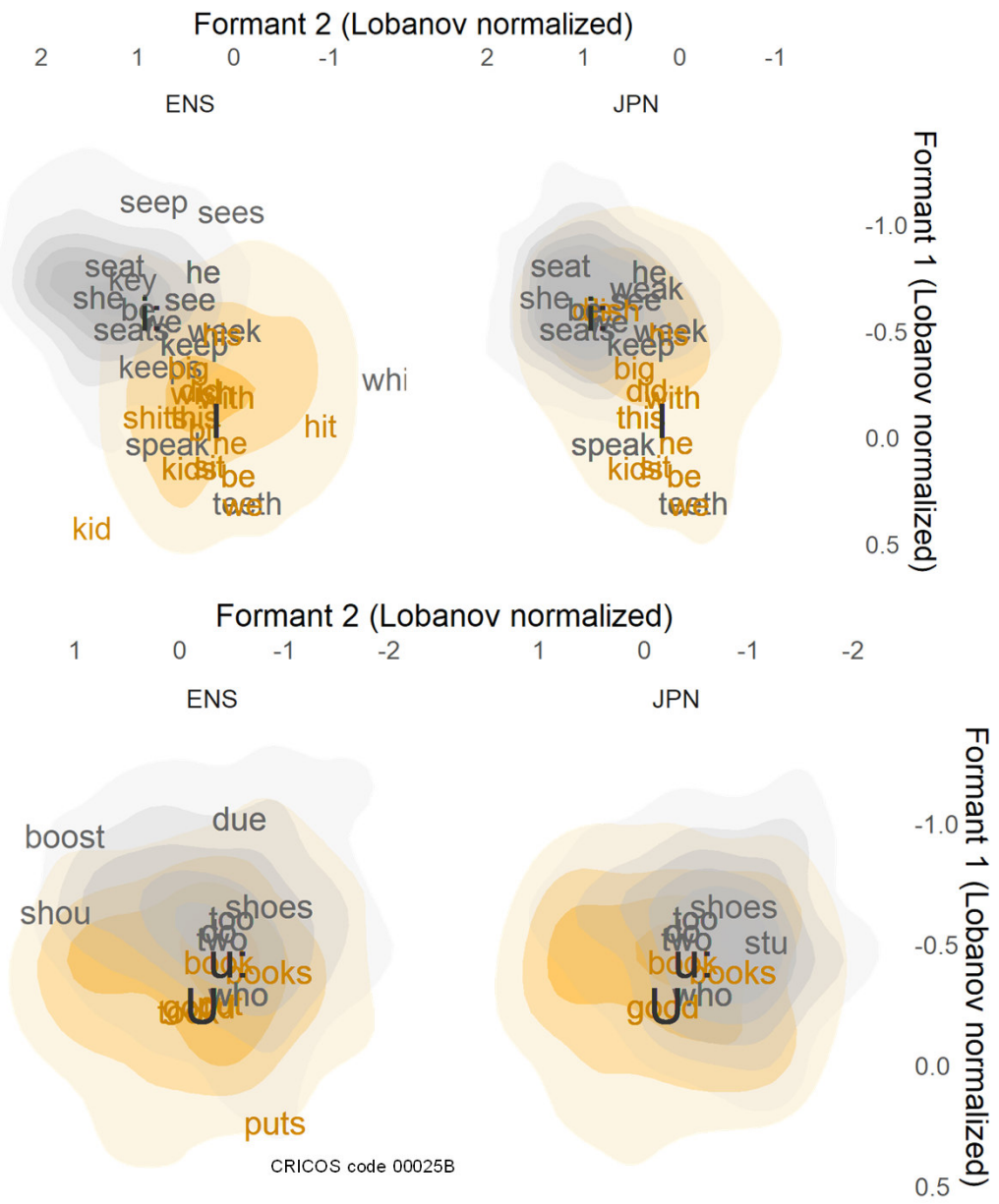
Results

Mergers

- /i:/ and /ɪ/
  - JPN Bhattacharya affinity: .901
  - ENS Bhattacharya affinity: .757

