Donders Institute for Brain, Cognition and Behaviour

(De)Composing auditory ERPs:

Estimating cross-linguistic variations by combining auditory change complex

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How it all started:
SOS (Sound of Silence) project

Geminate consonants

Singletons (/k/ /t/ /p/, etc.)

Geminates (/kk/ /tt/ /pp/, etc.)

- exist in various languages
- determined largely by timing (duration of words including geminates is longer than that including singletons)

Literatures

- Singletons ➔ short consonants
- Geminates ➔ long consonants

Moraic representation of geminates

Vance (1987): Moraic voiceless obstruent /Q/

- Moraic representation of Itta ➔ /i/ /Q/ /ta/
- Syllabic representation of Itta ➔ /i/ /ta/

Japanese way to represent geminates

Long consonants

/Q/ + singleton

However: no direct empirical evidence of the use of /Q/ while perceiving speech

What is /Q/ acoustically and perceptually?

あっす

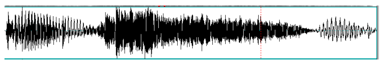
/assu/

What is the acoustic characteristics of “ss”?

Acoustics of /Q/

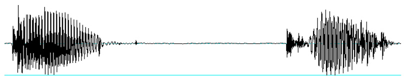
Fricative geminate consonants: ss, ff

- Frication
- /assu/



Stop geminate consonants: tt, kk, pp

- Silent duration
- /akku/



Do native speakers of Japanese maintain both representations?

How does /ss/ sound?
an informal observation

All Japanese natives around MS(N=10) thought that there is a "silent moment" in /assu/

/Q/

/assu/ = /a/ + /silent duration/ + /s/ + /u/

/assu/ = /a_su/

Japanese way to represent geminates

- **/_/ + consonant**
- **/_/ is so-called /Q/ (moraic voiceless obstruent)**

Non-Japanese way to represent geminates

- **Long consonants**

Experiment: Setup & predictions

16 Japanese native speakers (Kumamoto U)
16 Dutch native speakers (Nijmegen U)

- Discrimination test
- Categorization test
  - Stimuli type: /ss/ /_s/ /kk/
  - Words: assu / ossa / isse / ussa / ossu / usse

Summary SOS

Japanese:

✓Easy to discriminate between /_s/ and /ss/

✓Difficult to notice the difference between /_s/ and /ss/ when categorize these

Dutch:

✓Easy to discriminate between /_s/ and /ss/

✓Easy to categorize /_s/ and /ss/

Discussions

- When categorizing, /Q/ and /_/ are very similar to JP ears
- First empirical support for the claim that "Japanese use representation of moraic voiceless obstruent /Q/" when perceiving Japanese geminate consonants
- The effect was robust, not influenced by type of words and musical training
- Follow up: testing the effect with
  - Italian native speakers
  - Japanese native children (influence of literacy)

Next step:
DECO project

1. Compare ERP responses elicited by /asu/ and /assu/ between Japanese native and non-native listeners
   - EEG measurements

2. Gain more insight into a potential difference in ERP responses elicited by /asu/
   - Composition approach

Difference in response expected with regard to /s/

Composition approach?
Auditory ERPs

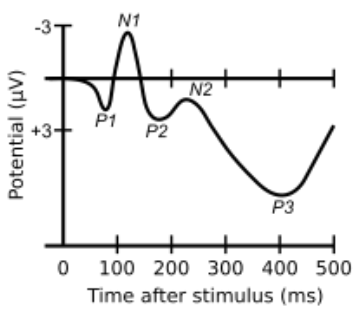
(P_1)-N_1-P_2-N_2

P_1 75-80 ms

N_1 100 ms

P_2 180 ms

N_2 220-240 ms



Composition approach?