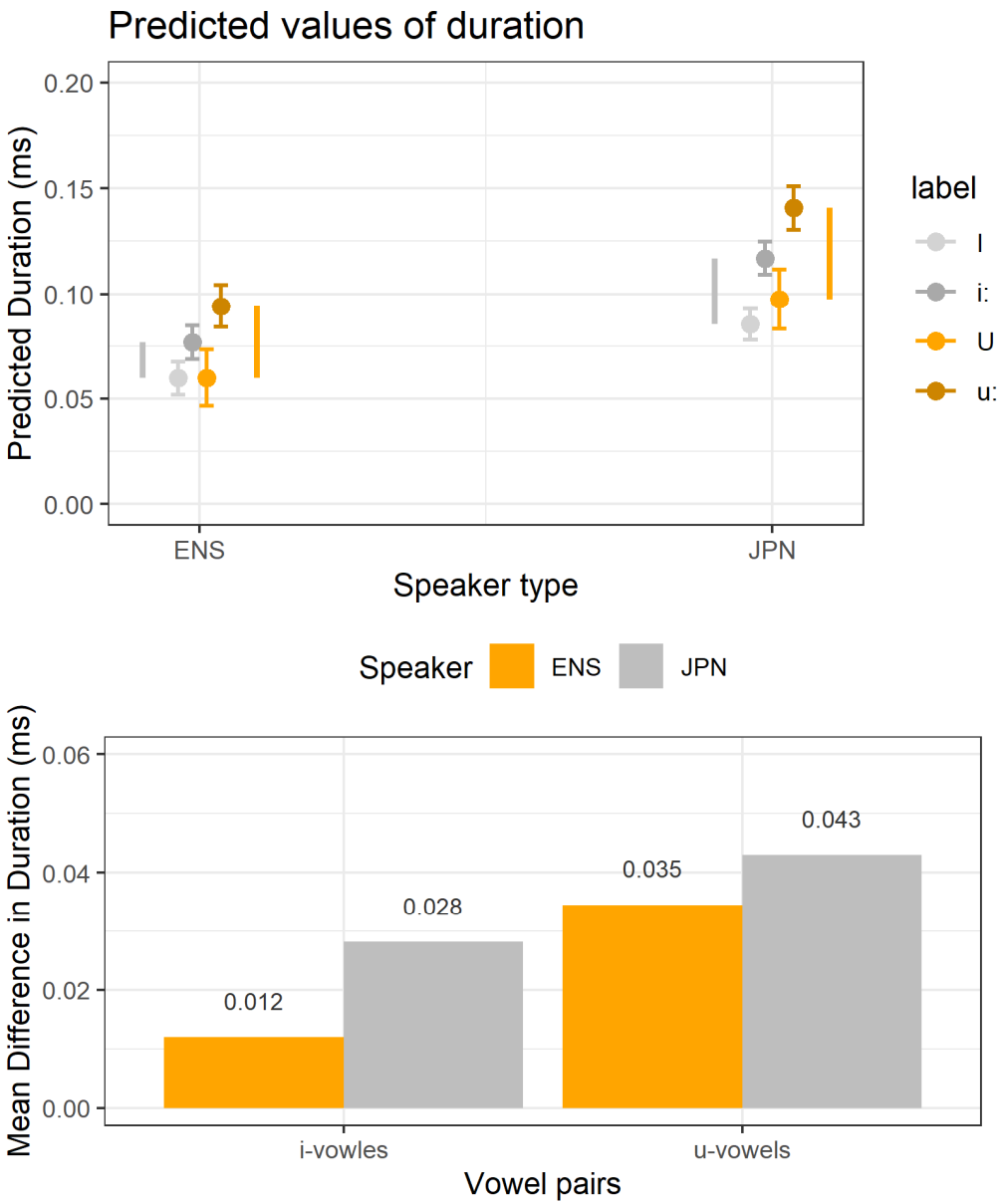
  Substantively more overlap among JPN!
- /u:/ and /ʊ/
  - JPN Bhattacharya affinity: .932
  - ENS Bhattacharya affinity: .952

Mergers confirmed for **spectrally similar vowels** (ENS also merge /u:/ and /ʊ/)!