Auditory Change Complex (ACC)

(P_1)-N_1-P_2, Sensitive to changes in auditory stimuli

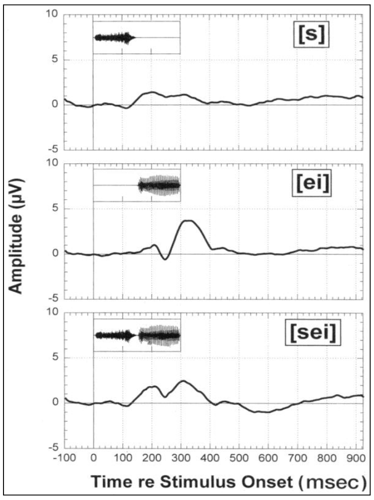
e.g. **phonemic boundaries /s/ /ei/**

Ostroff et al. (1998)

(P_1 80 ms)

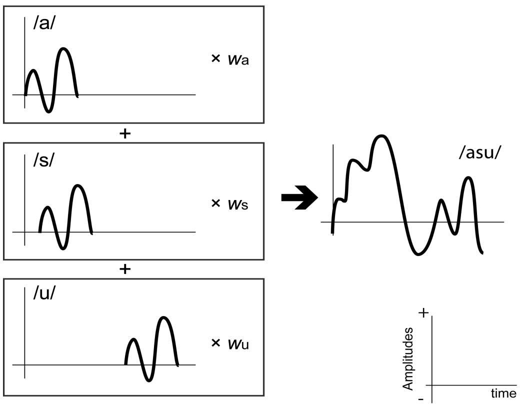
N_1 100 ms

P_2 180 ms



Composition approach?

(De)Composition approach



*Schematic diagram of the auditory ERP composition from e.g. P1-N1-P2 complexes of speech component. The **w** denotes weights.*

Dependent Variables: **GOF & W**

Methods

Stimuli

- /asu/ with different durations of /s/, ranging from 60-240ms with steps of 30ms, /a/=63ms, /u/=90ms
- /a/=63ms, /s/=60, 150 and 240ms, and /u/=90ms

Additional stimuli

- /asu/ with louder /s/ (+7.5dB/+15dB, /s/=240ms)
- /asu/ with long /a/ (93ms, /s/=240ms, /u/=90ms)
- /aku/ (/a/=63ms, silent = 200ms, /k/=40ms, and /u/=90ms)

Methods

Participants

- 8 Japanese native listeners
- 8 English native listeners

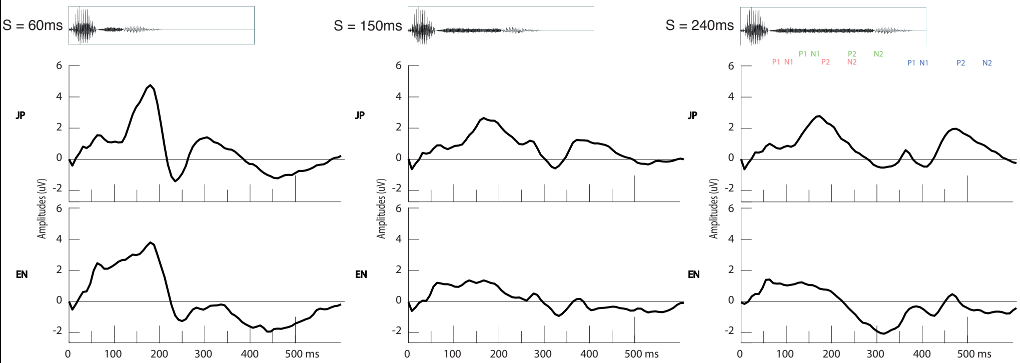
EEG recording

- 32 Electrodes + mastoid
- All stimuli presented 297 times each, mixed sequence
- Participants: watching a self-selected silent movie

Predicted peak timing (ms)

		Duration of /s/ (ms)						
		60	90	120	150	180	210	240
/a/	P1	80						
	N1	100						
	P2	180						
/s/	P1	143						
	N1	163						
	P2	243						
/u/	P1	203	233	263	293	323	353	383
	N1	223	253	283	313	343	373	403
	P2	303	333	363	393	423	453	483