Results

	final minimal adequate model		
Predictors	Est.	CI	p
(Intercept)	0.06	0.05 - 0.07	<0.001
type_{JPN}	0.03	0.02, 0.03	<0.001
$\text{label}_{i:}$	0.02	0.01, 0.02	<0.001
label_{U}	0.00	-0.01, 0.01	0.981
$\text{label}_{U:}$	0.03	0.02, 0.05	<0.001
gender_{male}	0.01	0.00, 0.02	0.001
type_{JPN} * $\text{label}_{i:}$	0.01	0.01, 0.02	0.001
type_{JPN} * label_{U}	0.01	-0.00, 0.02	0.056
type_{JPN} * $\text{label}_{U:}$	0.02	0.01, 0.03	<0.001
type_{JPN} * gender_{male}	-0.02	-0.03, -0.01	<0.001
Random Effects			
ICC		0.07	
N		149 speaker 46 word	
Observations		4342	
Mar. R^2 / Cond. R^2		0.115 / 0.178	

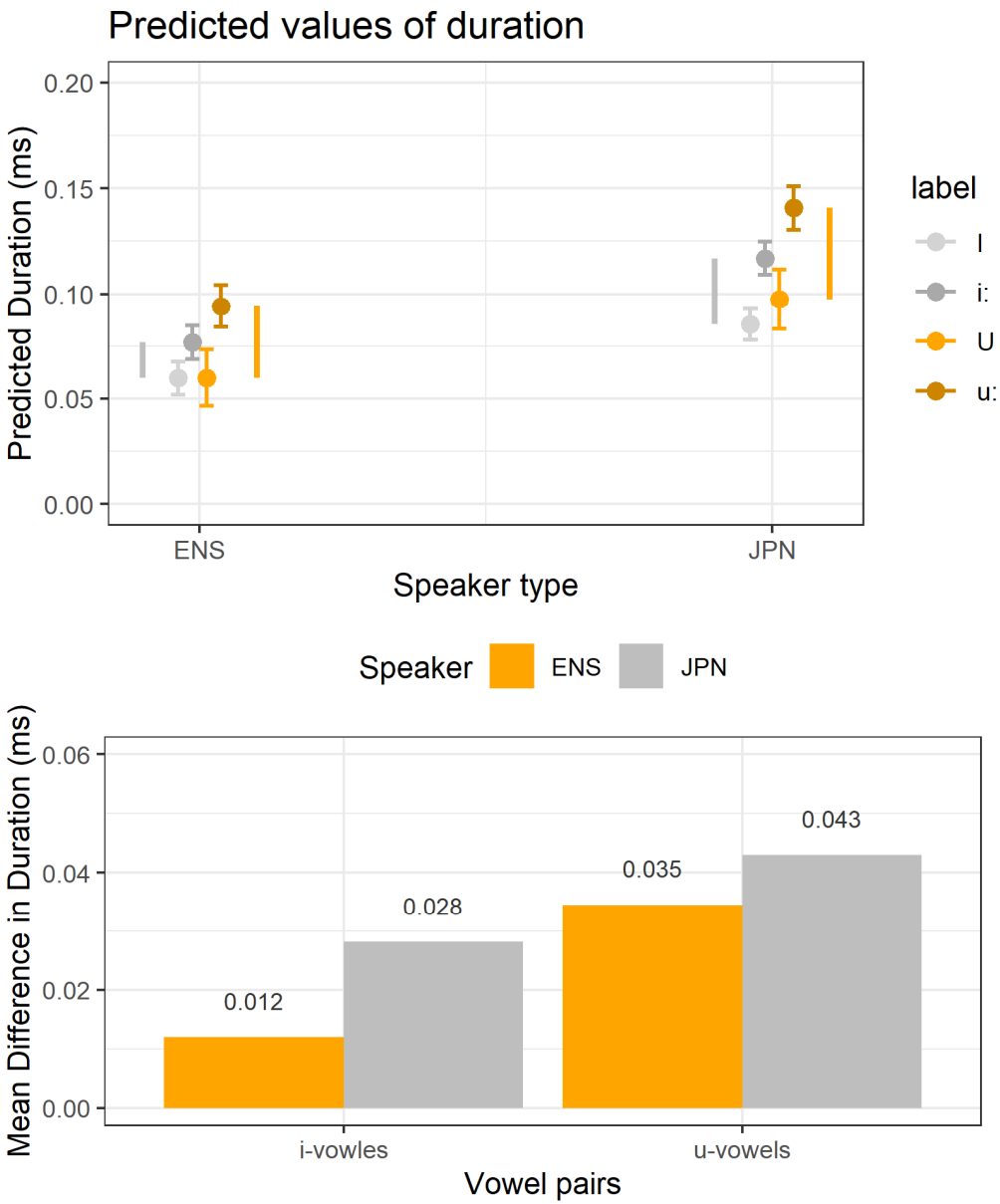


Results

Duration

- JPN extend all vowel durations (not just long vowels)! (expectation: short vowels shorter | long vowels longer!)
- JPN exaggerate the duration difference of both /i:/ and /ɪ/ as well as /u:/ and /ʊ/

Exaggerated duration difference by JPN speakers confirmed for **both /i:/** and **/ɪ/** as well as **/u:/** and **/ʊ/!**



Discussion | Outlook

Comparison with previous findings

- **Confirmation | Substantiation**
  - JPN: mergers of spectrally close vowels (lab settings: Ueyama 2003; Tsukada 2001)
- **Unique findings | Conflicts**
  - ENS: merger of /u:/ and /ʊ/ in spon. speech
  - JPN: exaggerated durational contrasts between spectrally similar vowels in nat. settings (lab settings: Tsukada 2009)

1. Apply same method to German learners and learners of other languages (e.g. German)
2. Determine what factors differentiate ENS and L2 speakers re. vowel production