Comparison of ERP responses elicited by /asu/ JP vs. EN



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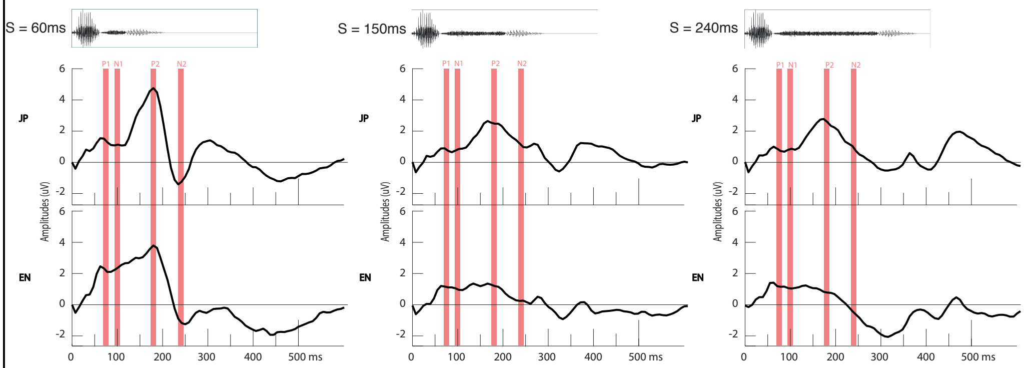

(A) Interaction between Peak amplitudes * Language group
N1: significantly higher for NL than JP
JP: P2 of /a/ higher than P1 N1
EN: all peaks (P1-N1-P2) not significantly different

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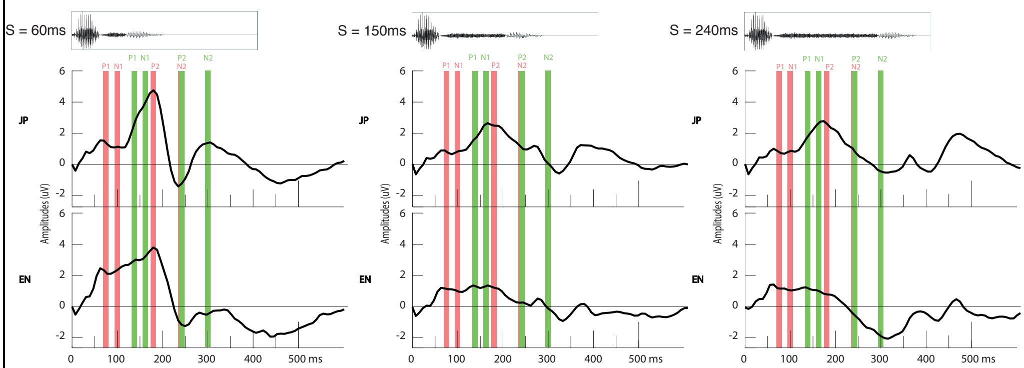

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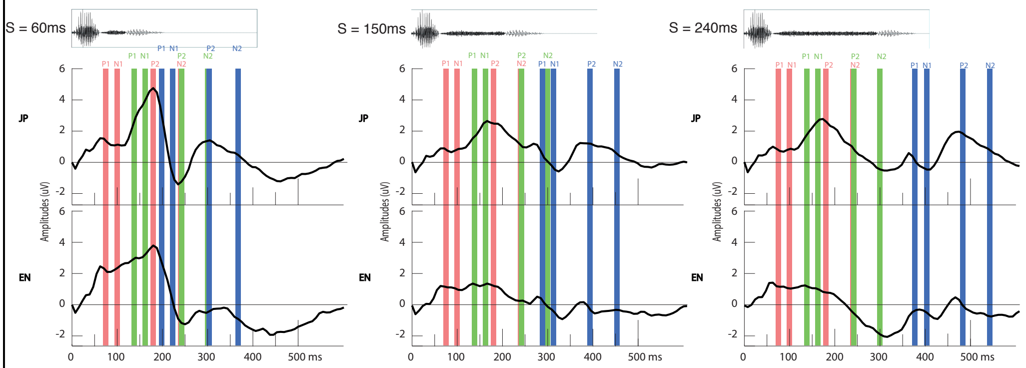