(potential MA theses!)

Limitations

- Quality of recordings is really poor! (minute-long recordings recorded on cell phones)!
- Difficult to control semantic | phonological environments (which is important) (see Visceglia et al. 2009)

Significance

- Bad quality could | can be compensated using advanced methods (Kernel Density Estimation)
- Insights into vowel production by JPN learners in **spontaneous speech** (underexplored) → natural setting allows to **generalise findings to real-life learner speech**
- **Automated** corpus-based investigation on larger samples

Potential Applications

Significance

- **First large-scale, corpus-based studies of ESL vowel production in natural speech!**

Possible Applications

- Extend study to L1 German learners of English (or learners of other languages)
- Can be applied to L3 and multilingual contexts (e.g., do multilingual learners have an advantage over bilingual learners?)
- Creation of targeted classroom materials or a a mobile app to improve L1-like vowel production among (advanced) learners

Thank you really very much!

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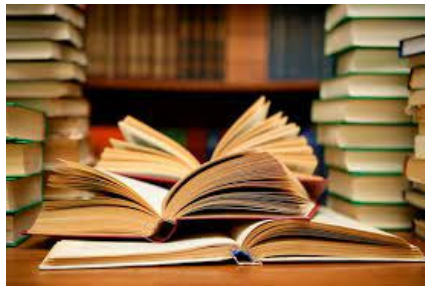

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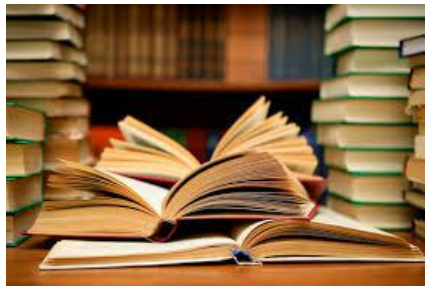

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Data & Software

Data

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Acknowledgements

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