Interaction between Peak amplitudes * Language group
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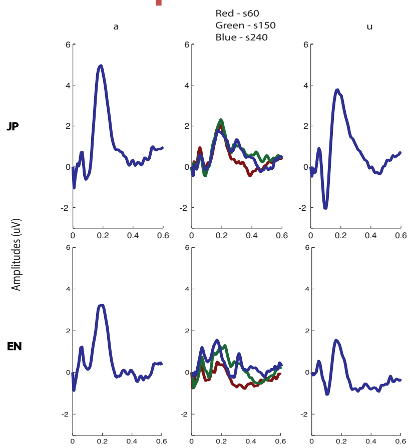
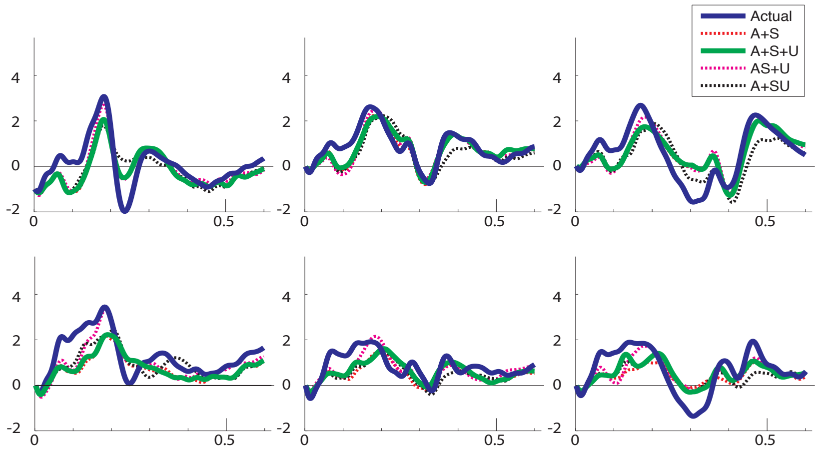
ERP: each component



The weighted sum of these components was calculated using a least squares fit for estimating the best possible composition of ERPs for the 3 versions of /asu/

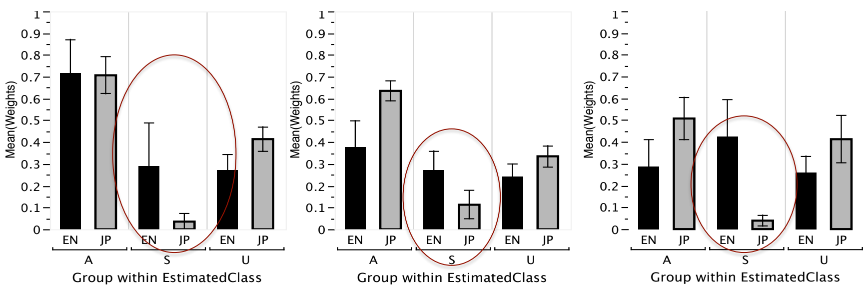
Comparison Real vs. Composed ERP



The goodness of fit: medium was better than the other two

No group difference (accuracy of composition was equivalent)

Weights



JP: weights for A was different from S and U (p<.01)

EN: weights for U was different from A and S (p<.05)

Weights for s was lower for JP than EN (p<.05)

Discussion and Summary 1

Japanese and English native listeners show differing amplitude patterns in the ERPs elicited by a multi-syllable speech sound (/asu/)

Significant differences were found in component amplitudes between 80 and 180ms following stimulus onset. This corresponds with the time window of ERPs associated with /a/, and partially with /s/

- JP: similar to more conventional P1-N1-P2 complex
- EN: additional peaks

Due to lack or presence of ACCs elicited by /s/ in the recorded ERPs?

Discussion and Summary 2

ERP composition approach suggested that Japanese ERP patterns can be predicted well when assigning **smaller weights** to the P1-N1-P2 complex of /s/ than for English native listeners

It was harder to find a trace of the ACC associated with /s/ in the actual ERP responses to /asu/ measured from Japanese native listeners

- The onset of /s/ may be perceptually **less important** for Japanese listeners in this context

The results could explain why Japanese native speakers **could** falsely perceive a silent duration during ongoing frication (SOS behavioural)

More discussions …

All English listeners had extensive exposure to Japanese speech but still showed difference

- Takes a long time to learn to perceive speech in the native way

Top-down information processing influences the elicitation of the ACCs: ACC may be sensitive to acoustic changes that correspond with language specific phonetic categories